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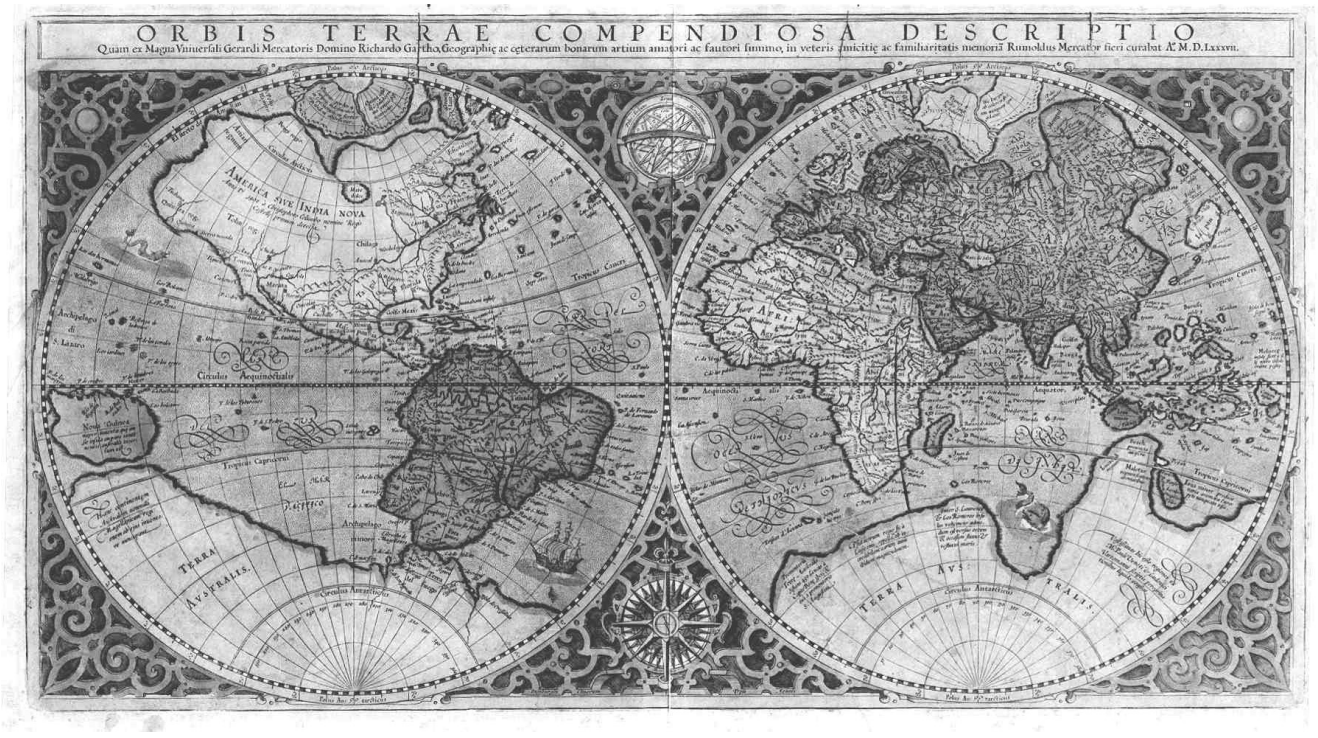

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PARTICULARITIES IN CONSTITUTING UNDERWRITER DISTRAINT

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ABSTRACT

Underwriter measures, also called "insurance measures" or "the insurance of rights that are capitalized through action", are defined as the possibilities given by the law so that, pendente lite, the court will impose, within appropriate limits, measures concerning the unavailability and preservation of goods, in relation to actions or deeds that may endanger the possibility of an effective exertion, at the moment of the compulsory execution of the decision, of the right of the creditor [1].

The underwriter measures consecrated by our civil law Code are: the underwriter distraint (art. 591- 596 civil law C.), the inhibition (art. 597 civil law C.), and the legal attachment (art. 598- 601 civil law C.)

Keywords: *Underwriter measures, Insurance measures, Underwriter distraint, Debt*

1. INTRODUCTION:

The underwriter distraint, regulated by the provisions of art. 591- 596 civil law C., consists in the unavailability, instituted by the court to which the main request has been pointed out, at the – optional – request of the creditor/ claimer, of movable or immovable goods belonging to the debtor, found in their possession or with a third party, so that, if necessary, the court can execute them compulsorily, with the aim of covering the alleged debt, and in proportion with its value [2].

In order to institute the underwriter distraint, the following conditions must be met: the creditor's debt must be acknowledged in writing, otherwise they will have to deposit a guarantee equal to half the claimed value; the petitioner should prove to the court that they have filed a debt request against the defendant; the debt that the claimer stands should be contingent, and if this requirement is not met, one of the following situations should be invoked: when the debtor has diminished by their actions the given guarantees or has not provided the promised guarantees, or there already is the risk for them to run away and hide their goods.

2. THE EXISTENCE OF A DEBT

According to art. 591, paragraph 1 civil law C., the underwriter distraint on the movable or immovable goods of the debtor can be requested by the creditor who does not have a compulsory execution title but has a contingent debt acknowledged in writing. There are waivers from this rule, regarding the contingent character of the debt and the need for it to be acknowledged in writing.

In the opinion of certain authors, the underwriter distraint is based on a certain, liquid, and contingent debt, and the debt can be easily acknowledged, without the need for detailed researches [3]. The opinion according to which a certain and liquid debt is not absolutely necessary, only a due debt, is more reasoned [4].

The certain and liquid character of the debt is requested only in the compulsory execution decision. The debt is certain when its existence results from the debt document itself or from other documents issued by the debtor or acknowledged by them. If such a condition were enforced, the institution of the underwriter distraint would be devoid of meaning, because, if the creditor had such a debt, they may resort to the more flexible procedure of the payment call, without starting a lawsuit that implies higher costs and a longer duration to be solved.

Basically, the debt must be acknowledged by a written document. However, the condition of acknowledging the debt through a written document has been considered met in case the debt was acknowledged by a court decision that is not yet final, because an appeal attack had been started against it, which is suspensive of execution [5]. Although, from the perspective of the application of the provisions of art. 379, paragraph 3 civil law C., in this case we cannot speak of a certain debt, the non-final court decision represents a sufficient guarantee of the claims invoked by the petitioner and justify the adoption of the measure of the attachment, under circumstances that leave the evaluation and amount of the guarantee at the latitude of the court.

The problem of this ascertaining document of the debt is difficult to approach, and the recent practice of law courts has not provided solutions to it. The explanation of this absence of recent jurisprudence lies in the fact that the application of the underwriter distraint in a civil context has an insignificant weight, and in a commercial context, the distinction between a debt acknowledged in writing and a debt without this quality is not essential, since the guarantee is compulsory in both cases.

The debt claimed by the petitioner must concern an amount of money, and the underwriter distraint cannot sanction the non-fulfillment of an obligation of action. In the hypothesis that the debtor refuses to fulfill an obligation of action, the creditor can request the compensation of the prejudices caused by the debtor's

obligation to pay damage – interests. Once such an action started, the creditor has the possibility to request an underwriter distraint even without depositing a guarantee, since it can be considered that they have a written document confirming the debt, and the object of the promoted action is the payment of an amount of money.

The same solution will also be adopted in case the creditor starts an action whose object is to establish the equivalent of the value of the goods in the case of the impossibility of fulfilling the obligation of its delivery, established through the execution title [6].

Finally, the debt invoked has to be contingent. However, the interest in acting towards obtaining an underwriter measure is also justified in case that the debt has not reached its deadline, but there can be noticed that the debtor has decreased through their actions the guarantees provided to the creditor or has not given the promised guarantees, as well as when there is the danger for the debtor to circumvent from prosecution or to hide or dispel their fortune (art. 591, paragraph 3 civil law C.). In these cases, the debtor is declined from any term, so that the creditor can file a suit request without the debtor to be able to oppose them with the exception of the premature character of their action. The same solution also results from the provisions of art. 1025 civil law C., according to which the debtor cannot request the benefit of the term anymore, when they are insolvable or when "through their actions, they have diminished the guarantees given by contract to their creditor".

3. THE PROOF OF FILING A LAWSUIT

The person who requests the enforcement of the underwriter distraint has to prove the fact that they have filed a lawsuit for recovering the debt claimed from the debtor. The existence of a lawsuit justifies the actual interest of the creditor in the process of obtaining an underwriter measure and also guarantees that the unavailability of the goods of the alleged debtor will be limited in time, during the lawsuit.

The object of the lawsuit initiated by the claimer should be the enforcement of de the debt right over an amount of money. In law practice, it has been evaluated that a petition whose object is to issue a payment call, stated based on G.O. no. 5/2001, is not able to allow enforcing an underwriter distraint. The solution of the courts is based on the fact that the procedure of issuing a payment call does not imply the legal analysis of the creditor's claims, as they have no authority over the judged goods and, as a consequence, they do not meet the condition of a lawsuit according with art. 591. paragraph 1, second thesis, civil law C.

However, the mentioned solution is arguable, in what concerns both its legitimacy and its opportunity. Indeed, doctrine has consecrated the necessity of the existence of a lawsuit over the debt right, whose preservation should be obtained following the enforcement of the underwriter distraint. Still, this conception has taken shape under the circumstances in which, at the moment, the legislation did not include a procedure that would allow issuing an execution title without reference to the basis of the legal, so that the only procedure that the creditor could use in order to recollect their debt was that of common law.

At present, jurisprudence has to take into account the reasons why underwriter measures have been regulated. In this sense, we can notice that the need to protect the creditor's rights can also be found in case they choose to issue a payment call with the purpose of obtaining the execution title against their debtor. Although the procedure of the payment call is implemented as urgent, if the debtor is unsatisfied with this solution, they can resort to a petition for annulling the payment call, and only in case it is rejected, the order of allowing the call will be able to be invested with an execution formula, according to the provisions of civil law C.

Between the moment when the creditor decides to act in the direction of obtaining an execution title and when the execution against the debtor can actually be started, there is enough time for a dishonest debtor to attempt to alienate their goods so as to create a context of insolvability, which would lead to the impossibility of the compulsory execution of the debt. Therefore, it is not fair that, in case the creditor chooses a simpler procedure for recovering their debt, they would be devoid of procedural means to preserve their rights against the risks implied by the length of the used legal procedure [7]. The fact that the procedure of the payment call excludes the analysis of the basis of the legal reports between the parties only during the first stage must also be taken into consideration. If the debtor against whom an order has been issued, according to O.U.G. no. 5/2000 files an annulment suit, the court invested with such a petition will analyze the basic defense formulated against the claims of the creditor, which implies that the second stage of the procedure can no longer be characterized as lacking any analysis of the basis of the legal reports between the parties [8].

We can state that the legislator gives in this case a right of option concerning the procedural means of invoking the basic defenses – exerting the annulling request or challenging the execution. If, however, in relation to the claims of the parties, the administration of unconscionable evidence in the procedure of the payment call would be required, then the court will reject the petition of the creditor – and, respectively, will allow the annulment petition filed by the debtor – and as a consequence the claims of the petitioner will be solved according to the common law procedure [9].

In all the cases where the law imposes the condition of the existence of an essential suit for the underwriter measure, the proof of the file of the lawsuit should be annexed to the underwriter distraint request. The doctrine also preserves the idea that this condition is not met unless the lawsuit file that triggered the basic suit is legally labeled and a solution deadline has been set, and not when, under the provisions of art. 114 civil law C., the claimer has been granted a short delay for completing or modifying their request. Also, it is considered that, in order for this condition to be seen as met, the petitioner must continue the lawsuit, because if the matter is left unanswered, the text request is not achieved [10].

4. DEPOSITING A GUARANTEE

The third condition that must be met in order to institute the underwriter distraint is the deposit of a guarantee. The purpose of this requirements is to test the seriousness of the claim filed by the creditor and to provide a guarantee for the debtor against possible damage they might incur through the unavailability of their goods, in case it will be proven that the basic lawsuit filed by the creditor has been unfounded or even exerted in dishonesty.

The guarantee represents therefore the amount of money that the petitioner of the attachment will make available to the court, with the purpose, on the one hand, to avoid clearly unfounded attachment requests and on the other to build a fund to compensate the party against which the underwriter distraint measure has been taken, in case the request was dishonest and has caused prejudices to that person.

The civil law Code distinguishes between the situation where the debt invoked is acknowledged through a written document and the one where there is no act to prove the debt.

If the creditor has a written document to prove the alleged debt, at the moment of the approval of the underwriter distraint request they may be forced to pay a guarantee, in an amount established by the court. In this case, the obligation of the claimer-creditor to pay a guarantee, as well as the amount of this guarantee, will be evaluated by the court.

In what concerns the notion of written document, jurisprudence has not reached a unique solution. Therefore, according to one opinion, a written document means any document that, irrespective of its form, includes a mention on the debt supported by the creditor. Another opinion claims that a written document means only that document from which the debt of the creditor results in a clear and categorical manner and which should only be authenticated in order to become complete evidence [11]. It has been considered that an underwriter distraint cannot be granted without any guarantee when the written document does not mention the amount of the requested debt. However, this solution has been criticized, because the law has not taken into account the amount of the debt, but its liquidity, which can only be determined upon the request for an underwriter distraint, and its exact amount will be computed during the lawsuit.

Most authors consider that a written document means a document issued by the debtor or that may be opposed to the debtor, on which the creditor's lawsuit file is based, and which has in itself enough evidence to support the lawsuit. Not any document issued by the debtor and that the court is forced to take into consideration can be regarded as a written document. If such documents are insufficient to prove the claims of the petitioner and the result of the trial depends on the provision of other evidence, the underwriter measure can only be enforced based on a guarantee for half of the claimed amount. The same problem arises in the case of the existence of a beginning of a written proof issued by the debtor [12].

A written document, based on which underwriter distraint can be instituted, under the circumstances where the guarantee is left for the court to evaluate, is not represented by a court decision presented by the creditor, which disposes a payment obligation for the debtor, if this decision is not final and therefore subject to a restatement following a regular appeal. In this sense, the court has decided in a case that "the first court decision, which is not yet final, does not represent an undisputable title that would exempt from a guarantee the party that makes an attachment based on that decision." [13]

Other court decisions have stated that a written document means any document that is not authentic and which mentions even a non-liquid debt. In this sense, it has been decided that it is not compulsory to deposit a guarantee, and the enforcement of this condition is left for the court to evaluate when the obligations of the parties are founded in a contract and the requests of the petitioner are proven by delivery documents annexed to the petition [14].

In all cases, irrespective of the meaning given to the notion of written document, the judge has the sovereign right to evaluate and decide whether or not the document invoked as a debt title meets the conditions imposed by the law.

If the debt is not proven by a document, the creditor can request the underwriter distraint, but because of the much reduced credibility of its request in a suit, they will also have to file a guarantee amounting to half the claimed value. Art. 591, paragraph 2 civil law C. refers to half the value of the debt requested in the lawsuit filed by the creditor [15]. In this case, the amount representing the guarantee has to be deposited before the measure is approved, because at the end the judge has to mention whether this condition was met or not.

Article 591, paragraph 3 civil law C. acknowledges the right to request an underwriter distraint to the creditors that do not have a contingent debt, in certain cases mentioned within limitations: when the debtor has diminished through their actions the guarantees given to the creditor or has not given the promised guarantees, or when there is the risk for the debtor to circumvent from prosecution or to hide or dispel their fortune. In these circumstances, the creditor must prove that they have filed a lawsuit and deposit a guarantee in the amount established by the court.

Considering that Section IV of Chapter I of Book V of the civil law Code, although entitled "On guarantees", rather treats the procedure of bringing a warrantor, several tendencies have developed in law practice concerning the manner of fulfilling the obligation of depositing a guarantee.

Therefore, the possibility to deposit the guarantee as a bank warranty letter has been discussed. In a decision, the former Supreme Court of Justice has made a statement concerning the non-acceptance of bank warranty letters as a means for depositing the guarantee, invoking the fact that the validity period of such an instrument would be incompatible with the purposes for which the measure of depositing a guarantee has been taken [16].

However, legal literature has expressed an opinion according to which the bank warranty letter can serve as

a means of fulfilling the obligation of depositing a guarantee, if it meets the conditions for guaranteeing the purposes for which the measure of depositing a guarantee has been taken [17].

In what concerns the establishment of the amount of the guarantee, there have also been various solutions during the ancient regulation of the warranty measures regarding the correct meaning of the "claimed value" on which the amount of the guarantee should be based. The current regulation bases the amount of the guarantee on the same notion, of claimed value. Generally speaking, the solutions provided by legal practice state that the guarantee is set based on the value claimed in the lawsuit, as half the claimed value [18].

In a commercial context, a guarantee is compulsory in all cases, according to art. 907- 908 com. C., except when the attachment request is made based on a bill of exchange or on another commercial effect to order or to bearer, claimed as unpaid. Since the text does not establish the amount of the guarantee, it has been decided that a guarantee for half the required amount does not apply. It has been evaluated that this amount should be reasonable and sufficient, since the interests of the creditor must also be protected, besides those of the debtor [19].

In what concerns the imposed conditions, fro its edification, the court is entitled to analyze in brief the issue of the eligibility of the main lawsuit, without bringing any prejudice to the essence of the lawsuit [20]. Examining the actual and legal foundations of the lawsuit, as well as the potential defenses of the defendant (for instance, the prescription or the exception of a non-eligibility), the court is able to avoid taking serious measures based on an audacious or doubtful lawsuit.

5. CONCLUSIONS

Underwriter measures that can be taken in a civil lawsuit are the most definite and repressive form of defending the rights of the creditor from the risk for the debtor's patrimony to suffer modifications that may hinder a potential compulsory execution. Besides all these, the legislator has also envisaged other legal means that serve to defend the debt rights and that are named generically preservation measures. Together with underwriter measures, they form the organized system whose purpose is to defend and guarantee the debt rights.

Once the requirements for the application of the underwriter distraint have been met, the request to apply this measure will be judged according to common law, but as an urgent matter and before the main lawsuit. This ensures the right of the claimer to pursue not only obtaining a decision that would give them satisfaction, but also a favorable perspective concerning its fulfillment.

In relation to the main lawsuit, the underwriter distraint – together with the other underwriter measures mentioned in the civil law Code, the underwriter distraint and the legal attachment – is merely an accessory. Therefore, taking into account the purpose of these procedural instruments and their connection to the civil lawsuit, they should be regulated in the future in the general section of the civil law Code and not in the section concerning special procedures or compulsory execution.

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CLIMATIC CONDITIONS AND THEIR INFLUENCE ON MARITIME SHORES

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ABSTRACT

The shore or the sea coast, as separation lines between land and sea, is subject to the permanent action of internal factors (tectonic movements and volcanism) and of external factors (processes of erosion, wind, waves, currents, tides, living organisms and humans), issues that complicate their development.

A good quality, stability and consolidation of shores or coasts have a special importance in the socio-economic life of each country limitary to the sea or navigable rivers. This is in view of the benefits arising from the safe operation of maritime and river ports, which, across time, transformed neighboring villages in great national or international port cities.

Keywords: *climatic conditions, maritime shores, geo-climatic factors*

1. INTRODUCTION:

The shore represents the separation line between land and sea, which permanently subject to internal factors (tectonic movements and volcanism), as well to external factors (wind, waves, currents, tides, living organisms and humans).

The total length of the shores of the world is of 299,000 kilometers, 109,000 kilometers of which represents the shores of inner seas. The shores length does not depend on the size of the continent or of the country; therefore, Europe has an area of 10,000,000 km and shores of almost 38,000 kilometers, and Africa has an area of 30,000,000 kilometers and 30,000 kilometers of shores.

Europe is surrounded by nine sea basins: the Mediterranean, the Black Sea and the Azov Sea, the Caspian Sea, the White Sea, the Barents Sea, the Norwegian Sea, the Baltic Sea, the North Sea and the North Atlantic Ocean. Human activities are often concentrated in the coastal regions that are least able to assimilate these activities and where their adverse effects are most visible [1].

The main problems of the European coastal areas are: water pollution and eutrophication, loss of biological diversity, land use and landscape damage, salt water inflowing the drinking water resources and soil erosion and coastal erosion affecting global commercial activities.

Sea shores have also a direct influence on human development. In time, the local populations that were established around sea shores and that have invested in economic exploitation by means of soil fertilization were not always successful, as there are situations in which people were poisoned because they used the waters which were crossing these soils. One can appreciate that the waters of the subsoil close to the zero altitude, the reference point of seas and oceans, have, through their collection from the spring to their flow, a certain pollution level.

In terms of genesis, shores are subject to natural and anthropic factors and they are classified into two broad categories: high and low.

2. GLACIERS' MELTING CONSEQUENCES ON SHORES

Glaciers are enormous masses of persistent ice, formed in polar and high mountainous regions, which, under the influence of gravity, move slowly down the valleys or on slopes. They are the largest reservoirs of fresh water and their cumulative surface area is equivalent to the surface of South America.

Glaciers began to retreat all over the world at the end of the Little Ice Age (around 1850), but since a few tens of years, they began to melt at a rate that cannot be explained. The expected climate changes in the next century will further affect the rate of glaciers' melting.

The average world temperature will increase by 1.4 - 5.8°C by the end of the XXI century. By 1970, only in the Alps there was lost about one third of the glacier area and half of their volume. Dramatically, the phenomenon of floods caused by glaciers' melting illustrates the possible impact of the climate change at the local scale.

Although only a small quantity of the permanent ice of the planet is situated outside Antarctica and Greenland, glaciers are important because they respond immediately to the effects of climate change and their loss affects all the shores of the planetary ocean – also called the world ocean- and also its people and ecosystems. If the warming process continues at the same pace, glaciers' melting in the next century will cause devastating floods, the loss of several water reserves that benefit millions of people and rising sea levels will threaten to destroy entire coastal communities.

2.1. The Consequences of Sea Level Rise on Shores

The main reason of the sea level rise is represented by the extension of waters, as a consequence of the increase of water temperature - a simple physical phenomenon. The additional factors contributing to this increase are glaciers' melting and the melting of the ice cap, caused by the increase of air temperature.

The sea level rise which is due to climate change is not a negligible risk in the process of soil and sea shores erosion. Also, sea level rise could cause the flooding of coastal and littoral areas or even of coastal towns situated at the oceans and seas of the world.

However, the damage caused by the sea level rise may lead to the irreversible degradation of soil shores and to the degradation of several complex ecological systems (coral reefs, the arctic region, coastal wetlands).

The effects of the sea level rise may affect the good running of port activities. The vulnerability of port structures, built on sea and river shores, will have a negative effect and will constitute a threat to international economic life, the ports themselves being indispensable elements of international transportation activities.

The side effects of the degradation of the structure of world ports will be devastating in developing countries, due to their climatic and geographical conditions, to the high degree of dependence on natural resources from other continents and to their reduced capacity of adaptation.

2.2. Regional Differences

The sea level does not increase equally in all geographical regions. Therefore, in some regions it is expected that the sea level will rise more than in others, because the increase in water temperature in water layers (vertically) takes place in different stages. Independently of global warming, regional changes of the sea level can be caused also by continental movements. For example, the soil level from the deltas of certain rivers drops a few millimeters per year because the sediments are retiring. In these cases, an increase in the sea level intensifies the existing regional effects. In other regions, an increase of the sea level remains subtle, because the soil level increases with the same value, or even at a higher rate than the one of the increase of the sea level.

Over one quarter of the population of Africa lives at distances less than 100 km from the shore and the largest cities are located on the coast, being vulnerable to sea levels rise, soil erosion and shoreline erosion and to extreme weather events.

2.2.1. Asia

In Asia, extreme weather events have multiplied in the area of temperate climate, including floods, drought, spontaneous fires and tropical cyclones. Areas which are at risk include the sectors of agriculture, water and food resources, biodiversity conservation and natural resources management, coastal zones and infrastructure management. Sea level rise and the frequency of tropical cyclones will result in the displacement of tens of millions of people living in low areas along the coast, in areas with tropical and temperate climate from Asia.

2.2.2. Latin America

In Latin America, glaciers withdrawal will cause landslides in the coastal area and the reduction of water resources, particularly in areas where the water from the melting snow is vital. Coastal settlements, production activities, infrastructure and mangroves will be negatively affected by the rise of sea levels.

2.2.3. The Island States

In the Island States, the expected increase of the sea level by 5 millimeters per year over the next 100 years will cause the soil erosion of sea shores, which will deepen the poverty, will lead to the displacement of communities, to increased risks of flooding, to the reduced resistance capacity of coastal ecosystems, to salt water inflowing into the drinking water resources and to high costs for adapting to changes. Also the coral reefs will be negatively affected by the oxidation process and by the low calcification degree, caused by high levels of CO2; the mangroves, the phytoplankton and other coastal ecosystems, as well as the biodiversity associated to them, will be affected by the temperature increase and by the rapid rise of the sea level.

2.2.4. The European Shores

In order to know the European shores, we must know the geographical characteristics which are in a continuous evolution.

Our continent is surrounded by oceans and seas to the west, south and north, and it is closely related to the Asian continent through the Ural Mountains. Since it is surrounded on three sides by water, the European continent has the appearance of a large peninsula. The length of the continent from east to west is of 5600 km and from north to south, in a straight line, is of 3900 km. It has an area of 10,000,000 km^2 and a population of 700,000,000 inhabitants.

Europe is considered the cradle of a civilization of 5 millenniums, where illustrious thinkers who opened the era of large geographical discoveries lived. The cultural and civilizing influence of the Europeans was felt in all the corners of the Earth.

Seen within the continental unity of Eurasia, Europe has the appearance of a huge peninsula which goes forward into the Atlantic Ocean. It stretches from the Ural Mountains and to the Atlantic Ocean (the Roca Cape) and from the Mediterranean Sea to the Arctic Ocean (the Nordkyn Cape). From north to south, the continent is spanning on a distance of about 4000 km, and from west to east- for about 6000 km. Europe is entirely located in the northern hemisphere. The first meridian (the 0° meridian) passes in its western part.

European shores are strongly stripped, forming many large gulfs, islands and peninsulas. The northern part is bathed by the seas of the Arctic Ocean: the Norwegian Sea, the Barents Sea, and the White Sea. The White Sea goes deeply into the dry land, forming the Kola Peninsula.

The southern part of Europe is bathed by the waters of the Mediterranean Sea, the Black Sea and the Azov Sea. The Mediterranean Sea is differentiated in the following seas: Liguria, Tyrrhenian, Adriatic, Ionian and Aegean. The last one communicates with the Black Sea through two clutches: Bosporus and Dardanelles. The space between these two clutches is formed by the Marmara Sea.

The most important peninsulas in Southern Europe are: the Iberian Peninsula, the Italian Peninsula (Apennine), the Balkan Peninsula and the Crimean Peninsula.

The western part of the continent is bathed by the seas of the Atlantic Ocean: the Narrow Sea, the North Sea and the Baltic Sea.

The European maritime shores are also directly affected by the rise of the sea levels.

2.2.5. The Romanian Shores at the Black Sea

A separate problem is given by the effects of the heating process of Danube River. However, taking into consideration the wider space of the Danube Meadow, the climate has several particularities.

The climatic nuances that Danube has during its course (sub-Mediterranean influences until Zimnicea; transition climate between Zimnicea and Oltenița; climate with shades of aridity until Tulcea, climate with pontic influences in the Delta) belong to the surrounding regions and not to the course itself. However several climatic elements have defining characteristics, partly influenced by Danube and by the low meadow relief. The average annual temperature is, for the Danube Meadow, the highest in the country (over 11°C) due to higher average temperatures in July (24°C) and in January (-1°C in the south, -2°C in the Delta).

Tropical days, like those in the southern part of the Romanian Plain and Baragan, are softened by the higher humidity of the air, caused by the water evaporation along Danube, but also from its meadow (where the underground water is at the surface).

Precipitations decrease towards the east, with their regional decrease, and the prevailing winds (the Dry South Wind in the western part of the Romanian sector of Danube and the Icy North Wind in the eastern part) are considerably softened by the relief "shelter" of the Danube Meadow.

Precipitations produced on the European continent are largely collected by the Danube River and the floods caused by its increased flow from the last period primarily affected its banks. This illustrates the possible impact of the climate change at the level of each river-side country and for the most part, on our country, where Danube covers a considerable distance until it flows into the sea. Basically, the hydrographic level - the essential element of the physical and geographical characteristics- affects, in the most aggravating way, the Danubian banks on the territory of our country, where it has the greatest flow of its entire route.

Danube increases its flow (to over 900 mc./sec. at Patlageanca), largely because of the direct tributaries of our country (Nera, Cerna, Topolnita, Drincea, Desnatui, Jiu, Olt, Vedea, Arges, Ialomita, Calmatui, Siret, Prut).

The solid flow at the entrance to the Delta is of 58.7 million tons of alluvia per year, which are deposited on the territory of the Delta or in the sea.

The process of covering a long-shore area, on the one hand with the sediments brought by the sea, and on the other hand with objects deployed from the impacts, but especially from the mixture of sea water with the water of Siutghiol and Techirghiol lakes, could cause irreparable consequences by altering the salinity and, in general, of the very different physic-chemical properties.

Coastal structures will also suffer, at the time of their construction, if seismic events or their consequences, determined by the endurance of coastal soils are not taken into account.

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AQUATIC ENVIRONMENT POLLUTION

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ABSTRACT

From immemorial times people have been concerned with environment protection, certainly on a scale corresponding to the impact of human activities on it, taking into account, from the very beginning, the interest on the "health" of drinking water sources, where their animals drank and where their respective communities could drink clean water and use it in daily cooking, until nowadays, when the marine environment has turned into an international policy.

Taking into account that the natural environment represents the set of natural conditions and elements of the Earth: air, water, soil and subsoil, all atmospheric layers, all inorganic materials and all the living beings which can not live without water, their protection knows today a regulation by means of legal norms- which are carefully monitored and punished from a legal point of view, in each state.

Keywords: *Dobrogea, Danube, Black Sea, aquatic environment,*

1. INTRODUCTION:

The European Union published in December 2000 a framework directive on waters (Directive 2000/60/EC of the European Parliament) which considerably changes the aquatic environmental control [1].

Usually, the water is a liquid, a hydrogenated compound of oxygen (H2O). But it can exist in three different states of aggregation, changing with relative ease (on Earth) from one into another: liquid, gas (vapors) and solid (ice). Water has several specific (geographical) characteristics:

- it occupies intense volumes at the surface of the Earth;
- it creates a continuous circuit between oceans, atmosphere and dry land;
- it represents the most widely spread solvent;
- it has a great capacity of absorbing the heat, it warms and cools more slowly than any other liquid, having a regulatory influence on the temperature of the Earth;
- it boils at 100 degrees C and it freezes at 0 degrees C;
- it reaches its maximum density at +4 degrees C; at 0 degrees C it becomes by 10% more voluminous than at +4 degrees C, which makes ice float. When the water from the rocks freezes, it desegregates them.

The geographical units of the hydrosphere, respectively the territorial systems in which water is organized, are: oceans, seas, flowing waters, lakes and underground waters, glaciers. However, water is a compound of other layers of the Earth, with which the actual hydrosphere is in a permanent exchange (circuit). We are talking about the water in the atmosphere (in the form of vapors), in the biosphere (80% of living matter is made of water), in the rocks of the geosphere (as free or chemically bound water) and in the soil.

The limits of the hydrosphere itself are given by the limits of the space with free liquid water. In the geosphere it descends to 5-10 km and in the atmosphere 90% of the water is localized up to 5 km altitude. However, the wider limits reach the Moho discontinuity (as in the case of the relief-sphere) and it ascends into the atmosphere to around 80 km.

Its total volume is of almost 1.4 billion cubic km, 96.5% of which is to be found in the oceans; 2.46% is represented by the underground water and only 0,0002% is to be found in rivers and 0,017% in lakes etc.

2. THE AQUATIC ENVIRONMENT

The aquatic environment is much more complex than the terrestrial and air environments because the interdependence between the environment and the body is much closer in the case of the aquatic beings than in the case of the terrestrial ones. As a consequence, the action exercised by the environmental factors on the poisoning process is more powerful in the case of the aquatic organisms.

Knowledge of water quality is the starting point in determining the measures which are necessary to their protection and to the systematic verification and correction of the applied measures.

2.1. The Environment of Surface Waters

Surface waters are standing or flowing inland waters from the surface of the land, as well as transitional and coastal waters.

In what concerns the actual outcome of the EU environmental policies, Nicolae Sfăcăreanu believes that some problems have been improved. These include surface water quality, air quality in relation to certain substances (acid rain, for example), the progressive designation of areas for wildlife and nature protection etc. Some areas have experienced deterioration, remaining huge challenges, even if the EU has given them substantial attention. These include the decline of biodiversity, global warming, deterioration of fauna fisheries and air pollution problems related to an increasingly busy traffic.

It is clear that the environment has undergone

fundamental changes in recent decades. From an issue which has been ignored when designing the European project of integration and cooperation, it has become one of the most powerful and visible areas.

Special situations regarding the water from a geopolitical point of view are represented by the areas where the amount of water is insufficient and where it can become a weapon [2].

The inequitable use of natural resources affects the interests of some actors and it may lead to tensed states within the geopolitical area.

The hydrographic basin of Danube River includes almost the entire surface of the Romanian hydrographic network (97.8%), with the exception of a part of Dobrogea's rivers which flow into the Black Sea. Romania has a hydrographic network with a length of 78,905 km. The water resources from the interior rivers are of 40 billion m3, which represents 20% of the water resources of the Danube River [3].

2.2. Marine and Coastal Environment

The Black Sea has an area of 413,490 km2; its maximum depth is of 2245 m; its water volume- 529,955 km2; the length of its shores - 4020 kilometers. Many great rivers flow into the Black Sea, which causes a reduced salinity of 20-20%: Danube, Dniester, Bug, Dnepr and Kizil. 78% of the river intake (assessed at 346 km2) belongs to the rivers in the north-western part of the basin, and of these, of course, to Danube.

3. THE INDIVIDUALITY OF THE AQUATIC ENVIRONMENT OF DOBROGEA

Due to the favorable natural environment, Constanta city is developing on a calcareous promontory that goes forward into the sea with approximately 1,500 m. The first boats Greek were sheltered in the bay formed by this peninsula, towards the south. The documents of the time, from the VIth century BC, talk about a city named TOMIS, as one of the most important ports on the eastern shore of the Black Sea. Its settlement at the crossroad of the main circulation arteries has played an important role in the development of the city, becoming a major attraction point of the main commercial routes that linked the Mediterranean ports with those of Pontus Euxin.

The Tomis Port also served as a call for the ships that linked the commercial centers of Histria, Arganum, Halmiris with the Danubian ports [4].

The roads connecting the far Euro-Asian regions with the Mediterranean world can be also added to these ways of maritime communication. Furthermore, the link to the mountainous areas of the Carpathians and to the Romanian Plain was made on the line of the main valleys.

3.1. The Climate of Dobrogea

The air temperature in Dobrogea undergoes changes which depend on altitude, season and distance from the sea; there are differences between the coldest month and the warmest month of the year. This difference is due to water and land heating and cooling particularities. These features are determined by the absorption of sunlight and by the different caloric capacity of water and soil particles, and especially by the existence of vertical and horizontal currents in the sea, which cause a turbulent heat transport between the water layers.

Another difference between the thermal regime of the sea and that of the land lies in the fact that water areas are, on average, warmer than the surface of the land because its radiation balance is higher than the one of the land. The difference between the air temperature of the land and that of the sea leads to the formation of air currents that periodically change their direction, depending on water and land heating and cooling processes.

As we move away from the sea shore, in January, the degree of continentalism increases and air temperature decreases from positive to negative values. In July, due to the influences of day breezes, the air temperature changes with up to 1-2°C, compared to the one of the dry land.

Starting with March, due to the increase of the intensity of solar radiations, the air temperature becomes positive, marking the emergence of differences of about 3-4°C, compared to the previous month. Sensitive growths between 5-6°C are recorded in April. On the one hand, they are due to the increase in value of the thermal balance of the active underlying surface and, on the other hand, they are due to the influence of the atmospheric circulation which is largely south western. Due to all these, the air temperature slowly increases in May and in June, reaching its maximum in July; then it begins, at first slightly and then increasingly, to decline by the end of the year. The emphasis of the differences between September-October (about 4-5°C) is due to the decrease of the radiation balance, but also because the influence of the masses of colder air from the east begin to change, which is determined during the cold period.

Summarizing those stated in connection to the monthly average temperatures and to the seasons, one can see that during the winter and summer months the air temperature varies little from one month to another compared to the transition months of March-April and October-December.

3.2. Rainfalls in Dobrogea

In terms of precipitations, Dobrogea is the driest region of the country: the average precipitation limits is between 350 and 510 mm annually. The coastal area - between the sea shore and a line approximately parallel to this one, situated at about 30 -40 km inland - is characterized by the lowest amounts of precipitations – under 400 mm annually. The largest amounts of precipitations fall in the south-western part of Dobrogea - over 450 mm annually – as well as in the western part of the Babadag Plateau – where there are recorded over 600 mm annually, and in the area of Macin Mountains.

Precipitations are more abundant during the warm period of the year - from April to October - when there are recorded about 60% of them. Heavy rains fall in late spring and in early summer; a second rainy period is

recorded in November. Sometimes these rains are torrential.

In what concerns the precipitations under the form of snow, they are also quantitatively reduced. The average annual number of snowy days is of 8-15 in the sea coastal area. The number of days with a continuous snow layer is of around 14 days on the sea shore and of 20-40 days towards the inland of Dobrogea; the thickness of the snow layer reaches the maximum values in the northern and north-western parts - 20- 40 cm, compared to only 5-7 cm in the southern part of the coast and in the Danube Delta.

4. THE POLLUTION OF THE AQUATIC ENVIRONMENT IN DOBROGEA

The existence of toxic substances in the environment, particularly in aquatic environments, as a result of municipal activities and developed industries, became an issue of major concern. Therefore, in many countries, a large number of organic substances are monitorized and this action is governed by international organizations (WHO, EPA, EU).

Environmental pollution has, at present, a general character, including the geosphere, the hydrosphere, the atmosphere and the biosphere. Inner seas and their continental shelves are the most ecologically affected.

The Black Sea is in a very unfavorable ecological situation; various polluting, natural and technogenic agents are being accumulated in the Black Sea, coming from a huge area of over two million kilometers from Europe and Asia.

The area which is the most affected by the intake of Danube is the one where water rivers are flowing into and mixing with the marine waters; this area is called "pre-delta" and here the content of pesticides and of polycyclic aromatic hydrocarbons (PAHs) depends on the great river flow and on the characteristics of maritime currents. In these circumstances, some of the content of the pollutants is considerably reduced, as a result of sedimentation processes, and another quantity is moved in the littoral area.

Polluting agents are brought mainly by the rivers tributary to the sea: Danube, Dniester, South Bug, Dnepr, Don, Cuban, amounting to a total flow of over 300 Km3/year; about 65% of this quantity flows into Danube (200 Km3/year) [5].

In what concerns the development of the macro-zoo-benthos, Black Sea waters show the gradual worsening of the ecological conditions in the area.

The hypoxia (low oxygen) and the anoxia (total disappearance of oxygen) became permanent phenomena (summer months) on the continental shelf located at the north of the Danube Delta, which leads to a decrease of the biomass and even to the total disappearance of the macro-zoo-benthos.

The determination of the organic compounds in Danube and Black Sea waters presents a major importance due to wastewaters (industrial and household wastewaters) with a high content of pollutants, which can affect physical, chemical and biological processes. The rivers which flow into the sea are carrying various pollutants and introduce them into the marine environment (including organochlorinated pesticides and polycyclic aromatic hydrocarbons used in order to combat agricultural and forest pests). The destruction of the ecosystems is due to the great number of activities such as shipping, intensive agriculture, fisheries, tourism; it is also due to the existence of metallurgical industrial centers, to the discharge of industrial and household wastewaters, to the discharge of petroleum products from cargo ships and from petroleum storage tanks. The atmospheric depositions, the global distribution and transport of these compounds, as well as their remanence and their long life cycle are also important, and they lead to the spread of contaminants in Black Sea waters. Due to the accumulation capacity and to the toxicity of these pollutants, there is an overall increased interest in determining and reducing them from the environment.

Knowing that Danube is the general collector of the waters from its entire hydrographic basin, protection measures must be taken within an international collaboration with the participation of all Danubian countries.

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SEA WATER TEMPERATURE REGIME IN THE ROMANIAN BLACK SEA COAST AREA

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ABSTRACT

The thermal analysis of marine waters in the Black Sea coastal area refers to the multi-annual average temperature values, maximum and minimum, both vertically and by comparing the area of shore and offshore waters. Aspects of daily and seasonal variations of seawater temperature are detected by analyzing a series of parameters such as: vertical and horizontal thermal gradients, temperature variation, thermal jump layer, thermal stratification and charts available for specific periods of day or year.

Keywords: *temperature variation, coastal waters, isotherm.*

Romanian coastal waters are characterized by multi-annual average surface temperature of about 12.6 ° C to 13 ° C shore and offshore. Since the average air temperature in the coastal area is 10.7 ° C, it can be said that the mass of sea water is a heat reservoir which significantly affect coastal climate by moderating the extremes during the winter.

Concerning the maximum temperature of sea water, the surface is reached in August.

Minimum temperature, the value recorded in February, it falls below the freezing point of salted water to a salinity of 18 per thousand.

Vertical temperature variation in the coastal highlights the existence of two water masses. The first is between surface and deep horizons of 70 meters and the second between 70-100 meters deep and up to the edge of the marine shelf that is 180-200 meters. The first horizon temperature varies greatly, here registering thermoclina. Vertical thermal gradient varies between 2° C and 20° C depending on the season. In the second horizon of water, extended to the shelf edge, the water temperature variations are small, the vertical thermal gradient between 1° C and 2° C.

In the cold months of the year (December, January, February) temperature variation shows some characteristics: water temperature increases with depth, increases are more pronounced during the cold, the variation is between 0.5° C and 2° C , the average water temperature at 50 m depth were averaged from 6° C to 7.5 ° C Celsius degrees. Between late March and early April there is the phenomenon of equalization of vertical water temperature (homothermy) in stratum between the surface and a depth of 40 meters, then, as warming surface layers of water, sense of variation of temperature change, the temperature started to rise toward the surface.

During homothermy phenomenon, the temperature of water ranges from 5° C to 6° C. The warm period from May to September, the sea water temperature decreases with increasing depth, water mass until 20-25 m is strongly heated, the variation being from 12° C to 24° C (the thermocline). Under the horizon to 25 meters deep and up to 75 meters depth, sea temperature drops to an average of 7.3° C.

For the cold period of the year, in November sees the second equalizing the mass of water surface temperature to a depth of 35 meters. Homothermy in autumn is characterized by temperatures between 10° C and 12° C.

Vertical distribution of isotherms show that after the heating period from August to November by 7.5° C isotherm appears twice in the vertical stratification, namely: once at the bottom of the layer under heating, and again in layer 100 meters deep layer is not subjected to intense mixing of water masses.

The water between depths of 70 and 100 meters store thermal characteristics of water masses bottom of the mass surface layer phenomenon which is subject to heating and, after cooling period (February-March), has a temperature of 7.5 ° C.

Arguably, the Isotherm of 7.5 ° C separating the upper body of water of the sea (seasonal thermocline subject to periodic heating and cooling) to deep water (the permanent thermocline, no changes in water temperature over time)

Changes in water mass temperature of Romanian coastal area between surface and depth is 70 meters depending on the periods of heating and cooling of atmospheric air. Thus, the mass of water heat and cool properly. This water feature has a decisive influence on the climate of the Romanian Black Sea coast.

The presence of a layer of water with temperature below the ambient air during heating makes sea water mass occur vertical gradients of temperature, whose value varies depending on local currents and the heating stage phenomenon.

Vertical gradients of temperature values change depending on time of year. During heating months (April-May), values of vertical temperature gradients are small, averaging 0.3 ° C / m. In the months from June to July, with warm air from the water table depth of 10...25 m, the gradient of temperature reaches 2 ° C / m. This value of thermal gradient that is related to the vertical distance between the upper limit of deep cold layer and the lower layer of atmosphere above the heated shrink greatly as the warm water masses acquire depth. In this way are recorded high values of temperature gradient.

This lasts until November and in cooling water temperature gradients at very small decrease (0.15 ° C / m).

Heat jump in the warm year (from July until September) is usually located between depths of -15 and -30 m, being limited to the top of the isotherm of 21 °C and at the bottom of the 10° C isotherm. Heat jump in October is at a depth of -35 m and thermal gradients are - 0.5 ° C / m.

Position of the thermocline in the coastal area is influenced by currents and wind regime.

If the wind blows from the north-eastern sector, it creates a strong flow south, creating a push to shore shallow warm waters, through the accumulation ashore, causing the descent of thermocline. Sometimes it happens that this phenomenon may be accentuated more and this time thermocline position changes, reaching larger depths (-180 m).

When the wind blows from the southeast, significant influence thermocline: offshore, at a distance of 18 km ... 22 km, masses of water down there where there is thermocline and, in the shore area, thermocline is at a shallow.

If the wind blows for several days in southern sector, is a phenomenon called upwelling or halodonic - as fishermen call it, which cause an elevation of water masses (with a temperature of 9 ... 10 ° C) from depth to surface.

Atmospheric air temperature influences the underlying water mass temperature to a depth of -75 m. At depths below, until the shelf edge (-180 ...- 200 m) water mass temperature remains constant, the variation being in the range value of 7 ° C - 8 ° C. The existence of these two features of water is related mixture of deep sea water, which is why the temperature increases with depth, is limited. Mass of water is warming up to a depth of - 40 m in coastal waters and - 60 m in the shelf waters. The mass of seawater warms harder and harder gives this accumulated heat, influencing thus the seasonal variation of water mass temperature. Water layer up to 10 meters deep register a variation of temperature similar to ambient air temperature. Surface water temperature maxima meet in July-August (25° C), in August at a depth of 10 m water temperature is 24 ° C, in September to 20 m depth is 9.18 ° C, in October at a depth of 30 meters is 18 ° C and in November it marks a significant increase of water temperature from 6 ° C to 9.5 ° C in shelf waters. Daily variation of seawater temperature recorded a magnitude ranging from 0.6 ° C in December and 1.9 ° C in July and August. Maximum amount of sea water daily thermal amplitude ranges from 2 ° C in December and 9 ° C during the months from May to August. Minimum value of daily amplitude of water temperature varies around 0 ° C.

During a day, minimum temperature of sea water is recorded in the morning around 5 ... 6 hours and maximum value is recorded in the afternoon between the hours of 15 ... 17. Water heating is most intense in the morning between 7 am to 10 am. This particularity of the daily variation of sea water temperature has a more pronounced in the offshore waters compared to coastal or shelf waters. Seawater temperature variations are also related by the currents and wind regime.

Sudden changes in temperature occur mainly in changing the currents along the Romanian Black Sea Coast. Northern flow (north-south currents) generated during the summer sudden drops in water temperatures and, during cold season, water temperature increases. For example, in July, temperatures can drop shore waters where there is a south wind from a value of 24 ° C to a value of 7°C ... 8 °C. In winter, under the same wind regime, shore water temperature increases by 1°C to 6°C…7°C.

Besides water temperature variation vertical space Romanian Black Sea coast, the sea water has a temperature variation in the horizontal plane. This horizontal variation has a character of heterogeneity in offshore and coastal waters and a weaker variation at greater depths in shelf waters.

Isotherms shape located along hydrological profiles perpendicular to the coast (deep ashore and built in shelf waters) show that the processes of heating and cooling water range from shore to sea. Depending on the ambient air temperature regime over large vertical temperature gradients both appear and horizontal gradients due to complex phenomena that occur in sea water interface - atmosphere by energy changes that occur.

Phenomena occurring in atmospheric air - the sea surface interface have an important role in explaining the physical, chemical and dynamic processes. Also, should not be neglected influence they have on the system interface phenomena of wind and wind potential default on the influence of which is materialized by the existence of different roughness coefficients depending on the specifics of these interactions.

Phenomena occurring in atmospheric air - the sea surface interface have an important role in explaining the physical, chemical and dynamic processes. Also, should not be neglected influence they have on the system interface phenomena of wind and wind potential default on the influence of which is materialized by the existence of different roughness coefficients depending on the specifics of these interactions.

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THE ROLE OF HUMAN FATIGUE FACTOR TOWARDS MARITIME CASUALTIES

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ABSTRACT

The international studies on maritime accidents has shown that fatigue is continuing to be either the main cause or a contributory factor in a considerable number of casualties at sea resulting in the loss of life and damage to the environment and property. In fact, fatigue's detrimental role toward performance at work is leading to errors being made and consequently resulting in fatalities. In light of these considerations, fatigue issue is of great importance to seafarers, the shipping industry and to the international maritime organizations. Therefore, the purpose of this paper is to analyze the impact of fatigue on seafarers which leads to casualties of human life and property at sea. In this regard, the authors support the idea that indeed fatigue plays a detrimental role on seafarers which in turn may impact the normal operation of ships while at sea resulting thus in accidents.

Keywords: *Human factor, Performance onboard ship, Fatigue at sea, Maritime casualties, Maritime disasters.*

1. INTRODUCTION

Generally perceived as a major concern in the shipping industry, fatigue has been subject to many studies, books and papers. Reyner and Baulk (1995) studied and examined technical data on fatigue among seafarers particularly on ferry crews, providing thus a proactive approach in fatigue management. Also, Cardiff University (1996) addressed the fatigue issue in terms of identifying important elements for further research and analysing the unresolved components of fatigue itself. More recently in 1997, Parker, Hubinger, Green, Sargent, & Boyed in their study focused on the health and lifestyle behaviours of seafarers leading to an efficient investigation regarding fatigue issues. Furthermore, IMO`s concern toward fatigue at sea, resulted in 2001 in the adoption of the foremost important document regarding fatigue issues "Guidelines on Fatigue", which directly tackles this significant issue.

Despite many studies and research projects being undertaken by many authors concerning fatigue, the complexity and the difficulties that the fatigue issue represents today in the shipping industry in terms of structural adjustments, technological changes and operational requirements reveal the need for further research to tackle fatigue issues at sea. Considering also the permanent and the potential hazard that fatigue factors are posing towards the personnel in the shipping industry at present it is relevant now for additional studies in this area to be undertaken in order to find more efficient solutions to combat fatigue at sea.

The purpose of this research paper is to define the role of fatigue issues toward maritime casualties by identifying the main components of fatigue and its impacts on the performance at work which in turn leads to errors being made. In order to have a comprehensive analysis of fatigue, relevant information regarding the understanding of fatigue at sea will be first provided in this paper. The second aim is to describe appropriate examples of maritime casualties worldwide when fatigue is reported to be either a primary cause or key contributory element in this matter. In addition, the contributing factors to fatigue followed also by fatigue's effects upon seafarers will be identified in the paper. Finally, recommendations on how to address fatigue's threat, suggestions which can probably lead to the impairment of the fatigue factor at sea will be proposed in the last chapter.

2. UNDERSTANDING FATIGUE AT SEA

2.1 Background of fatigue at sea:

Fatigue at sea is extensively perceived as a complex factor within the shipping industry and a comprehensible overview of this matter in terms of historical and current events is important. In the past, characteristics such as behaviour, intellect, education, training, abilities, inspiration, rewards, physical size, strength, attractiveness and professionalism were believed to be barriers against fatigue factor at sea. This misunderstanding was the main reason that fatigue's impact as a potential cause to human error was underestimated (Fatigue: IMO guidance, 2006). Nevertheless, recent studies have rejected this theory and further research reveals fatigue's detrimental role on performance as an important factor toward marine casualties (IMO, 2001).

In the meanwhile, a good understanding of fatigue requires the identification of some possible obstacles within human factor which is quite a hard task due to the complex nature of this issue. In this context, studies on fatigue at sea have shown that measuring fatigue in a person's performance and the under-reporting of fatigue cases to maritime agencies are some of the obstacles in alleviating fatigue effects onboard. Another obstacle observed by Mucsio in 1921 regarding this issue was that, there are no observable criteria for fatigue factor in general (Cardiff University, 1996). Similarly, the identification of the maritime groups most vulnerable to fatigue is an important issue, which provides a complete picture of the real problem. According to Cardiff University Research Workshop on Fatigue, groups such as ferry crews, Masters, Chief Officers and Chief Engineers remain the most vulnerable to fatigue due to their constant workload and the responsibility they carry.

Within the accurate perception of the fatigue issue, the establishment of an appropriate definition is particularly essential in order to prepare the ground for an efficient alleviation of this problematic issue. Traditionally the fatigue issue has been on the agenda of the maritime organizations for more than half century and the efforts for a universally accepted definition has failed. Regardless of the diverse approaches undertaken, common to all definitions worldwide is the term "degradation of human performance at work" (Fatigue: IMO guidance, 2006). With respect to this approach, the Seafarers International Research Centre (SIRC) definition contends that "Fatigue is a consequence of continuously high or prolonged levels of information load which involves subjective feelings of tiredness or a disinclination to work" (Cardiff University, 1996, p. 5) In other words, a broader view of this definition describes fatigue as acute or chronic tiredness, depression, sleepiness, stress, disturbed circadian rhythm and boredom.

On the other hand, IMO describes fatigue as a "State of feeling tired, weary, or sleepy that results from prolonged mental or physical work, exposure to harsh environment, or loss of sleep which can lead to the impairment of performance and to the reduction of alertness" (IMO, p.1) Furthermore, in the IMO`s MSC/Circ.813/MEPC/Circ.330 fatigue within the human element is described as a "Reduction in physical and mental capability as the result of physical, mental or emotional exertion which may impair nearly all physical abilities including: strength; speed; reaction time; coordination; decision making; or balance" (as cited in Fatigue: IMO guidance, 2006, p.7). All the above definitions, despite some differences, are very valuable in terms of understanding fatigue and finding the appropriate approach in the resolution of this problem.

Fatigue is a major concern currently in the transportation industry worldwide, and particularly fatigue's impact in the shipping industry is more hazardous than elsewhere due to the exclusive aspects that seafaring presents. In light of these considerations, the unique environment of seafaring is characterized by harsh working conditions including permanent noise, vibration, heat and bad weather. In addition, the seafarer is forced to live and work for a period up to six months away from home and family, exposed also to unpredictable environmental factors. In the same way, the working nature of seafaring represents a vague separation between work and leisure leading to a stressful situation for the seafarer. Furthermore, various nationalities and cultural elements represented in the vessel's environment today indicate another problematic issue for the seafarer (Parker et al, 1997). Finally, the operational aspects of shipping such as variety of ship types, port rotation and the pattern of sea passage are some other elements apparently revealing the unique aspects that seafaring represents today (Fatigue: IMO guidance, 2006).

3. MARITIME DISASTERS RELATED TO FATIGUE

3.1 Importance of fatigue at sea

The investigation reports of most marine accidents occurring worldwide considers fatigue as one of the main contributing factors toward these disasters leading to many fatalities (Time to wake up to consequences of fatigue, 2007). With regard to this issue, the biggest concern currently by the maritime organization is the loss of lives resulted from maritime accidents. Seafarers' lives are endangered every day and many of them have died due to the maritime disasters caused by fatigue factors onboard ship. Another issue which emphasises the importance of fatigue at sea is that accidents caused by the latter are having a negative impact on the environment. In other words, oil pollution caused by the groundings or collisions of ships due to fatigue factors is damaging the maritime environment and causing a huge financial impact on the coastal countries and companies. Finally, the importance of fatigue at sea stands also in the fact that property is being damaged heavily or lost because of fatigue's contribution to accidents. Regarding this matter, ships and cargoes in a case of accident are totally lost or useless causing to the shipping companies huge financial impact and sometimes bankruptcy. On the whole, the above concerns indicate that fatigue at sea is of a great importance to all the parties interested in the maritime affairs.

3.2 Statistics of maritime disasters caused by fatigue

Identifying the impact of fatigue toward maritime casualties is quite a difficult task and an overview of statistics regarding maritime casualties caused by fatigue will assist in the efficient perception of this matter. In this framework, a study carried out by the US Coast Guard Research and Development Centre defines fatigue as a primary source contributor to 16% of vessel casualties and to 33% of injuries onboard (Rothblum, 1996). In addition, Great Britain's Department of Transportation in a study which involved 1.647 collisions, groundings and near collisions occurred between 1994 and 2003 contends that "A third of all the groundings involved a fatigued officer alone on the bridge" (2004, p.4) emphasizing the problematic nature of fatigue regarding accidents.

Furthermore, other sources indicate the fact that fatigue as primary cause is the contributor of 11% -23% of all the collisions reported and according to the same source this percentage might be greater due to under-reporting cases of fatigue (Houtman, 2007). Similarly, fatigue's detrimental impact on human alertness has proven to be the main cause of many accidents involving Coast Guard ships in USA when "70% of CG personnel studied exhibited signs of compromised alertness"(Comperatore, 2001, p. 5). Emphasizing the importance of fatigue's impact toward maritime accidents the Japanese Maritime Research Institute takes the view that the lack of alertness within fatigue element accounted for approximately 53% of the marine casualties in the category of collisions and stranding (as cited in Cardiff University, p.10).

In order to have a comprehensive understanding of maritime accidents caused by fatigue the investigation of the periods of time when the most accidents occur is of a

great significance. In light of these considerations, studies regarding this issue have shown that the time between 00:00 and 00:06 hours is the most dangerous period for accidents (Great Britain, Department of Transportation, 2004). This statement is reinforced also by the US Coast Guard Research and Development Centre which maintains the fact that "Inevitably, fatigue-inducted performance degradation occurs mostly during night time hours" (Comperatore, 2001, p. 3-18). The same period of time is suggested as the most dangerous for marine accidents due to biological clock within the human organism which makes a person subject to heavy sleep at that period of time (Fatigue: IMO guidance, 2006).

3.3 Maritime disasters related to fatigue

Traditionally, fatigue has been perceived as possible factor in maritime accidents but it was the Exxon Valdez case that triggered the outmost attention of the maritime organizations regarding this hot issue. The US tanker Exxon Valdez during its navigation near Alaska's coast got strand on Bligh Reef, on March 24th 1989 (Cardiff University, 1996). The investigation conducted by US National Transportation Safety board revealed the fact that fatigue was identified as the major contributor to this accident citing also that "there were no rested officer to stand the navigation watch during the voyage" (WMU, 2006). The financial impact caused by this accident was huge and was estimated at around 8 billion dollars in claims and clean up operations (Cardiff University, 1996).

Another maritime accident demonstrating the negative effect of fatigue's implication in the chain of events of the casualty was the *Cittas* case in the English Channel. The German-owned container ship in 1997 ran aground off the coast of the Channel leading to the damage of the ship and to the environment. Similarly, as in the Exxon Valdez accident, fatigue was found to be the primary cause of the grounding. In brief, the investigation revealed that the watch keeper was short of sleep as a result of the shipboard organization, leading thus to the accident (Reyner & Baulk, 1998).

The most recent in a series of extraordinary accidents caused by fatigue factor, are the cases of the vessel *Jambo* off the coast of Scotland in 2003, and the sinking of the tug Thomas Herbert off the New York coast in 2004. Both of these cases had as a common feature a fatigued officer on watch operation. While in the *Jambo* case the watch keeping officer missed course alteration as a result of his impaired performance caused by fatigue, in Thomas Herbert case the watch keeping seafarer fell asleep due to the workload and tiredness, leading to the death of five seafarers. The consequences in both accidents were devastating, causing environmental damage and loss of property in *Jambo* accident and in the loss of innocent lives in the second casualty (Great Britain, Department for Transportation, 2004; Gulf Coast Mariners Association, 2004). As a result, all the above cases indicate the important role that fatigue factor plays in maritime casualties worldwide.

4. CONTRIBUTING ELEMENTS TO FATIGUE AT SEA

4.1 Human factor

The most crucial element which poses a great danger toward human performance at work is obviously sleep and rest. Regarding this element many studies have confirmed the fact that features such as quality, quantity and duration of sleep can play a significant role in a good sleep. In order to have a good performance at work a normal seafarer should have a deep and uninterrupted sleep during rest hours (IMO, 2001,). According to US Coast Guard Research and Development Centre energy is produced during uninterrupted sleep putting also emphasis on the fact that people need 7-8 hours of sleep per 24-hour to perform their best. In addition, sleep disorders such as insomnia and apnea, which is a condition when breathing stops during the sleep are major concerns regarding sleep, leading thus to the impairment of alertness of the seafarer (Fatigue: IMO guidance, 2006). Furthermore, rest breaks during work, particularly aboard ship should be sufficient and strictly complied by seafarers and management of the vessel due to the importance of this element which can also impair the performance and alertness of seafarers. As a result, the implementation of all the factors above is difficult onboard ship due to the harsh environment that vessel represents.

Another important factor within the human element which contributes to fatigue is the biological clock/circadian rhythm. The biological clock within human's body makes a person sleepy or alert on normal schedule whether they are working or not (Cardiff University, 1996). Similarly, circadian rhythm represents various processes and states in our body within 24 hours such as sleeping/waking, hormone levels and body temperature. In light of these considerations, the biological clock heavily conflicts with the working patterns of the seafarers due to the irregular schedules aboard ship caused mainly by crossing time zones while the vessel is en route and shifting rotations (IMO, 2001). Consequently, the circadian rhythm of the seafarer will be out of synchronization leading to sleep disorders and tiredness which are contributing factors to the impairment of the seafarer's performance at work (Fatigue: IMO guidance, 2006).

The unique aspect that seafaring symbolizes today in the international industry leads to the enhancement of stress factors among mariners. Stress represents a complex issue currently because it thwarts mariners from achieving a good sleep and causes the release of energy reducing alertness (Comperatore, 2001). Naturally, the inability of the seafarer to cope with an environment that poses demand or threat which is quite often aboard ship will definitely initiate the development of stress. Consequently, this can result in diminished work performance and health trouble among seafarers. Features such as noise, vibration, temperature, personal problems and interpersonal relationships are the most known contributors to stress onboard ship (IMO, 2001).

To efficiently analyze the human element as a contributing factor of fatigue it should be taken under

consideration also the identification of many other secondary factors which are part of this issue. Some of the factors within human element which can potentially cause fatigue are as follows:

- Mental and emotional factors such as fear, monotony and boredom, which are characteristics of seafaring in general. (IMO, 2001);
- Physical conditions such as diet (fat, fried food, sugar content food) and illness as common problem aboard ship due to harsh environment. (Comperatore, 2001; IMO, 2001);
- Ingested chemicals such as alcohol, drugs and caffeine used very often among seafarers to overcome sleep and boredom (Fatigue: IMO guidance, 2006);
- Workload aboard ship and in ports,
- Age of seafarer;
- The "Can do" attitude of seafarers, a sensitive problem traditionally due to the nature of seafaring which promotes a culture of self reliance (Patraiko, 2006);
- The increased volume of workload at ports today (Patraiko, 2006).

4.2 Management factor

The management of the vessels can potentially cause stress problems toward the seafarer and the organizational aspect within the management factor plays a key role concerning this issue. A comprehensive evaluation of the organizational aspects proves the fact that inefficient employment policies and insufficient training by the management of the ship are affecting depressingly the operations onboard causing stress and fatigue in the crew. In addition, tasks such as paperwork requirement, schedule shifts and overtime can have big impact on seafarer's fatigue onboard leading to errors being made. Without a doubt, the management style that shipping companies implement on ships are of great significance in terms of fatigue's impact among seafarers. In this context, the company management style sometimes does not respect the needs and the requirements of the seafarers, imposing harsh rules generating thus conflicts and stress among the personnel. Furthermore, considering the harsh conditions onboard ship and multi-task environment of the seafaring, it is very difficult for the mariners to comply with all the existing regulations leading to a high level of stress. As a result, the compliance of the national/ international rules and regulation by the seafarers is another source of fatigue which can lead to the impairment of alertness. Finally, the regular maintenance of the ship which is difficult work can prove to be another heavy burden for the mariners (IMO, 2001; Fatigue: IMO guidance, 2006).

Besides the organizational aspect, another essential component within management factors is the voyage and scheduling aspect. Regarding this matter, the scheduled time between ports arranged by the shipping management can be very frustrating for the seafarers, who must work overtime and under pressure to be on time. Also, required to follow the schedule, the seafarers are exposed many times to harsh weather and dangerous sea conditions, factors which can result in stress, fear and extreme fatigue levels. Likewise, the traffic density encountered by the vessel during the navigation at sea is another aggravating factor leading to many problematic issues such as diminished alertness and impaired performance at work (Fatigue: IMO guidance, 2006).

4.3 Vessel factor

Another important feature that can cause or affect fatigue upon seafarers is ship design. Many ship design features can impact the workload onboard while others affect the crew's ability to sleep and the level of stress. Understanding the basic operations of the ship a professional seafarer will lead to the conclusion that the level of automation is very important in terms of reduced workload, low stress level and less fatigue. The high level of automation is important because it facilitates the work of the seafarers due to less time required to accomplish a task and effortless operation of equipment aboard ship. Moreover, spending up to six months aboard ship, subject to harsh weather, the life of the seafarers is heavily dependent on the ship's equipment reliability which has proven to be a crucial factor leading to fatigue.

Certainly, it is widely perceived among seafarers that old ships are usually more difficult to operate, less safe and more uncomfortable in terms of living conditions in comparison with new vessels. Consequently, the age of the ship is an important element which can lead to the enhancement of the mariner's stress aboard ship. Considering also that sleep and rest are among essential components of good performance, the physical comfort in work and quarters are important features of the ship design vital in alleviating fatigue factor. Finally, the ship motion (instability) caused mainly by poor design of the vessel influences also upon seafarers, increasing the level of tiredness and fatigue (IMO, 2001).

4.4 Environmental factor

The excessive exposure of the seafarers to the internal environmental factors can cause not only fatigue but also health problems. Features like noise within the ship have been defined to be an important cause of fatigue at sea. Noise is caused mainly by the engine operation, ventilation and ship motion during harsh weather. Another internal feature contributing to fatigue is vibration caused by the engine and ship motion leading to the tiredness of the seafarer. Naturally, working aboard ship a mariner is subject to harsh environmental conditions including internal features such as heat caused by the engine and the ship's structure material and cold mainly attributed to weather conditions and humidity from sea water. All the above internal features are directly influencing the fatigue impact toward the seafarers (Fatigue: IMO guidance, 2006).

The second element within the environmental aspect is the external factor which has the same impact on the enhancement of the fatigue level onboard. Some of the main external features contributing to fatigue are port conditions, weather conditions and vessel traffic.

The last two components are already explained in the previous sections and are identified as important elements contributing to fatigue. In light of these considerations, the port conditions are becoming a problematic issue of the ships and seafarers at present time due to the huge workload, additional burden of safety, a large number of inspections and pressures for turnarounds leading thus to immense stress on the seafarers (Patraiko, 2006).

5. EFFECTS OF FATIGUE ON SEAFARERS

5.1 Fatigue's impact on alertness

Considering the global concern toward maritime disasters, studies and reearch regarding this issue have proven the fact that fatigue has a tremendous impact on seafarer's alertness. In a maritime study concerning fatigue conducted by Chalmers University of Technology, Sweden, in 1995, was concluded that 30% of the officers onboard declared that they worked under extensive fatigue which indicates a reduced alertness during work hours (as cited in Cardiff University, 1996).

Research has revealed that fatigue has a confirmed destructive effect on alertness which is considered to be the best state of the brain leading to conscious decision-making (IMO, 2001). In other words, with a diminished alertness a seafarer will take a longer time to react or respond to signals, difficult situations and other tasks aboard ship. Furthermore, "a decline in alertness will lead to reallocation of attention to central features rather than peripheral ones" (Cardiff University, 1996, p.34). In light of this consideration, the concentration and sustainable attention of the seafarer will be drastically impaired leading to poor performance. As a result, the alertness negatively impacted by fatigue can cause a significantly reduced performance at work in terms of physical, psychological and mental aspects (IMO, 2001).

5.2 Fatigue's detrimental role on performance

Fatigue factor has been classified a hazardous element not only because it impairs the performance at work but also because it is very difficult to be understood by the people, who often can not distinguish their level of exhaustion (Fatigue: IMO guidance, 2006). The most important of fatigue's effects toward performance at work have been identified by many studies and research, leading thus to a clear picture of this matter. The first effect is the individual's errors of awareness and memory resulting in the loss of information, data and steps in a sequence. The second effect is the high degree of risk undertaken by the seafarer in difficult tasks performed during the navigation. With respect to this issue, a fatigued seafarer always strives to find an easy way to the resolution of critical situations and puts less effort needed to accomplish this task, subsequently leading to wrong decisions being made.

Another effect is fatigue's impact on individual's skills to react, recognize and interpret stimuli (driving force) in the work environment. In addition, fatigue encourages the apathy status and reduces motivation at work contributing consequently toward seafarer's poor performance at work. The last effect is the detrimental impact that fatigue has in problem-solving and decision-making which are integral and essential components of the seafaring task (IMO, 2001). On the whole, fatigue's effects toward performance at work are very important to perceive and understand, because they pose a potential threat to seafarer's life and ship's safety.

6. RECOMMENDATIONS TOWARDS THE ALLEVIATION OF FATIGUE AT SEA

6.1 Main recommandations on fatigue`s mitigation

The unique aspects of operational regime onboard that shipping industry represents today, based mainly in prolonged working hours is an important element in generating fatigue and especially stress among seafarers. Regarding this issue it is important by the maritime organizations to undertake a complete review of the working schedules and the duration of the rest breaks with the purpose to find new working strategies to reduce the impact of fatigue factors toward seafarers (Parker et al, 1997). In addition, many studies conducted by maritime institutions suggest that a good monitoring of working hours will assist the seafarers to make a clear separation between work and rest leading to the relief of fatigue at sea (IMO, 2001). Furthermore, the verification of the working hour procedures by external authorities will definitely assist the seafarers to respect rest hours which in turn will mitigate fatigue onboard (Parker et al, 1997).

Another important recommendation toward alleviation of fatigue at sea is a "thorough examination of sleep patterns and their effects on work performance" (Parker et al, 1997, p. 10; IMO, 2001). This assessment can be achieved by a regular review of the procedures of rest periods at sea stated in the international conventions followed by a strict verification that these regulations are implemented aboard ship. In addition, the analysis of sleep data and the assessment of sleeping quality in general will reveal essential information within the examination of sleep patterns (Parker et al, 1997, p. 10).

In any case, a strong support to assist seafarers to cope with the changes that shipping industry has undergone recently in terms of technical and emotional aid is another crucial recommendation regarding fatigue's mitigation. In light of these considerations "appropriate training/retraining in terms of manning level, skills, managing issues both on managerial staff and onboard personnel" are of a great significance in combating fatigue (Parker et al, 1997, p. 11; IM O, 2001). In addition, appropriate training of the port personnel which can facilitate the work of the seafarers at peak periods while at port and the publication of the support systems regarding industry improvements are also important to assists seafarers to adjust with the new changes (Parker et al, 1997, p. 10).

Next suggestion recommends the improvements that should be made in order to minimize the negative effects of environmental hardships upon seafarers. The studies regarding fatigue has shown that continuing exposure to excessive levels of environmental sufferings

is potentially hazardous to mariner's health and work performance (Fatigue: IMO guidance, 2006). In this framework, is very important that steps are taken to reduce the effects of noise, heat, cold and humidity aboard ship as harmful factors contributing to fatigue of the seafarers. Other positive factors improving the environmental hardships onboard are good illumination and music on the working places of the mariners (IMO, 2001). Finally, compliance with the respective international regulations and the use of protective equipment are important to minimize the negative effects of environmental hardships onboard (Parker et al, 1997, p. 10).

The last main recommendation emphasizes the need of establishing safety culture among the personnel aboard ship (Bhatt, 2006). This approach underlines the fact that more efforts should be undertaken to convince the seafarers that compliance with the international maritime regulations regarding safety should be made consciously. In addition, the philosophy, prevention better than cure concerning fatigue problem, highlights the need of a systematic report of fatigue cases by the seafarers which can assist in a comprehensive assessment of the problem (Bhatt, 2006).

6.2 Other recommendations on fatigue's mitigation

Besides the main recommendations, other approaches within lifestyle behaviors need to be considered to alleviate fatigue at sea (Parker et al, 1997, p. 10). Traditionally, it is well known that physical exercise is an important technique to relieve stress and the development of exercise models onboard as well as a good motivation for seafarers to participate in exercises are some of the solutions regarding this issue. In the same way, the improved time for relaxation and appropriate programs offered by the management concerning this matter is an excellent approach in managing fatigue issues. Furthermore, in a study conducted by the US Coast Guard Research and Development Centre, Comperatore claims that nutrition onboard is crucial factor contributing to fatigue. The same author comments that the reductions of fat and fried food as well as the consumption of regular meals are important in diminishing fatigue. Finally, the review of alcohol policy and the establishment of cessation programs for smoking in the seafaring community are some other recommendations regarding fatigue's alleviation issue aboard ship (2001).

7. CONCLUSIONS

In conclusion, analyzing all the main components of fatigue issue and its impact on the human performance at work is an efficient approach in defining the role of fatigue toward maritime casualties. In light of these indications, a comprehensive understanding of fatigue by identifying fatigue's background, possible obstacles, its definition and the exclusive aspects of shipping industry is achieved, leading to the conclusion that fatigue factor is a complicated issue which posses a potential hazard in shipping industry. Naturally, the examination of maritime disasters related to fatigue can reveal valuable information regarding fatigue's role toward accidents. With regard to this issue, the importance of fatigue, relevant statistical data and the examination of accident cases related to fatigue indicate a determinant role that fatigue factor plays toward maritime casualties and their consequences.

Furthermore, the fundamental elements contributing toward fatigue issue are proven in this paper to be as follows; human, management, vessel and environmental factors. These essential elements are of a great importance in analyzing fatigue issue with the final purpose to identify the role of fatigue in accidents. Another essential point is that fatigue's effect on seafarers plays a detrimental role in the impairment of performance at work and in diminishing the human alertness leading to errors being made which in turn results in maritime casualties. In other words the impacts of fatigue on performance at work such as errors of awareness and memory, high degree of risk undertaken, negative effect on stimuli, detrimentally effect on problem-solving and decision-making as well as other problems of this kind are the key factor in identifying the role of fatigue in accidents and leading to the resolution of this issue.

With respect to possible mitigation of fatigue, some of the recommendations are considering a comprehensive review by international regulatory bodies of working schedule and sleeping issues, supporting seafarers to adjust to industrial changes, reducing the environmental hardships and establishing safety culture aboard ship. On the whole, the detrimental role of fatigue on person's performance and its negative effects toward effectiveness, productivity and standards at work are the main concerns which can lead to fatal errors. In light of these considerations fatigue is a very important issue at present time to the whole maritime community due to the crucial role that plays toward maritime casualties posing thus a dangerous risk to human life, environmental damage and economic impact.

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HAMBURG RULES V HAGUE VISBY RULES AN ENGLISH PERSPECTIVE

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ABSTRACT

It has often been argued for the effect of defences provided to carriers under Art IV (2) of Hague Visby Rules to almost nullify the protection guaranteed to shippers in other provisions of this convention. Therefore an all embracing universal shipper friendly convention, merely the Hamburg Rules, need be incorporated in all countries in order to address this issue and fully satisfy the intentions of the parties for the establishment of international rules in international trade.

1. INTRODUCTION

In this article it is maintained for Hague Visby Rules to provide shippers with much greater protection than what has often been claimed from its critics. It proves the effect of defences contained in this convention have been restricted from vast amount of obligations imposed upon carriers. These defences have been restrained through courts' narrow interpretative application, and the heavy burden of proof placed on carriers in trying to successfully exploit their beneficence.

While there will be a summary of the significant changes likely to have been introduced from incorporation of Hamburg Rules into UK law. It will also be shown these are no profound changes and their imported improvement to 'cargo owners' position is still dubious, taking account of the practical implications likely to be embarked upon with their implementation in England.

2. EFFECT OF LIABILITY EXCLUSIONS IN ART IV

Hague Rules were first established in the Hague Convention 1924, supplemented with Brussels Protocol, The Hague Visby Rules 1968, incorporated in UK through the Carriage of Goods by Sea Act 1971. In order to avoid the hard-line approach imposed under existing common law rules, and ultimately provide shippers with protection from unreasonable exclusion clauses which the powerful contracting party, ship-owners, could impose upon them. This convention purported establishment of uniform sea carriage legislation.

A levelled negotiating ground for these unequal bargaining parties was secured through imposition of obligations upon common carrier in Hague Visby Rules.[1] Nevertheless these obligations were accepted, in exchange for a long list of defences included in it, therefore giving strength to arguments of its critics that it has not achieved its purpose.

Carriers primary and overriding duty is to "exercise due diligence in providing 'sea and cargo worthy' ship before and at the beginning of the voyage".[2] With respect to this standard requirement, carrier is responsible not only for itself and its servants,[3] but also for reputable independent contractors,[4] and even Lloyds Surveyors.[5]

In any event of cargo loss or damage, the shipper bears the initial evidentiary burden to prove vessels' lack of seaworthiness.[6] This is not easy completed task having account of contradictory precedents dealing with this point. In both *Maxine Footwear*[7] and *The Apostolis*[8] servants negligence caused fire to goods, nevertheless, the court held vessel unseaworthy in the first but seaworthy on the second case.

Once the shipper establishes lack of seaworthiness, the carrier must primarily prove it exercised 'due diligence'. This necessary prerequisite shall be accomplished before a defence in Art IV could even be claimed by the carrier.[9] Considering carriers multiple duties calling fulfilling before due diligence requirement can even be pretended to have been satisfied,[10] adding here the widely interpreted statement, 'before and at the

[1] Hague Visby Rules [1968], Art III (1)'The carrier shall be bound before and at the beginning of the voyage to exercise due diligence to (a) make the ship seaworthy, (b) properly man equip and supply the ship and (c) make the ship seaworthy with regard to the specific goods. (2) Carrier shall properly and carefully load, handle, stow, carry, care, keep and discharge the goods'.

[2] ibid

[3] Maxine Footwear Co Ltd v Canadian Government Merchant Marine [1959] AC 589

[4] Riverstone Meat Co Pty Ltd v Lancashire Shipping Co. Ltd (The Muncaster Castle) [1961] 1 Lloyd's Rep 57

[5] Union of India v NV Reederij Amsterdam (The Amstelslot) [1963] 2 Lloyd's Rep. HL 223.

[6] The Hellenic Dolphin [1978] 2 Lloyds Rep 336

[7] Maxine Footwear Co Ltd v Canadian Government Merchant Marine [1959] AC 589

[8] Meredith Jones & co Ltd v Vangemar Shipping Co. Ltd [1997] 2 Llloyds Rep 241 welding carried on the ship exposed the cargo of cotton to the risk of ignition.

[9] Eridania SpA (formerly Cereol Italia Srl) v Oetker (The Fiord Wind) [2000] AC 2 Lloyds Rep 191

[10] Hague Visby Rules [1968] Art III(1) Make the ship Seaworthy, properly man equip and supply the ship, make the holds, refrigerating and cool chambers and all other parts of the ship fit and safe for the particular cargo.

beginning of the voyage'[11] sometimes covering fault occurring on sail.[12] It can be confidently stated that, notwithstanding shippers' apparent difficulty in claiming carriers' obligations, carriers have it far more difficult to exclude liability preconditioned from proof of due diligence.

Where claimants loss or damage is independent of 'due diligence' requirement, shipper can still argue carriers failure to fulfil its continuing obligation to ''properly and carefully care for goods''.[13] Because, carriers are *prima facie* liable for all loss or damage to goods received in good order, as evidenced with clean bill of lading.[14] The claimant only needs establishing orderly quantity and quality of goods before loading and their changed condition on discharge. Carriers may then only exclude liability through proving the particular cause to be one included in Art IV (2) (a) to (p). But even satisfying this condition will not conclusively relieve carrier from liability. Because, shipper may at this stage still claim carriers' negligence with respect to the goods.[15]

It was once suggested that in addition to satisfying one of the defences, the carrier also had to disprove negligence on its part.[16] This is no longer the case after Albacora decision.[17] It has however been argued that House of Lords decision in Albacora ''is consistent with the fact that they were dealing with an inherent vice which naturally is not brought about by anything done by the carrier''.[18] Therefore, it remains to be seen whether shippers shoulder the burden of proving negligence, where loss or damage is caused from something other than inherent vice of goods themselves.

Proving negligence can be difficult burden for shippers because practically all evidence is on carriers hands.[19] Nevertheless, shippers find great assistance from courts wide interpretative approach to negligence and restricted construction of carriers defences. As indicated in *The Hill Harmony*[20] and *Gosse Millerd*[21] judgments where what appears to be negligence in navigation or management which would have secured exclusion of liability for the carrier as provided under Art IV (2) (a), was held to be cargo neglect thereby prohibiting it from pleading exception. Both these judgements have received academic support stating that, ''unless the rules are strictly construed the careful compromise worked out between carrier and shipping interests will be defeated, and this should be the uppermost consideration of courts when construing the rules''.[22] Establishing carriers' cargo negligence automatically deprives it from claiming any of the defences in Art IV (2).[23]

Whereas inability to plead specific defences in paragraphs (a) to (p), will not exhaust all of the carriers options, due to paragraph (q) 'catch all exception'. It must first disprove negligence in order to enable itself to claim defence under paragraph (q). Negligence cannot be easily discharged, considering carrier needs doing so for its servants, independent contractors and surveyors.[24] Adding to carriers difficulties in striving to avoid obligations imposed under Art III(2) of the Hague Visby Rules, is the situation where part of damage or loss caused to the goods is attributable to the excepted perils under Art IV(2) of the Rules and the rest resultant of carriers negligence to prevent its furtherance. Unless carrier apportions the damage caused from the excepted peril, he will be held accountable for the whole loss or damage.[25] Discharging liability under paragraph (q) is hardened from the fact that absence of negligence will not release carrier from responsibility, where the cause of loss remains inexplicable.[26]

Notwithstanding the list of defences in Art IV of the Rules is long and therefore creating good chances for carriers to escape liability. Unlike common law defences, it is an exhaustive list, and any attempts to add on exclusion or limitation clauses in the bill of lading will be rendered null and void.[27] Furthermore, where the carrier is either unable to prove that it exercised "due

[11] Maxine Footwear Co Ltd v Canadian Government Marine Ltd [1959] AC 589 ' covered from at least the beginning of loading until ship started sailing'

[12] (The Subro Valour) [1995] Lloyds Rep 509.

[13] Art III (2) Hague Visby Rules [1968]

[14] Gosse Millard v Canadian Government Merchant Marine [1927 29 Lloyds Rep 190,. Article III (2) Hague Visby Rules

[15] Constantine SS v Imperial Smelting Corp [1942] AC 154 'if the carrier pleads an exception the cargo-owner may counter by pleading fault on the carrier, but the onus of proving that is on the party who makes the claim'.

[16] F.C. Bradley & Sons Ltd v Federal Steam Navigation Company Ltd [1927] 27 L.J.L. Rep 395.

[17] Albacora SRL v Westcott & Laurence Line [1966] 2 Lloyd's Rep 53

[18] C. Ezoeke ''Allocating the onus of proof in sea cargo claims: the contest of conflicting principles'' [2001] Lloyd's Maritime and Commercial Law Quarterly, pp. 177-320

[19] Encyclopedia Britanica Inc v SS Hong Kong Producer [1969] 2 Lloyd's Rep 536

[20] Whistler International Ltd v Kawasaki Kisen Kaisha [2001] 1 AC 638

[21] Gosse Millard v Canadian Government Merchant Marine [1927 29 Lloyds Rep 190, 'A reasonable construction of the rules requires that a narrow interpretation shall be put on the excepting provisions of Art IV(2)(a) of Hague Visby Rules'.

[22] W. Tetley, 'Interpretation and Construction of the Hague/Visby and Hamburg Rules [2004] 10 JIML' 30-70.

[23] The Satya Kailash [1984] 1 Lloyd's Rep 588

[24] International Packers v Ocean SS Co [1955] 2 Lloyds Rep 218 McNair J in International Packers v Ocean SS held, ''I see no difference between Art III (2) and (1), as a matter of law, therefore, I would hold the defendant liable for the negligent advice of the surveyor''

[25] The Evegrafov [1987] 2 Lloyd's Rep 634

[26] Pendle & Rivet v Ellerman Lines Ltd

[27] The Hague Visby Rules (1968), Art III (8)

diligence", disprove "professional negligence",[28] or fails to bring itself within one of the exculpatory provisions provided under Art IV(2) of Hague Visby Rules, it will be held accountable for loss or damage caused to the goods.[29] Therefore, to argue that Art IV defences potentially diminish carrier's obligations in an unacceptable manner, would ignore huge amount of liabilities placed on the ship-owners and the barriers it needs to overcome in order to succeed on these defences made a lot harder with narrow construction of the court.

3. HAMBURG V HAGUE VISBY RULES

Many provisions in the Hague Visby, especially the limitation period of one year under its Art III(6)[30] which is disproportionate to the amount of time necessary for allocating the contractual carrier,[31] low amount of compensation calculated in terms of package or unit, insufficient period of coverage under the 'tackle to tackle' principle, exclusion of deck cargo ignoring the increasing use of containers, the long list of defences especially the catch all provision in Art IV (2) (q), lack of uniform standard of proof, and apparent permission of deviation for the sole purpose of saving property remain favourable to the carrier at the shippers expense.

Following demand for change from developing states, all the above-stated criticisms were addressed in Hamburg Rules (1978).

First, Art.10[32] and Art 20(1)[33] of Hamburg Rules have dramatically lessened the possibility for shippers to lose their right of suit due to time lapse, as they risked doing under Hague Visby. As it has been shown above, Hamburg Rules appear to be more 'cargo friendly' than Hague Visby, as they really are to some extent. However, a closer look reveals that many of its provisions are simply a codification of what has already been established by the cases decided under the Hague Visby and in some respects even less favourable to the shipper.

Second, limited amount of compensation for loss or damage to goods under Art 6(1) of Hamburg Rules is more favourable to shippers than under Hague Visby. Nevertheless, package or unit limitations are defined almost in a similar way as they were in the Hague Visby, and despite the limitation amount being greater under Hamburg Rules it is not reflective to inflation change. Leading some commentators to argue that in this respect it was even lower.[34]

Third, the time of coverage commencing at the loading port and ending with handing goods to the shipper or his agent, ''port to port'', under Hamburg Rules whereby transhipment is also included, is broader than ''tackle to tackle'' as it is under Hague Visby Rules. However, almost as much had already been provided for the shipper, under Hague Visby Rules in *Pyrene Co Ltd*.[35]

Forth, considering popularity of containerised shipment in international trade, the fact that in Hamburg Rules deck cargo is treated same as all other cargo signifies a move in step with the changes in trade practice. Nevertheless, there is no major innovation being introduced from Hamburg Rules on this point. Similarities between its Art 9 and *Svenska Tractor*[36] ruling decided under Hague Visby are indistinguishable with respect to deck cargo. Whereas cargo carried on deck short of agreement between parties would deprive the carrier of his limitation were Art 9 of Hamburg Rules to be applied, under Hague Visby unauthorised carriage on deck will also deprives it from limiting liability.[37]

Fifth, probably the most important change brought by the new rules, at least for the purposes of this document, is the abolition, of the long list of defences granted to carriers under Art IV and the confusion created by the burden of proof associated with it. In contrast to its respective counterpart provisions in Hague Visby, Art 5(1) in Hamburg Rules codifies all carriers' obligations and defences in one single concise provision. Clarifies aspects of burden of proof, placing it on carrier all the time and makes specific reference to loss or damage caused by delay or miss-delivery. Furthermore, under this convention the duty to exercise 'due diligence to provide a seaworthy ship' runs throughout the voyage rather than before and at the beginning of it.

Continuation of carriers obligation to exercise 'due care' throughout the voyage was covered by *The Subro Valour*[38] ruling decided under Hague Visby. With respect to damage caused by fire, under Hague Visby it was carriers' obligation to disprove negligence, whereas under Art 5 (4) (a) of Hamburg Rules, such burden has shifted on the shipper despite carriers handling of evidence. Art 5 replaces deviation with measure to save life or reasonable measure to save property, which is simply a codification of the decision in *Stag Line*[39] complemented by *Photo Production v Securicor*[40] both decided under Hague Visby. Art 5 also leaves open the argument whether carrier will be responsible for defaults

[28] Union of India v NV Reederij Amsterdam (The Amstelslot) [1963] 1 Lloyds Rep 255 'Lack of due diligence is equal to professional negligence'.

[29] Hague Visby Rules [1968] Art III (1) and (2)

[30] Carrier and the ship shall in any event be discharged from all liability whatsoever unless suit is brought within one year of their delivery or the date when they should have been delivered.

[31] The Stolt Loyalty [1993] 2 Lloyds Rep 281

[32] Hamburg Rules [1978] Art 10(1)-(4) states: both the carrier and actual carrier are liable, jointly and in several.

[33] Hamburg Rules [1978], Art 20(1) states: there is a two year limitation period for any action relating to the carriage of goods by sea.

[34] William Tetley, "The Hamburg Rules - A Commentary", Lloyd's Maritime and Commercial Law Quarterly, [1979] pp. 1-20, States: ''Hamburg Rules failed to adopt a value even as high as Visby adjusted for 10 years of inflation''

[35] Pyrene Co Ltd v Scindia Navigation [1954] 2 QB 402

[36] Svenska Traktor v Maritime Agencies [1953] 2 QB 295.

[37] Encyclopedia Britanica v Hong Kong Producer [1969] 2 Lloyd's Rep536

[38] The Subro Valour [1995] Lloyds Rep 509.

[39] Stag Line v Foscola Mango and Co [1932] AC 328

[40] Photo Production v Securicor [1980] AC 827

of independent contractors whereas under Hague Visby it is the carriers who shoulder this responsibility.
Incorporation of Hamburg Rules into major maritime countries may lead to some practical difficulties. One major drawback of these Rules is its ambiguous drafting, ‘‘occasionally done so with intention so the differing parties left the table convinced that their interpretation was the correct one’’.[41] This renders practically impossible the very core purpose of this convention, merely promotion of uniform interpretation.[42] Being a mixture of civil and common law drafting style, Hamburg Rules may pose interpretation difficulties in United Kingdom courts, where ‘‘international conventions are treated very much as English legislation’’.[43] Major shipping nations like England and USA have invested vast amount of judicial time and expense in striving to shape Hague Visby Rules, it would be overoptimistic to pretend incorporation of an ambiguous convention within their territories, since it would lead to a whole new generation of litigations generating a fresh load of expense.

4. CONCLUSION

From the foregoing analysis we conclude that despite the fact that the long list of defences under Hague Visby Rules may serve as useful channel through which the carrier can avoid the flow of responsibilities running against it. This escape provisions have been narrowed down from courts’ precedents to such degree that carrier may find it extremely difficult to succeed in avoiding liability. Many remaining deficiencies in Hague Visby were not fully remedied from Hamburg Rules, which while inheriting some of the problems created from its predecessor, carries unique problems of its own. Therefore if a whole embracing uniform set of international rules is to be accepted from all the countries all the above stated issues need to be addressed with a conscious thought on the practicality matter.

5. REFERENCES

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[2] ibid
[3] Maxine Footwear Co Ltd v Canadian Government Merchant Marine [1959] AC 589
[4] Riverstone Meat Co Pty Ltd v Lancashire Shipping Co. Ltd (The Muncaster Castle) [1961] 1 Lloyd’s Rep 57
[5] Union of India v NV Reederij Amsterdam (The Amstelslot) [1963] 2 Lloyd’s Rep. HL 223.
[6] The Hellenic Dolphin [1978] 2 Lloyds Rep 336
[7] Maxine Footwear Co Ltd v Canadian Government Merchant Marine [1959] AC 589
[8] Meredith Jones & co Ltd v Vangemar Shipping Co. Ltd [1997] 2 Llloyds Rep 241, welding carried on the ship exposed the cargo of cotton to the risk of ignition.
[9] Eridania SpA (formerly Cereol Italia Srl) v Oetker (The Fiord Wind) [2000] AC 2 Lloyds Rep. 191
[10] Hague Visby Rules [1968], Art III(1) ‘Make the ship Seaworthy, properly man equip and supply the ship, make the holds, refrigerating and cool chambers and all other parts of the ship fit and safe for the particular cargo’.
[11] Maxine Footwear Co Ltd v Canadian Government Marine Ltd [1959] AC 589 ‘covered from at least the beginning of loading until ship started sailing’
[12] “The Subro Valour” [1995] Lloyds Rep 509.
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[14] Gosse Millard v Canadian Government Merchant Marine [1927] 29 Lloyds Rep 190 and Article III (2) Hague Visby Rules [1968]
[15] Constantine SS v Imperial Smelting Corp [1942] AC 154, States : ‘if the carrier pleads an exception the cargo-owner may counter by pleading fault on the carrier, but the onus of proving that is on the party who makes the claim’
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[19] Encyclopedia Britanica Inc v SS Hong Kong Producer [1969] 2 Lloyd’s Rep 536
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[41] William Tetley, “The Hamburg Rules - A Commentary”, Lloyd's Maritime and Commercial Law Quarterly, [1979] pp. 1-20.
[42] Hamburg Rules 1978, Art 3.
[43] Charles Debatista ‘‘Carriage convention and their interpretation in English courts’’ [1997] Journal of Business Law 130

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THE IMPACT ON LANDSCAPE GENERATED BY THE CONSTRUCTION OF THE BRIDGE OVER DANUBE FROM CALAFAT -VIDIN

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ABSTRACT

The future road and railway joint bridge it will be constructed over Danube, in Vidin (Bulgaria)-Calafat (Romania) area, on 796 km, at the north side of these two cities. This transport infrastructure is representing in the same time an integrated component of international motorways system and a part of the south section of Pan-european Corridor (no. IV). The bridge construction has the potential to generate an environmental unfavourable impact, mainly as a result of its structures and the infrastructure's exploitation. Landscape's impact may be percepted in two ways: first, the impact on landscape aesthetics and physical structures and the second, the impact on landscape attractivity regarded from the point of view of those people who has into their observation area the constructed structures or its component elements.

Key words: *Calafat-Vidin bridge construction, landscape impact assessment.*

INTRODUCTION

The construction of the mixed road and railway bridge will be performed over Danube river in the Vidin (Bulgaria) and Calafat (Romania) area situated north from the two cities at km 796. This transport infrastructure represents a component part of the European system of international motorways as well as a part of the Southern sector of the Pan-European Fourth Corridor (Berlin-Salonic). The importance of tackling this subject mainly refers to providing a clear image of the positive and negative effects that result from the construction of this bridge over Danube, from Calafat to Vidin taking into account the initial environmental conditions. Therefore, an assessment of the landscape characteristics is proposed being established the current situation and being determined the types of impact resulting from the construction of the bridge.

1. THE LANDSCAPE CHARACTERISTICS

Considering the construction area of the future transport infrastructure, we can state that the Danube river is the dominant landscape element. In this respect, at the proposed chainage of the bridge at kilometer 796 the river is 1300 m wide, in the middle of the river there being situated an island without name which is covered by poplars and willows. Currently, the small forest on the island without name is subject to clearing for the purposes of building the bridge but before this it was performed illegally. The ferry harbors on both Danube shores are situated north east of Vidin and west of Calafat respectively.

Generally speaking, the relief on both shores is plain, without well defined positive or negative forms. The Bulgarian shore's quote is 25 m lower than the Romanian one, under these conditions the river forming a wider valley on the Bulgarian shore.

The holm of the river is on the Bulgarian shore where it reaches up to 1700 m width, the quotes of the soil varying between 30,0 and 31,5 m from the sea level. The first easily flodded terrace is on both Bulgarian and Romanian shores closely to the river bed and the quotes of the land vary between 35,0 and 48,0 from the sea level on the Bulgarian shore and growing toward the interior of the country and being of 53,0 and 56,0 on the Romanian shore. According to the Bulgarian classification (Georgiev, 1977) the site belongs to the area of moderately continental steppe, holm steppe and forest steppe; the group of chernozem steppe and the loess horizon having a wide agricultural use.

The access area on the Bulgarian shore is located in the old holm which has been recently protected by a dyke and the shore line is situated on a narrow area with poplars, between the river and the protection dyke. Behind the dyke there is a narrow service corridor including meadows and forest plantations. In the past, the Bulgarian side of the studied zone has been occupied by numerous humid areas with running and stagnant waters. One of these marshes, Balta Lata was situated between Antimo and Pokraina villages, on the Danube's shore. In the '50s, this marsh has been drained and it is currently used as agricultural soil. On the alignment corridor there was located a vineyard as well. The Vidin commercial free zone is located South of the future bridge also the villages Antimovo and Pokraina are situated in the vicinity of the investigated corridor, both of them having a rural character.

The Bulgarian shore of the Danube is affected by erosion processes which according to the data are caused by the retention of the sediments from the accumulation lakes from Portile de Fier. The Romanian shore is formed of a steep wooded versant whose upper side is 30 m above the river's shores being also used for agricultural purposes. On this agricultural surface which will be crossed by the future alignment there are small military installations (buildings, antennas).The alignment corridor (eastern DN56 Craiova-Calafat) crosses an industrial area and a tree plantation on whose location a custom point will be installed. The railroad alignment crosses several smaller orchids and

the connects with the existing railroad. The connection between the landscape units is determined by surface and deep waters. Under normal conditions, the deep waters run towards the Danube but during high floods the waters of the river trickle into the aquifer. The phreatic aquifer is constituted on the alluvial terrace of the Danube.

The images presented below present a general view on the landscape factor in the analyzed area on which this paper focuses on.

Figure 1. The area of the future bridge access infrastructure - west view from the dyke to the alignment (source: EIA Calafat-Vidin Bridge - Final Report, ERM GmbH, Neu-Isenburg, 2004)

Figure 2. Area on the Bulgarian border where the bridge end is will be positioned - image from the dyke on the holm, poplars plantation and Danube river- kilometer 796 is situated on the spot where the tree line is interrupted (source: EIA Calafat-Vidin Bridge - Final Report, ERM GmbH, Neu-Isenburg, 2004)

Figure 3. View towards Calafat of the Romanian shore from the future alignment's location - the tall buildings belong to the hospital (source: EIA Calafat-Vidin Bridge - Final Report, ERM GmbH, Neu-Isenburg, 2004)

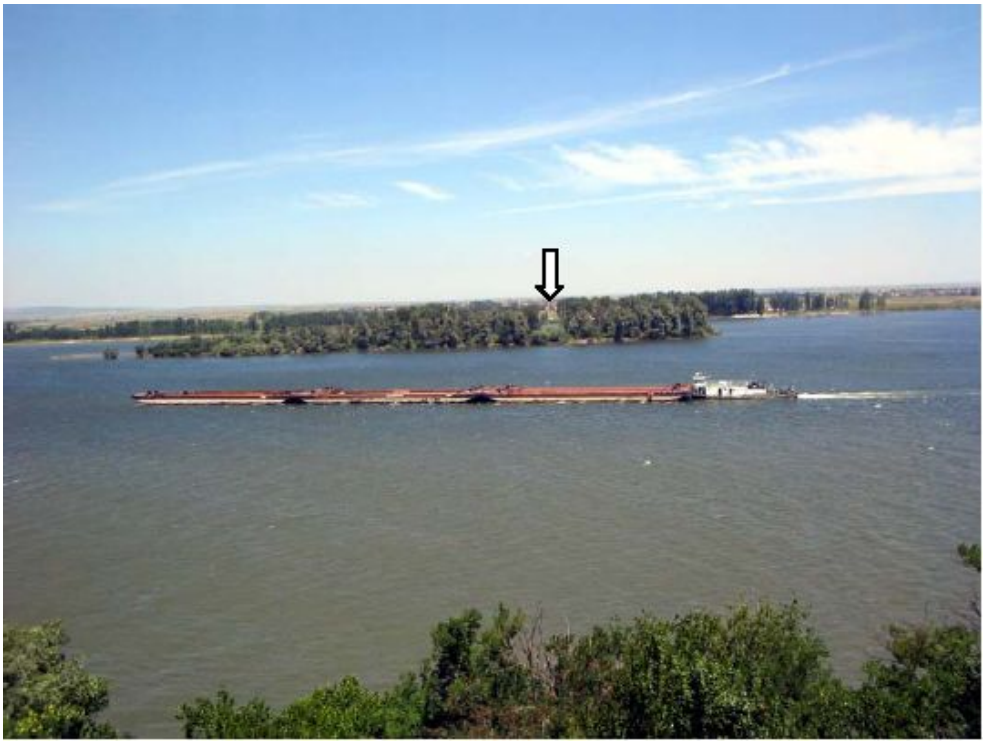

Figure 4. View from the Romanian shore towards Bulgaria - The shipping channel and the island without a name (the arrow indicated the location of the future bridge) (source: EIA Calafat-Vidin Bridge - Final Report, ERM GmbH, Neu-Isenburg, 2004)

The construction of the bridge over Danube from Calafat to Vidin has the potential to generate an unfavorable impact on the environment as a result of its physical structures, of construction activities and exploitation of infrastructure. In the following lines, the effects and impact of this infrastructure on the landscape factor are presented, as well as the measures for avoiding and diminishing the negative impact generated by the construction of the bridge over Danube, from Calafat to Vidin.

2. THE IMPACT ON THE LANDSCAPE

The modifications of the landscape are difficult to assess since they depend on the subjective perception; they only affect a limited area on both sides

of the river. The impact on the landscape can manifest itself in two ways: the impact on the physical structure and the aesthetics of the landscape and the impact on the attractiveness of the natural environment from the point of the receivers, meaning those persons who have in their observation area the structure and elements of the construction.

As far as the first aspect is concerned, the most obvious impact factors are represented by the scale modifications that are generated by the structures of the future infrastructure. As far as the viewers are concerned, the inhabitants of the neighboring villages and localities are considered as the most sensitive group both in terms of the value of land but also in terms of permanent exposure once the construction works are finished.

There are included here factors as the perception of the landscape, its attractiveness from the perspective of the locality and the neighboring areas, for example from the perspective of the dwellings, public spaces, paths, personal use lots of land and recreational areas.

Also the prospective users of the road can be considered as receivers. Despite these, the temporary character of the landscape's perception qualifies this group as being less sensitive than those who are permanently exposed to the afferent structures and traffic. More than this, the perception of the landscape will have positive effects on the drivers in terms of the impressive views that can be seen from the bridge.

2.1. The impact caused by the afferent structures of the future infrastructure

The construction of the bridge produces significant modifications of the landscape mostly because of the fact that for an important sector of the road and railway, they are at a higher level than the dominant quote of the soil (bridge, pillars and platforms). Given the topographical conditions, this aspect is more relevant for the Bulgarian side. In some sectors with high embankments, the modifications of the topography will be significant. The structures for access to the bridge on the Bulgarian shore will have a more prominent character because of their height compared to the soil's quote. The perception of the view from the Pokraina village, situated in the area where the embankment of the road turns north-west will be significantly changed since the inhabitants of the peripheral houses will be looking directly towards this structure.

The structures of the bridge will be also visible for the inhabitants of Vidin. Despite all these, the bridge will be situated at a distance long enough not to have an intrusive effect on the landscape. The bridge itself will represent a reference point in this more or less plain relief.

2.1.1. Measures of diminishing the impact on the landscape

The impact of these structures on the landscape can be attenuated in a certain measure by forest planning or by an architectural design which would integrate the respective structures in the landscape. While forest planning will have an immediate effect of covering the exposed soil surfaces and slopes, it will not generate immediate landscape effects, a period of 10- 15 years being necessary for obtaining significant shielding results.

It must also be considered the structure and type of the autochthonous vegetal layer, being planted only the typical species for the region, excluding the agricultural plants.

In order to diminish the types of impact described above, the implementation of the below measures is necessary:

- planting the grades on the Bulgarian shore with trees and shrubs;
- planting vegetation shields of trees and shrubs around the Vidin ware train station;
- planting vegetation shields of trees and shrubs between the transport alignment from the grade and Antimovo village;
- replacing the poplar plantation on the Bulgarian border with riparian shrubs and trees which will also have the role of vegetation shield for the upstream recreational area;
- planting trees and shrubs on the grades on the Romanian shore;
- planting vegetation curtains made of trees and shrubs between the road and railway infrastructure and Calafat;
- planting vegetation shields for the customs point on the Romanian shore which will play a protection role for Basarabi village.

2.2. The impact of the construction works

Besides the modifications of the landscape resulting from the new structures of the infrastructure, there are temporary modifications caused by the construction activities.

During the construction phase of the infrastructure, some areas will be used for arranging the construction site. They will be used temporary, there will be losses of significant resources like shrubs and trees, for example. The temporary deposits of the surplus of excavated material will also have a negative impact on the landscape.

A significant impact on the recreational function of the landscape can occur as a result of noise and dust emissions and as a consequence of the general perturbation generated by the presence of vehicles and of the progress of the construction activities.

2.2.1. Measures for diminishing the impact

The visible perturbation factors like dust clouds from the construction sites can be diminished by applying measures as wetting the asphalt areas. There will be planted vegetation on the excavated areas in order to prevent the soil erosion. The measures of restoring the construction areas will equally serve to reconstitute the attractiveness factor of the landscape.

2.3. Impact caused by the exploitation/circulation

The circulation will produce visual changes at the level of the new structure because the flux of the vehicles will become noticeable and it will be emphasized by the vehicle headlights. The bridge and the customs point on the Romanian shore will have an illumination system.

Besides the visual aspects, the landscape's perception will be influenced by noise as well. Even though the noise level in the inhabited areas will be below the admissible limits, the background noise of the traffic, more or less permanent will become a constituent part of manner of perception of the open spaces situates at approximately 350 m on the both sides of the alignment

A noise level that exceeds 55 db(A) is usually considered a factor that decreases the recreational potential of the landscape. More than this, the emissions of noxa contribute to the diminishing of the general recreational potential.

After the construction and inauguration of the bridge, the area around the Bascov recreational perimeter will be significantly developed in order to become a recreational area both for the inhabitants and tourists of Calafat and the neighboring areas. The recreational areas on the Romanian shore including the small beaches are supposed not to be substantially affected by the construction of the bridge and of the transport infrastructure.

On the Bulgarian shore, there will be some modifications in the vicinity of the bridge. Despite all these, the summer recreational areas at chainage 796+200 and the temporary sand island that appears during the summer season close to the shore will probably not be affected. t is not foreseen that the island disappears as a consequence of the modifications of the hydraulic regime generated by bridge's construction.

2.3.1. Measures for diminishing the impact

The measures that envisage the plantation of the vegetation curtains described above will also contribute to the diminishing of the effects on the landscape generated by the exploitation of the bridge.

CONCLUSIONS

The construction phase of the future infrastructure is the one with the most significant potential to generate a negative impact deriving from the size of the construction installations and from the duration of the construction works. The description and evaluation of the initial conditions represent the foundation of the assessment process of the impact on the landscape factor.

In this respect, there have been identified and evaluated the anticipated effects on the landscape and in the same time there have been emphasized the measures of avoiding or reducing, repairing and /or compensation of the negative impact generated by the construction of the bridge over Danube from Calafat to Vidin. Also the specific measures to attenuate the impact and the manner in which they have been adapted to the requirements of these constructions.

The main negative effects mainly refer to the following aspects:

- The construction phase for a structure of such dimensions has a time limited duration. The clearing and construction operations on the ground and in the river will represent the main issue. The proportions of the construction and the number of workers on the construction site will require a cautious environment management;
- The impact on the flora and fauna is constituted by the destruction of the habitats. The only element of national importance both for Romania and Bulgaria that is affected by the construction of the bridge is the Danube river;
- In the areas where the structures of access to the bridge will be mounted on embankments which are significantly higher than the basis level of the ground, the landscape will suffer a clear deterioration. The bridge itself may not represent a disturbing factor from the point of view of the landscape, adding a new structural element in the natural predominant setting. The bridge may also be regarded as an attraction or reference point, depending on the personal perception;
- The impact on other environmental factors will be controlled by applying a suitable environmental management, especially in the construction phase.

The importance of the construction of this infrastructure refers mainly to the positive effects on the socio-economic field while all the other important environmental aspects (eg. flora, fauna, soil and water) will be more or less affected, depending on the efficiency and promptness of the implementation of the measures necessary to diminish the negative effects which will manifest themselves during the execution of works and the exploitation/circulation period.

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THE USE OF ECDIS IN MODERN NAVIGATION

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ABSTRACT

A good navigator gathers information from the electronic aids like Chart Display & Information System (ECDIS), evaluates this information, determines a fix, and compares that fix with his pre-determined "dead reckoning" position. By using the ECDIS a navigator constantly evaluates the ship's position, anticipates dangerous situations well before they arise, and always keeps "ahead of the vessel". This paper intends to emphasize the manner in which the modern navigator must also understand the basic concepts of ECDIS, evaluate its output's accuracy, and arrive at the best possible navigational decisions. But navigation must be done by keeping in mind that successful navigation cannot be acquired only by using electronic aids like ECDIS. Old fashion navigation is still needed. Therefore, our final objective is to show the benefits of using ECDIS but also to point out the importance of traditional navigation.

Keywords: *electronic aid, navigation, modern, ECDIS.*

1. INTRODUCTION

Electronic integrated bridge concepts are driving future navigation system planning. Integrated systems take inputs from various ship sensors, electronically display positioning information, and provide control signals required to maintain a vessel on a preset course. The navigator becomes a system manager, choosing system presets, interpreting system output, and monitoring vessel response.

In practice, a navigator synthesizes different methodologies into a single integrated system. He should never feel comfortable utilizing only one method when others are available for backup. Each method has advantages and disadvantages. The navigator must choose methods appropriate to each particular situation.

With the advent of automated position fixing and electronic charts, modern navigation is almost completely an electronic process. The mariner is constantly tempted to rely solely on electronic systems. This would be a mistake. Electronic navigation systems are always subject to failure and the professional mariner must never forget that the safety of his/her ship and crew may depend on skills that differ from those practiced generations ago. Proficiency in conventional piloting and celestial navigation remains essential.

For some years a new concept has been making its presence felt in shipping circles: ECDIS. Better known under the term electronic nautical chart, all kinds of nautical chart presentations on computers are often called ECDIS, not just by landlubbers but also by seafarers and the equipment suppliers.

2. ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM (ECDIS)

2.1 Historical Background

Since 1983, when the first electronic sea chart with radar overlay was demonstrated in the USA, electronic navigation charts have gradually been taking precedence over paper charts for use on the ship's bridge.

In 1988 IHO published the first standards for harmonized Electronic Chart Display and Information System (ECDIS).

There are standards and specifications that precisely define for professional shipping. What an ECDIS is, what are its component parts, who supplies the chart data, what standards have to be met, who uses ECDIS and nature of an item of equipment that may be designated ECDIS and is intended what advantages it offers are the questions we answer below.

2.2 The ECDIS Short Presentation

ECDIS is thus more than an "electronic nautical chart". Nautical charts are in fact presented electronically, but in principle all kinds of charts: aviation charts, street maps, and railway maps etc. – could be presented on a computer display using the same methodology. However, we shall restrict ourselves to comment on the electronic nautical charts.

Electronic chart presentation is only one aspect of ECDIS. ECDIS is also an information system. As an information system, ECDIS enables the user to call up information on the items displayed in addition to the graphics presentation.

2.3 The Components of ECDIS

For the user, i.e. the navigator, ECDIS is only one item of equipment among many on the bridge of a modern ship. Operating the ECDIS is thus not the main duty of a ship's officer. Rather, the system replaces the conventional chart table and is intended to permit all types of work traditionally connected with the paper nautical chart and to make these activities easier, more precise and faster. These include route planning, entry of observations, instructions and notes, position determination and, last but not least, updating charts with the aid of the Notices to Mariners (NTM).

ECDIS represents an item of equipment consisting of hardware, software and the data. The hardware of the ECDIS is generally a computer with graphics capability,

a high performance PC or a graphics workstation installed in a console linked with other items of ship's equipment. Thus, ECDIS obtains the course from the gyro compass, the rate of turn from the turn indicator, and the ship's speed through water from the log (the ship's "speedometer"). Key features are the links with the position sensors of the ship (Decca, Loran, transit satellite navigation system) and in particular with the GPS (global positioning system, a satellite based positioning system), supplying via the NMEA interface a constant stream of highly precise position data (NMEA National Marine Electronics Association; NMEA0183 Standard for Interfacing Marine Electronic Devices, data record). Even radar pictures can be superimposed, either as raw data from raster scan radar, or as synthetic ARPA (automatic radar plotting aid) radar information.

The software that makes the computer an ECDIS consists of the user interface (UI) and the so called ECDIS kernel, the software that makes it possible to read the data and display a chart. This software is also called "function library". In addition to the chart picture, the user interface shows buttons and keys for operating the nautical chart.

The official original data (S57) of the electronic nautical chart is usually supplied on CD-ROM or, in case of updates, via digital telephone or satellite communication system. This original data is also called electronic nautical chart (ENC).

The chart database is organized in cells that cover the entire earth's surface without overlapping. The cells store all nautical chart objects as well as objects created only during the operation of the system, such as waypoints and leg lines, notes, positions of own ship and of other vessels, etc. The data in the System Electronic Nautical Chart (SENC) is generated from the original data of the ENC. The ENC has to be kept unaltered in order to be able to reconstruct the SENC data if this is unintentionally damaged or destroyed. In SENC, the chart data is stored a proprietary file format designed by the ECDIS manufacturer for speed and reliability.

3. THE ADVANTAGES OF ECDIS

An ECDIS satisfying all the above requirements is not only an adequate replacement for the paper nautical charts but also a system containing all information important for navigation that can be called up at any time and without delay.

Today, this information is still scattered about in various publications, and manual search procedures are laborious and time consuming. ECDIS also offers the possibility of automatic anti-grounding alarm, which is not possible with any other navigation aid.

In 1989, the "Exxon Valdez" ran aground in Prince William Sound in Alaska as a result of prematurely changing course due to false identification of an island. It leaked oil, causing a major environmental catastrophe. If "Exxon Valdez" would have had an ECDIS on the bridge, she could have avoided running aground.

With a continually updated display of the position of the ship, the premature change of course would have probably never occurred. Moreover, the ECDIS anti-grounding function would have produced an alarm when the vessel was approaching the shallows, warning the officer on duty of the danger.

A further advantage of ECDIS compared to all other navigation aids is the individual adaptation of the chart picture to the particular requirements. This is possible because the chart picture is produced only during operation. It is possible to produce the relevant shallow water contour for a super-tanker with a draught of 25m or for a ferry with a draught of only 3m. The presentation library controls this via adjustment of the safety depth/safety contour. Automatic updating is much faster, easier and also less prone to error than chart adjustment currently laboriously carried out manually with considerable time lag. Updating can even be called up on a digital telephone or via satellite, and incorporated instantaneously. ECDIS makes seafaring easier and thus also safer.

4. METEOROLOGY FOR ECDIS

One of its future aims is to start working on interfacing meteorological and oceanographic parameters with ECDIS, leading to creation of new Marine Information Objects (MIO) necessary to provide a most up-to-date image of these phenomena. This will make ECDIS a more versatile tool to assist the mariner in decision-making, and in making navigation more efficient and safer as a result. It will also promote cost effectiveness of shipping and better protection of the environment.

There are several meteorological parameters essential for safety of navigation and it was agreed that the basic display of meteorological data on an ECDIS screen should follow the mandatory requirements of the Global Maritime Distress and Safety System (GMDSS): wind, sea state, visibility and significant weather.

4.1 Wind

Wind information is provided as a surface (10m height) means value – direction and speed (in knots or m/s) and as gusts – direction and speed.

The wind field data for the surface wind is derived from numerical models, the gust information from forecasts and real-time observations. There are WMO (World Meteorological Organization) symbols for the mean wind values which ECDIS is expected to use, but no separate symbol for gusts. This is a matter that ECDIS developers will need to look into and continue to confer with WMO on the subject. One of the options is an operator switch able symbol, another – alphanumeric display alongside the standard wind symbol, but other solution is also possible.

There is also a question of interpretation of the gust information: Is the gust the same as maximum speed?

The WMO definition of a gust is "a sudden, brief increase of the wind in a period of at least 3 seconds, where the value exceeds the mean wind speed by more than 10 knots or 5 m/s" (International Meteorological Vocabulary, WMO No. 182). However, it was felt that mariners are interested in what is the maximum possible value of the gust.

4.2 Sea State

Sea state information is provided as direction seas (sea waves), period of sea waves and height of swell.

At present, these data are represented in form of continuous lines for the sea waves and of dotted lines for the swell; both supplemented by alphanumeric information alongside. It is proposed that ECDIS should follow these principles with an addition of isoclines in a global view and of pick reports for the single point data. Another possibility for graphical representation of swell forecast is to plot arrows showing direction of swell with their length depending on the height of the swell.

Significant wave heights are usually disseminated by the NMS. Additional information for the sea state in form of wavelength and maximum wave height is generally available at the NMS, but not disseminated widely at present. They are made available for site-specific operations. Some new symbols may be needed to display this information by ECDIS if there is a requirement for it by the mariners.

4.3 Visibility

Visibility data is usually a time and location specific information at the point of observation (e.g. ship report). Interpolation or data smoothing is not viable.

When visibility information is forecast, the predictions apply to an area. It is possible to draw a parallel with the aviation visibility forecasts where general, occasional (i.e. temporally variable) and isolated (i.e. space variable) and isolated (i.e. space variable, e.g. fog patches) conditions are predicted for a given area with the following thresholds of visibility:

- > 5nm – good
- 2-5 nm – moderate
- 2 nm – poor
- < 0.5 nm – very poor

WMO has developed a very comprehensive symbology for point data on fog/visibility. Its symbol for an area affected by fog is solid shading in yellow which is the same as the land areas in ECDIS, thus requiring development of a different method. One option is enclosing the affected area in a frame of different colour for different fog conditions (occasional, isolated, etc.). Another one is using a yellow kind of different kind for each type of conditions enclosing an area with additional point data symbols inside. The final solution will have to be protected by the ECDIS developers in cooperation with the WMO.

4.4 Significant weather

Significant weather data can be considered as one meteorological parameter which provides additional values to the general weather information (e.g. description of precipitation: rain, showers, drizzle, squalls, etc.). WMO symbology applied to the affected area will need to be used in ECDIS, possibly using the frames of various colours do delimit such areas.

General weather information for mariners is provided in form of warnings (for gales, storms and tropical cyclones), and of weather forecasts. The requirements for both these forms, as well as for the SAR operations are very precisely described by the WMO Technical Regulations.

The warnings are normally transmitted in plain language, and at present there is no facility of translating this into a graphic representation. The mandatory GMDSS requirements for the weather forecasts are as mentioned above, and at present sent in plain written language and as weather fax which can be adapted for ECDIS. Any other 5 information is optional for general forecasts; however it may be of value to SAR operations, and is then provided.

ECDIS should follow the WMO requirements and symbology in every case.

4.5 Integration of MMSI/GMDSS Data and Meteorological Alarms on ECDIS

The GMDSS mandatory set of information should form the basis for the meteorological input to the ECDIS overlay. The format of data transmission to vessels is open for discussion.

WMO provides several standards for data transmission (ASCII, binary, Weather fax), but there is no provision for a format readable by ECDIS at present. S-57 format is a possibility; however some countries responsible for data transmission in their GMDSS areas of responsibility may find it impossible for financial reasons. The cost of satellite transmission of large data files for graphic display may be considerable and would have to be borne by these countries, as provision of meteorological data is at present free to the end users. As from 1 Feb. 1999 Inmarsat C onboard receivers are mandatory for all SOLAS class vessels to enable them to receive the GMDSS messages. These plain text messages may be interfaced with ECDIS after format conversion. It is possible that graphic images can be transmitted in the future. If transmission of these images using S-57 format is too costly, then the existing WMO formats may have to be used for transmission, with format conversion being performed within the onboard ECDIS.

Interaction of meteorological data with the ECDIS functionality offers a possibility of alarms raised when certain threshold are reached or exceeded. The most important is a storm alarm. This would inform the navigator that the vessel is likely to encounter storm conditions within a preset number of hours. Both the number of hours and the threshold of e.g. wind speed or wave height should be selectable within the ECDIS equipment by the operator. Specialized alarms could also be provided, e.g. when certain air/water temperature levels are important for vessels transporting fragile cargo.

5. ECDIS FOR VTS

More and more VTSs are using custom electronic vector charts with associated custom databases, although relatively few have so far adopted ECDIS. There are arguments for adopting ECDIS as a standard for VTS, although significant modifications will be needed, for example:

- The same information is available on board and in the VTS. This could be especially beneficial for shore-based pilotage and navigational assistance operations;
- Charts are standardized, using performance standards as agreed by IHO/IMO;
- Updates are possible;
- Different VTSs would use the same chart standards and could exchange display data easily.

The standard "IMO-ECDIS" needs to be modified for use in VTS. On the one hand some items are not needed. VTS operators are familiar with their area and do not need the detailed labels available in the standard ECDIS data set. On the other hand VTS operators need information not contained in the standard IMO ECDIS, for example:

- Radar target tracking acquisition zones;
- Radar target tracking reporting lines;
- Navigable space, e.g. Fairway boundaries (often differently defined for VTS purposes than in the IMO-ECDIS);
- Fairway centre lines (in Germany also called the "Radar line");
- Additional text notes (Temporary notes for dredging activities etc.);
- Areas of responsibility for VTS operators;
- VTS areas limits;
- Harbour responsibility area limits;
- Details related to harbour management;
- Positions of other VTS related objects;
- Other details which still emerge with each new VTS project and in the course of technical and technological VTS development.

Meanwhile, the VTS display is designed to be watched for long periods, so the VTS ECDIS should use a palette of colours that is not tiring for the operator. VTS charts also need to integrate local information for example on water depths, which are usually more up-dated than the more data supplied by IHO for ECDIS.

A solution would be to provide special overlays for VTS containing the appropriate VTS objects sets for each area. Compared to IMO ECDIS, some of the more obvious VTS ECDIS requirements include the ability to customize the data set:

- A reduced background data set;
- A chart editor;
- An object editor (lines, symbols, etc.);
- A colour editor.

There are also some functional modifications for operational purposes, such as:

- VTS specific automatic alarms and alerts;
- VTS specific new chart details, such as automatically tracked buoys;
- VTS specific chart details, such as additional text bodies, temporary chart objects.

6. CONCLUSIONS

Internationally the future of ECDIS depends on several factors, the most significant of which is the lack of ENCs. This lack, in turn, is suppressing demand for ECDIS with the result that interest in setting up an infrastructure to distribute ENCs and updates has stalled. Given the international trend toward smaller government it doesn't seem likely that the production of ENCs will dramatically increase in the near future.

ECDIS is influencing the way mariners and navigation service providers (typically Coast Guards) approach the safe and efficient management of shipping.

There is no doubt that ECDIS, supported by ever faster and smaller computers and higher resolution video displays will continue to revolutionize marine navigation for many years to come.

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PIRACY IN THE GULF OF ADEN – A PROBLEM OF OUR DAYS

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ABSTRACT

The present paper tries to elaborate on the causes of maritime piracy in the region of Somalia. The authors support the idea that there is no real incentive for the Somali government to contain piracy in the Gulf of Aden, apart from pressures of the international community and the need to improve one's image therein.

However, the efforts to counter piracy attacks must be continued and further enhanced by multinational cooperation due to the importance this region has for the international maritime trade.

In recent years, piracy and terrorism on high seas are posing serious threats to international security and economic development. With increasing interdependence, the use of sea route for transportation has become vital. Three main issues arise in relation to this threat: piracy with focus on Somalia and the Gulf of Aden; terrorism impacting trade through Malacca Straits; and policy response of the countries whose trade is adversely affected by sea piracy and terrorism.

Keywords: *piracy, Somalia, sea route, Gulf of Aden.*

1. INTRODUCTION

To the passive observer, the multinational approach to fight piracy seems like a straightforward case of the international community working hand in hand to eradicate piracy in waters where there is much international stake riding on them. However, upon closer inspection, they can be construed as a part of a purposeful strategy to placate the maritime powers and keep them at arms length from getting involved in the Strait. The littoral states have done well to preserve the notion – if not the reality - that their sovereignty reign supreme in the Strait, while they welcome international assistance to maintain the sea-lane.

The recent spike in pirate attacks off the coast of Somalia has generated a great deal of international media attention. Somalia's modern pirates represent not only a very real menace to maritime security, but also a growing threat to international commerce. The sensational nature of their crimes, while drawing the ire of the international community, has also ensured that the Somali pirates remain shrouded in mystery.

2. PIRACY IN GULF OF ADEN

Piracy is not a thing of the past, a romanticized form of crime from the pages of history. It still happens every day, and the victims don't always live to tell the story. In recent years piracy has hit the headlines as even the largest super-tankers have fallen victim to attack by gun-wielding cutthroats.

2.1 Definition of Piracy

A number of attempts have been made to elaborate a definition of piracy. If one takes the time to make a comparison between the various accepted definitions, then we can notice some differences as well.

For example, there are certain differences between the International Maritime Organization (IMO) and the International Maritime Bureau (IMB) definitions of piracy. The contrast is best observed when the two definitions are analysed side by side. There has yet to be an internationally agreed set of definitions.

Table 1. Definition of Piracy

IMO definition	IMB definition
Piracy must be committed on the high seas or in a place outside the jurisdiction of any state. A criminal attack with weapons on ships within territorial waters is an act of armed robbery and not piracy.	Distinctions do not exist between attacks on the high seas and territorial waters.
Piracy necessitates a „two-ship" requirement. Pirates need to use a ship to attack another ship. This excludes mutiny and privatising from acts of piracy.	A „two-ship" requirement is abolished. Attacks from a raft or even from the quay are acts of piracy.
Piracy is committed for private ends. This excludes acts of terrorism and environmental activism.	Piracy may not only be committed for private ends. Attacks on a ship for political or any environmental reasons qualify as piracy.
Because pirate attacks have to be committed by the crew or passengers of privately owned vessels, attacks by naval craft fall outside the bounds of piracy.	The acts of government naval craft can be deemed as piracy in certain circumstances.

Specifically related to piracy and armed robbery against ships, IMO, the United Nations Agency concerned with the safety of shipping and cleaner oceans, has issued written guidance to the maritime

industry suggesting that an armed response to any attack is discouraged: "Aggressive responses, once an attack is underway and, in particular, once the attackers have boarded the ship, could significantly increase the risk to the ship and those on board…The carrying and use of firearms for personnel protection or protection of a ship is strongly discouraged ... Carriage of arms on board ship may encourage attackers to carry firearms thereby escalating an already dangerous situation, and any firearms on board may themselves become an attractive target for an attacker. The use of firearms requires special training and aptitude and the risk of accident with firearms on board ship is great. In some jurisdictions, killing a national may have unforeseen consequences even for a person who believes he has acted in self-defence."

2.2 A Brief History of Piracy

In April 2007, the International Chamber of Commerce (ICC) issued a warning addressed to commercial ships. Over the past two decades organizations like the ICC have been monitoring pirate attacks and have identified clear pirate hot-spots, where attacks are commonplace events. A brief history of piracy will help us acquire a better understanding of the phenomenon.

A reasonably tentative definition of piracy might be 'armed robbery at sea by private actors acting for selfish purposes, especially economic gain.' This already allows us to distinguish piracy from related contemporary and historical phenomena such as coastal raiding, unarmed theft from ships, maritime terrorism, maritime aspects of insurgency, and the raiding of merchant or other civilian ships belonging to an enemy nation as a strategy of naval warfare. There is definitely a certain overlap between each of these and piracy, as when a terrorist group engages in piracy as defined above, yet with the intention of using the proceeds for terrorist activities, or when commerce raiding is outsourced to privateers, who are often former pirates. Analytically, however, the six phenomena are best kept separate.

Piracy has been around since man first took to sea, a maritime scourge that appeared in historical records since before the building of the Egyptian pyramids. The Mediterranean, otherwise known as the "cradle of civilization", was also a pirate hot-spot.

At any period, piracy in the ancient world flourished when there was a lack of central control and in areas beyond the reach of major powers such as the Egyptians, the Assyrians or the Mycenaean Greeks. The first distinction that must be made is that between 'pirates' and 'privateers', where the latter is state commissioned private or commercial vessels intimately connected to the role of the state. This argument is very important, not only because it widens the intellectual scope of the general discussion about pirates, but it also points to key factors associated with piracy which help us to understand the ramifications of the Somali piracy situation in particular.

One of the earliest recordings of piracy is by the Thracians who, during antiquity, used the island Lemnos, in the Greek archipelago, as a safe haven when targeting merchant ships. But, piracy has, in all likelihood, existed as long as the oceans have been used for trade and transport. The Thracians might have been the first recorded pirates, but, all over the globe, up to the present day, piracy has been a recurring phenomenon, mostly on a rather small scale, but, at times, reaching levels that also incited a response. During the 10th and 11th centuries, the Vikings, who primarily targeted coastal areas, prompted heavier coastal defences and the Cretan pirates impelled the Venetians to re-route and alert their merchant fleet.

2.3 The Strategy of Piracy

Piracy can be both a means and an end: a means for certain states to weaken adversaries and enrich themselves and/or an end for the individual pirate who could stand to profit a great deal from the profession. The Elizabethan Sea Dogs were a means for the English Crown to fight Spain and protect itself. Their subsequent effect in repelling the Spanish Armada, in 1588, also increased the English Crown's willingness to use privateers. But, for the pirates and the privateers themselves, it was clearly an end in itself. For privateers like Drake, Raleigh, Cavendish and Cumberland, privateering was a way not only to enrich them, but also to make a career.

The incentives for the pirate have always been about the potential riches. These incentives must be higher than the risk of being caught. It could also be argued that historically, at least in part, piracy was about an alternative lifestyle, with greater individual freedom compared to work as a regular sailor on a commercial ship or in a national navy. This has to be balanced with an efficient form of organization that prevents internal predation, minimizing conflicts within the crew while still maximizing the profit. Historically, many pirates also created systems of checks and balances and a democratic system of how to divide the loot.

Somali piracy does not seem to contain any such system. It does, however, provide a way to earn a living in a country deprived of employment opportunities. This might simply be enough. The low risk with which the Somali pirates seem to view their operations, is quite telling to their alternative livelihoods. The piracy offers an expansion of the choices available to the people of Puntland. Such an expansion of choice, which implicates a possibility to earnings incomparable to the alternative choices ashore, is the major reason for the existence of the Somali piracy.

However, for any state that is more actively sponsoring piracy, there is a clear risk in losing control over it. Although pirates and privateers are valuable in times of war and useful in tapping competing states' trade in peacetime, they may eventually become a liability. Interestingly the liability of being associated with piracy is only expressed in political disincentives, whereas the incentives are typically a combination of economical as well as political incentives.

When England, during the reign of the Stuarts in 1604, sought a more stable peace with Spain, the privateers became an acute problem. Sir Walter Raleigh's sacking of San Thomé, in 1616, prompted the

Spanish ambassador to demand compensation and the imminent execution of Raleigh. England abided, and Sir Walter Raleigh was condemned and executed in Whitehall, two years later.

Hence, the unclear border between piracy and privateering has often been instrumental for states that suddenly needed to distance themselves from piracy. Conversely, the rise in piracy increased in peacetime. Between the years 1690–1730, the piracy deeds peeked, most notably in the Caribbean, the Mediterranean and off the coast of Madagascar. In cases where the state was so weak that confrontation was not an option, as with Madagascar and Jamaica in the 18th century, the governments were eventually controlled directly by the pirates.

William E. Hall points out that an important element in the distinction of piracy is to distinguish who ultimately bears responsibility for an act of piracy. According to Hall acts of piracy "are done under the conditions which render it impossible or unfair to hold any state responsible for their commission".

So, an important question is whether the Somali piracy activity are carried out under such conditions that it is impossible or unfair to hold Somalia, as a state, responsible.

2.4 Who Is the Controller and Who Are the Controlled?

Somalia is grappling with one of the most dire and acute security situations in the world. Therefore, the question of whether it is impossible or unfair to hold Somalia responsible might not be readily answered. The lack of an efficient central Somali government might be enough to seek responsibility elsewhere. Nevertheless, the Somali government has, on occasion, engaged in the piracy question. One clear measure is the TFG's occasional allowance of foreign navy vessels to in "hot pursuit" follow suspected pirates over the Somali territorial water border.

If it is not reasonable to seek responsibility in the TFG, the next instance would be the Puntland authorities. It seems, however, that the piracy situation in Puntland has grown so strong that it is virtually impossible for the Puntland government to effectively exercise any authority over the pirates. As previously mentioned, it is not unusual for a weak state to be unable to do anything about piracy. Further, for the weak state piracy easily becomes an important means of acquiring revenues. This creates a state dependency from the state on piracy, which means that the pirates do not necessarily have to exercise any direct control over the government in order to get the political protection they need.

It could be said that although it might not be unfair to hold parts of the Puntland and Somali regimes responsible, at least in part for the piracy the situation in Somalia render it quite impossible to hold them responsible.

2.5 Political Agenda?

The discussion has already indicated that Somali piracy is a money-driven business, so well functioning that it has integrated into the socio-economic fabric of Puntland. So, does such a constituency have a political agenda? The Nigerian Movement for the Emancipation of the Niger Delta (MEND) has conducted acts of piracy. But although MEND commits piracy deeds, it is also a political entity pursuing greater liberties for the people in the Niger Delta.

The political ambitions of MEND also leave an imprint on their operational behaviour. MEND is known for sometimes boarding a ship and trying to negotiate political reform, rather than ransom.

There is, however, no indication that the Somali pirates are pushing a political agenda of any kind, save perhaps for its potential deterrent against foreign fishing vessels.

However, though this might have been the motivation at the outset, fishing vessels are no longer the primary target for Somali pirates. It has been suggested that Somali piracy should be viewed as terrorism.

If concepts like piracy and organized crime are complicated, the concept of terrorism is marred with conceptual difficulties and heavily affected by political opinions. It is, however, not unheard of with maritime terrorism.

A possible future scenario is that some group with a political agenda and willingness to use force take up piracy as a mean to acquire funding. This is not uncommon, e.g. the German Red Army Fraction repeatedly robbed banks to finance their activities.

It should be pointed out that the organization of a terror group is not unlike that of organized crime as they share certain communalities: they both participate in legitimate market to improve their standing on the criminal market, they benefit from a state which cannot enforce property and contractual rights, and that they both have vertical hieratical structures.

Although the Somali pirates have no clear political agenda, there is another aspect of the piracy which could be said to be political. Given the economic injection the piracy gives to the poor and underdeveloped region of Puntland, and the integration of the Somali pirates into the Puntland society, they have, effectively, become a political actor. That the Somali pirates also exercise political influence in order to keep their business intact is supported by the claim that some of the piracy money goes to President Yussuf for his lack of action. Whether president Hersi of Puntland also is implicated is not clear. The inability of the Puntland militia to challenge the piracy might indicate that Hersi too is implicated, but it might simply be that his militia is too weak. If indeed Hersi too is connected to the piracy, it would not be surprising, as indicated by our previous discussion; pirates operating in a weak society regularly integrate into political life in order to safeguard their business.

An interesting question is to what extent the Somali pirates are, or could be, used as a political proxy for other actors. The case with the hostage-taken Ukrainian Faina ship, carrying weapons believed to be destined for South Sudan, is interesting. The Sudanese president Al-Bashir would, in all likelihood, be very interested that such a cargo never arrived at its destination.

3. ENDING OR CONTAINING PIRACY

If the root causes to the Somali piracy are the poverty in combination with a weak state and a fragile society, it is clear that piracy is very difficult to root out once it has established itself. To reply with a naval presence might create a change in tactics and a temporary reduction in acts of piracy, but, ultimately, change very little. This is because piracy is a profit-generated enterprise and until there are no more profits to be made, other economical enterprises become more lucrative or the probability of success goes down so significantly that it is not worth the effort, the piracy attacks will continue to exist.

The piracy has meant an expansion of the choices available to parts of the Puntland communities. Hence, to seriously address the piracy would mean that the choices available to the people of Puntland must be further expanded to include businesses which also offer an income. Since no legal business can possibly compete with the piracy concerning the direct earnings, the incentives for the piracy must be altered. There are a number of actions that can be taken to change these incentives for piracy to disincentives. Some of these are already being implemented and some are up for review. This section will deal briefly with the existing and potential counter-measures to piracy. These will be discussed on a tactical, operational and strategic level.

As mentioned in the introduction, the Gulf of Aden and the Somali coast is one of the most heavily trafficked maritime parts in the world. An estimated 16,000 ships pass annually, and many of the major shipping companies have vessels passing through at one point or another. In addition, many fishing vessels also traffic the water to fish, especially tuna.

So, it is not surprising that most maritime nations are concerned with the Somali piracy. According to statistics, the flag states most affected by Somali piracy are Liberia and Panama. This is because most ships sail under these so-called flags of convenience, to avoid certain forms of taxation. However, by reviewing the IMB piracy statistics, with reference to the managing countries of the ships, a better representation of which states are actually concerned with Somali piracy can be obtained. Germany, Singapore and Greece are over represented in the statistics of Somali piracy.

This might have contributed to the difficulty the shipping industry have had in coordinating a response to the Somali piracy. A limited number of countermeasures are in place, but it is unclear as to what extent they actually work. Still, there are a number of countermeasures which can be utilised. According to the shipping companies, these are: The high freeboards and the high speed to make it more difficult for the pirates to board a ship. It has been suggested that a fire hose can be used to fend off attackers, but since this practise exposes the crewman operating it to hostile fire it is by some considered too dangerous. Flashlights, increased watch in combination with a constant update of the situation and sailing along the suggested coordinates increase the probability to avoid pirates and for the coalition forces to come to rescue. Captains are also encouraged to call in suspected pirate vessels. Some shipping companies also advocate that the Automatic Identification System (AIS) should be turned off when passing through the Gulf since its beacon can be used to track the location of a ship.

Most of the major shipping companies also entertain a non-violence policy, to reduce the risk of violent responses and long-term escalation. While exceptions exist, the majority of the attacked ships have refrained from returning fire, although some of them have been equipped to do so. A combination that, at least in part, seems to be effective is the combination of high speed, high freeboards, increased watch and keeping to the suggested coordinates by the coalition forces. Even so, ships applying all of these means have still fallen a prey to the Somali pirates.

There are a number of operational methods that governments have used in attempts to root out piracy. The only technique which seems to be 100% effective is to occupy the country from which the pirates operate. The French invasion of Algeria in 1830 effectively rooted out the notorious Barbary Corsairs. An occupation of Puntland is, however, not on the international community's political agenda.

The AU intervention mission AMISOM that is currently being built up in Mogadishu would, hypothetically, be instrumental in impeding Somali piracy. However, AMISOM is grappling with economical difficulties and finding enough troop contributing countries (TCC), so far only Uganda and Burundi have sent troops. Even if funds and troops could be allocated, it is unlikely that the priority would be Puntland, far away from the more acute problems in the south. This is unfortunate, since a land operation is probably the only way to really address the problem of piracy.

There are already two naval components on station, the CTF-150, and operation Alycon. When the WFP ship MV Rozen was hijacked, food destined for Somalia was kept on board for 100 days by the pirates. An additional WFP ship was hijacked only two months later. As a result, France took the initiative to operation Alycon, France, the Netherlands, Denmark, and lately, Canada has escorted the WFP ships in the hostile waters

It has been proposed that the WPF escorts should be expanded to general convoys of the ships passing through the Gulf of Aden. The idea of convoying merchant vessels has been proposed on several occasions, but it seems to be difficult to implement. Many of the larger shipping companies have vessels that travel at far greater speed than most of the smaller vessels. To slow down the bigger vessels is not an option, since they then would lose valuable time. In addition, the use of high speed is one of the few techniques that are known to be working to avoid being targeted by the pirates. A cluster of ships passing at low speed might also risk inspiring more piracy.

Surveying the Gulf of Aden and the Somali coast is a general problem for the warships on station, since their relative low number must cover a rather large area. A blockade of certain ports might also be difficult since the skiffs easily can be transported by lorry to a different harbour or simply be put out from an uncontrolled beach. Deterring the Somali pirates seems to be difficult.

Deterrence relies on the psychological factor that the threat is, or appears to be, credible. So far, the only deterring factor that has worked is close escort with navy vessels. France is one nation which has carried out a rescue operation. The hijacked cruiser Le Ponant, with a 30 hostages, was re-claimed and the hostages liberated by French forces. Although the operation was a success, it does not seem to have deterred the pirates, as the number of hijacked ships continued to rise during last years.

To increase the deterring effect of the naval presence, it would be possible to escalate by responding through the use of more force. But, this presupposes two things: first, that there is legal room for such use of force, and, second, that it does not, in turn, escalate the pirates' behaviour – which would involve a long-term risk. It is questionable whether the international community could afford an escalation of the situation. The Somali pirates are well armed and do not seem to hesitate to use violence, although they have avoided it if possible. Therefore, a departure from the more cautious approach may have tragic consequences.

The legal aspects have created some insecurity on how UNCLOS, UNSCR 1816 and 1838 relate to the penal laws of the TCC. In addition, most TCC's are reluctant to hand over captured pirates to the Puntland government since they fear that the Somali authority's treatment of apprehended pirates might not be in accordance with human rights. As a consequence the TCC have responded differently when pirates have been apprehended. The Danish Navy frigate which intercepted 10 Somali pirates decided to release them after confiscating their weapons, citing an unclear mandate. This can be compared with the French Navy, which brought the perpetrators from the Le Ponant hijacking to Paris to stand trial. Although the French rescue was made ashore while the Danes intercepted the pirates at sea, the states participating in the naval operation in the Gulf of Aden seem to view the mandate differently.

A possibility, which, so far, has not been discussed, would be to single out the strongest pirate group and put them in charge of coastal security, a sort of coastal privateering party. This would have the added benefit of providing Somalia with a service that they need. If viewed as a serious option, it would require some additional training and approval by the TFG as a legitimate Somali coastguard. Historically, experiences have not been overly successful in employing this method, as some of the pirates operating now are suspected to once have received such training, and put it to a different use. But, as it is possibly the most cost-effective method of impeding the piracy attacks, it may be worth another try.

4. CONCLUSIONS

Piracy is one of the oldest and most lucrative illicit professions. It is an aggressive and often violent means to embezzle goods and capital, with the possibility of providing temporary but effective acquiescence from multiple stakeholders. Opportunities for attack and escape in harbour or on the high seas are aplenty in the maritime arena and it usually takes the collective effort of nation states to crack down on what is essentially a trans-national criminal activity.

Somalia has not had a government since 1991 when warlords took over and a series of clan wars engulfed the country. Apart from the hundreds of thousands that have died in this conflict, about three million people are desperately in need of aid. However, even for the international community to provide aid is a tricky matter, given the politically volatile environment.

As of 2009, there are over twenty nation states patrolling the Gulf of Aden through the US Navy's Combined Task Force 151 and NATO efforts. According to the US State department this collection constitutes an unprecedented international armada. It includes EU member states, China, India, Japan, Malaysia Singapore and Russia. This contact group also establishes a trust fund that shall be applied towards prosecuting suspected pirates. These initiatives were undertaken after the UN Security Council unanimously passed Resolution 1851(6) which allowed all states to use force both on land and off shore if they are granted permission by Somalia's government.

However, in a region such as the Gulf of Aden, with a water space of nearly 3800km, it is still impracticable to protect every vessel along the Somali coast. Even if there is a multitude of ships operating in the area, it is not feasible to be in all places and be able to thwart all attempts of piracy. The issue however, is not piracy for that is only a symptom of the larger problem of civil strife and absence of effective governance that Somalia has been experiencing since 1991. This lack of governance has allowed piracy to proliferate to the intensity that it has. Also, the Somali piracy bears an element of patriotic justifiability to this underground business and there is indeed a public empathy for the pirates.

A counter campaign against piracy in the Gulf of Aden requires both onshore and offshore targeting of pirate strongholds. Piracy in Somalia has become a well established and organized business that is dominated and mitigated by the various clans. It is a phenomenon that has brought an economic boon to a country that has been in economic and political limbo. The regions where pirates reside have witnessed a drastic rise in the level of prosperity. This inflow of wealth has in turn affected governance in Somalia, where due to the all pervasive poverty, the corruption of government officials is hard to avoid.

There is no real incentive for the Somali government to contain piracy in the Gulf of Aden, apart from pressures of the international community and the need to improve one's image therein. However, irrespective of the sentiments of the Somali state, the international community has to continue in its counter piracy efforts in the Gulf of Aden due to the multiple global stakeholders and its importance to international maritime trade. Moreover, the area of operation of Somali pirates is far from coast, not under control of any one state and therefore the burden of all stakeholders.

A solution suggested for the problem of piracy has been to allow pirates formal ownership rights in the waters that nobody claims. Western countries such as the United States especially are against this type of solution

due to its policy of not negotiating with criminals and terrorists.

Moreover, perhaps the ownership issue should not involve pirates but other legal actors, especially nation states. Maritime security entails a range of things apart from countering piracy and if pirates are granted ownership rights, it shall leave no room for environmental concerns, marine research, and tourism or even guarantee smooth international commerce.

The best form of protection can only be afforded if states decide amongst themselves who owns the waters. Then that particular country should take the lion's share of responsibility in making that region safe, along with the opportunity to utilize the collective resources of the international community as and when the need arises.

Paying ransom to pirates in return for crew should be the last resort method and instead an efficient security apparatus should be developed, the kind that was applied by the US in rescuing the captain of US merchant ship Maersk Alabama. This is primarily because ransom money often goes towards financing arms and ammunition that would be used by the nexus of pirates in further attacks.

One of major challenges of the escalated and prolonged practice of piracy is that marauders acquire sophistication and take the hijacked ships further out to sea. This brings to the fore debates on whether or not the crews should be armed or not. This is something that shall never quite be supported by international law because it entails some kind of an authorization for escalation to full blown armed conflict at Sea.

Moreover, there is also the argument that pirates tend to be more merciful towards unarmed crews. Ultimately there would have to be agreements between individual states and the space of their respective territorial waters where it shall be feasible to arm crews of civilian vessels. Apparently, it is even a Somali pirate 'code' not to harm innocent sailors that they take over. While escorts for civilian merchant shipping vessels by naval warships provide an effective form of deterrence, it is not possible to avail their protection at all times but mostly during high alert.

While all countries in the world today engage in varying degrees of maritime trade, it is countries with naval forces that shall lead the piracy debate and not the entire international community. Apart from the dearth of strong stable governance, there are other factors including the differing progression of piracy as well as the existing infrastructure and laws in the two regions, which contribute to the current circumstance.

Pirates are essentially businessmen. The maritime arena is a highly material world where both the marauder as well as the marauded is looking for the most cost efficient means of doing business. Piracy is a complex problem that cannot be solved overnight nor entirely done away with in the near future. It can however be contained to the extent that it is a marginal concern as opposed to a looming menace.

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THE CORROSION BEHAVIOUR OF THE CHROMIUM COATINGS IN SEA WATER

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ABSTRACT

The work intituled "The corrosion behaviour of the chromium coatings in sea water" presents the research done by the authors in order to cover with superficial metallic layers, some OL 37 carbon steel mechanical parts, by the use of some electrodes made of a corrosion resistant material (Cr). The corrosion resistance of the experimental layers was obtained using gravimetrical method and the polarization curves method. The superficial layers subjected to corrosion were analyzed by the use of an atomic force microscope. The investigations proved an improvement of the superficial layers quality in regard to the thermodynamics corrosion probability.

Keywords: *Superficial layers, corrosion, electrical discharge, cromim.*

1. INTRODUCTION

Processing by sparks is a simple and cheap process, in comparison with other methods to process the surfaces and it has wide applicability in industry. The method of processing using electric sparks of the surfaces of materials is based on the phenomenon of electric-erosion and the polar transfer of the anode material (the electrode) to the cathode (the metallic piece) during the electric discharges in impulses between the anode and the cathode. That discharge takes place in a gas environment. Unlike the classic processing through electric-erosion, at the electric sparking is used a power that is recovered pulsate with reversed polarity. In this case the processing through electric spark has the air as a gas environment and the electrode execute a vibrating movement.

2. EXPERIMENTAL RESEARCH

The experiments where done for the superficial treatment through impulse electrical discharges made with the ELITRON 22 A equipment, using Cr electrodes, on the OL 37 steel carbon samples. The samples were subjected to gravimetrical corrosion are parallelepiped with the surface of 0,00127512 m^2 . It's were suspended with an synthetic line (nylon) of $\phi = 0{,}2\,mm$ in a plastic material tub at 4 cm above the tubes liquid level (sea water), being immersed 285 days in static see water at the environments temperature .

The samples on which the superficial treatment was made through impulse electrical discharges where individually weighted on the analytic balance at different time intervals, determining the corrosion process speed

At long immersions of the probes in sea water, the exposed surface suffers modifications in the way of puncture of the superficial layer resided and corrosion takes place in dots after the penetration of the corrosive agent.

The mass variation for the OL 30 steel covered through sparking with the Cr electrode and the steel support is presented in figure 1, and the speed corrosion variation based on the immersion time is presented in figure 2.

Preparing the surfaces presumes a thorough treatment and degrease with a powerful solvent

The treatment through electrical discharges where made manually, the active electrode is under a 60^o angle with the treated surface.

When treatment with electrical discharges a significant importance in the formation of the superficial layer and it's qualities, has the electrode section surface, influence that will be manifested at the working regime temperature variation and at the current density which passes through the electrode.

In the experiments wasn't specified the electrode vibration amplitude value because this does not influence neither the layer thickness, or it's structure, the only importance is to be big enough to prevent the solder of the electrode with the surface which will be treated.

In table 1 are presented the recommended values for the electrode cross section in regard to the work regime of the ELITRON – 22A equipment and the current value at every regime.

Table 1 The recommended values for the electrode cross section

Electric work regime ELITRON – 22A	**Electrode cross section value [mm]**	**Work current [A]**
1	4	0.5
2	5	0.8
3	4÷6	1.3
4	5÷6	1.8
5	6÷9	2.3

The geometric and microstructure characteristics of the superficial layers experimental obtained depend on the work parameters used in the treatment process.

The optimal values of the discharge process parameters are construed only from experimental research.

The samples were subject to electrochemical corrosion have a circular plane surface. The OL 37 stell carbon samples was inserted in a Teflon holder so it can be mounted into the electrode equipment. The corrosion testing was done on the samples sparking at three work regimes of the ELITRON 22 A equipment: R_1 = 0.5 Å, R_2 = 1.3 Å and R_3 = 2.3 Å.

The corrosion resistance was studied through electrochemical methods determining the potential in open circuit, the corrosion potential and marking the polarization curves (linear and cyclic) with VOLTALAB 32 equipment. The experimental data acquisition and processing were done by the use of VOLTMASTER 2, specialized software

Experimental results were compared for both the surface of the initial sample material (OL 37) and the surface of the sample covered with a Cr layer.

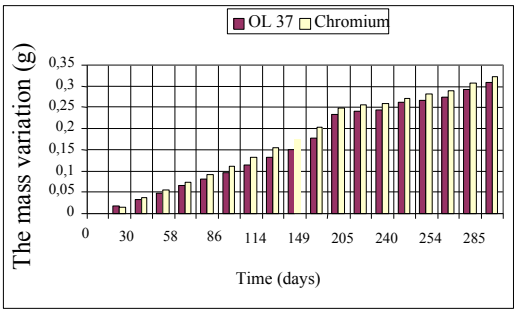

Figure 1 The mass variation

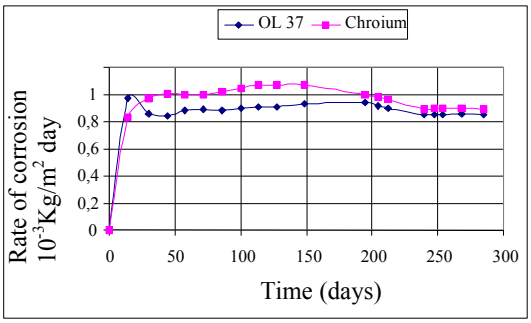

Figure 2.Rate of corrosion

The corrosion potential was determined by tracing the curves of linear polarization, recorded in sea water, using the Evans coordinates: E = f(log I) (Marcus 2002) (figure 3).

The corrosion process analysis was made also based on the cyclic polarization curves (figure 4).

The fine determining of the topography surfaces exposed to the action of the corrosive environment was made using the atomic force microscope (AFM).

The support but also the sparking probes, present the same type of corrosion; a general corrosion, which in the initial moments is represented by the appearance of corrosion dots.

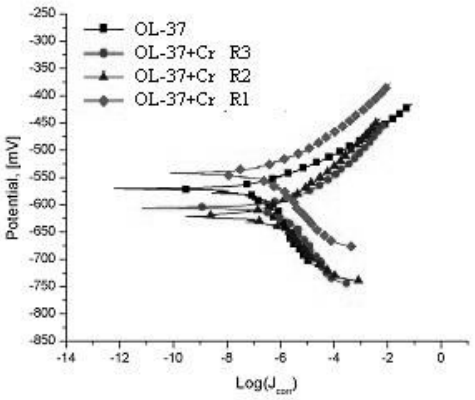

Figure 3 Linear polarization curves for the chromium sparking samples

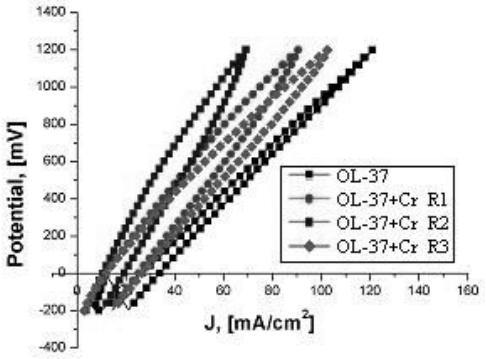

Figure 4. The cyclic polarization curves for the support sample and for the samples covered with copper at different sparking regimes (R1-0.5 A; R2-1.3 A; R3-2.3 A)

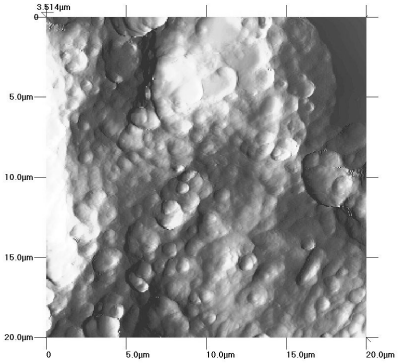

Figure 5. Superficial treated sample with Cr electrode- "wave mode" image – 2d on a scanned area of 10x10 µm – regime R1

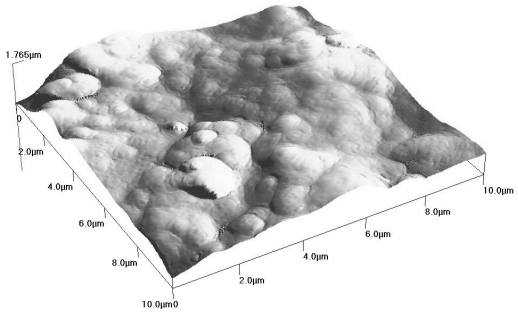

Figure 6. Superficial treated sample with Cr electrode-"wave mode" image – 3d on a scanned area of 20x20 µm - regime R2

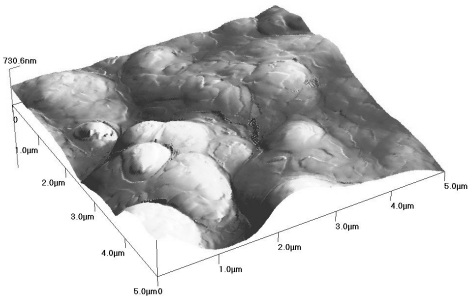

Figure 7. Superficial treated sample with Cr electrode-"wave mode" image – 3d on a scanned area of 5 μm^2 - regime R2

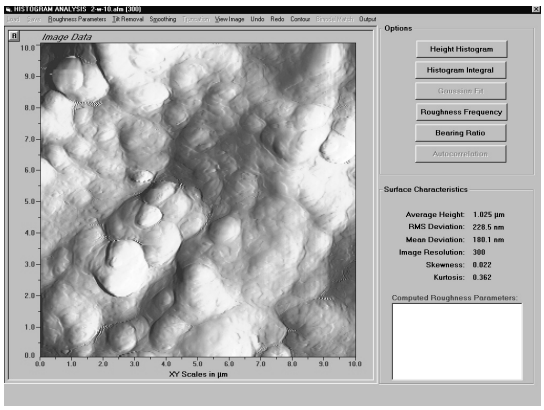

Figure 8. The histogram of the untreated probe surface profile after the exposure to the action of the corrosive environment in the same conditions as the superficial treated probes.

We'll observe that the value of the difference in height of the relatively homogeneous surface leads to the conclusion that Cr deposited layer not provides good resistance to corrosion in the presence of an aggressive environment.

The above statement is supported by a histogram of the sample surface relief sparkling with chrome electrode and is shown in figure 6, which certifies that mean a surface profile measurements value, on the test sample reach 1.025µm**,** which shows a marked levelling of all surface areas.

5. CONCLUSIONS

From the variation graphics of the masses, in time it can be noticed that, for the OL 37 steel sparked with Cr electrode, the material loss are grater then for the steel carbon used as support.

For superficial layers obtained using Cr electrodes are increasing corrosion. Chromium forms a very compact layer which very stable at attack Cl ions in sea water, but in sea water with little dissolved oxygen chromium oxides formed in the dry layer which is not provides protection to clorine compounds.

So the support and the sparking samples, present the same type of corrosion which is a general corrosion type, in the initial stage being represented as corrosion dots.

The "wave-mode" images from the AFM microscope of the samples superficial treated with the Cr electrode, presents the surface relief using colour shades (figure 4). The light colour zones are the highest ones.

The AFM analysis done on the samples superficial treated with chromium electrode, show a non uniform layer. This layer has discontinuities where the corrosive agent might have access to the sample basic material.

A specific trait of the Cr layer is that the difference between the lowest and the highest area of the layer reaching only up to 1765 µm.(figure 6)

Low height difference relatively homogeneous surface leads to the conclusion that Cr layer deposited not provide good corrosion resistance in the presence of an aggressive environment

Small amount of height difference for relatively homogeneous surface shows that Cr layer deposited does not offer good corrosion resistance in the presence of an aggressive environment

Image in Figure 8. shows globular appearance of the parties have left the electrode material.

6. ACKNOWLEDGMENTS

Some of the ideas presented in the paper are based on the results of the Ph.D. thesis, Research on obtaining and structural analysis of thin layers of corrosion-resistant metal, Technical University Gh Asaci, Iasi, 2007

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NOISE MARINE DIESEL ENGINES AND THE ENVIRONMENT - PART I

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ABSTRACT

Nowadays, more and more consideration is being given to environmental issues. Formerly, noise was considered a necessary, but harmless, evil. Today, excessive noise is considered a form of pollution which, in the long run, may cause permanently reduced hearing. As a consequence, authorities now demand that noise levels are kept below certain specified limits. Today, there are numerous national and international codes which both recommend, and demand, maximum permissible noise levels in the various parts of a ship. The greater demand for noise limitation in the maritime area has, of course, aroused wide interest. Consequently, greater demands are now made on the engine designer to provide more detailed and precise information regarding the various types of noise emission from the engine. After a brief definition of what noise actually is, this paper will attempt to clarify "noise" as applied to MAN B&W's two-stroke engines, and will then go on to discuss the primary noise sources and types of engine-related noise emissions, noise level limitation, and the current situation in relation to noise

Keywords: *sound, noise, marine engines, noise level limitation*

1. INTRODUCTION

A popular definition of noise is "an undesirable sound". To what extent a sound can be characterised as noise is, of course, a personal evaluation. However, if the sound level is so high as to be damaging to health, it will normally be considered by one and all as undesirable and, therefore, as noise.

Sound is the result of mechanical vibrations occurring in an elastic medium, e.g. air. When the air starts to pulsate, the variations in air pressure will spread from the source through the transfer of energy from molecule to molecule. The more energy transferred, the higher the sound level.

2. BASIC ON ACUSTIC THEORY

2.1 Intensuty of sound

The physical intensity of sound, $\tilde{I}$ which expresses the volume of the sound is defined as the energy emitted per second, per m^2 of a surface which is at right angles to the direction of propagation of the sound wave, as shown in Table 1 and Fig. 1.

2.2 Sound Level Measurement Units

The International Standards Organisation (ISO) has determined the following reference values for acoustics:

Reference for sound intensity:
$I_o = 10^{-12}$ W/m^2
Reference for sound pressure:
$p_o = 2 \times 10^{-5}$ Pa

The above-mentioned reference values represent sound intensity and sound pressure at the lowest levels perceptible to the human ear.

As the ear is not particularly sensitive and is just able to discern that a sound has doubled in intensity, a linear division of the intensity would be impractical. For this reason, decibel (dB) has been introduced as a unit for measuring sound.

This unit is logarithmic and is defined as 10 times the logarithmic relationship between the actual intensity of the sound and the reference value:

Sound intensity level (dB):
$L_I = 10 \times \mathrm{Log}_{10}(I/I_o)$;
re $I_o = 10^{-12}$ W/m^2

Table 1.: Sound wave formulas

Intensity of sound

$I = pu = \rho c u^2$

and if we use $k = \sqrt{\rho c}$, the corresponding mean effective sound pressure (p) and the pulsation velocity (u) may be stated as follows:

$p = k \times \sqrt{I}$ and $u = \frac{1}{k} \times \sqrt{I}$

where,

I	= Intensity of sound	(W/m^2)
p	= Mean effective sound pressure	(N/m^2)
u	= Mean effective pulsation velocity	(m/s)
c	= Velocity of sound in medium (air)	(m/s)
ρ	= Specific mass of medium (air)	(kg/m^3)
k	$= \sqrt{\rho c} \cong \sqrt{1.2 \times 340} = 20$ at normal ambient air temperature.	

Reference for sound levels

Reference sound intensity
$I_o = 10^{-12}$ W/m^2

Given a sound intensity $I_o = 10^{-12}$ W/m^2 and using the above formulas, we can state the corresponding reference mean effective sound pressure (p_o) and mean effective pulsation velocity (u_o) as follows:

Reference sound pressure level
$p_o = 20 \times \sqrt{10^{-12}} = 2 \times 10^{-5}$ Pa (Pascal = N/m^2)

Reference velocity level
$u_o = \frac{1}{20} \times \sqrt{10^{-12}} = 5 \times 10^{-8}$ m/s

As sound pressure squared corresponds to the intensity of the sound, the following corresponding values are valid when we use sound pressure as a basis:

Sound pressure level (dB):
$L_p = 20 \times \text{Log}_{10} (p/p_o)$;
re $p_o = 2 \times 10^{-5}$ Pa.

Normally, it is the sound pressure level which is measured, and when nothing else is given, it will be re 2 x 10^{-5} Pa.

On the basis of the above, a sound intensity of 10^{-12} W/m^2 corresponds to a sound level of 0 dB, and a sound intensity of 1 W/m^2 corresponds to a sound level of 120 dB. Incidentally, 120 dB is the level at which the ear begins to feel pain; normal conversation is usually conducted at around 55 dB.

At the so-called "far-field", i.e. where no sound is reflected and where sound waves can be assumed to be propagated spherically, a doubling of the distance will reduce the intensity of the sound to 1/4, corresponding to a sound reduction of 6 dB, see Fig. 1.

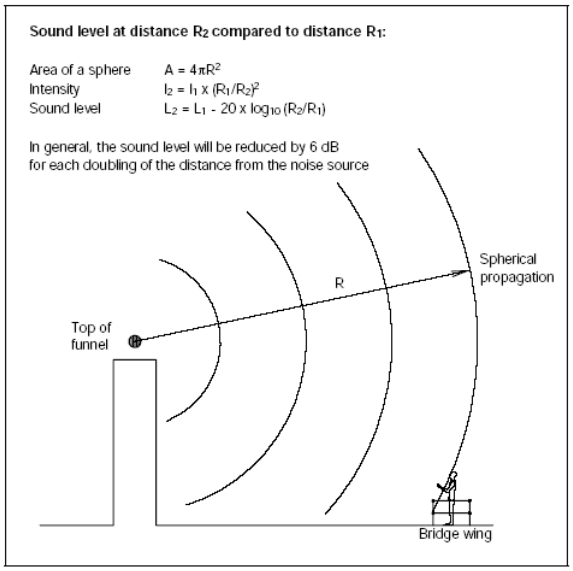

Figure 1 Spherically propagated sound waves; far-field law
Distance R from noise source (point source assumed)

2.3 The Influence of Sound Frequency

The sensitivity of the human ear is closely related to frequency (Hz = vibrations per second). Sensitivity is low at low frequencies, so it is often necessary to take measurements at different frequency ranges. Normally, these measurements are made in the so called octave bands. The octave bands are intervals between two frequencies where the upper frequency is twice as high as the lower.

Octave band frequencies, which are named according to their geometrical average frequencies, 31.5, 63, 125, 250, etc. up to 16,000 Hz, are specified by ISO. The audible frequency range for young people with undamaged hearing is around 20-20,000 Hz.

As a result of the ear's varying sensitivity to combinations of different frequencies and sound levels, ISO has introduced special noise curves, and ISO's "Noise Rating" curve sheet is very often used, see Fig. 2.

The groups of curves shown correspond, more or less, to the hearing characteristics of the ear with the sound level of the 1000 Hz octave band used as a reference. As an example, curve NR 60 shows that the sensitivity of the ear to 60 dB in the 1000 Hz octave band roughly corresponds to its sensitivity to 75 dB in the 125 Hz octave band.

If the sound pressure levels of the various octave bands for a given noise measurement are drawn-in on the curve sheet, the octave band with the highest NR-figure will give the resulting NR noise level for the measurement and, at the same time, show which frequency range(s) should be attenuated.

Another, simpler method of compensating for the ear's subjective perception is the use of sound level meters fitted with internationally standardized frequency weighting curves, i.e. electrical filtering curves, the socalled A, B, C, and now (for aeroplanes) also D filters. See Fig. 3.

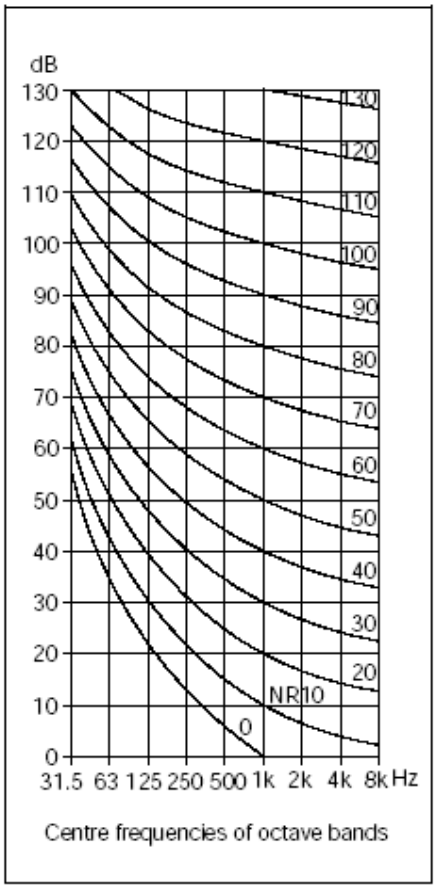

Figure 2 ISO's Noise Rating curves
Octave band pressure levels, re 2 x 10^{-5} Pa

In principle, to compensate for the frequency dependent sensitivity of the ear at various loudness levels, weighting curves A, B and C correct the actual linear (un-weighted) noise levels in relation to 1000 Hz corresponding to, respectively, the average 'Noise

Rating' curves NR 0-55 for A, NR 55-85 for B, and higher than NR 85 for C.

In particular, the A filter is often used to give the final results of a sound measurement as a single value. The measured A-weighted value, designated dB(A), is also regularly used, even in cases where the sound level is high and a B or C-weighting curve would have been more appropriate.

A sound level obtained by linear measurement, i.e. without any correction for the sensitivity of the ear, is designated dB(Lin).

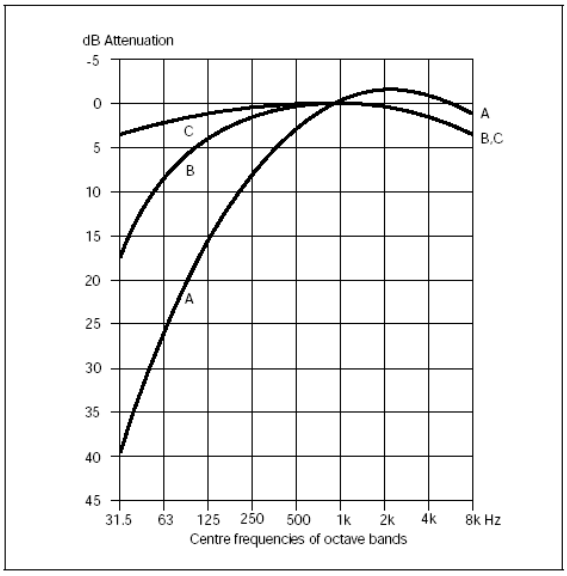

Figure 3 Filtering (weighting) curves for sound level meters

3. MARINE ENGINE NOISE

3.1 Primary Sources of Engine Noise

On the basis of engine noise measurements and frequency analyses, it can be ascertained that noise emissions from the two-stroke engine primarily originate from:

- The turbocharger, air and gas pulsations
- Exhaust valves
- Fuel oil injection systems

and, to a certain extent,

- The chain drive.

The best way of reducing engine-related noise is, naturally, to reduce the vibrational energy at the source or, if this is neither feasible nor adequate, to attenuate the noise as close to its source as possible.

The different noise sources of the diesel engine, of which the primary ones are mentioned above, will, as a result, generate various types of noise emission to the environment. The types of engine related noise emission will be discussed in the next section.

3.2 Two-Stroke Engine Noise Emissions

On the basis of theoretical calculations and actual measurements, we employ computer models to provide our customers with data regarding the sound levels of the following engine related noise emissions, which are typical of our two-stroke engines:

1. Exhaust gas noise (gas pulsations)
2. Airborne noise (engine room noise)
3. Structure-borne noise excitation (vibration in engine feet)

4. EXHAUST GAS NOISE

Our constant-pressure turbocharged two-stroke diesel engines are, unlike the former impulse turbocharged engines, equipped with a large exhaust gas receiver located between the gas outlets of the cylinders and the turbocharger(s).

Thanks to its ideal location, i.e. close to the noise source, this gas receiver also functions as an exhaust gas silencer, in particular attenuating the low-frequency gas pulsations. Fig. 4a curve 1 shows a 6L80MC engine, running at nominal MCR, where the calculated octave band analysis of the exhaust gas noise from an exhaust gas system without boiler and without silencer has been drawn in.

The noise level calculation is based on a distance of 15 meters from the top of the funnel to the bridge wing. The curve sheet shows that the noise level in the octave band frequencies between 125 and 1,000 Hz is decisive for the total noise level of NR 81, and that the A-weighted sound level corresponds to 86 dB(A). The dB(A) figure is calculated by accumulating the intensities of the octave band sound levels, including the A-weighted attenuation, as shown in Fig. 3.

Fig. 4b shows the similarly calculated noise levels for a nominally rated 6S26MC engine where the distance from the funnel top to the bridge wing is 7 metres.

To keep noise below a maximum permissible level of, for example, 65 dB(A) on the bridge wing, a relatively voluminous 25 dB(A) exhaust gas silencer of the absorption type will normally be adequate, as this attenuates the dominant frequency ranges in question.

As the exhaust gas arrangement itself (for example the exhaust gas boiler) can generate noise, we recommend that the exhaust gas silencer is inserted as close to the funnel top as possible.

The most frequently used absorption silencer is a flow silencer, i.e. a pipe with sound-absorbing wall material (mineral or glass wool). Fig. 5a shows such a flow silencer which, apart from having good attenuating qualities in the high-frequency ranges can, by virtue of its size, also be used to attenuate some of the lower frequency ranges.

The typical noise attenuation achieved with such a silencer type is shown in Fig. 5b as a function of the octave band frequencies.

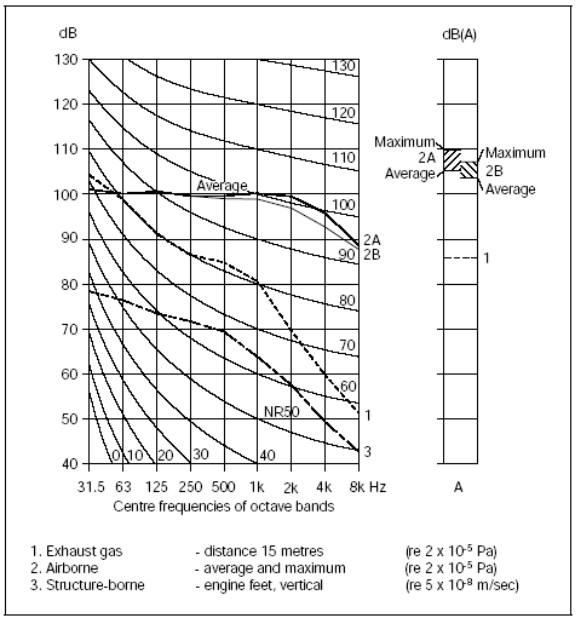

Figure 4a ISO's NR curves and noise levels for a 6L80MC engine with
A) high efficiency T/C and/or B) conventional T/C.
MCR: 20,580 kW at 93 r/min

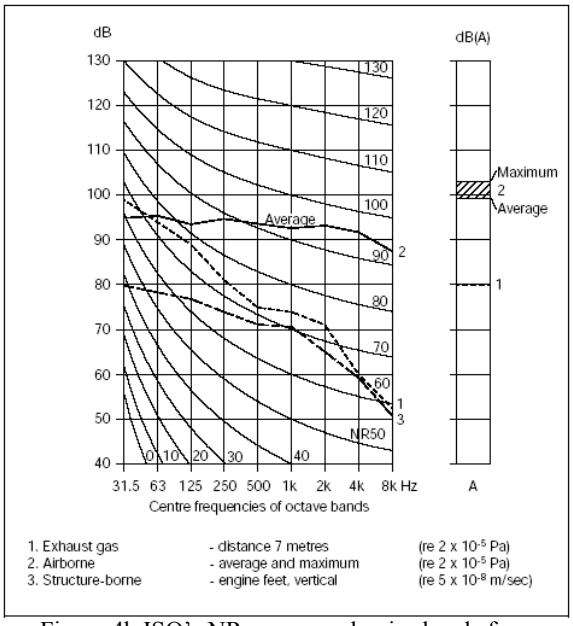

Figure 4b ISO's NR curves and noise levels for a 6S26MC engine.
MCR: 2,400 kW at 250 r/min

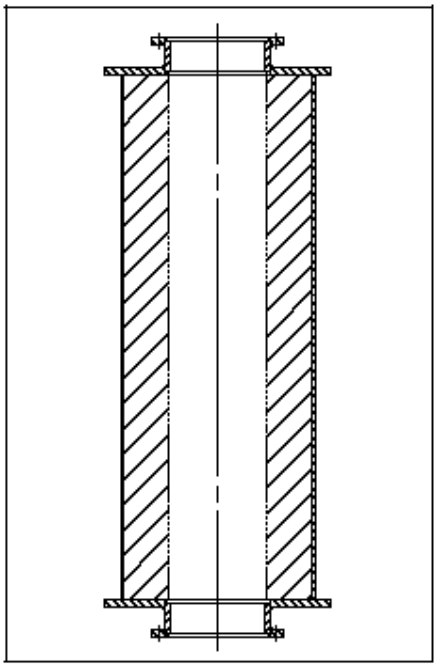

Figure 5a Absorption silencer

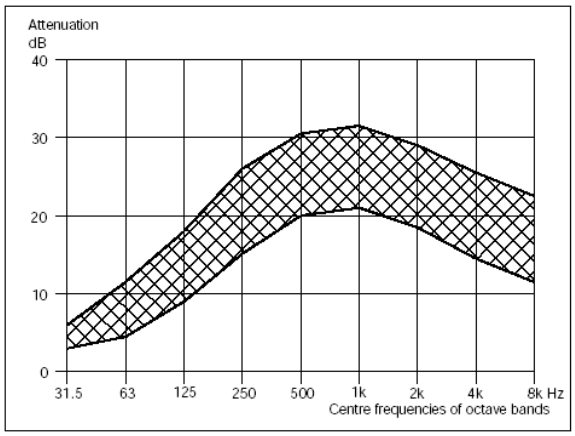

Figure 5b Typical noise attenuation for a 25 dB(A) absorption silencer

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NOISE MARINE DIESEL ENGINES AND THE ENVIRONMENT - PART II

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ABSTRACT

Nowadays, more and more consideration is being given to environmental issues. Formerly, noise was considered a necessary, but harmless, evil. Today, excessive noise is considered a form of pollution which, in the long run, may cause permanently reduced hearing. As a consequence, authorities now demand that noise levels are kept below certain specified limits. Today, there are numerous national and international codes which both recommend, and demand, maximum permissible noise levels in the various parts of a ship. The greater demand for noise limitation in the maritime area has, of course, aroused wide interest. Consequently, greater demands are now made on the engine designer to provide more detailed and precise information regarding the various types of noise emission from the engine. After a brief definition of what noise actually is, this paper will attempt to clarify "noise" as applied to MAN B&W's two-stroke engines, and will then go on to discuss the primary noise sources and types of engine-related noise emissions, noise level limitation, and the current situation in relation to noise

Keywords: *sound, noise, marine engines, noise level limitation*

6. AIRBORNE NOISE

Engine room noise is primarily generated by emissions from the individual engine components and their surfaces, which cause the air to pulsate.

The average engine noise levels measured, for example according to 'CIMAC's Recommendations for Measurements of the Overall Noise for Reciprocating Engines', or other similar standards, are used to express the typical airborne sound pressure level of the engine.

The calculated average sound level corresponds to the average value of sound intensity measured at different points around the engine. Measuring points are - depending on the engine size - located at two or three heights around the engine, and at a distance of approximately one meter from the engine surface. Along each side of the engine, the number of measuring points at each level must equal half the number of cylinders. Fig. 6 shows where these measuring points could be located.

In general, depending, of course, on the type of engine, the average airborne noise level of a nominally rated engine will be around 104 dB(A), whereas the maximum level measured around the engine, and normally near a turbocharger, will be about 108 dB(A).

Fig. 4a (see Part I) curve 2 shows the average airborne noise level calculated for a nominally rated 6L80MC engine with a noise level of approximately NR 101 and 105 dB(A) for an engine with high efficiency turbochargers, (curve 2A) and approximately NR 98 and 103 dB(A) for an engine with conventional turbochargers (curve 2B). The difference in noise levels originates from the difference in noise emission from the turbochargers themselves. In general, the higher the turbocharger efficiency, the higher the noise emission from the turbocharger and the engine.

Fig. 4b (Part I) shows the corresponding average airborne noise level calculations for a 6S26MC engine.

Because of the reverberations of sound in the engine room, the sound pressure based noise levels measured in the vessel may be 1-5 dB higher than the calculated sound intensity based noise levels.

Measurements show that the turbocharger noise has a dominant influence on the total average airborne noise level, an influence which has become greater and greater because of the increasingly efficient and high powered engines demanded by the shipyards and shipowners.

The maximum noise level measured near a turbocharger will normally be about 3-5 dB(A) higher than the average noise level of the engine, using the high figure for high efficiency turbochargers. Often it is the maximum noise level measured at an engine that has to meet the specified noise limit requirements.

Especially in large diesel engines, it may sometimes be necessary to meet the noise limit requirements to introduce additional noise reduction measures, see Table 2.

These measures may reduce the maximum noise levels by 3-5 dB(A) and sometimes more, depending on their extent.

It would be extremely difficult to meet stricter requirements with regards to maximum engine room noise level of, for example, 105 dB(A) instead of 110 dB(A), especially in view of the influence of sound reverberations and the noise emitted by other machinery. The possibility of reducing the noise from an existing engine is greatly limited because, as previously mentioned, the noise stems from many different sources, and because the noise transmission paths through which vibrational energy is transferred from one area to another through the engine are numerous.

However, in principle, the transmission of airborne noise from the engine room to other locations, e.g. accommodation quarters, normally has no influence on the actual noise level in these locations.

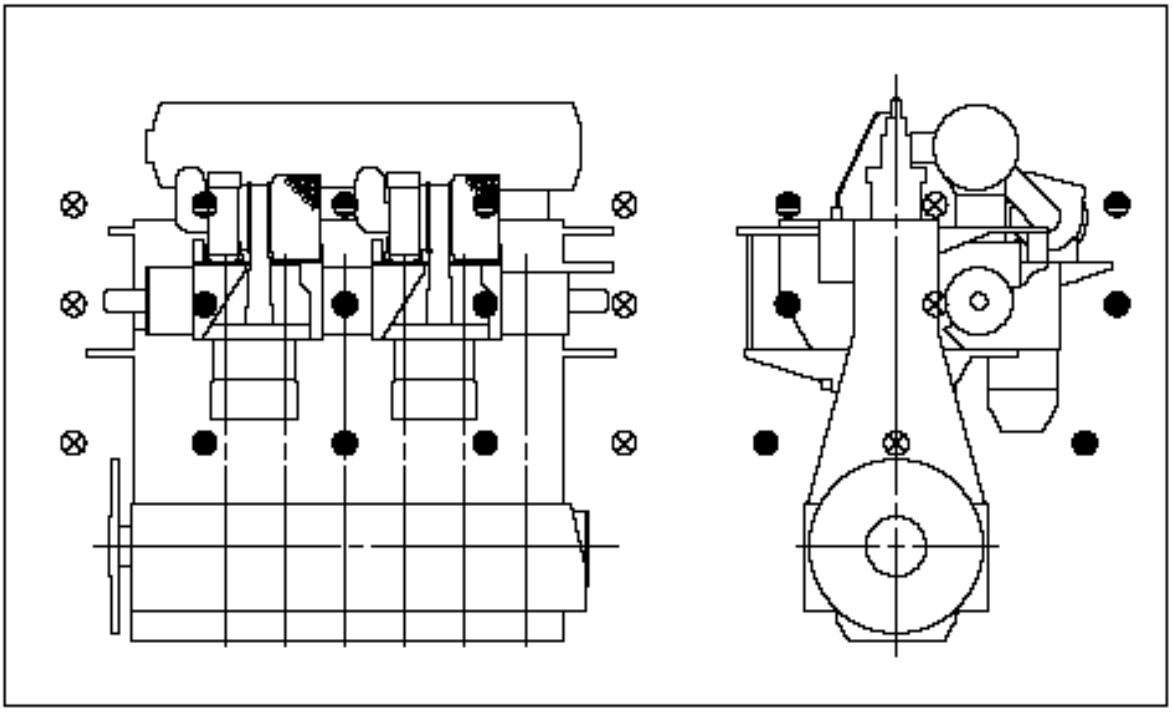

Figure 6 Example of location of measuring points on a diesel engine in accordance with 'Cimac Recommendations of Measurement'

Table 2. Additional noise reduction measures on diesel engines

1. Internal absorption material in scavenge air pipe
2. Ring diffusor absorption plate in the top of the scavenge air cooler
3. External insulation of the scavenge air cooler
4. Additional absorption material at the engine and/or at the engine room walls (yard's responsibility)
5. Additional turbocharger intake silencer attenuation (turbocharger maker's responsibility)
6. Additional attenuation material at the turbocharger's inspection cover

7. STRUCTURE-BORNE NOISE EXCITATION

Vibrational energy in the engine is propagated, via the engine structure, to the engine bedplate flanges, i.e. the "feet" of the engine. From here, the energy is transferred to the ship's tank top, and then outwards to the ship's structure which starts to vibrate and thus emits noise.

Among the sources which can generate vibrational energy are the pulses caused by the combustion process of the engine and the reciprocating movement of the pistons.

The vibrational energy transferred between the contact surfaces of the engine bedplate and the ship is largely amplitude-dependent, so the velocity can normally be employed as a unit of measurement. Like the sound pressure level, the velocity is best expressed in dB, see also Table 1:

Velocity level (dB):
$L_v = 20 \times \text{Log}_{10} (v/v_o)$;
re $v_o = 5 \times 10^{-8}$ m/sec.

The reference velocity used corresponds to the previously used intensity and sound pressure reference values and has therefore been selected by MAN B&W Diesel. According to the latest ISO Standard, the reference value 10^{-9} m/sec is now used in this norm.

Figs. 4a and 4b (Part I) curve 3 also show the structure-borne noise excitation levels from a nominally rated 6L80MC and a 6S26MC engine, given as a vertical vibration velocity level in the engine feet.

Incidentally, the vibration velocity level in a two-stroke engine is, on average, approximately 15-20 dB lower than in a four-stroke engine which, therefore, may sometimes have special vibration isolators (resilient mountings) built-in between the engine feet and the tank top of the ship. The structure-borne sound attenuation achieved is of some 15-20 dB, which means that the final result corresponds to the level of a solid-mounted two-stroke engine.

The above-mentioned vibration velocity levels in the diesel engine feet can, with the aid of empirical formulas, be used to calculate the excitation velocities and, thus, the sound pressure levels in the accommodation quarters. The shipyards, or their consultants, normally have these formulas at their disposal.

8. NOISE LIMITS

Limits for the maximum sound pressure level are either defined specifically between owner/shipyard and engine builder, or indirectly by referring to national or international legislation on the subject. Many owners refer to the SBG (See-Berufsgenossenshaft) specifications or the IMO (International Maritime Organisation) recommendations. The IMO noise (sound pressure) limits for different ship spaces are listed in Table 3.

The appearance of national and international standards for noise levels in ships has, in general, resulted in a considerable reduction of the noise levels in newly-built ships.

Table 3. IMO noise limits (sound pressure level)

	dB(A)
Work spaces	
Machinery spaces (continuously manned) **	90
Machinery spaces (not continuously manned) **	**110**
Machinery control rooms	75
Workshops	85
Unspecified work spaces **	90
Navigation spaces	
Navigating bridge and chartrooms	65
Listening posts, including navigating bridge wings and windows	**70**
Radio rooms (with radio equipment operating but not producing audio signals)	60
Radar rooms	65
Accommodation spaces	
Cabins and hospital	60
Mess rooms	65
Recreation rooms	65
Open recreation areas	75
Offices	65

** Ear protectors should be worn when the noise level is above 85 dB(A), and no individual's daily exposure duration should exceed four hours continuously or eight hours in total.

Accommodation – *Structure-borne noise excitations*

For example, the introduction of a "floating floor" construction in the accommodation quarters has reduced the effect of the structure-borne noise excitation. Today, depending on the noise standard to be met, the noise limit requirements for accommodation are between 45 dB(A) and 65 dB(A), or lower, similar to those required in passenger ships. These noise requirements can, as a rule, be observed by taking adequate noise-attenuating precautions, e.g. the above-mentioned floating floor construction.

Engine room – *Airborne noise*

On the other hand, it is apparent that the above-mentioned general noise reductions have not been achieved in the engine room itself, where the airborne noise from the diesel engine dominates.

The reason for this is that the acceptable noise limits for periodically manned engine rooms have, for many years, been set at around 110 dB(A), and the introduction of stricter requirements has not been realistic as the noise emission from a diesel engine has increased over the years because of the higher rated engines.

The unchanged noise limit thus in itself seems to have constituted a serious limitation for the engine builders. However, it is a recognized fact that a noise level of over 110 dB(A) can, in the long term, cause permanent damage to hearing, and therefore this limit cannot be expected to be eased, rather on the contrary.

This means that as engine designers, even though our engines generate no more noise than the engines of our competitors, we must, in future engine designs, pay particular attention to the airborne noise emitted by our engines.

Bridge wing *Exhaust gas noise*

On the bridge wing, where it is the exhaust gas noise that predominates, there are also certain limitations, as the bridge wing is regarded as a listening post. The requirement here, depending on the noise standard to be met, is a maximum of 60-70 dB(A), which can always be met by installing a suitable exhaust gas silencer.

9. CONCLUSION

Generally, the noise emitted by the engine's exhaust gas, and the structure-borne noise excited by the engine, are so low that it is possible to keep within the noise requirements for the bridge wing and accommodation.

On the other hand, the airborne noise emitted from the engine in the engine room is so high that in some cases there is a risk that the noise limits for the engine room cannot be met, unless additional noise reduction measures are introduced.

In future, therefore, it must be expected that it will be very important, from a marketing point of view, to develop an engine with reduced airborne sound levels.

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EXPERIMENTAL STUDY ON THE INFLUENCE OF CUTTING PARAMETERS ON SURFACE ROUGHNESS TO EXTERNAL CYLINDRICAL TURNING

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ABSTRACT

In this paper we determined the influence of the cutting parameters (*v* and *s*) on the mean width of the profile elements RSm and we established the correlation between the RSm and Ra roughness parameters for exterior cylindrical lathing of the semi-product made of steel X 17 CrNi 16-2.

The experiments were conducted on the basis of factorial research programs and processing was done in real processing conditions by turning the cylindrical surface, using such tools used in steel processing and part geometry recommended for cutting these materials.

The regression analysis of the experimental results indicate that there is a positive linear correlation between the RSm and Ra roughness parameters, close to a functional dependence.

Keywords: *Roughness parameters, correlation, turning, cylindrical surface.*

1. INTRODUCTION

The roughness of splinting processed surfaces can be defined on lead motion direction and on prime motion direction. For mostly situations, the roughness on lead motion direction has a main influence over the function status of the respective surface and that's why we consider it when appreciating the surface quality. Roughness is often closely related to the friction and wear properties of a surface. A surface with a large R_a value, or a positive R_{sk}, will usually have high friction and wear quickly. As a consequence, for most manufacturing products establish an upper limit on roughness, but not a lower limit. An exception is in cylinder bores and tribology where lubricant is retained in the surface profile and a minimum roughness is required.

Because many factors contribute to obtain surface roughness, must be considered and that the production cost greatly increases with the decrease of roughness tolerance.

It has been demonstrated that the tracks of mechanical working , the accidental scratches and the corrosion of superficial layers of worked out material have a very strong influence over the endurance limit, contact rigidity of a machine part [1]. This also corresponds to cylindrical lathing.

The experimental research on proof samples made of granular structured hard steel revealed that the existence of the smallest tracks of grinding decrease with 10-12% the breaking strength of the proof sample [1]. It is also known that the resistance of machine parts made of alloyed high-resistance steel and the one of special material is mostly influenced by the undue state of the surfaces (cracks, corrosion a.s.o.) than of carbon steel or low-alloy steel, the resistance diminishing more in the first case.

The micro-irregularities turned metal surfaces are characterized as fully by several profile parameters which is evaluated roughness size. The parameters Ra, Rz and Rt, currently using, offering limited information on roughness and do not allow decisive as a means to improve functional properties of the surface parts.

In technical literature, the mean width of the profile elements (RSm) can give important information on processed surfaces quality and these parameters have to be considered because they have a great influence on the functioning behaviour of different machine parts.

It has been experimentally proved that by modifying the cutting parameters could be obtain surfaces with values close to the Ra parameter of roughness (the deviation arithmetic average of the measured profile), but somehow different of the mean width of the profile elements RSm (see table 1). On the other hand, the experimental research indicates the existence of a dependence between the RSm and Ra roughness parameters.

In conformity with standard SR EN ISO 4287:2003, the RSm roughness parameter is defined by the relation:

$$RSm = \frac{1}{m}\sum_{i=1}^{m} Xs_i \qquad (1)$$

where Xs is the width of profile element (the step irregularities of profile); m - the number of profile elements is limited by the length.

The Ra roughness parameter is defined by the relation:

$$Ra = \frac{1}{l}\int_0^l |Z(x)|dx \qquad (2)$$

where Zx is the ordinates of points on the profile; l- the length basis

In this paper we determined the influence of the cutting parameters (*v* and *s*) on the mean width of the profile elements RSm and we established the correlation between the RSm and Ra roughness parameters for exterior cylindrical splinting of the semi-product made of X 17 CrNi 16-2.

2. EXPERIMENTAL CONDITIONS

The experiments have been made by exterior cylindrical lathing on a SN 400x1500 lathe. The semi-

product has been installed in lathe chuck and supporting bracket and the turning has been made without using cooling and lubricating liquid. The cutting depth, the same for all determinations, was t=0,5 mm, being a semi-product process.

In conformity with DIN 17007 the breaking strain of X 17 CrNi 16-2 steel is at least 98 daN/mm^2. Romanian equivalent of this steel is 22 NiCr 170 (STAS 11523-80). These are stainless steel with high corrosion resistance. It considers corrosion resistant steels containing chromium those at least 12% by weight and carbon content is less than 1.2%. Even if their machinability is more difficult than for ordinary steels, due to other properties, stainless steels are used in chemical, food, civil engineering, but has a growing interest in the engineering industry.

The tool used in experiments was a carbide-tipped tool P20. The geometry of the cutting side of the tool is: $\alpha=8^0$, $\gamma=10^0$, $\chi=70^0$, $\chi_1=20^0$, $\lambda=0^0$, and *r=1 mm*.

The measurement of the RSm and Ra roughness parameters was made with a Surtronic 4 roughness measuring device having a liquid crystals display storing and displaying roughness parameters. For the results recording and scale graph of the measured surface's profile we have used the printer of this apparatus. The roughness parameters are measured in μm with an 0,01 μm accuracy and 2% of measured value measuring fault.

Table 1. The factorial programs of experiments

Nr. exp.	Independent variables				Dependent variables	
	Code		Natural			
	x_1	x_2	v	s	Ra	RSm
1	+1	+1	153	0,4	8,76	0,383
2	+1	0	153	0,2	3,67	0,141
3	+1	-1	153	0,1	2,90	0,097
4	-1	+1	112	0,4	8,89	0,382
5	-1	0	112	0,2	4,71	0,140
6	-1	-1	112	0,1	3,85	0,117
7	0	+1	130,9	0,4	9,31	0,335
8	0	0	130,9	0,2	3,99	0,157
9	0	-1	130,9	0,1	4,44	0,121
10	0	0	130,9	0,2	5,03	0,160
11	0	0	130,9	0,2	5,31	0,148
12	0	0	130,9	0,2	4,22	0,152

It has been analysed the roughness value on lead motion direction because it characterizes the quality of the turned surface and highly influences the functioning behaviour of that surface.

The experiments have been made on the basis of a factorial programs presented in table 1. We have used programs of 12 experiments, made in accordance with planning experiments method. The natural values of *v* and *s* variables are in geometrical progression. The natural values of the lead s_1=0,1 mm/rot.; s_2=0,2 mm/rot. and s3=0,4 mm/rot. could be obtained because they are in the feed range of the used lathe. The rates of cutting speed had these values in geometrical progression: v_1*=112 m/min.;* v_2*=130 m/min.* and v_3*=153 m/min.* obtained by an appropriate combination between rotation of the main shaft and turning shaft diameter. The system's variables are indicated in table 2.

Table 2. The system's independent variables

Symbol	Code	-1	0	+1
v	x_1	112	130,9	153
s	x_2	0,1	0,2	0,4

3. THE INFLUENCE OF THE LEAD OF THE CUTTING SPEED ON THE RSm AND Ra ROUGHNESS PARAMETERS

After the processing in established in concordance with factorial programs presented in table 1, we measured the values of the mean width of the profile elements Sm, which are indicated in the same table. The results of the processing was made using C++ computer programs. Thus has been determined the regression function which shows the Sm roughness parameter's dependence on *v* and *s* cutting parameters:

$$RSm = 1{,}7478 \frac{1}{v^{0,19}} \cdot s^{0,86} \qquad (3)$$

From correlation matrix (table 3) you can notice that v and s variables are independent and the cutting speed has a small influence (-0,04) over the RSm roughness parameter, while s lead highly influences this parameter (0,93). Also from relation (3) results that for the experimental conditions, the values of RSm parameter decrease with increasing v speed and decreasing s working lead.

Table 3. The correlation matrix (for RSm parameter)

	RSm	*v*	*s*
RSm	1	0	0
v	-0,04	1	0
s	0,93	0	1

After regression analysis resulted that:

- Confidence interval limits for exponents of cutting speed and working lead as a result of calculus , are:
  - for speed exponent t1=0,074; t2=-0,454
  - for lead exponent t1=-434; t2=2,154
- Student Test (t)

Adopting the statistic hypothesis of zero coefficients (H_0), together with is alternative non-zero coefficients (H_1), in accordance with the test result we reject the H_0 hypothesis because $|t_c| > t_{(v,a,P)}$. As a result, the coefficients are non-zero and they have a student distribution (close to normal distribution). In this case the test is significant and the variables' are considered significant.

For the case of determinations done for RSm parameter the result of "t" test is presented in table 4 and it comes out that the H_1 hypothesis is carried out only for the coefficient of the *s* variable. Adopting the H_0 hypothesis, the coefficient of the *v* variable has a low significance in relation to the coefficient of the *s* variable.

Table 4. The result of "t" test (for RSm parameter)

Variable's coefficient	t_c	$t_{(v,1-\frac{\alpha}{2})}$	Coefficient's significance
v	-0,55	2,228	low significance
s	11,21	2,228	significant

We considered the risk a=0,05, the probability P=0,95 and the number of degrees of freedom $v=n-m$ (12-2=10), where n is the number of experiments and m is the number of independent variables.

- The Fisher test result is:

$$F_c = 68,21 > F_{(v,a,P)} = 3,89 \quad (4)$$

where F_c is the estimated value and $F_{(v,a,P)}$ is the value for a risk of $a=0,05$ (from table). This test shows that the regression equation is linear in logarithmical coordinates ($F_c>F_{(10;0,05;0,95)}$).

For the deviation arithmetic mean of measured profile (Ra) we got the following function:

$$Ra = 401,497 \cdot \frac{s^{0,66}}{v^{0,68}} \quad (5)$$

From correlation matrix (table 5) it can be noticed that v and s variables are independent and that cutting speed influences a little (-0,17) the Ra roughness parameter, while the s lead highly influences this parameter (0,86). Also, from relation (5) results that for the experimental conditions the values of the Ra parameter decrease while v speed increase and s lead decrease.

Table 5. The correlation matrix (for Ra parameter)

	Ra	*v*	*s*
Ra	1	0	0
v	-0,17	1	0
s	0,86	0	1

After regression analysis resulted that:

- Confidence interval limits for exponents of cutting speed and working lead, as a result of calculus, are:
  - for speed exponent t_1=0,036; t_2=-1,206
  - for lead exponent t_1=-0,276; t_2=1,566
- Student's Test (t) results is presented in table 6 and it comes out that in this case the test is significant for the coefficient of s variable and less significant for the coefficient of v variable.

Table 6. The result of "t" test (for Ra parameter)

Variable's coefficient	t_c	$t_{(v,1-\frac{\alpha}{2})}$	Coefficient's significance
v	-1,62	2,228	low significance
s	8,00	2,228	significant

- The Fisher test result is:

$$F_c = 37,99 > F_{(v,a,P)} = 3,89 \quad (6)$$

So, this test case the regression equation is also linear in logarithmical coordinates ($F_c>F_{(v,a,P)}$).

4. CORRELATION BETWEEN MEAN WITH OF THE PROFILE ELEMENTS (RSm) AND DEVIATION ARITHMETIC AVERAGE OF THE MEASURED PROFILE (Ra)

On the basis of measured values of the two roughness parameters RSm and Ra we established the correlation between them for cylindrical lathing of a shaft made of X 17 CrNi 16-2. For this purpose it had been calculated the selection correlation coefficient of variables with regular distribution x=Ra and y=RSm using the relation [4]:

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\cdot\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} \quad (7)$$

where x_i, y_i are the values of Ra and RSm parameters in number i exponent; $\bar{x}$, $\bar{y}$ - arithmetic mean selection values of Ra, RSm parameters; n - number of experiments.

The determined coefficient of correlation r, such determined represents a measure of linear relation between RSm and Ra variables. For $|r|=1$, the variables are in linear functional dependence; for $r=0$ the variables are independent; for $0<|r|<1$ the correlation between the two variables is between the two extremes.

After calculus made using a computer program we got r=0,9638. So, between the RSm and Ra roughness parameters there is a strong linear correlation. Because $r>0$ the correlation is positive, which means that when a variable increases, the other also tends to an average increase .

To check if the calculated correlation coefficient is significant we use the null hypothesis test H_0:r=0 with the alternative H_1:r≠0. We calculate and reject the H_0 hypothesis if:

$$|t_c| > t_{(n-2;1-\frac{\alpha}{2})} \quad (8)$$

where a=0,05 represents significant threshold adopted.

After calculation results that:

$$t_c=11,433 > t_{(10;0,975)}=2,228$$

so, the condition (8) is respected and the H_0 hypothesis is rejected, meaning that RSm and Ra variables are correlated.

Considering the variables x = Ra and y = RSm the regression linear function is:

$$y - \bar{y} = r \cdot \frac{s_y}{s_x}(x - \bar{x}) \quad (9)$$

where s_x, s_y represent standard deviation of x and y variables.

After calculation we got the regression line equation:

$$RSm = 0{,}046 \cdot Ra - 0{,}053 \quad (10)$$

where RSm is in *mm* and Ra in μm.

5. CONCLUSIONS

1. For cylindrical lathing the cutting lead influences significantly the mean width of the profile elements RSm, but cutting speed has a less influence.

2. The research made have indicated that there is a positive linear correlation between the RSm and Ra roughness parameters, close to a functional dependence, considering that correlation coefficient is close to 1. The mean width of the profile elements RSm decreases while deviation arithmetic average of the measured profile (Ra) decreases.

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THE INFLUENCE OF SOM E PROCESS PARAMETRERS ON THE FORMING FORCES IN THE COLD TEETHING BY INTERMITTENT BLOW PROCESS

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Abstract: The paper presents aspects of experimental research for machining of cold teething by intermittent blow. There are presented the expressions of the consecutive forming forces (pressures) by using the mathematical statistics and the conclusions which highlight the fact that the forces of deformation at cold teething by intermittent blow depend on the nature of the material to be machined and the teething process parameters the fed travel of the module (m*),* axial advance (s_a) and teething speed(v_d).

Key words: *cold, gear generation, forces, intermittent, shock.*

1. INTRODUCTION

Gear cutting by temple (copy) cold forming consists in the formation of the piece profile (of the tooth space) by two or more adequately formed tools, the blank rotation with an angular pitch (angular spacing) and the renewal of the process. In this case there are used special tools with a working tooth space mating profile.

The temple cold teething by intermittent blow can be performed with the help of two, three or four roller-tools, which have similar processing diagrams. A processing method by temple cold teething is that named processing method by hammering (intermittent blow, shocks), at which the material forming is achieved as a consequence of a planetary motion performed by the roller tools.

The main principle of this process consists in dividing the whole deformation in a large number of partial forming processes by using a pair of profile gear cutting tools.

In the present work, it is presented the simulation of the forming forces' dependence on some parameters of the teething process, the axial advance and the forming speed and the module of the working gear.

The values of the two constituents of the gear force were backhand achieved, by measuring the deformations of several elastic bodies through the agency of an electrical parameter.

2. EXPERIMENTING CONDITIONS

The constituents of the forming force in the cold teething process by intermittent blow, for the maximum value of the forming depth comply with the situation from fig. 1.

The roller tool of radius r is in contact with the part on the arch EB, and the maximum-sectioned view on which it rolls is BB_1. The arch EB corresponds to the α_2 angle, and the roller centre rotated vis a vis the maximum position with the α_1 angle. The deformation research for machining of cold teething by intermittent blow radial forces manifest under the form of a pressure, vis a vis the part it will have two components:

F_n, radial force (conventional) at the part (is a conventional force on the surface of the part);

F_a, axial force on the part.

The simulation of the forming forces was performed for the processing of an involutes profile, and as a study material were chosen the steels OLC25 and OLC45, materials which were obtained by hot rolling.

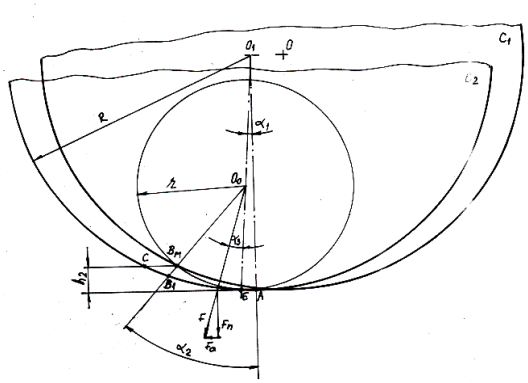

Figure 1. Components of the deformation force at cold generation by intermittent bounce

Table 1. Data about the research means

Machine tool		Universal milling machine FU32 Teething device
Cutting tool		Involutes profile roller Characteristics: Module, m=1,058; 1,5; 2,1 Number of teeth, z=16 Pressure angle, $\alpha_n=45^0$ Division diameter, $D_d=33,6^{0}_{-0,016}$ mm
Blank (semi-products)	Form	Cylindrical, Φ48X60
	Material	OLC25, OLC45
	Material hardness	HB=172 [Kg/mm^2], HB=194 [Kg/mm^2]

The teeth that must be obtained after the processing has the shape of the profile after J 498 SAE, the dimensional deviations are after STAS 6858-63. The research means used and their methods of use in the achievement of the research are presented in table 1.

The values of the arguments, in natural units corresponding to the three levels (+1, 0, -1) are presented in table 2, table where is presented the experimental plan of the forces determination.

In this plan were taken as input parameters, module m, the axial advance s_a and the forming speed $v_{d.}$.

Table 2. Natural levels of the input parameters

Argument	Code levels	Natural levels
Axial advance s_a [mm/rot]	-1	0,05[37,5/750]
	0	0,1[95/950]
	+1	0,2[150/750]
Forming speed v_d [m/min]	-1	259,05
	0	328,13
	+1	407,57
Module m [mm]	-1	1,058
	0	1,5
	+1	2,1

3. THE EXPERIMENTS PERFORMED AND THE RESULTS OBTAINED

In order to determinate the sizes of the influences over the constituents F_n and F_a of the forming force, of each of the control input s_a, v_d and m, there were performed experiments in which a value was varied and the other ones were maintained at average values, table 3.

The experimental plan for each of the two materials included $3^2 + 2$ central experiments. From the diagrams resulted at the measurements were hold the maximum values of the two constituents: $F_{n\text{-}max}$ and $F_{a\text{-}max.}$

Table 3. Structure of the experimental research program

X_i/i	X_1	X_2	X_3	F_n [daN]		F_a [daN]	
				OLC 25	OLC 45	OLC 25	OLC 45
1.	-1	-1	-1	23,76	27,48	5,9	6,37
2.	+1	-1	+1	88,0	108,2	22	23,5
3.	-1	+1	+1	51,14	60,1	18,7	19,5
4.	+1	+1	-1	47,12	57,1	14,6	16,35
5.	0	0	0	46,71	56,57	13,6	15,21
6.	0	0	0	47,28	57,0	14,15	14,86

For the two materials analyzed, OLC25 and OLC45, for establishing the dependence of the normal force F_n and of the axial force F_a by the three parameters s_a v_d and m, it was considered that this dependence corresponds to the model:

$$F = C_F . s_a^b v_d^c m^d \qquad (1)$$

By looking up the logarithm and changing the variables one obtains gradually:

$$\lg. F = \lg.C_F + b \lg.s_a + c \lg.v_d + d \lg m$$

$Y = A_0 + A_1 X_1 + A_2 X_2 + A_3 X_3$, equation in life variable; (2)

$Y = B_0 + B_1 z_1 + B_2 z_2 + B_3 Z_3$, equation in rated variable. (3)

The average values of the forming force compounds, obtained after the performance of the experiments, were statically processed, by the multivariable regression calculation, and their expressions are presented in table 4.

Table 4. Main results of the regression calculation

Material	Optimal determinant function	Coef. R^2
OLC25	$F_{n.\max.} = 35,31 s_a^{0,442} v_d^{0,156} m^{1,014}$	0,996
	$F_{a.\max.} = 0,185 s_a^{0,385} v_d^{0,819} m^{1,139}$	0,975
OLC45	$F_{n.\max} = 45,04 s_a^{0,512} v_d^{0,157} m^{1,036}$	0,950
	$F_{a.\max.} = 0,194 s_a^{0,407} v_d^{0,833} m^{1,079}$	0,992

From the statistical representation of the expressions of the forming forces at cold teething by intermittent blow, obtained after the regression calculation, resulted the following:

- from the regression analysis it results that the function chosen as a model is adequate;
- the normal forming forces have much higher values than the axial forces, so they have the biggest weight in determining the total forming force;
- the advance of blank s_a and the module m are characteristic agents for both materials analyzed, and the forming speed is an irrelevant agent;
- the coefficients B_1, B_2 and B_3 from the equation in rated variables 3 have positive values and consequently an increase of the advance values s_a, of the forming speed v_d and of the module of the tooth gear m leads to the increase of the forming forces;
- analyzing the relative share indicators it can be noticed that the highest influence on the forming forces has, the tooth gear module, the blank advance and then the forming speed;
- the increase of the forming force is influenced by the nature and by the mechanical characteristics of the material, having higher values for the material OLC45 by comparison with the material OLC25. The nature of the working material, by its chemical composition, constitutes, an influence factor on the size of the forces necessary for its plastic deformation.
- the correlation factors R^2 have values close to 1, which indicates that the variables have strong connections.

4. CONCLUSIONS

The experimental results obtained emphasize the fact that the forming forces at the processing of the teeth by cold flow by intermittent blow (hammering), depend on the nature and on the mechanical characteristics of the work material as well as on the operating conditions, the axial advance of the blank and the forming speed. The nature of the work material, by its chemical composition, is therefore, an influence factor on the size of the forces necessary for its plastic forming.

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CONSIDERATIONS REGARDING THE USE OF DISTORSIONAL SIMULATION FOR STUDYING LONG BREAKE-WATERS

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ABSTRACT

In the paper we propose to use the FLUENT to calculate the water current action on the break-waters. This calculation is made on models at one and two scales. The results are converting into reality using the similarity criterions. We also calculated the action of the current on the break-waters in the nature.

We are interesting about the correspondence between the values in the nature and the values obtained using the similarity at one scale and two scales.

Keywords: *break-water, distorsional simulation, current action.*

1. INTRODUCTION

It is difficult to achieve a model for experimenting. Also it is difficult to calculate the phenomena in the nature scale using the FLUENT. So we calculated the physical parameters, using FLUENT, on the model and we pass them, with the similitude criteria help, in the nature.

The results obtained using the single scale similitude method are very close to the nature. The main idea is that FLUENT can be used as an experimental stand.

Some problems, especially related to the long objects (conduit, break-waters, etc.) can be solved using two geometrical scales (one for length and one, smaller, for diameter). By applying the formulas for distortional similitude, we can pass from the model to the nature.

2. THE MODEL OF A BREAK-WATER UNDER CURRENT ACTION

2.1 One scale model

We consider the case of a break-water designated to protect the harbour area, situated perpendicularly on the current velocity direction of a river.

The dimensions of the underwater part are: L = 200 m; l = 2,5 m; h = 12,5 m.

The velocity of the water current: v = 2 m/s.

The model, built at the scale 1:25, will have the dimensions:

L' = 8 m; l' = 0.1 m; h' = 0.5 m.

By applying Froude similitude we'll obtain **v' = 0.4 m/s:**

$$\frac{v^2}{gl} = \frac{v'^2}{g'l'} \qquad (1)$$

We have noted with ' the model magnitudes.

Taking into account that g = g', it results:

$$k_v = \sqrt{k_l} = 5\,, \qquad (2)$$

and v' = v/5 =0.4 m/s.

We establish the forces scale using the formula $F = \gamma V$, where γ is the specific gravity of the water. Having the same fluid in the nature and on the model, we conclude:

$$k_F = k_l^3\,. \qquad (3)$$

In the Figure 1 we have the construction in GAM BIT programme of the model:

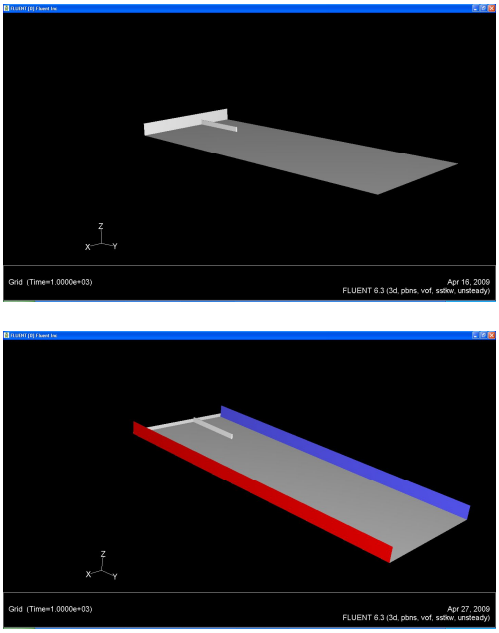

Figure 1 The model construction

To solve the problem, using FLUENT programme, we'll make the conditions:

- implicit formulation;
- 3 D;
- unsteady movement;
- turbulence model: k-omega.

We'll consider the biphasic flow, with free surface and with contact between air and water. The

calculation begins from an entrance velocity, Ox positive direction: v' = 0.4 m/s.

After iterations (300 steps), we observed the linearization of the solution for C_D – the resistance coefficient, the three components of the velocity, k and omega.

After linearization of the solutions we can see the contour of the static pressure and the velocity vectors in various sections (Figure 2).

The forces acting on the break-water is presented in the Table 1.

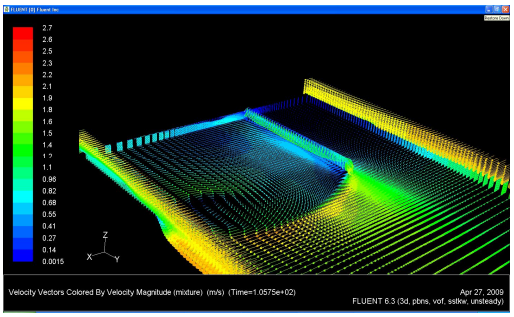

Figure 2 The velocity vectors

Table 1

Force vector: (1 0 0)

zone name	pressure force	viscous force	total force	pressure coefficient	viscous coefficient	total coefficient
			n	n		
fundul-apei	0	1803.9548	1803.9548	0	1.2026366	1.2026
mal	0	-2.540731	-2.540731	0	-0.00169382	-0.00169
dig	8681.01	0.10	**8681.11**	5.7873457	7.0015152e-05	5.787
mal.2	0	0.18278292	0.1827829	0	0.00012185	0.000121855
net	8681.01	1801.7019	10482.72	5.7873457	1.2011346	6.98

To calculate the force in the nature, we apply the relation (3):

F = F' x k_F = 8681 x 25 x 25 x 25 = **135 660 625 N = =13 566 x 10^3 daN.** (4)

2.2 Two scales model

We'll take the two scales as follows:

$$k_x = k_z = 25; k_y = 200.$$

The distorsional rate will be:

$$k_1 = \frac{k_y}{k_x} = 8. \quad (5)$$

The model, built at two scales, will have the dimensions:

L' = 1 m; l' = 0.1 m; h' = 0.5 m.

By applying Froude similitude (1) we'll obtain also **v' = 0.4 m/s.**

In this case the force scale will be:

$$F = \gamma V \Rightarrow k_F = k_\gamma k_x^2 k_y \quad (6)$$

and taking into account that $k_\gamma = 1$, it results:

$$k_F = k_x^2 k_y . \quad (7)$$

In the Figure 3 we have the distortional model of the break-water:

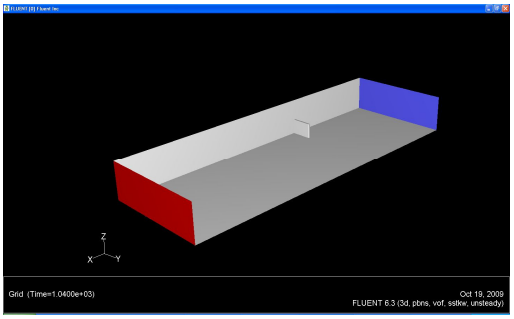

Figure 3 The distortional model

Using FLUENT programme we calculated the force acting on the distortional break-water model (Table 2).

Table 2

Force vector: (1 0 0)

zone name	pressure force	viscous force	total force	pressure coefficient	viscous coefficient	total coefficient
	n	n	n			
fundul-apei	0	380.88428	380.88428	0	0.25392285	0.25392285
mal	0	-2.4170322	-2.4170322	0	-0.001611354	-0.001611354
dig	1207.32	0.002225	1207.3285	0.804884	1.4837e-06	0.8048856
mal.2	0	0.95656317	0.95656317	0	0.00063770	0.000637708
net	**1207.32**	379.42603	1586.7523	0.804884	0.25295069	1.0578349

To obtain the force acting on the real break-water we apply the relation (7):

$$F = 1207 \times 25^2 \times 200 = 150\ 875\ 000\ N = 15\ 087{,}5 \times 10^3\ daN \quad (8)$$

3. THE BREAK-WATER IN THE NATURE

The break-water is designated to protect the harbour area and it is situated perpendicularly on the current velocity direction of a river.

It is necessary to remember the dimensions of the underwater part: L = 200 m; l = 2,5 m; h = 12,5 m. The velocity of the water current: v = 2 m/s.

The general conditions to solve the problem are the same as presented in the previous chapter.

After calculation we obtained the following spectrum for the velocity (Figure 4).

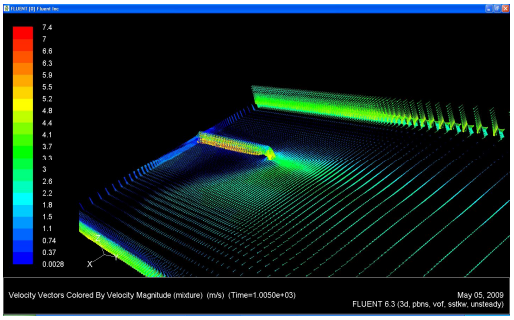

Figure 4 The velocity vectors for the brake-water in the nature

Also, we obtained the forces acting on the brake-water (Table 3).

Table 3

zone name	pressure force	viscous force	total force	pressure coefficient	viscous coefficient	total coefficient
	n	n	n			
fundul-apei	0	1320574.3	1320574.3	0	880.38283	880.38283
mal	0	-3526.4692	-3526.4692	0	-2.3509795	-2.3509795
dig	1.189e+08	149.354	1.18915e+08	79277	0.099569478	79277
mal.2	0	127.4361	127.43618	0	0.084957453	0.08495
net	1.189e+08	1317324.6	1.20232e+08	79277	878.21638	80155.31

$$F = 118\ 900\ 000\ N = 11\ 890 \times 10^3\ daN. \quad (9)$$

4. CONCLUSIONS

The comparative analysis can be made in different way:

- between the values obtained using the similarity at one scale and two scales;
- between the values in the nature and the values obtained using the similarity at one scale and two scales.

If we refer only to the force of the current acting on the break-water, we notice that the difference of the total value is 26% between the "nature" and the "model" at two scales. The difference between the "nature" and the "model" at one scale is only 11%.

However, we consider that the two scales similarity method mustn't be eliminate because it is more suggestive in the simulation of phenomena and, in a "virtual stand", with exotic liquids, the conclusions can be different.

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A PRACTICAL APPROACH TO VIBRATION DETECTION AND MEASUREMENT

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ABSTRACT

This article addresses the physics of vibration; dynamics of a spring mass system; damping; displacement, velocity, and acceleration; and the operating principles of the sensors that detect and measure these properties.
Vibration is oscillatory motion resulting from the application of oscillatory or varying forces to a structure. Oscillatory motion reverses direction. As we shall see, the oscillation may be continuous during some time period of interest or it may be intermittent. It may be periodic or non-periodic, it may or may not exhibit a regular period of repetition. The nature of the oscillation depends on the nature of the force driving it and on the structure being driven.

Keywords: *Vibration, detection, measurement, sensors, oscillation, force, system.*

1. INTRODUCTION

Motion is a vector quantity, exhibiting a direction as well as a magnitude. The direction of vibration is usually described in terms of some arbitrary coordinate system (typically Cartesian or orthogonal) whose directions are called axes. The origin for the orthogonal coordinate system of axes is arbitrarily defined at some convenient location.

2. PHYSICAL PRINCIPLES AND DETECTION TECHNIQUES

Most vibratory responses of structures can be modeled as single-degree-of-freedom spring mass systems, and many vibration sensors use a spring mass system as the mechanical part of their transduction mechanism. In addition to physical dimensions, a spring mass system can be characterized by the stiffness of the spring, K, and the mass, M, or weight, W, of the mass. These characteristics determine not only the static behavior (static deflection, d) of the structure, but also its dynamic characteristics. If g is the acceleration of gravity:

$$F = MA \tag{1}$$

$$W = Mg \tag{2}$$

$$K = F / d = W / d \tag{3}$$

$$d = F / K = W / K = Mg / K \tag{4}$$

2.1 Dynamics of a Spring Mass System:

The dynamics of a spring mass system can be expressed by the system's behavior in free vibration and/or in forced vibration.

Free Vibration. Free vibration is the case where the spring is deflected and then released and allowed to vibrate freely. Examples include a diving board, a bungee jumper, and a pendulum or swing deflected and left to freely oscillate.

Two characteristic behaviors should be noted. First, damping in the system causes the amplitude of the oscillations to decrease over time. The greater the damping, the faster the amplitude decreases. Second, the frequency or period of the oscillation is independent of the magnitude of the original deflection (as long as elastic limits are not exceeded). The naturally occurring frequency of the free oscillations is called the natural frequency, f_n:

$$f_n = (1/2\pi)(K/M)^{1/2} = (1/2\pi)(Kg/W)^{1/2} \tag{5}$$

Forced Vibration. Forced vibration is the case when energy is continuously added to the spring mass system by applying oscillatory force at some forcing frequency, f_f. Two examples are continuously pushing a child on a swing and an unbalanced rotating machine element. If enough energy to overcome the damping is applied, the motion will continue as long as the excitation continues. Forced vibration may take the form of self-excited or externally excited vibration. Self-excited vibration occurs when the excitation force is generated in or on the suspended mass; externally excited vibration occurs when the excitation force is applied to the spring. This is the case, for example, when the foundation to which the spring is attached is moving.

Transmissibility. When the foundation is oscillating, and force is transmitted through the spring to the suspended mass, the motion of the mass will be different from the motion of the foundation. We will call the motion of the foundation the input, I, and the motion of the mass the response, R. The ratio R/I is defined as the transmissibility, Tr:

$$Tr = R / I \tag{6}$$

Resonance. At forcing frequencies well below the system's natural frequency, R≅I, and Tr≅1. As the forcing frequency approaches the natural frequency, transmissibility increases due to resonance. Resonance is

the storage of energy in the mechanical system. At forcing frequencies near the natural frequency, energy is stored and builds up, resulting in increasing response amplitude. Damping also increases with increasing response amplitude, however, and eventually the energy absorbed by damping, per cycle, equals the energy added by the exciting force, and equilibrium is reached. We find the peak transmissibility occurring when $f_f \cong f_n$. This condition is called resonance.

Isolation. If the forcing frequency is increased above f_n, R decreases. When $f_f = 1.414$ fn, R = I and Tr = 1; at higher frequencies R <I and Tr <1. At frequencies when R <I, the system is said to be in isolation. That is, some of the vibratory motion input is isolated from the suspended mass.

Effects of Mass and Stiffness Variations. From Equation (5) it can be seen that natural frequency is proportional to the square root of stiffness, K, and inversely proportional to the square root of weight, W, or mass, M. Therefore, increasing the stiffness of the spring or decreasing the weight of the mass increases natural frequency.

Damping

Damping is any effect that removes kinetic and/or potential energy from the spring mass system. It is usually the result of viscous (fluid) or frictional effects. All materials and structures have some degree of internal damping. In addition, movement through air, water, or other fluids absorbs energy and converts it to heat. Internal intermolecular or inter-crystalline friction also converts material strain to heat. And, of course, external friction provides damping.

Damping causes the amplitude of free vibration to decrease over time, and also limits the peak transmissibility in forced vibration. It is normally characterized by the Greek letter zeta (ζ) , or by the ratio C/C_c, where c is the amount of damping in the structure or material and C_c is "critical damping." Mathematically, critical damping is expressed as $C_c = 2(KM)^{1/2}$. Conceptually, critical damping is that amount of damping which allows the deflected spring mass system to just return to its equilibrium position with no overshoot and no oscillation. An under-damped system will overshoot and oscillate when deflected and released. An over-damped system will never return to its equilibrium position; it approaches equilibrium asymptotically.

2..2. Displacement, Velocity, and Acceleration

Since vibration is defined as oscillatory motion, it involves a change of position, or displacement (see Figure 1).

Velocity is defined as the time rate of change of displacement; acceleration is the time rate of change of velocity. Some technical disciplines use the term *jerk* to denote the time rate of change of acceleration.

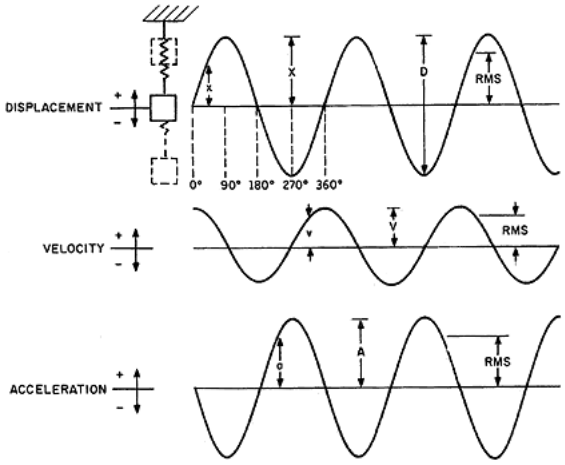

Figure 1. Phase relationships among displacement, velocity, and acceleration are shown on these time history plots.

Sinusoidal Motion Equation. The single-degree-of-freedom spring mass system, in forced vibration, maintained at a constant displacement amplitude, exhibits simple harmonic motion, or sinusoidal motion. That is, its displacement amplitude vs. time traces out a sinusoidal curve. Given a peak displacement of X, frequency f, and instantaneous displacement x:

$$x = X \sin 2\pi ft \tag{7}$$

at any time, t.

Velocity Equation. Velocity is the time rate of change of displacement, which is the derivative of the time function of displacement. For instantaneous velocity, v:

$$v = 2\pi fX \cos 2\pi ft \tag{8}$$

Since vibratory displacement is most often measured in terms of peak-to-peak, double amplitude, displacement D = 2X:

$$v = \pi fD \cos 2\pi ft \tag{9}$$

If we limit our interest to the peak amplitudes and ignore the time variation and phase relationships:

$$V = \pi fD \tag{10}$$

where:

V = peak velocity.

Acceleration Equation. Similarly, acceleration is the time rate of change of velocity, the derivative of the velocity expression:

$$a = 4\pi^2 f^2 X(-\sin 2\pi ft) \tag{11}$$

and

$$A = 2\pi^2 f^2 D \tag{12}$$

where:

A = peak acceleration

It thus can be shown that:

$$V = \pi f D \quad (13)$$

$$A = 2\pi^2 f^2 D \quad (14)$$

$$D = V / \pi f \quad (15)$$

$$D = A / 2\pi^2 f^2 \quad (16)$$

From these equations, it can be seen that low-frequency motion is likely to exhibit low-amplitude accelerations even though displacement may be large. It can also be seen that high-frequency motion is likely to exhibit low-amplitude displacements, even though acceleration is large. Consider two examples:

• At 1 Hz, 1 in. pk-pk displacement is only ~0.05 g acceleration; 10 in. is ~0.5 g

• At 1000 Hz, 1g acceleration is only ~0.00002 in. displacement; 100 g is ~0.002 in.

2.3. Measuring Vibratory Displacement

Optical Techniques. If displacement is large enough, as at low frequencies, it can be measured with a scale, calipers, or a measuring microscope. At higher frequencies, displacement measurement requires more sophisticated optical techniques.

High-speed movies and video can often be used to measure displacements and are especially valuable for visualizing the motion of complex structures and mechanisms. The two methods are limited by resolution to fairly large displacements and low frequencies. Strobe lights and stroboscopic photography are also useful when displacements are large enough, usually >0.1 in., to make them practical.

The change in intensity or angle of a light beam directed onto a reflective surface can be used as an indication of its distance from the source. If the detection apparatus is fast enough, changes of distance can be detected as well.

The most sensitive, accurate, and precise optical device for measuring distance or displacement is the laser interferometer (see Figure 2).

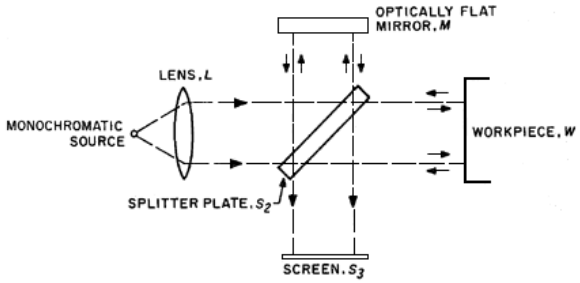

Figure 2. Interference patterns are created on the screen of the laser interferometer and can be related to displacement of the work-piece.

With this apparatus, a reflected laser beam is mixed with the original incident beam. The interference patterns formed by the phase differences can measure displacement down to <100 nm. NIST and other national primary calibration agencies use laser interferometers for primary calibration of vibration measurement instruments at frequencies up to 25 kHz.

Electromagnetic and Capacitive Sensors. Another important class of non-contact, special-purpose displacement sensors is the general category of proximity sensors. These are probes that are typically built into machinery to detect the motion of shafts inside journal bearings or the relative motion of other machine elements. The sensors measure relative distance or proximity as a function of either electromagnetic or capacitive (electrostatic) coupling between the probe and the target. Because these devices rely on inductive or capacitive effects, they require an electrically conductive target. In most cases, they must be calibrated for a specific target and specific material characteristics in the gap between probe and target.

Electromagnetic proximity sensors are often called eddy current probes because one of the most popular types uses eddy currents generated in the target as its measurement mechanism. More accurately, this type of sensor uses the energy dissipated by the eddy currents. The greater the distance from probe to target, the less electromagnetic coupling, the lower the magnitude of the eddy currents, and the less energy they drain from the probe. Other electromagnetic probes sense the distortion of an electromagnetic field generated by the probe and use that measurement to indicate the distance from probe to target.

Capacitive proximity sensor systems measure the capacitance between the probe and the target and are calibrated to convert the capacitance to distance. Capacitance is affected by the dielectric properties of the material in the gap as well as by distance, so calibration can be affected by a change of lubricant or contamination of the lubricant in a machine environment.

Contact Techniques. A variety of relative motion sensors use direct contact with two objects to measure relative motion or distance between them. These include LVDTs, cable position transducers (string-pots), and linear potentiometers. All of these devices depend on mechanical linkages and electromechanical transducers.

Seismic Displacement Transducers. These devices, discussed in detail later, were once popular but now are seldom used. They tend to be large, heavy, and short lived.

Double Integration of Acceleration. With the increasing availability and decreasing cost of digital signal processing, more applications are using the more rugged and more versatile accelerometers as sensors, then double integrating the acceleration signal to derive displacements. While older analog integration techniques

tended to be noisy and inaccurate, digital processing can provide quite high-quality, high-accuracy results.

2.4. Measuring Vibratory Velocity

Transducers. Some of the earliest "high-frequency" vibration measurements were made with electro-dynamic velocity sensors. These are a type of seismic transducer that incorporates a magnet supported on a soft spring suspension system to form the seismic (spring mass) system. The magnetic member is suspended in a housing that contains one or more multi-turn coils of wire. When the housing is vibrated at frequencies well above the natural frequency of the spring mass system, the mass (magnet) is isolated from the housing vibration. Thus, the magnet is essentially stationary and the housing, with the coils, moves past it at the velocity of the structure to which it is attached. Electrical output is generated proportional to the velocity of the coil moving through the magnetic field. Velocity transducers are used from ~10 Hz up to a few hundred Hz. They tend to be large and heavy, and eventually wear and produce erratic outputs.

Laser Vibro-meters. Laser vibro-meters or laser veloci-meters are relatively new instruments capable of providing high sensitivity and accuracy. They use a frequency-modulated (typically around 44 MHz) laser beam reflected from a vibrating surface. The reflected beam is compared with the original beam and the Doppler frequency shift is used to calculate the velocity of the vibrating surface. Alignment and standoff distance are critical. Because of the geometric constraints on location, alignment, and distances, they are limited to laboratory applications. One version of laser vibro-meter scans the laser beam across a field of vision, measuring velocity at each point. The composite can then be displayed as a contour map or a colorized display. The vibration map can be superimposed on a video image to provide the maximum amount of information about velocity variations on a large surface.

Integration of Acceleration. As with displacement measurements, low-cost digital signal processing makes it practical to use rugged, reliable, versatile accelerometers as sensors and integrate their output to derive a velocity signal.

2.5. Measuring Vibratory Acceleration

Most modern vibration measurements are made by measuring acceleration. If velocity or displacement data are required, the acceleration data can be integrated (velocity) or double integrated (displacement). Some accelerometer signal conditioners have built-in integrators for that purpose. Accelerometers (acceleration sensors, pickups, or transducers) are available in a wide variety of sizes, shapes, performance characteristics, and prices. The five basic transducer types are servo force balance; crystal-type or piezoelectric; piezo-resistive or silicon strain gauge type; integral electronics piezoelectric; and variable capacitance. Despite the different electromechanical transduction mechanisms, all use a variation of the spring mass system, and are classified as seismic transducers.

Seismic Accelerometer Principle. All seismic accelerometers use some variation of a seismic or proof mass suspended by a spring structure in a case (see Figure 3). When the case is accelerated, the proof mass is also accelerated by the force transmitted through the spring structure. Then the displacement of the spring, the displacement of the mass within the case, or the force transmitted by the spring is transduced into an electrical signal proportional to acceleration.

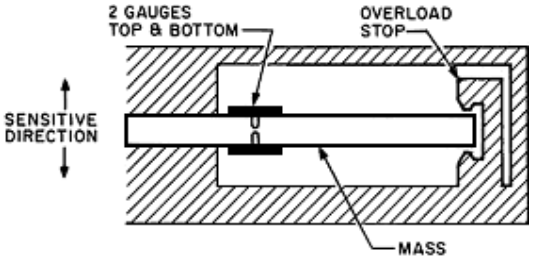

Figure 3. The notched beam is used as the (seismic) spring mass system of a piezo-resistive accelerometer.

Accelerometers. Transducers designed to measure vibratory acceleration are called accelerometers. There are many varieties including strain gauge, servo force balance, piezo-resistive (silicon strain gauge), piezoelectric (crystal-type), variable capacitance, and integral electronic piezoelectric. Each basic type has many variations and trade names. Most manufacturers provide excellent applications engineering assistance to help the user choose the best type for the application, but because most of these sources sell only one or two types, they tend to bias their assistance accordingly.

For most applications, my personal bias is toward piezoelectric accelerometers with internal electronics. The primary limitation of these devices is temperature range. Although they exhibit low-frequency roll-off, they are available with extremely low-frequency capabilities. They provide a pre-amplified low-impedance output, simple cabling, and simple signal conditioning, and generally have the lowest overall system cost.

Most important to the user are the performance and environmental specifications and the price. What's inside the box is irrelevant if the instrument meets the requirements of the application, but when adding to existing instrumentation it is important to be sure that the accelerometer is compatible with the signal conditioning. Each type of accelerometer requires a different type of signal conditioning.

Accelerometer Types. The most common seismic transducers for shock and vibration measurements are:

- Piezoelectric (PE); high-impedance output
- Integral electronics piezoelectric (IEPE); low-impedance output
- Piezoresistive (PR); silicon strain gauge sensor

- Variable capacitance (VC); low-level, low-frequency
- Servo force balance

Piezoelectric (PE) sensors use the piezoelectric effects of the sensing element(s) to produce a charge output. Because a PE sensor does not require an external power source for operation, it is considered self-generating. The "spring" sensing elements provide a given number of electrons proportional to the amount of applied stress (*piezein* is a Greek word meaning to *squeeze*). Many natural and man-made materials, mostly crystals or ceramics and a few polymers, display this characteristic. These materials have a regular crystalline molecular structure, with a net charge distribution that changes when strained [3].
Piezoelectric materials may also have a dipole (which is the net separation of positive and negative charge along a particular crystal direction) when unstressed. In these materials, fields can be generated by deformation from stress or temperature, causing piezoelectric or pyro-electric output, respectively. The pyro-electric outputs can be very large unwanted signals, generally occurring over the long time periods associated with most temperature changes [3]. Polymer PE materials have such high pyro-electric output that they were originally used as thermal detectors. There are three pyro-electric effects, which will be discussed later in detail.
Charges are actually not "generated," but rather just displaced. (Like energy and momentum, charge is always conserved.) When an electric field is generated along the direction of the dipole, metallic electrodes on faces at the opposite extremes of the gradient produce mobile electrons that move from one face, through the signal conditioning, to the other side of the sensor to cancel the generated field. The quantity of electrons depends on the voltage created and the capacitance between the electrodes [3]. A common unit of charge from a PE accelerometer is the pico-coulomb, or 10-12 coulomb, which is something over 6×10^6 electrons.
Choosing among the many types of PE materials entails a tradeoff among charge sensitivity, dielectric coefficient (which, with geometry, determines the capacitance), thermal coefficients, maximum temperature, frequency characteristics, and stability. The best S/N ratios generally come from the highest piezoelectric coefficients[8].

Naturally occurring piezoelectric crystals such as tourmaline or quartz generally have low-charge sensitivity, about one-hundredth that of the more commonly used ferroelectric materials. (But these low-charge output materials are typically used in the voltage mode, which will be discussed later.) Allowing smaller size for a given sensitivity, ferroelectric materials are usually man-made ceramics in which the crystalline domains (i.e., regions in which dipoles are naturally aligned) are themselves aligned by a process of artificial polarization.

Polarization usually occurs at temperatures considerably higher than operating temperatures to speed the process of alignment of the domains. Depolarization, or relaxation, can occur at lower temperatures, but at very much lower rates, and can also occur with applied voltages and preload pressures. Depolarization always results in temporary or permanent loss of sensitivity. Tourmaline, a natural crystal that does not undergo depolarization, is particularly useful at very high temperatures.

Because they are self-generating, PE transducers cannot be used to measure steady-state accelerations or force, which would put a fixed amount of energy into the crystal (a one-way squeeze) and therefore a fixed number of electrons at the electrodes. Conventional voltage measurement would bleed electrons away, as does the sensor's internal resistance. (High temperature or humidity in the transducer would exacerbate the problem by reducing the resistance value.) Energy would be drained and the output would decay, despite the constant input acceleration/force [3].
External measurement of PE transducer voltage output requires special attention to the cable's dynamic behavior as well as the input characteristics of the preamplifier. Since cable capacitance directly affects the signal amplitude, excessive movement of the cable during measurement can cause changes in its capacitance and should be avoided. Close attention should also be paid to the preamp's input impedance; this should be on the order of 1000 M Ω or higher to ensure sufficient low-frequency response[4].

In practice, a charge amplifier is normally used with a PE transducer (see Figure 4).

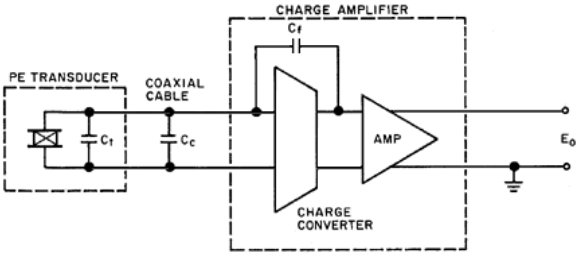

Figure 4. The feedback capacitance of the charge converter determines the ratio of output voltage to input charge of a charge amplifier.

Instead of measuring voltage externally, a charge should be measured with a charge converter. It is a high-impedance op amp with a capacitor as its feedback. Its output is proportional to the charge at the input and the feedback capacitor, and is nearly unaffected by the input capacitance of the transducer or attached cables. The high-pass corner frequency is set by the feedback capacitor and resistor in a charge converter, and not the transducer characteristics. (The transducer resistance changes noise characteristics, not the frequency.) If time constants are long enough, the AC-coupled transducer will suffice for most vibration measurements[6].

Perhaps the most important limitation of high-impedance output PE transducers is that they must be used with "noise-treated" cables; otherwise, motion in the cable can displace triboelectric charge, which adds to the

charge measured by the charge converter. Triboelectric noise [2,13] is a common source of error found in typical coaxial cables.

Most PE transducers are extremely rugged. Each of the various shapes and sizes available comes with its own performance compromises. The most common types of this transducer are compression and shear designs. Shear design offers better isolation from environmental effects such as thermal transient and base strain, and is generally more expensive. Beam-type design, a variation of the compression design, is also quite popular due to its lower manufacturing cost. But beam design is generally more fragile and has limited bandwidth [2].

Integral Electronics Piezoelectric (IEPE). Many piezoelectric accelerometers/force transducers include integral miniature hybrid amplifiers, which, among their other advantages, do not need noise-treated cable. Most require an external constant current power source. Both the input supply current and output signal are carried over the same two-wire cable. The low-impedance output of the IEPE design (see Figure 5) provides relative immunity to the effects of poor cable insulation resistance, triboelectric noise, and stray signal pickup [1,5,7].

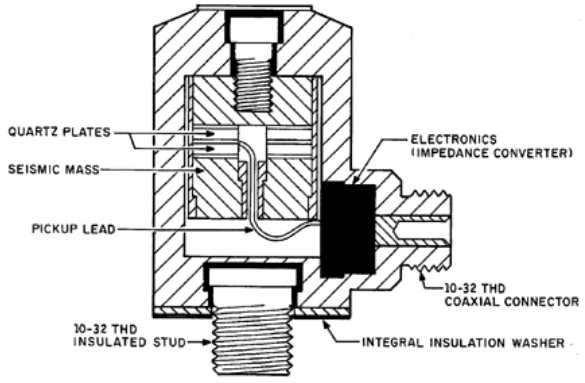

Figure 5. This IEPE accelerometer has an inverted compression seismic system and an electronic module in the connector.

Output-to-weight ratio of IEPE is higher than with PE transducers. Additional functions can be incorporated into the electronics (see Figure 6), including filters, overload protection, and self-identification.

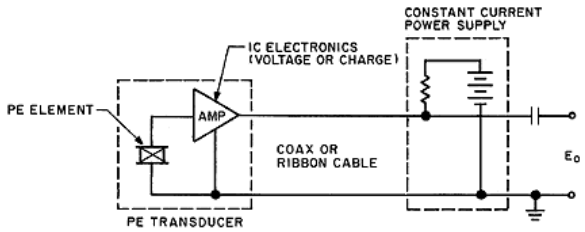

Figure 6. The IEPE accelerometer system provides a constant current source for the internal amplifier and a capacitor to block the DC bias of the output signal.

Lower cost cable and conditioning can be used since the conditioning requirements are comparatively lax compared to PE or PR. The sensitivity of IEPE accelerometers/force transducers, in contrast to PR, is not significantly affected by supply changes. Instead, dynamic range, the total possible swing of the output voltage, is affected by bias and compliance voltages. Only with large variations in current supply would there be problems with frequency response when driving high-capacitance loads [9].

A disadvantage of built-in electronics is that it generally limits the transducer to a narrower temperature range. In comparison with an identical transducer design that does not have internal electronics, the high-impedance version will always have a higher mean time between failures (MTBF) rating. In addition, the necessarily small size of the amplifier may preclude some of the desirable features offered by a full-blown laboratory amplifier, such as the ability to drive long cable. Slew limiting is therefore a concern with these transducers (some designs have relatively high output impedance) when driving long lines or other capacitive loads. The problem can be remedied by increasing the amount of drive current within the limit specified by the manufacturer [9].

The circuits need not necessarily be charge converters because the capacitance due to leads between the sensor and the amplifier is small and well controlled. Quartz is used in the voltage mode, i.e., with source followers, because its small dielectric coefficient provides comparatively high voltage per unit charge. Voltage conversion also aids ferroelectric ceramics that have the sag in frequency response in charge mode due to their frequency-dependent dielectric coefficient. The amplitude frequency response in the voltage mode is quite flat[11].

Variable Capacitance. VC transducers are usually designed as parallel-plate air gap capacitors in which motion is perpendicular to the plates. In some designs the plate is cantilevered from one edge, so motion is actually rotation; other plates are supported around the periphery, as in a trampoline. Changes in capacitance of the VC elements due to acceleration are sensed by a pair of current detectors that convert the changes into voltage output. Many VC sensors are micro-machined as a sandwich of aniso-tropically etched silicon wafers with a gap only a few microns thick to allow air damping. The fact that air viscosity changes by just a few percent over a wide operating temperature range provides a frequency response more stable than is achievable with oil-damped PR designs[12].

In a VC accelerometer, a high-frequency oscillator provides the necessary excitation for the VC elements. Changes in capacitance are sensed by the current detector. Output voltage is proportional to capacitance changes, and, therefore, to acceleration. The incorporation of over-travel stops in the gap can enhance ruggedness in the sensitive direction, although resistance to over-range in transverse directions must rely solely on the strength of the suspension, as is true of all other transducer designs without over-travel stops. Some designs can survive extremely high acceleration over range conditions-as much as 1000 × full-scale range [10].

The sensor of a typical micro-machined VC accelerometer is constructed of three silicon elements

bonded together to form a hermetically sealed assembly (see Figure 7). Two of the elements are the electrodes of an air dielectric, parallel-plate capacitor. The middle element is chemically etched to form a rigid central mass suspended by thin, flexible fingers. Damping characteristics are controlled by gas flow in the orifices located on the mass.

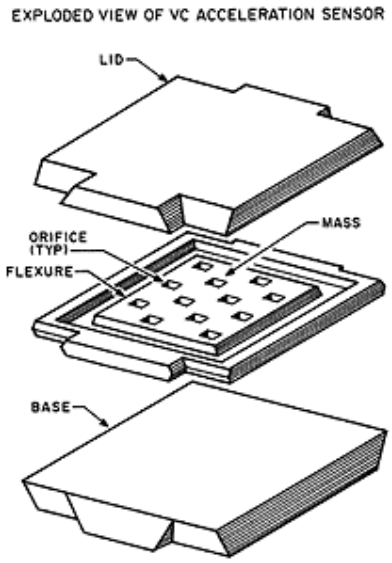

Figure 7. An exploded view of a variable capacitance accelerometer shows its primary elements.

VC sensors can provide many of the best features of the transducer types discussed earlier: large overrange, DC response, low-impedance output, and simple external signal conditioning. Disadvantages are the cost and size associated with the increased complexity of the onboard conditioning. Also, high-frequency capacitance detection circuits are used, and some of the high-frequency carrier usually appears on the output signal. It is generally not even noticed, being up to three orders of magnitude (i.e., 1000 ×) higher in frequency than the output signals.

Servo (Force Balance). Although servo accelerometers are used predominantly in inertial guidance systems, some of their performance characteristics make them desirable in certain vibration applications. All the accelerometer types described previously are open-loop devices in which the output due to deflection of the sensing element is read directly. In servo-controlled, or closed-loop, accelerometers, the deflection signal is used as feedback in a circuit that physically drives or rebalances the mass back to the equilibrium position. Servo accelerometer manufacturers suggest that open-loop instruments that rely on displacement (i.e., straining of crystals and piezoresistive elements) to produce an output signal often cause nonlinearity errors. In closed-loop designs, internal displacements are kept extremely small by electrical rebalancing of the proof mass, minimizing nonlinearity. In addition, closed-loop designs are said to have higher accuracy than open-loop types. However, definition of the term *accuracy* varies. Check with the sensor manufacturer.

Servo accelerometers (see Figure 8) can take either of two basic geometries: linear (e.g., loudspeaker) and pendulous (meter movement).

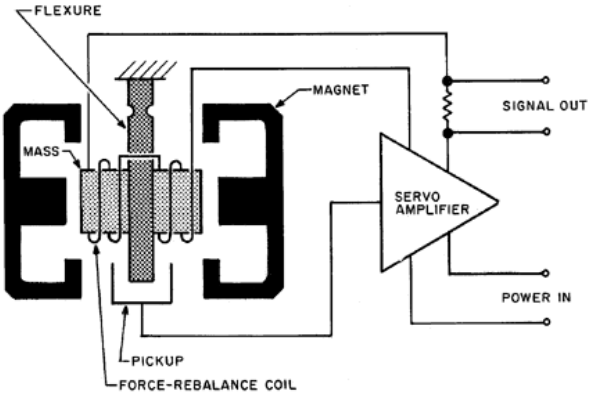

Figure 8. The servo force balance accelerometer produces an output proportional to the force required to maintain the mass in an equilibrium position.

Pendulous geometry is most widely used in commercial designs. Until recently, the servo mechanism was primarily based on electromagnetic principles. Force is usually provided by driving current through coils on the mass in the presence of a magnetic field. In the pendulous servo accelerometer with an electromagnetic rebalancing mechanism, the pendulous mass develops a torque proportional to the product of the proof mass and the applied acceleration. Motion of the mass is detected by the position sensors (typically capacitive sensors), which send an error signal to the servo system. The error signal triggers the servo amplifier to output a feedback current to the torque motor, which develops an opposing torque equal in magnitude to the acceleration-generated torque from the pendulous mass. Output is the applied drive current itself (or across an output resistor), which, analogous to the deflection in the open-loop transducers, is proportional to the applied force and therefore to the acceleration[14].

In contrast to the rugged spring elements of the open-loop transducers, the rebalancing force in the case of the closed-loop accelerometer is primarily electrical and exists only when power is provided. The springs are as flimsy in the sensitive direction as feasible and most damping is provided through the electronics. Unlike other DC-response accelerometers whose bias stability depends solely on the characteristics of the sensing element(s), it is the feedback electronics in the closed-loop design that controls bias stability. Servo accelerometers therefore tend to offer less zero drifting, which is the major reason for their uses in vibration measurements. In general, they have a useful bandwidth of <1000 Hz and are designed for use in applications with comparatively low acceleration levels and extremely low frequency components.

5. CONCLUSIONS

This article addresses the physics of vibration; dynamics of a spring mass system; damping; displacement,

velocity, and acceleration; and the operating principles of the sensors that detect and measure these properties.

Vibration is oscillatory motion resulting from the application of oscillatory or varying forces to a structure. Oscillatory motion reverses direction. The oscillation may be continuous during some time period of interest or it may be intermittent. It may be periodic or non-periodic, it may or may not exhibit a regular period of repetition. The nature of the oscillation depends on the nature of the force driving it and on the structure being driven. Motion is a vector quantity, exhibiting a direction as well as a magnitude. The direction of vibration is usually described in terms of some arbitrary coordinate system (typically Cartesian or orthogonal) whose directions are called axes. The origin for the orthogonal coordinate system of axes is arbitrarily defined at some convenient location. Most vibratory responses of structures can be modeled as single-degree-of-freedom spring mass systems, and many vibration sensors use a spring mass system as the mechanical part of their transduction mechanism. The dynamics of a spring mass system can be expressed by the system's behavior in free vibration and/or in forced vibration.

In contrast to the rugged spring elements of the open-loop transducers, the rebalancing force in the case of the closed-loop accelerometer is primarily electrical and exists only when power is provided. The springs are as flimsy in the sensitive direction as feasible and most damping is provided through the electronics. Unlike other DC-response accelerometers whose bias stability depends solely on the characteristics of the sensing element(s), it is the feedback electronics in the closed-loop design that controls bias stability. Servo accelerometers therefore tend to offer less zero drifting, which is the major reason for their uses in vibration measurements. In general, they have a useful bandwidth of <1000 Hz and are designed for use in applications with comparatively low acceleration levels and extremely low frequency components.

6. ACKNOWLEDGMENTS

As the pinnacle of my education, this thesis is distiled from the input and advice of great many teatchers. I can name only a few, perhaps the most pronounced.

From Constanta Maritime University: prof.univ. dr.ing. Nicolae ZIDARU.

From Bucharest Polytechnica University: prof. univ.dr.ing. Constantin ION.

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NUMERICAL SIMULATION OF THE COMBUSTION IN GAS TURBINES COMBUSTORS

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ABSTRACT

A Numeric simulation of the combustion in Gas Turbines has been performed and proposed for the complete combustor and exhaust area numerical treatment, the model being obtained using multiple species concept, the chemistry approach being with Eddy-Dissipation chemistry model, the turbulence model being *k-ε*. The rich palette of results shown below are thoroughly investigating the combustion parameters and mass fractions of the species, all this by using the software Fluent 6.1

Keywords: *Gas Tubine, Numeric Simulation, Reacting Flow, Combustion*

1. INTRODUCTION

The Numeric simulation is becoming a standard tool to study the dynamics of turbulent flames and the reacting flows into the Gas Turbines, being a key tool for predicting and studying the combustion process encountered in many combustion devices as gas turbines but, also, rocket engines or industrial furnaces.

Up to now the reacting flows, combustor geometries, thermodynamic and transport properties were limited to fairly simple schemes for obvious purpose of cost and complexity reduction. This study presents the computation of a rather complex system as the burner of a Gas Turbine available on market (with main dimensions and input data changed), shown in Figure 1.

Figure1The Gas Turbine geometry considered in the study.

The main objectives of the study is to investigate the main thermodynamic parameters of the combustion process as flow velocities, temperatures and pressures, and supplementary, to investigate the main species mass fraction distribution and physical properties as enthalpies, entropies and so on.

The CAD simulation of the burning zone is given in Figure 2 and the "negative" of it to simulate the flow paths of air and CH4, is given in Figure 2 and 3.

On the above figures it may be identified the air inlet area having the diameter of *500 mm*, the fuel inlet in burners, having the diameter of *30 mm*, and the outlet area for the combustion chamber having the diameter of *570 mm*. The entire modeled assembly has the overall length of *1900 mm*. It was generated only a slice of 60^0 of the burner for computational purposes, the exit of the burning gases is passing through the two rows of blades of turbine, colored in blue on the figure.

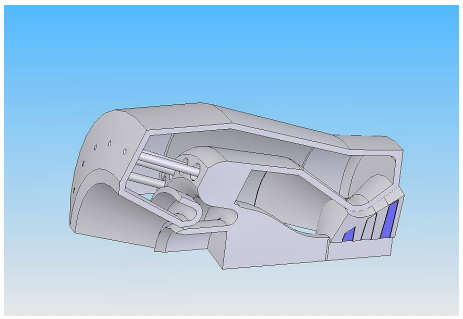

Figure 2 The CAD geometry

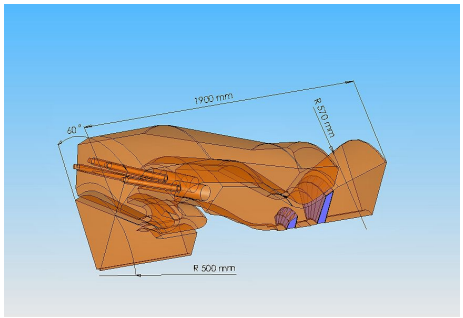

Figure 3 The "negative" of the CAD geometry simulating the flow paths of Air, Fuel (methane) and combustion products

2. NOMENCLATURE

A, B, $C_{1\varepsilon}$, $C_{3\varepsilon}$, $C_{2\varepsilon}$, C_{μ} - Constants,

$C_{i,r}$ -Net rate production of specie i by the chemical reaction r,
G_k -Generation of turbulence kinetic energy due to the mean velocity gradients,
G_b - Generation of turbulence kinetic energy due to the buoyancy,
i -Index defining the i^{th} species,
$\vec{J}_i$ -Diffusion rate of each species,
k -Turbulence kinetic energy,
k/ε – Large-Eddy time mixing scale,
$M_{w,i}$ -Molecular weight of species i,
N -The total number of fluid phase chemical species present in simulation,
$S_{i,m}$ -Diffusion coefficient for species i,
Sc_t -Schmidt number,
T_{ij} -Strain rate tensor,
X_i -Local mass fraction of each species,
X_P -Mass fraction of any product species,
X_R -Mass fraction of any reactant species,
Y_M - The contribution of the fluctuating dilatation in compressible turbulence to the overall dissipation rate,
ρ -Density,
μ_t -Turbulent viscosity,
$\upsilon'_{i,r}$ -Stoichiometric coefficient for reactant i in reaction r,
$\upsilon''_{i,r}$ -Stoichiometric coefficient for product i in reaction r,
γ_{sgs}^{-1} - Sub-grid scale mixing rate,
ε - Specific dissipation rate
σ_k -Turbulent Prandtl number for k,
σ_ε - Turbulent Prandtl number for ε,

3. THE NUMERIC MODEL OF THE COMBUSTION'S CHEMISTRY

One of the major hypotheses made in this simulation, regarding the combustion chemistry, is that the combustion reactions mechanisms are developing accordingly to the Eddy-Dissipation model. For such a model the conservation equation is:

$$\frac{\partial}{\partial t}(\rho X_i) + \nabla(\rho \vec{v} X_i) = -\nabla \vec{J}_i + C_{i,r} \tag{1}$$

This kind of equation should be written and solved for $N-1$ species. The diffusion flux for the specie i in the laminar flow is:

$$J_i = -\rho S_{i,m} \nabla X_i \tag{2}$$

But since we explicitly consider the turbulent case, this will become:

$$J_i = \left(-\rho S_{i,m} + \frac{\mu_t}{Sc_t} \right) \nabla X_i \tag{3}$$

The fuel (CH_4) has the overall rate of reaction controlled by turbulent mixing, the oxidizer (O_2) being mixed in the reaction zone where they burn fast. In the Eddy-Dissipation model provides a concept of turbulence-chemistry interaction, where the net rate of production of the species I due to reaction is given by the smaller of the equations bellow:

$$C_{i,r} = \upsilon'_{i,r} M_{w,i} A \rho \min_R \left(\frac{X_R}{\upsilon'_{R,r} M_{w,R}} \right)$$
$$C_{i,r} = \upsilon'_{i,r} M_{w,i} AB \rho \frac{\varepsilon}{k} \min_R \left(\frac{\sum_P X_P}{\sum_j^N \upsilon''_{j,r} M_{w,j}} \right) \tag{4}$$

In this concept turbulence is preceding combustion and combustion is developing whenever the turbulence is present in system.

Usually, the turbulent mixing rate k/ε is replaced by the sub-grid scale mixing rate:

$$\gamma_{sgs}^{-1} = \sqrt{2 T_{ij} T_{ij}} \tag{5}$$

The turbulence was modeled by using the Standard k-ε model. This model is a semi-empirical one being based on the transport equations for the turbulence kinetic energy and the specific dissipation rate. The model for transport equation k is deduced from the exact equation whilst the transport equation for ε was deduced by empirical rationale. It is assumed that the flow is fully turbulent and the effects of molecular viscosity are small.

The abovementioned transport equations are:

$$\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_i}(\rho k u_i) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_k} \right) \frac{\partial k}{\partial x_j} \right] + G_k + G_b - \rho\varepsilon - Y_M$$

(6)

$$\frac{\partial}{\partial t}(\rho \varepsilon) + \frac{\partial}{\partial x_i}(\rho k u_i) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_\varepsilon} \right) \frac{\partial \varepsilon}{\partial x_j} \right] + C_{1\varepsilon}(G_k + C_{3\varepsilon} G)_b -$$
$$- C_{2\varepsilon} \rho \frac{\varepsilon^2}{k}$$

(7)

The turbulent viscosity in this approach should be:

$$\mu_t = \rho C_\mu \frac{k^2}{\varepsilon} \tag{8}$$

4. INPUT DATA FOR THE MODEL OF THE COMBUSTOR AREA AND THE OUTLET

The Finite Volume Element Grid comprises *763.892* tetrahedral cells, as it's seen in figure 4.

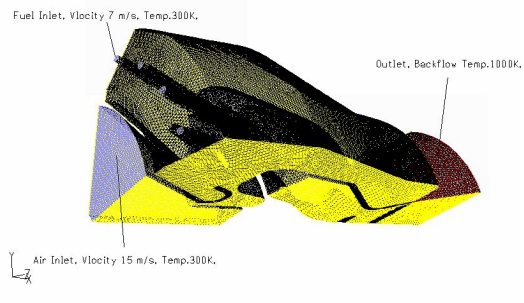

Figure 4 The element's grid

There were defined the boundary conditions as follows:

- The air-inlet zone having a hydraulic diameter of *0.25 m*, the temperature of 300^0 *K* and the velocity magnitude of the air coming from compressor, *15 m/s*.
- The fuel-inlet (CH_4) zone modeling the inlet into the burners, having a hydraulic diameter of *0.03 m*, the temperature of 300^0 *K* and the velocity magnitude, *7 m/s*.
- The outlet zone modeling the outlet from the blades row, having a hydraulic diameter of *0.27 m*, the backflow total temperature of 1000^0 *K* .
- The walls have been set to have the temperature of 900^0 *K*.

The mixture material is methane-air, and the defined species are CO_2, CH_4, N_2, O_2, H_2O, with the properties given in Table 1.

Table 1. Species Properties

	CO_2	CH_4	N_2	O_2	H_2O
Weight [kg/kgmol]	44.009	16.043	28.013	31.998	18.015
Enthalpy [J/kgmol]	-3.93e8	-7.48e7	0	0	-2.41e8
Entropy [J/kgmolK]	213715	186040	191494	205026	188696

The specific heat for the mixture was taken accordingly a mixture law and for each species this was deemed non-constant, obeying a piecewise-polynomial function.

5. NUMERICAL PREDICTIONS AND DISCUSSION

The program, after 500 iterations, provided the results discussed below:

Pressure

The maximum pressure (Fig.5) was found to be *34.2e6 Pa* in the burner zone and right before the blades row, in the outlet zone decreasing sharply, being identified some portions with cavitations conditions (min. pressure *1.1e5 Pa*).

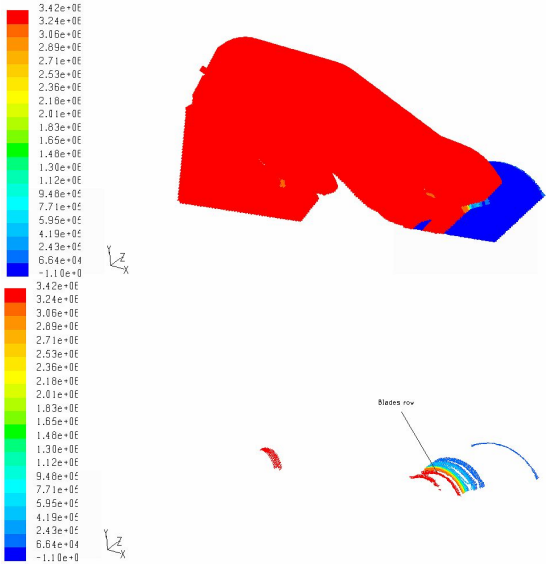

Figure 5 The pressure distribution

Velocity

Starting from the burner's zone, the velocity of the fluid (Fig.6) sharply augment to *119 m/s,* the maximum being calculated in the blades row and outlet zone where, on very thin areas, it reaches the staggering value of *2380 m/s*, about *7* times the speed of sound.

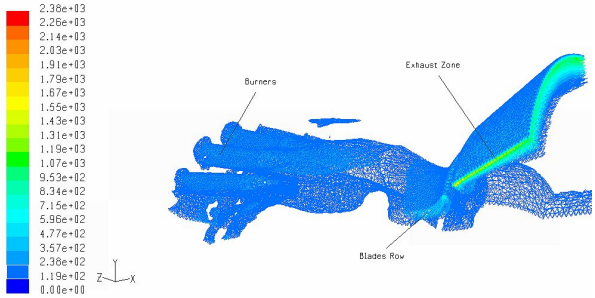

Figure 6 The velocity distribution

Temperature

The highest temperature (Fig.7), as is expected, was calculated in the burner's zone, where it achieves the maximum value of *1870* ^{0}*K,* in the exhaust zone being *926* ^{0}*K*.

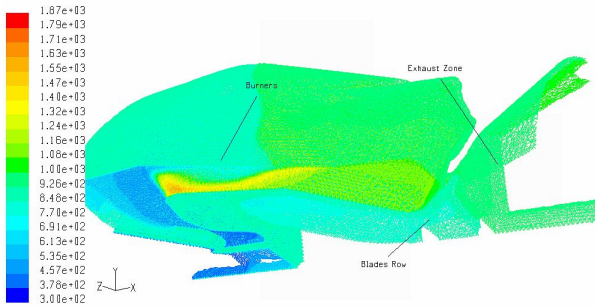

Figure 7 The temperature distribution

Specific Heat

As was stated above, the specific heat (Fig.8) for each species was deemed to obey a non-constant piecewise-polynomial function, the mixture being calculated considering a mixing law, therefore the specific heat varies within the domain, reaching a maximum of *4090 J/kg-K* in the burner's and outlet zone, in the rest of the domain being averaged on *1470 J/kg-K*.

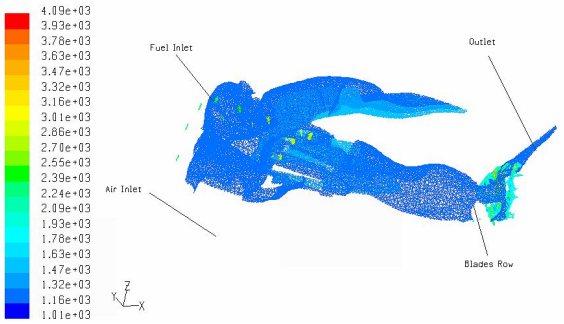

Figure 8 The specific heat distribution

Enthalpy

The maximum enthalpy (Fig.9) was calculated in the burner and blade's row zones, reaching a value of *2.35e6 J/kg*, the rest of the domain having an average of *3.55e5 J/kg*.

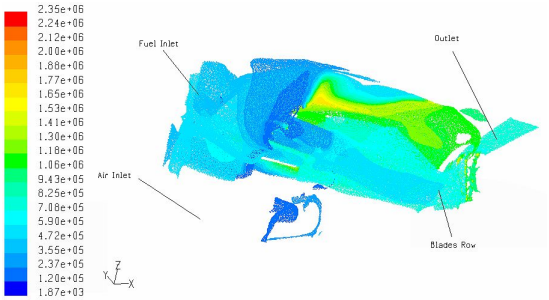

Figure 9 The enthalpy distribution

Entropy

The entropy distribution (Fig.10) follows the same pattern as enthalpy; the maximum was calculated in the burner and blade's row zones, reaching a value of *3.34e3,* the rest of the domain having an average of *700*.

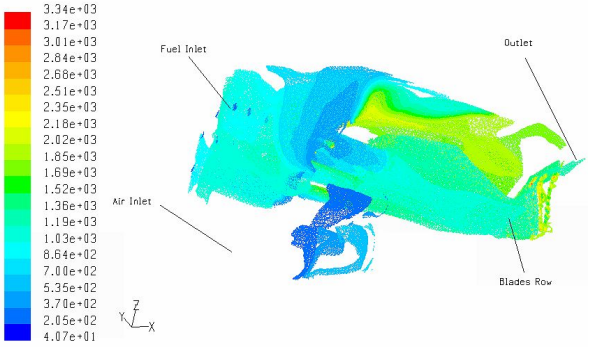

Figure 10 The entropy distribution

Total Energy

The maximum total energy (Fig.11) is reached in the outlet zones, being *8.02e6 J/kg*.

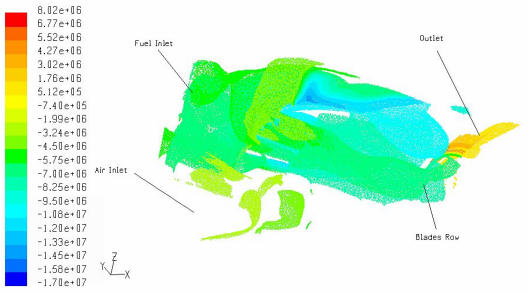

Figure 11 The total energy distribution

Reaction Rate

The most intense zone of the reaction (Fig.12) is in the burner's area, where it reaches a maximum of 3.52 *kmol/m^3-s* at *30-50 mm* away of the zone entrance.

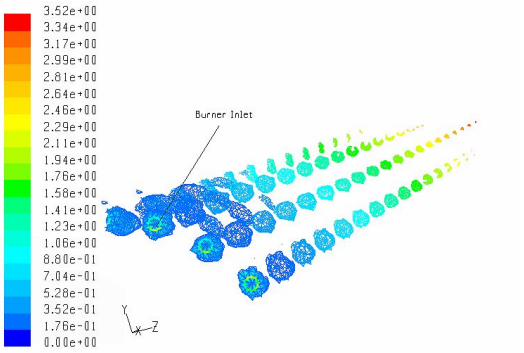

Figure 12 The reaction rate distribution

CH_4 Mass Fraction

The mass fraction of CH_4 is maximum, as it was expected (Fig.13), at the entrance in the burner (value *100 %)* and shortly after the reaction decreasing sharply to an average of *5 %*. The concentrating zone of outlet is "pilling up" the mass fraction to an average of *20%* which is burned shortly after.

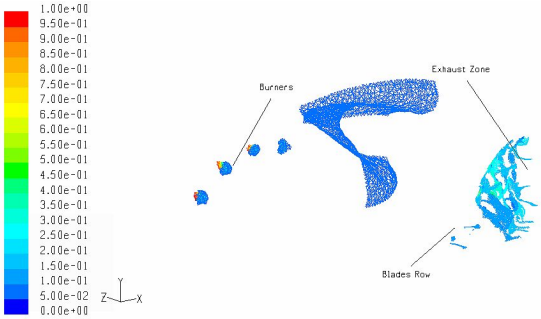

Figure 13 The CH_4 mass fraction distribution

CO_2 Mass Fraction

The maximum values of the CO_2 mass fraction (Fig.14) were determined on the burner and exhaust areas, the value being *90%,* in the rest of the domain varying between *5* to *31 %.*

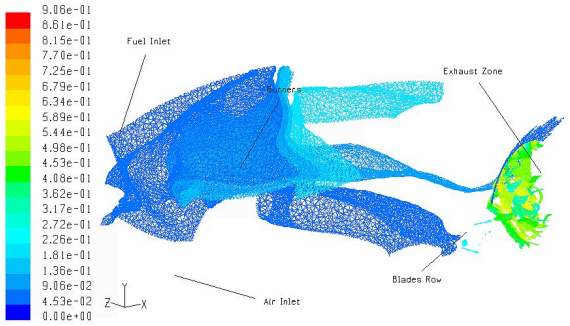

Figure 14 The CO_2 mass fraction distribution

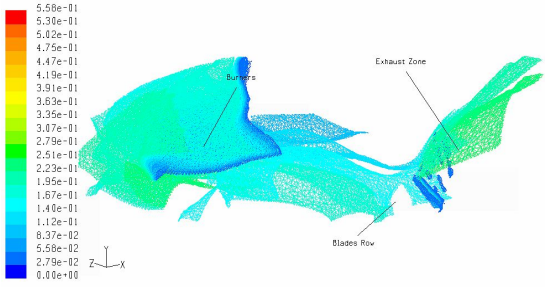

Figure 15 The O_2 mass fraction distribution

O_2 Mass Fraction

The O_2 mass fraction distribution (Fig.15) is reaching maximum values to the air-inlet and outlet zones where the system is in direct contact with the air pumped by the compressor and the atmospheric conditions (average *23%*), and due to the varying density, it has peak values of *55.8 %* on small regions within these areas.

N_2 Mass Fraction

The N_2 maximum concentration is *77%* in the domain (Fig.16), with slightly decreasing values in the central area of the combustor, to *53%.*

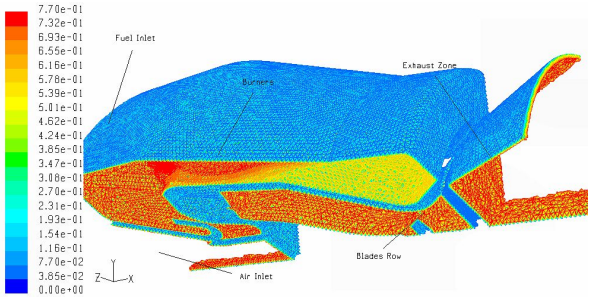

Figure 16 The N_2 mass fraction distribution

H_2O Mass Fraction

The maximum for the H_2O distribution (Fig.17) is reached in the burner and the outlet area where the reactions are the most intense (*72%)* , in the rest of the domain being averaged to *3* to *10%.*

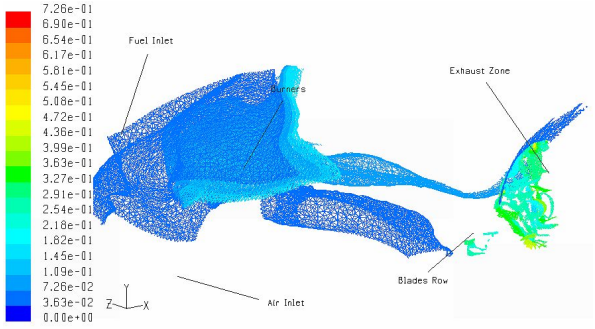

Figure 17 The H_2O mass fraction distribution

6. CONCLUSIONS

The authors feel to have developed and presented in this paper an advanced numerical tool for combustion processes' prediction. The still today highly complex task of reliably predicting combustion processes, mostly the combustion in the gas turbines, has been approached with an advanced simulation strategies and modeling procedures.

The entire palette of the results presented above, may be and they are critical for establishing the flow topology, strength of the structure, size, the flame position etc. and the final shape and optimization of any gas turbine project.

The numerical results are highly dependant of the input parameters and the geometry of the combustor, the optimization of this sensitive area of the gas turbine leading to the final results of the overall efficiency of the turbine and the noise/NOx effluents.

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TESTING AND NUMERICAL SIMULATION OF A FUEL INJECTOR IN A SUPERSONIC AIR STREAM

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Abstract

The new idea of liquid fuel (kerosene) aeroramp injector/plasma igniter was tested in cold flow using a supersonic wind tunnel at Mach 2.4. The liquid fuel (kerosene) injector is flush wall mounted and consists of a 2 hole aero-ramp array of impinging jets that are oriented in a manner to improve mixing and atomization of the liquid jets. The two jets are angled downstream at 40 degrees and have a toe-in angle of 60 degrees. The plasma torch used nitrogen and air as feedstocks and was placed downstream of the injector as an ignition aid. First, schlieren and shadowgraph photographs were taken of the injector flow to study the behavior of the jets, shape of the plume, and penetration of the liquid jet. The liquid fuel aeroramp was found to have better penetration than a single, round jet at 40 degrees. Next, the Sauter mean droplet diameter distribution was measured downstream of the injector. The droplet diameter was found to vary from 21 to 37 microns and the atomization of the injector does not appear to improve beyond 90 effective jet diameters from the liquid fuel aeroramp. At the end, a model of the assembly was designed using Fluent 6.1 and more analytical results were developed.

Keywords*: Simulation, Fuel-Injector, Plasma-Igniter, Aeroramp.*

1. INTRODUCTION

Scramjet combustion is a difficult and daunting task to tackle. Among other problems there is the difficulty in mixing and ignition of fuel, especially hydrocarbons in a supersonic flow. The application of gaseous or liquid hydrocarbon fuels to scramjets has been studied on and off for about 50 years. Researchers at Fairchild, United Technologies, Applied Physics Laboratory of Johns Hopkins University, Air Force Research Labs and others in the US and overseas have contributed to this effort. A few representative examples of relatively recent studies are in References [1] – [6].

A substantial amount of research has been performed in the field of gas injection in supersonic flows. This research has included techniques such as: transverse injection,[7-12], slots,[7,8,13] ramps,[14] and jet swirl, [7,8]. The aeroramp involves an array of angled jets that induces additional vorticity and enhances mixing.

An important component of a supersonic combustion system is the ignition aid. It is difficult to ignite either a gas or liquid hydrocarbon in a supersonic flow. It has been decided to use a plasma torch to overcome these difficulties.

At present, the flight test vehicles for cold-start combustion uses silane as an ignition aid. Silane is a dangerous gas that ignites upon contact with oxygen. Because of the dangers of this setup, it was decided that another solution needed to be explored for cold-start combustion. The next idea was to use JP7 for both cold-start combustion and normal combustion. The concept is to cold-start the engines with liquid JP7 and to circulate the liquid JP7 through the airframe for cooling purposes. Over time, the liquid JP7 would then be heated up due to the flow around the airframe and the liquid would then be cracked into a gas for subsequent combustion.

This gas could then be used as the main combustion source. In order for this to work a combined liquid and gas injection system with an effective ignition aid must be designed.

It was decided that the liquid injection system should be an impinging jet/aeroramp. The impinging jets would help create more atomization of the liquid jets, while the aeroramp induces additional vorticity and mixing. This system would in essence create a liquid fuel aeroramp. The liquid fuel aeroramp consists of an array of liquid jets that are angled downstream and then toed in towards each other based on past research.

2. EXPERIMENT SETUP

The experiments were done in a blow-down supersonic wind tunnel. The tunnel was configured with a convergent-divergent nozzle that resulted in a free-stream Mach number of 2.4. During a representative run the measured free-stream stagnation pressure, and temperature, T, were 345 kPa and 292 K, respectively. Figure 1 shows a sketch of the wind tunnel test arrangement. The typical run time for the tunnel in this experiment was seven seconds.

Analog signals from the pressure transducers and thermocouples were through a National Instruments AMUX-64T multiplexor board to a personal computer via a National Instruments AT-MIO-16XE-50 multifunction high speed analog/digital I/0 board. The AT-MIO-16XE-50 was operated in 32 channel differential mode. The measured data was then recorded using Lab-View software. The tunnel and measurement devices were all controlled and run using Lab-View.

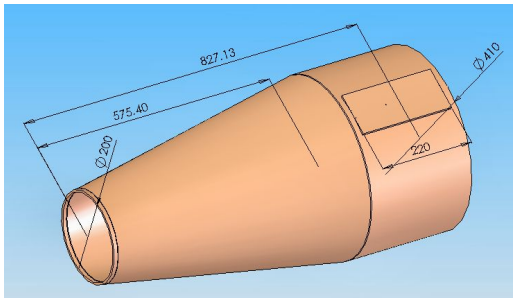


Figure 1 Tunnel setup with injector and plasma torch

The liquid injector was designed by looking at the advantages of impinging liquid jets and combining them with the advantages of an aeroramp.

It was decided that the angles from the gaseous fuel aeroramp should be made the same in the liquid injector and the fuel flow rate should be matched as closely as possible to the earlier gaseous fuel aeroramps in order to take advantage of the improved mixing found there. The liquid injector was designed to have a volumetric flow rate of 1.37 lpm. By fixing these requirements, the number of holes, jet diameter, and angles were determined. The liquid injector consisted of two holes, each 0.533 mm in diameter. Two holes were used in the liquid fuel aeroramp array rather than the nine or four holes used for gaseous fuel aeroramp arrays because the higher density of liquids which leads to very small holes. These holes were spaced 4.34 mm apart ($s/d_{eq} = 5.76$), while being angled downstream 40 degrees and toed in 60 degrees. The spacing of the liquid jets was based off of direct photographs of the liquid aeroramp. Figures 2 and 3 show sketches and a picture of the liquid injector used in this experiment:

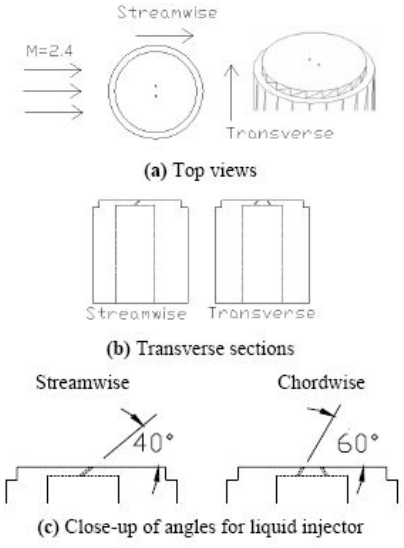


Figure 2 Liquid injector layout

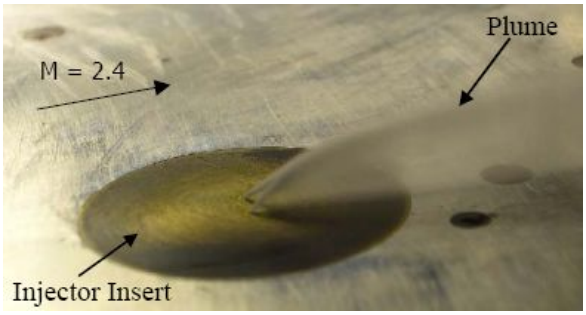


Figure 3 Liquid injector in Mach 2.4 flow

In order to inject the liquid into the supersonic tunnel, an injection system was needed, and a pressurized system was chosen. The pressurized system consisted of a liquid tank, used to hold reserve fuel, and a pressurizing gas which was used to force the liquid out of the tank as shown in Figure 4.

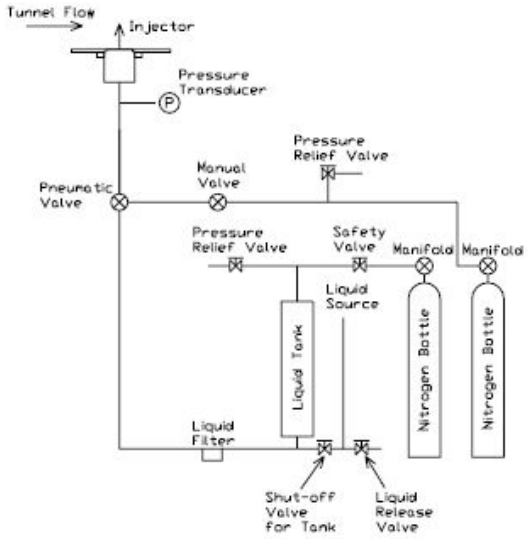
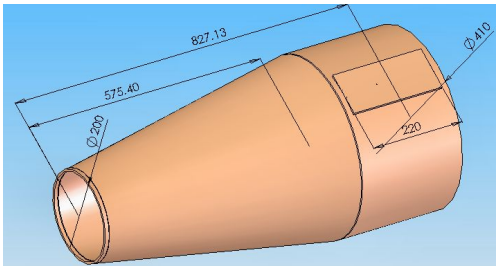


Figure 4 Liquid injector setup

3. NUMERICAL TREATMENT OF THE EXPERIMENT

a. Input Data for the Numerical Model

The CAD model of the experimental setup is given in the figures below, with all the main dimensions:



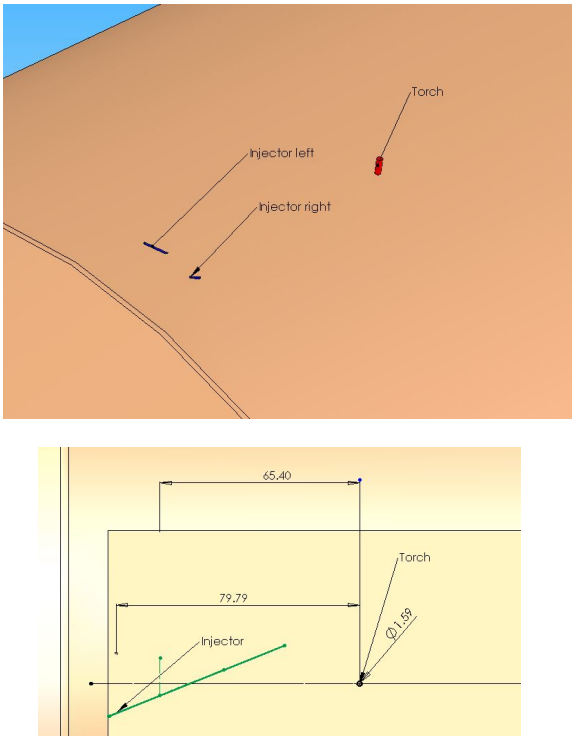


Figure 4 The CAD Model

The inlet diameter of the wind tunnel has 200 mm and the outlet has 400 mm, the total length being 830 mm. On one side of it the injection and the plasma torch areas were modeled, the injectors having the above established angles to obtain the aeroramp effect, the distance of 65.4 mm (on the inner side of the wind tunnel; 79.79 mm on the outer side).

In order do simulate the fluids paths, the "negative" of the above model was obtained:

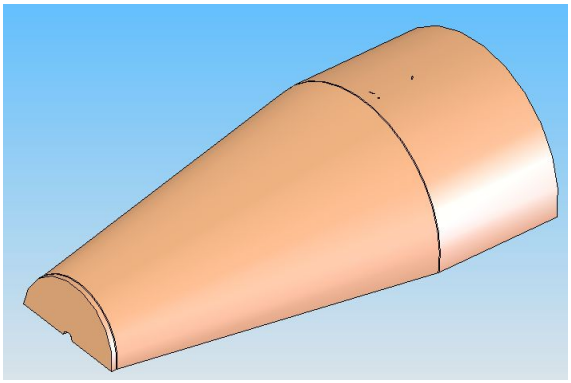


Figure 5 The fluid paths (the "negative" model)

Based on the negative model, the Finite Element Grid was developed, comprising *90,168* tetrahedral cells. There was modeled only half of the structure in order to spare some computer memory and to ease the computing process. The missing part was modeled by imposing the proper symmetry boundary conditions.

There were defined the boundary conditions as follows:

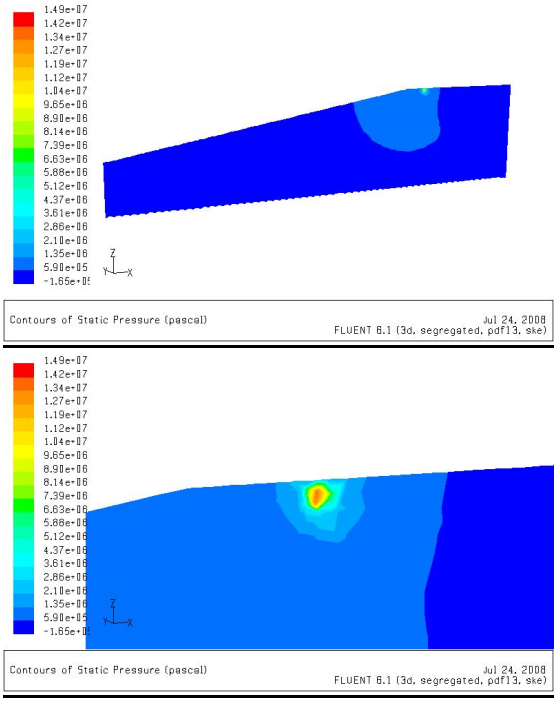
- The air-inlet zone having a hydraulic diameter of *0.2 m*, the temperature of 300^0 *K* and the velocity magnitude of the air coming from compressor, *2.4 Mach*.
- The fuel-inlet (Kerosene) injection zone model, two plain orifice atomizers being defined so that the fuel jets are simulating the aeroramp effect. The fuel temperature was set at 300^0K, the flow rate at 0.0143 kg/sec (the density of the fuel was considered 800 kg/m^3), the orifice inner diameter was set at 0.000533 m and the length at 0.005 m. The number of particle streams was set to 20 and the turbulent dispersion was selected to be the stochastic model.
- The outlet zone modeling the outlet of the wind tunnel was set to *0.4 m*, the backflow total temperature of 2000^0 *K* .
- The plasma injector was modeled with the orifice of 0.00159 mm in diameter and 25 slpm mass inlet flow of hot air at $2000^{\ 0}$ *K* which triggered the combustion reaction.

b. Numerical Predictions

The program, after 300 iterations, provided the results discussed below. The results and graphs are defined on a plane which passes thru one of the injectors. The analysis is done for the full extension of the flame and in equilibrium conditions.

Pressure

The maximum static pressure (Fig.6) was found to be *1.49e7 Pa* in the injection zone, and, as one may be seen on the graphic, it sharply decrease toward the inlet and the outlet zones of the wind tunnel.



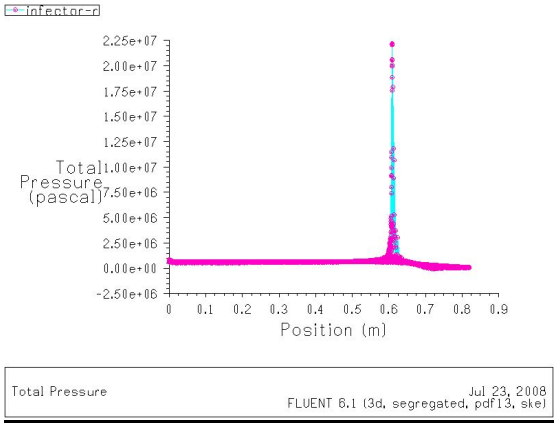


Figure 6 The pressure distribution

Velocity

In the injection zone, the velocity of the fluid (Fig.7) sharply augments to *17900 m/s,* and then decreasing to an average of *3000 m/s* in the outlet zone.

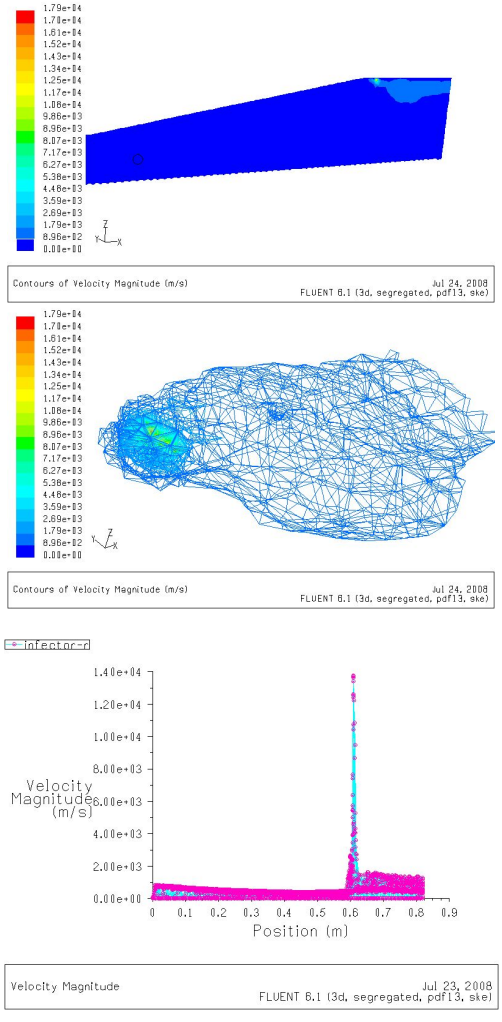


Figure 7 The velocity distribution

Temperature

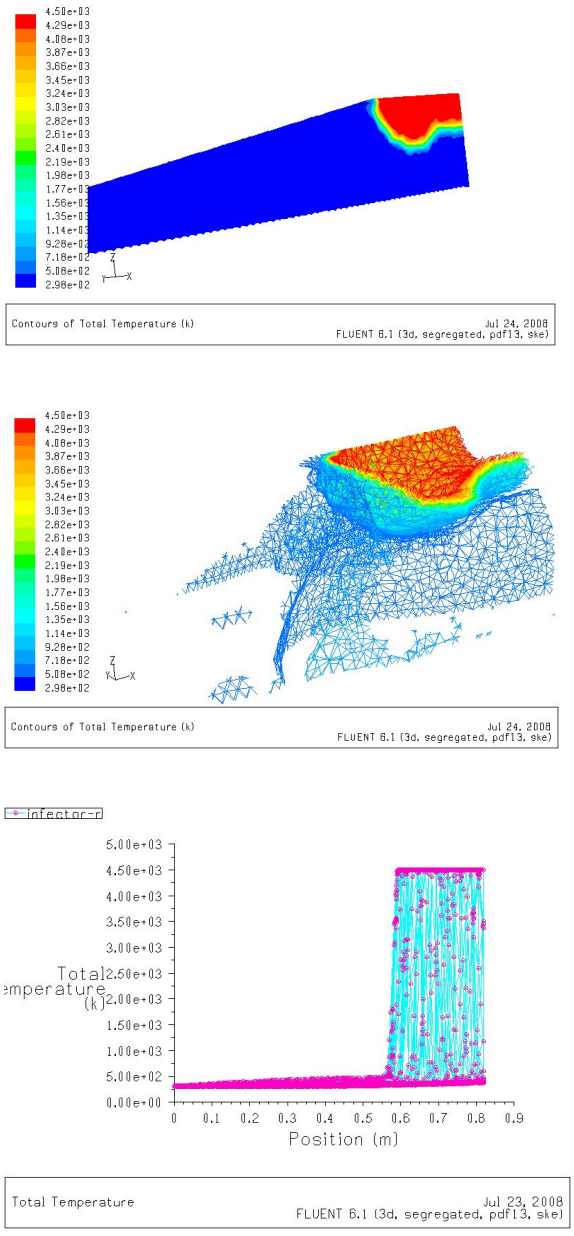


Figure 8 The temperature distribution

As it was expected, the maximum temperature was calculated to be reached in the injection zone and toward the outlet zone where the value is 4500^{0} *K.* The distribution of temperature is closely mimicking the distribution of velocities, the fuel having the maximum dispersion in this area.

Enthalpy

The maximum enthalpy (Fig.9) was calculated in injection zone, reaching a value of *2.35e6 J/kg*, the rest of the domain having an average of *3.31e16 J/kg*.

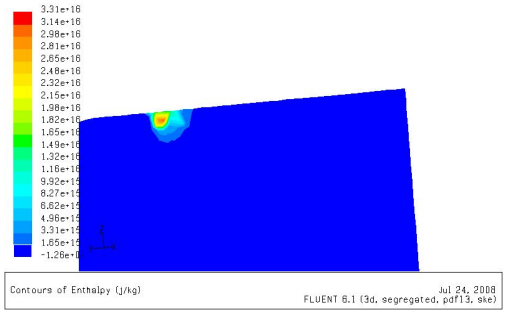


Figure 9 The enthalpy distribution

Density

The lowest densities are reachable in the injection zone and toward the outlet, where the average values are computed to be 6.47e-2 kg/m^3, in the rest of the domain the values spanning between 1...1.18 kg/m^3.

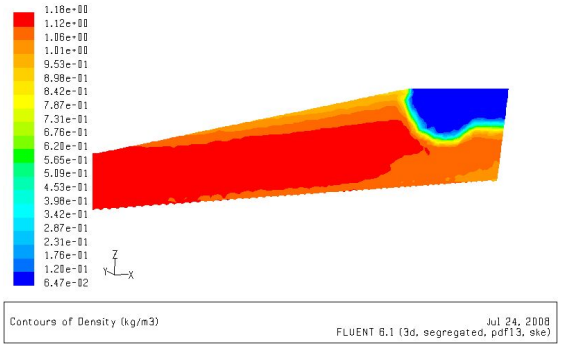
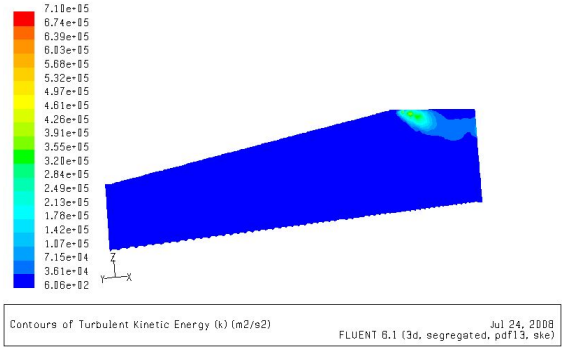


Figure 10 The density distribution

Turbulent kinetic energy

The maximum turbulent kinetic energy (Fig.11) is reachable in the injection zone (*7.1e5 Km^2/s^2*) and in the zone toward the outlet from the wind tunnel.



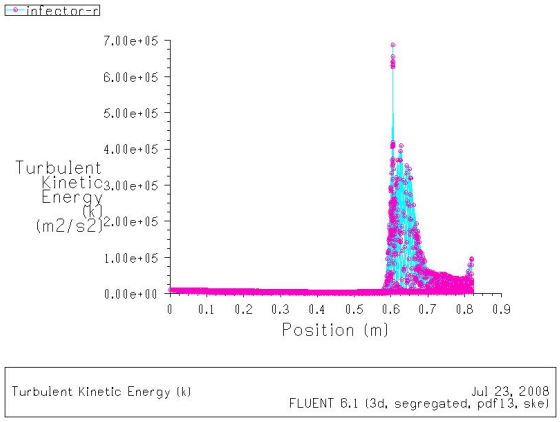


Figure 11 The turbulent kinetic energy distribution

Mean mixture fraction

The mean mixture fraction, which is so important for the description of the combustion process, has, as expected, the highest values in the injection zone (142).

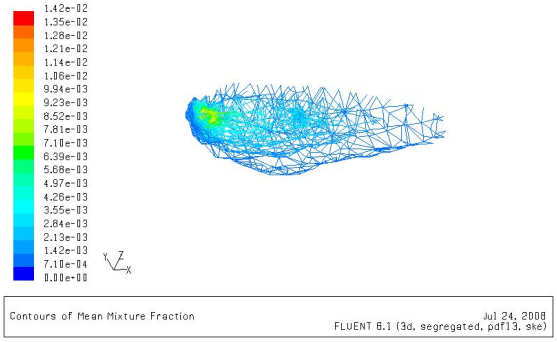


Figure 12 The mean mixture fraction distribution

Discrete Phase Mass Source

The discrete phase mass source distribution is useful to visualize the distribution of mass in the injection zone, where the maximum value is *0.01 kg/sec.*

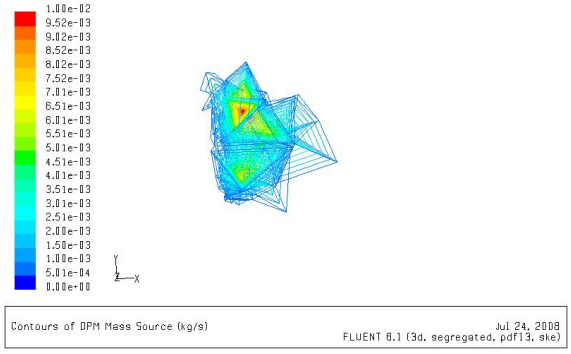


Figure 13 The Discrete Phase Mass Source distribution

Discrete Phase evaporation rate

The evaporation rate has the biggest values in the injection zone, where it reaches *1e-2 kg/sec*.

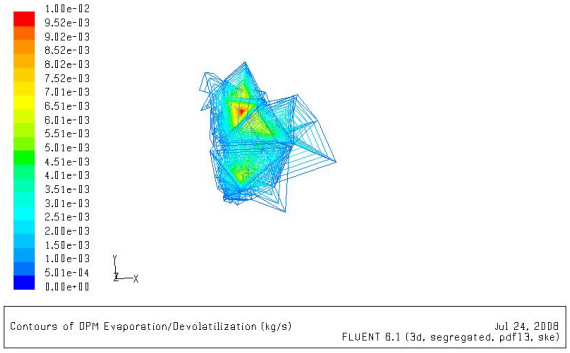


Figure 14 The Discrete Phase Mass evaporation rate distribution

CH_4 Mole fraction

The mole fraction of CH_4 is maximum, as it was expected (Fig.15), at the injection zone (value *8.54e-14)* and shortly after the reaction zone.

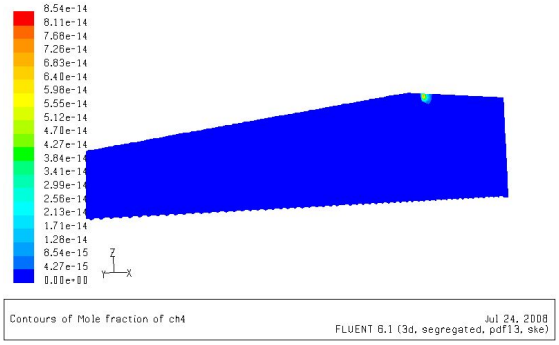


Figure 15 The CH4 Mole Fraction distribution

CO_2 Mole Fraction

The maximum values of the CO_2 mass fraction (Fig.16) were determined on the injection areas, the value being *2.45e-4,* in the rest of the domain varying between 0 to *1.22e-5.*

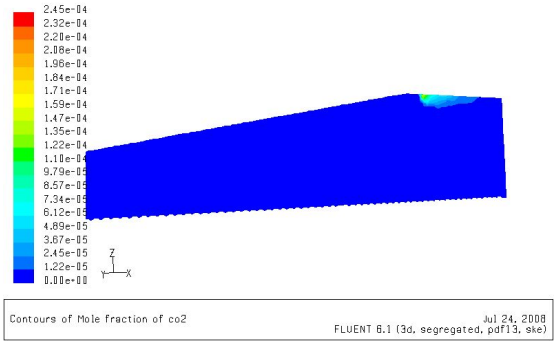


Figure 16 The CO2 mole fraction distribution

O_2 Mass Fraction

The O_2 mass fraction distribution (Fig.17) has, as expected, an opposite shape as the CO2 distribution, being the lowest in the reaction zone (*7.95e-13*) and the highest in the rest of the domain (*0.21*).

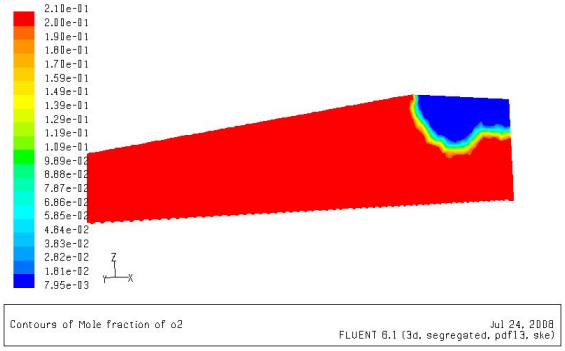


Figure 17 The O2 mole fraction distribution

H_2O Mass Fraction

The maximum for the H_2O distribution (Fig.18) is reached in the injector's area where the reactions are the most intense (*1.49e-5)* , in the rest of the domain being spanned between to *0* to *7.43e-7.*

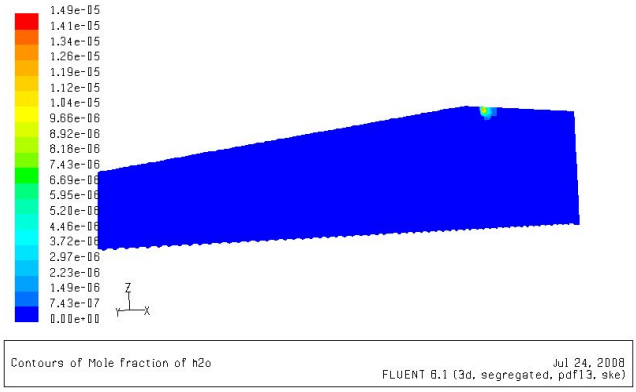
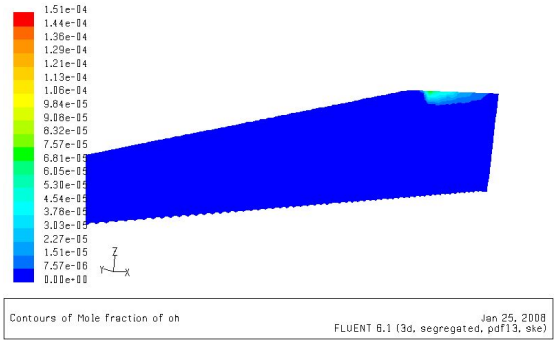


Figure 18 The H2O mole fraction distribution

OH Mass Fraction



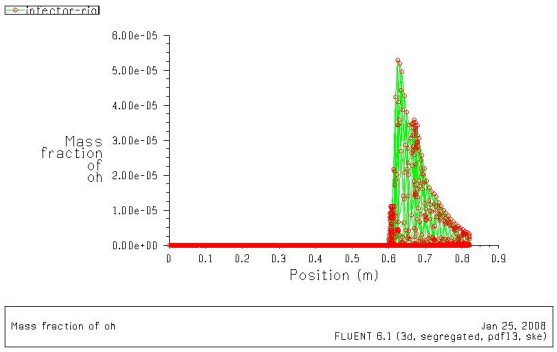


Figure19 The OH mole fraction distribution

Since the OH presence is the sign that the combustion process takes place, the maximum mole fraction (*6e-5*) is found in the injection zone and toward the outlet zone of the wind tunnel.

4. CONCLUSIONS

Conclusions from the experiment can be summarized. First, the aeroramp liquid injector functions as originally intended. Good penetration and atomization with a weak interaction shock was documented. Second, the liquid fuel flow rate has an effect on the height and width of the bright plume according to the OH wavelength filtered photographs. As the liquid fuel flow rate increases, the bright plume increases in height by 30% and increases in width slightly (2%). While, a decrease in liquid fuel flow rate resulted in an increase in height by 9% and an increase in width by 10%. Thus, as the liquid fuel flow rate varies around the baseline the width and height of the bright plume appear to always increase. This could be explained by noticing that the shape of the bright plume changes as the liquid fuel flow rate varies. Perhaps anode erosion during a test series also plays a part in this variation. The direct photographs of the liquid injector also show that the liquid fuel flow rate has an effect on the bright plume. Third, from the OH wavelength filtered photographs it was also shown that the bright plume appears to decrease in width by 9% and increase in height by 22% when the plasma torch is set at a lower power setting (1909 W). Fourth, when air is used as the torch feedstock, instead of nitrogen, the bright plume can increase by as much as 19% in width and 17% in height for a liquid fuel volumetric flow rate of 1.1 lpm and plasma torch power of 2516 watts for the nitrogen feedstock and 3336 watts for the air feedstock. Part of this increase in height and width can be attributed to the fact that the air feedstock would not run very well around 2500 W. Fifth, it was found that the plasma torch was much more consistent at around 3300 watts using air as the feedstock. It was also found that the height and width of the bright plume decreased slightly (2%) as the fuel flow rate increased when using air as the torch feedstock. Last, it is difficult to determine if any combustion is present in this cold-flow, low-pressure conditions based on direct photographs or OH filtered photography alone. One concern here is that we are not seeing combustion, but rather a large amount of scattering of the bright light from the plasma torch by the mist created from the liquid fuel injector. Of course, it would be surprising if much combustion did occur under these cold-flow, low-pressure conditions. Testing at hot-flow conditions is needed.

Regarding the numeric treatment of the experiment, the authors feel to have developed and presented in this paper an advanced numerical tool for combustion processes' prediction. The still today highly complex task of reliably predicting combustion processes, mostly the combustion in the high speed/supersonic air streams, has been approached with an advanced simulation strategies and modeling procedures.

The numeric predictions showed a good correlation with the experimental results, the shape of the combustion "cloud" and the OH mole fraction distribution being closed to the experimental ones.

The entire palette of the results presented above, may be and they are critical for establishing the flow topology, strength of the structure, size, the flame position etc. and the final shape and optimization of any jet engine project based on such combustion system.

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FLUID-STRUCTURE INTERACTION IN A SUBMARINE STRUCTURE UNDER BLAST LOADING

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ABSTRACT

Recently, numerous flexible structures have been employed in various fields of industry. Loading conditions sustained by these flexible structures are often not described well enough for engineering analyses even though these conditions are important. Here, a Submarine Class Seawolf, which is subjected to an explosion, is analyzed. To solve this kind of problem it is mandatory the blast loading and the structural response to be analyzed together due to the interaction between the flexible structure and the dynamic pressure loading. In this paperwork, the dynamic loadings imposed on the exterior sides of the Submarine structure due to the underwater blasts and the resulting dynamic responses were studied. A numerical method of an iterative Fluid-Structure Interaction using Computational Fluid Dynamics and Computational Structural Dynamics was employed to simulate the blast wave propagation outside the structure and to calculate the structure response on it. The rich palette of results shown below are thoroughly investigating the fluid parameters and structure loading/response, all this by using the software Ansys 9.

Keywords: *FEA, Fluid Structure Interaction, Submarine, Underwater, Blast.*

1. INTRODUCTION

Seawolf-Class submarines were designed to operate autonomously against the world's most capable submarine and surface threats. The primary mission of the Seawolf was to destroy Soviet ballistic missile submarines before they could attack American targets. In addition to their capabilities in countering enemy submarines and surface shipping, Seawolf submarines are suited for battlespace-preparation roles. It incorporate many of sophisticated electronics produces enhanced indications and warning, surveillance, and communications capabilities. These platforms are capable of integrating into a battle group's infrastructure, or shifting rapidly into a land-battle support role.

Figure 1 Submarine Seawolf Class

The Seawolf has the highest tactical speed of any US submarine. Much of the design effort was focused on noise reduction, and it is expected that the fully coated boat will restore the level of acoustic advantage which the US Navy enjoyed for the last three decades. The Seawolf's propulsion system makes it ten times quieter over its full range of operating speeds than the Improved-688 class and 70 times quieter than the initial generation of Los Angeles 688-class submarines.

The Seawolf's quieter propulsion system will also enable it to have twice the tactical speed as the I-688. Tactical speed is the speed at which a submarine is still quiet enough to remain undetected while tracking enemy submarines effectively. Overall, the Seawolf's propulsion system represents a 75-percent improvement over the I-688's - the Seawolf can operate 75 percent faster before being detected. It is said that SEAWOLF is quieter at its tactical speed of 25 knots than a LOS ANGELES-class submarine at pier-side.

A *coupled-field analysis* is an analysis that takes into account the interaction (coupling) between two or more disciplines (fields) of engineering. A piezoelectric analysis, for example, handles the interaction between the structural and electric fields: it solves for the voltage distribution due to applied displacements, or vice versa. Other examples of coupled-field analysis are thermal-stress analysis, thermal-electric analysis, and fluid-structure analysis. Some of the applications in which coupled-field analysis may be required are pressure vessels (thermal-stress analysis), fluid flow constrictions (fluid-structure analysis), induction heating (magnetic-thermal analysis), ultrasonic transducers (piezoelectric analysis), magnetic forming (magneto-structural analysis), and micro-electromechanical systems (MEMS).

A numerical method of an iterative Fluid-Structure Interaction (FSI) using CFD and CS-Dynamics was employed to simulate the blast wave propagation outside the flexible structure of the Submarine, and to calculate the dynamic loads on the flexible structure. For the numerical simulation using a commercial program, Ansys 9, the dynamic flow field outside the structure

was solved numerically to simulate the propagation of the explosive wave over the structure.

2. THE BLAST LOADING

Historically the analysis of explosion phenomena has been studied either through simplified analytical or empirical models, or using intensive numerical simulations involving computer technologies.
Due to an explosion's potential threat to military targets, much detailed work on explosive loading is inaccessible. External explosions are divided into three types: free airblasts (underwater-blasts), airblasts, and surface (or mine) blasts. The free airblast is an explosion that occurs sufficiently above a structure that the shock wave due to the explosion hits the structure before it interacts with the ground surface. In the airblast, the interaction with the ground (sea bottom) surface is considered for the shock wave. In the surface blast, an explosion occurs at or near the ground surface so that the shock wave is instantly reflected and strengthened by the ground surface.

When a shock wave developed by one of the three types of explosions hits a structure, it is reflected and magnified by the structure, depending on the incident angle between the moving direction of the wave and the surface of the structure. Blasts can impinge on a structure either normally or obliquely. In the case of oblique reflection, an event known as Mach reflection can occur, in which the incident and reflected shock waves are joined by a third shock wave called the Mach stem. The pressure imposed on the surface of the structure right after the shock wave is reflected is called the reflected pressure (*i.e.*, blast loads on the structure due to the explosion). This reflected pressure is compared with the incident (or side-on) pressure that is defined when the incident angle is 0°, *i.e.*, αB in Figure 2. The reflected pressure is always higher than the incident pressure at the same distance from the origin of the explosion , with the highest difference at an incident angle of 90°. After impingement, the blast is diffracted around the structure. The pressure decays with distance from the explosion, and the form of the loading becomes more complex as the shock wave engulfs the structure.

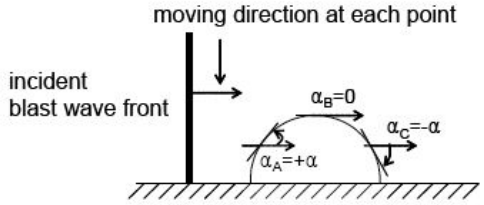


Figure 2 Definition of angle of incidence, α, with positive sign countclockwise

The blast load imposed by an external explosion on a structure is generally described by time-varying pressure profiles at selected locations over the whole structure. The profiles usually have two phases: (i) positive phase, *i.e.*, overpressure period – a sudden rise in pressure (called a peak overpressure) above the pressure (called the reference or ambient pressure) before the explosion, then a quick decrease to the reference pressure, and (ii) negative phase, *i.e.*, under-pressure period - a continuing slow decrease below the reference pressure, then an increase over the reference pressure. In most blast studies, only the overpressure profile is considered.

When the rigid or flexible structures are placed under the dynamic loading condition such as airblasts, the response depends on the duration of the loading, the peak load, and the shape of the pressure pulse.

There have been many studies involving explosive loads on plates. The failure mechanism may involve tension, shear, or a combination of tension and shear. The effects of the distribution and magnitude of the loading were examined. For small impulses, bending and shear resistance are important, whereas membrane stretching resistance dominates for large loads. Two main failure modes are described: one involves tensile necking at the outer edge of the loading area, and the other involves fracture at the clamped boundary
An explosion, *i.e.*, the rapid propagation of blast waves, is created by the sudden and violent release of energy in the gaseous products of detonation and this blast wave propagation causes the ensuing sharp rise in the pressure of the surrounding aero or hydro medium. When this blast wave propagations collide and then reflect or pass over a structure, the structure sustains the similar pressure loads varying over a very short time which can be represented by blast loadings, *i.e.*, time histories of pressure change at points caused by the propagation of an explosive blast waves over the points. This blast loading can be shown quantitatively by a pressure profile as shown in Figure 3.

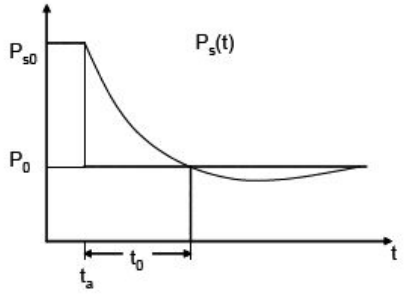


Figure3 A general pressure profile, caused by the propagation of an explosive blast wave

As shown in Figure 3, these pressure profiles usually have two phases: (i) positive phase, and (ii) negative phase. In most blast studies, the positive phase has been considered to be the more important of the two phases and has been the general concern in explosion-related engineering problems. This positive phase is usually known as an overpressure profile, and numerous model equations have been proposed for it. In the present work, the overpressure profile, Equation (1), which fits experimental results with a curve, is used as the basic profile equation:

$$P = P_{s0}\left(1 - \frac{t - t_a}{t_0}\right)e^{\frac{-(t-t_a)}{t_0}} \quad (1)$$

where P_{s0} is a peak overpressure, t_0 is duration of the positive overpressure on the wall, t_a is the time when a blast wave arrives at a measuring point, and P_0 is ambient (or reference) pressure.

When a blast wave travels parallel to the surface, the initial highest overpressure is called a side-on or incident peak overpressure. Since a side-on overpressure is caused by an undisturbed blast wave, to measure this side-on overpressure the pressure probe hole should be placed on the surface parallel to the moving direction of the blast wave at the same point. When a blast wave is disturbed by a structure, the property of a peak overpressure at a point on the structure should be adjusted from a side-on peak overpressure which is measured at the same distance as the distance from the origin of an explosion to the measuring point on the surface in accordance with the incident angle at the point.

When a blast wave front is reflected by the surface, the peak overpressure is much higher. Therefore, this windward-side overpressure has been called "reflected overpressure", and much research has investigated this reflected overpressure. When a blast wave front is passing over the leeward side, the blast wave is diffracted or expanded, and the leeward-side peak overpressure is reduced from the side-on peak overpressure.

In the usual process classified as an explosion, energy is released in a fairly quick time and in a small volume, and some properties of a blast loading are strongly affected by both sources and manner of explosives. The general properties of an explosion source are described by its total energy, E, its energy density, E/V (V is a volume), and the rate of energy release, *i.e.*, power, as listed in Table 1.

Table.1.Properties of various condensed phase explosives and conversion factor of equivalent TNT magnitude

Explosive	Mass Specific Energy (kJ/kg)	TNT Equivalent	Density (Mg/m^3)	Detonation Velocity (km/s)	Detonation Pressure (GPa)
Pentolite (50/50)	5110	1.129	1.66	7.47	28.0
TNT	4520	1.000	1.60	6.73	21.0
RDX	5360	1.185	1.65	8.70	34.0
Comp. B	5190	1.148	1.69	7.99	29.5
HMX	5680	1.256	1.90	9.11	38.7

In this paperwork a Pentolite (50/50) charge explosion was considered and the detonation pressure was deemed to be P_{s0} =28 GPa with a variation law in time given by the Equation (1). The time interval for simulation was t=0.1 sec, t_a =0.054 sec, t_0 =0.08 sec, all this derived from the distance between the blast and structure aprox. 100 m, pressure wave speed in sea water 1833 m/sec.

3. THE FEA MODEL

The first step in obtaining the FEA model of the Submarine was to generate the simplified CAD geometry with the dimensions given above, using the software SolidWorks:

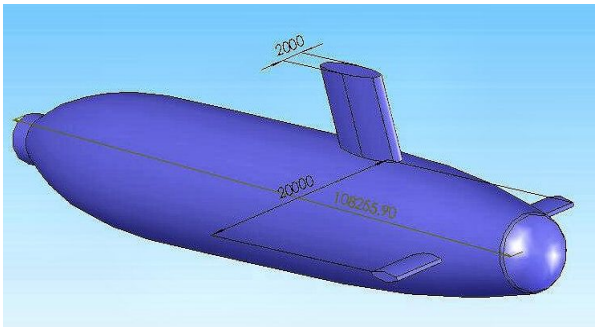


Figure 4 The CAD model of the submarine

Next the fluid domain was obtained from which half of the submarine model was 'carved out' so that the result would be the simulation of a finite fluid domain having at one of its frontier a surface mimicking the shell of the submarine. The CAD model was conceived to be only half in order to save computational resources by imposing to the final FEA model the proper symmetry boundary conditions.

The underwater blast was simulated by a quarter sphere situated on aprox. 100 m above the submarine, as seen in the figure below:

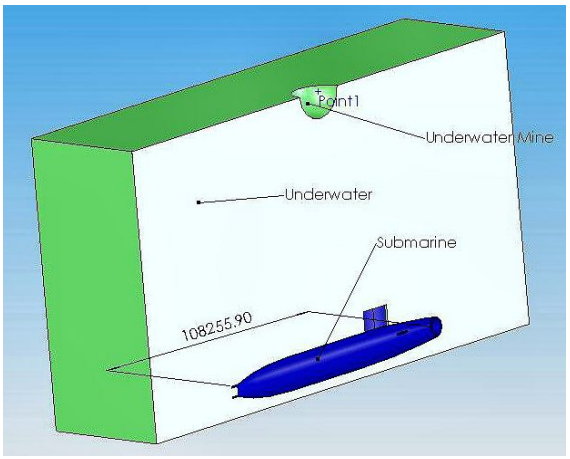


Figure 5 The CAD model of the fluid and solid domain

The so obtained geometrical model was then exported in the Ansys 9 software which leads to the geometry shown below:

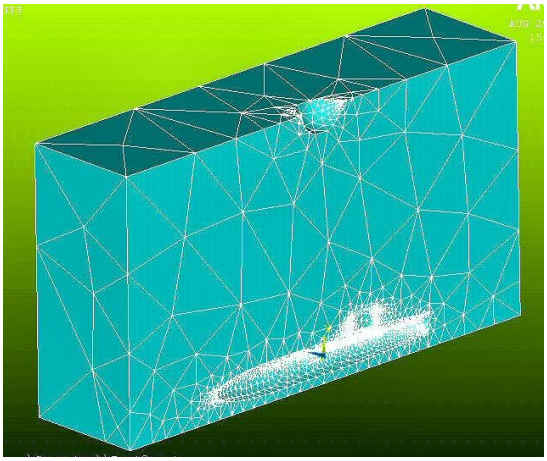


Figure 6 The FEA model

The fluid domain was populated with 3D Fluid 142 finite elements allowing morphing and the solid with Shell 63 type with the thickness of 4". Between them a FSI interface was established in order to transfer the loads and displacements in both directions.

The main load imposed to the model was the pressure varying in time as per the Equation (1) which, modeled via a pressure function in FEA model, looks like below:

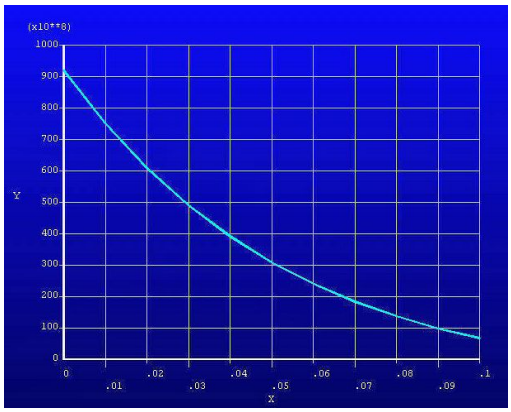


Figure 7 The time varying blast pressure imposed to the model

At time 0 the pressure magnitude is 0.9e11 Pa.

The material for the solid part was selected as being construction steel with E=2.1e11 Pa and Poisson's coefficient 0.3.

The fluid material was the sea water having the density of 1012 kg/m^3 and viscosity 4.6e-4 kg sec/m.

The FEA was done in transient mode both for the solid and the fluid part of the model, the time for the 10 iterations imposed within the domain 0…0.1 sec.

4. NUMERICAL PREDICTIONS AND DISCUSSION

First of all such a blast is impinging the water around the blast wave with a tremendous velocity. The FSI solver calculated the velocity for all the iterations, from which we picked as exemplification the ones of the starting and end of the calculation time interval.

The calculated maximum velocity of the fluid is quite near the blast front, the maximum of 19.366 m/sec was calculated for the iteration no.1 at 0.01 sec after the blast, and at the end of iterations increasing at 26.161 m/sec.

More interesting for simulation is the pressure wave front which is time varying within the interval 0…0.1 sec.

At time 0, the pressure wave is spreading throughout the fluid domain as seen in the figure 9 below:

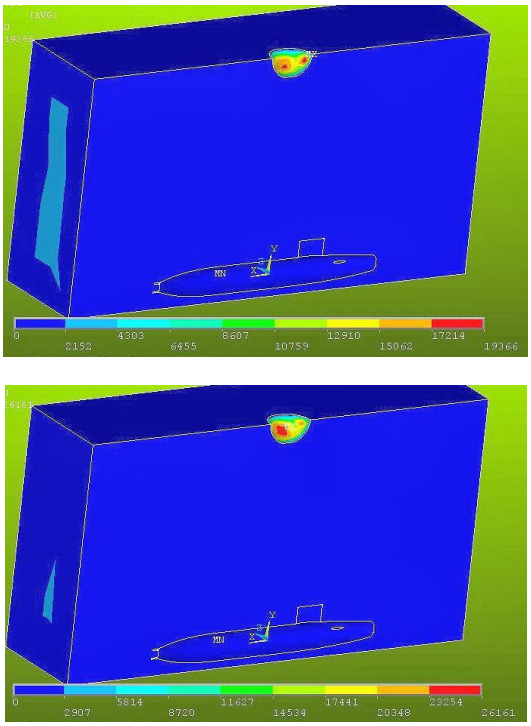


Figure 8 Fluid velocity at 0.01 and 0.1 sec after the blast

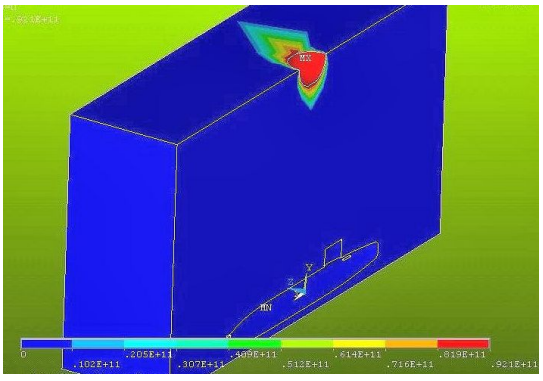


Figure 9 Pressure wave at time 0

It may be noticed that the pressure in the vicinity of the blast front is 0.9e11 Pa, slowly decaying in its neighborhood.

At the middle of the calculation interval (0.05 sec) the pressure wave is leaving the domain through its

boundaries and a "reverse/negative phase pressure" starts to act in the opposite direction amplified, reaching a top value of -.019e-15 Pa:

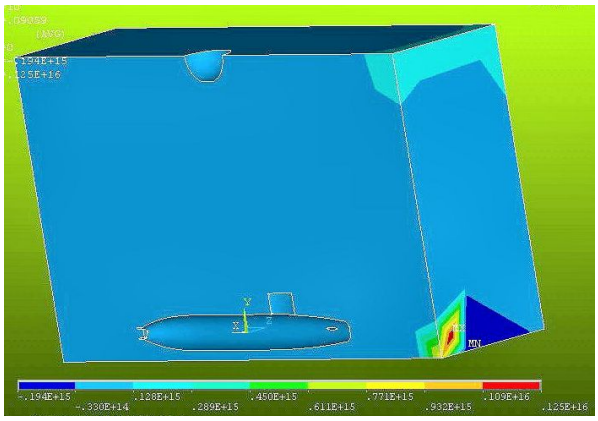


Figure 10 Pressure wave at time 0.05 sec

At the end of the calculation interval (0.1 sec.) the shockwave looks as in figure 11.

In order to evaluate the impact of the shockwave of blast over the structure, 4 reference points were established, at the top, middle, front and back of the submarine, as in the figure 12 below.

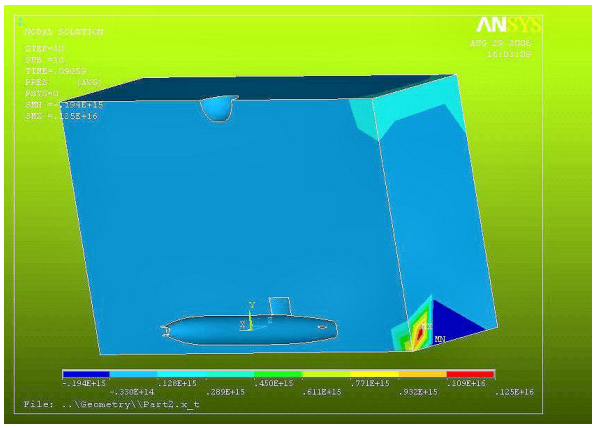


Figure 11 Pressure wave at time 0.1 sec

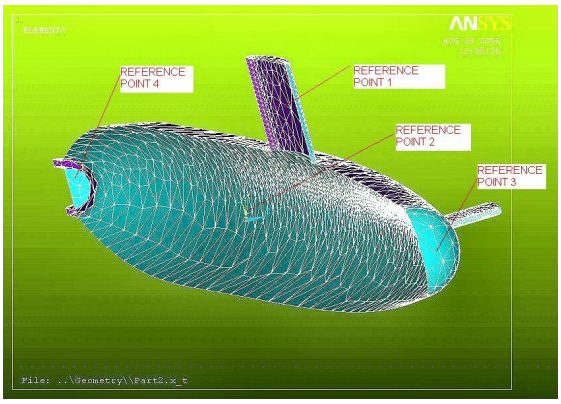


Figure12 The reference points over the structure

For the Reference point number 1 which is in the top of the structure, the pressure variation curve is as follows:

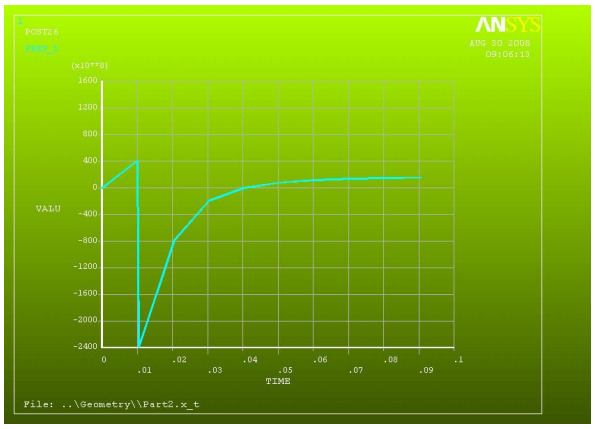
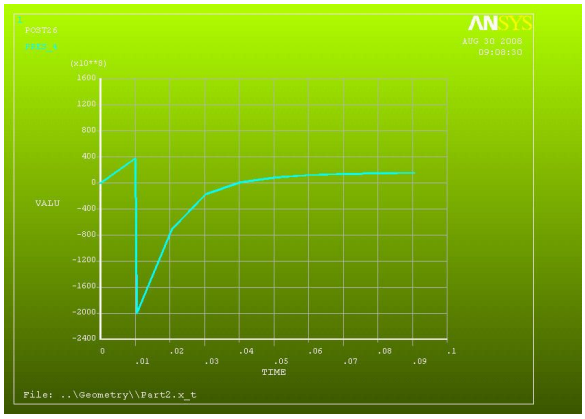


Figure 13 The pressure variation in time of the shockwave on the reference point no.1

This numerical result is in very good accordance with the experimental knowledge, that says in the underwater blasts not the direct shockwave is most dangerous, but the opposite direction wave (negative/reflected phase) which is several times grater.

This opposite pressure is generated by the reflected shockwave on the sea bottom or by the structure. In the graphic is clearly shown that the direct shockwave (4e10 Pa) last until 0.01 sec, after which a sudden opposite shockwave is developing into the fluid domain (-24e10 Pa) which is 8 times the magnitude of direct shockwave and almost 3 times the pressure of initial blast. This is due to the reflection on the walls of the fluid domain or the structure. The reflected pressure is always higher than the incident pressure at the same distance from the origin of the explosion, with the highest difference at an incident angle of 90°.

The same situation is valid for the other 3 reference points, with very small variations pertaining the position in report to the direction of the wave.



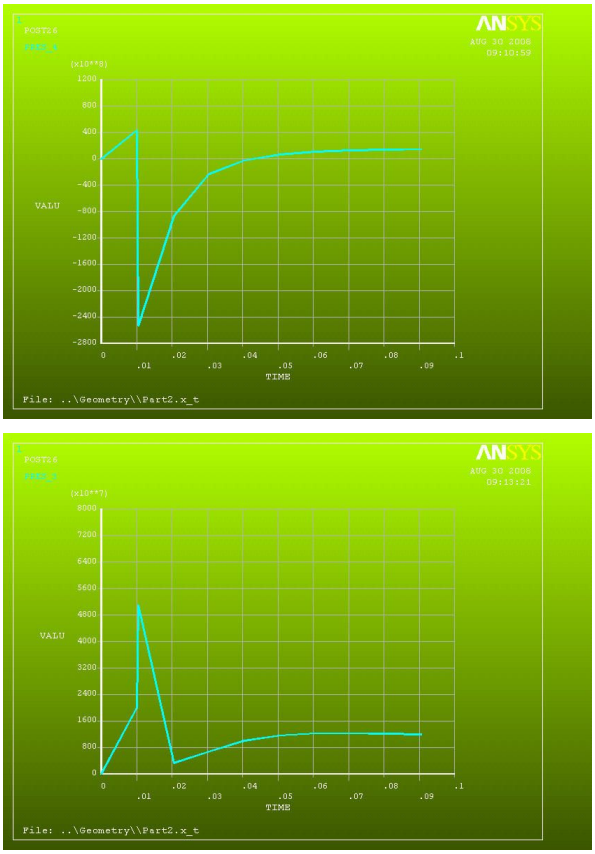


Figure 14 The pressure variation in time of the shockwave on the reference point no.2,3,4

Such o tremendous pressure exerted on the structure is merely crushing it. The destruction of the structure is beyond any doubt since the program is calculating stresses several times above the ultimate toughness of the material:

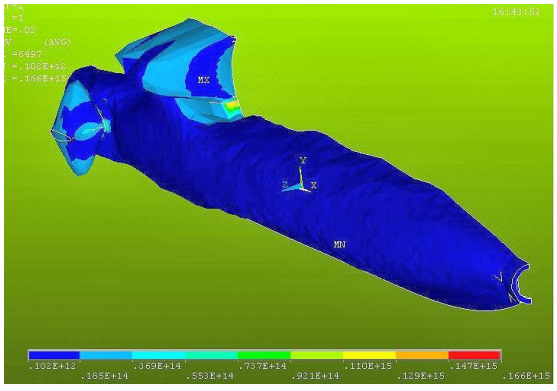


Figure 15 The von Mises equivalent stresses in the structure at time 0.02 sec

The average von Mises equivalent stress calculated for the structure is 0.102e12 Pa. The maximum value is 0.166e15 Pa, which is far beyond any known material capability to bear.

For the calculation time 0.07 and 0.1 sec, the stresses distribution in the structure are given below:

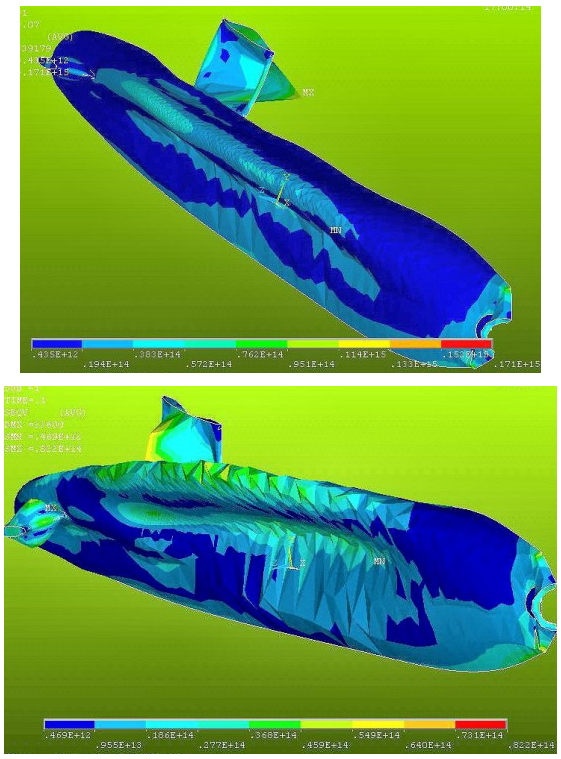


Figure 16 The von Mises equivalent stresses in the structure at time 0.07 and 0.1 sec

At the established reference points 1;2;3;4, the variations in time of those stresses are given below:

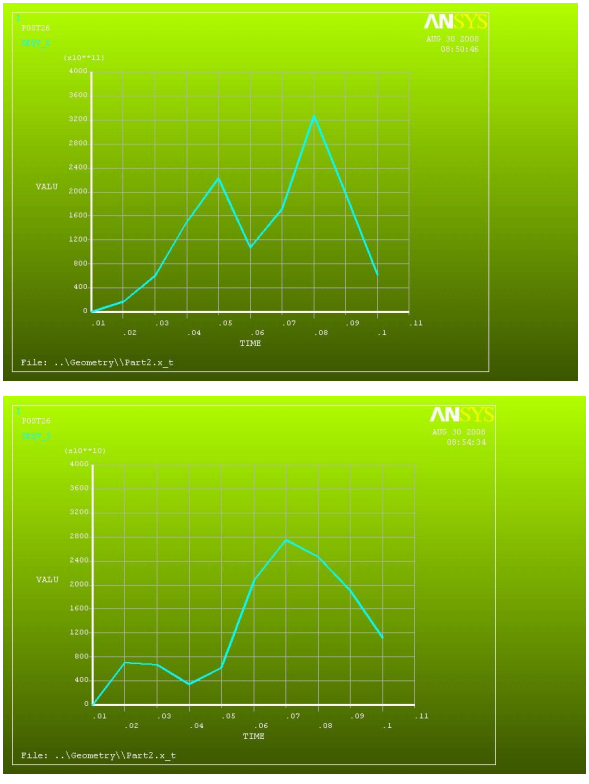


Figure 17 The von Mises equivalent stresses in the structure variation in time at reference points 1;2;3;4

Since is obvious that the structure is disintegrating, the von Mises equivalent Strains are pure for information, their physical meaning being no longer relevant:

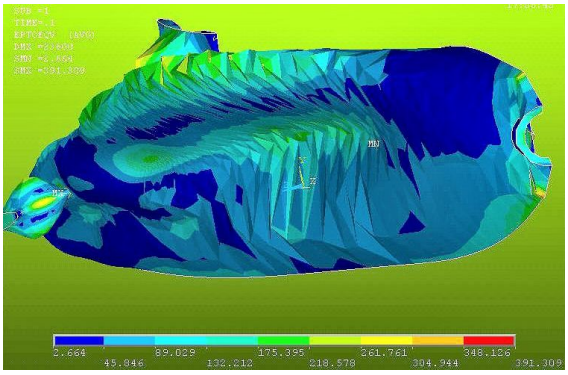


Figure 18 The von Mises equivalent stains in the structure at time 0.1 sec

5. CONCLUSIONS

The paperwork is circumscribed to the "numerical experiments" family of works, being obvious that nobody (yet) made such expensive and costly experiments in real world like blasting a submarine underwater and measure the effects. It is meant to underline the new frontiers and the new domains of FSI algorithms which may accurately describe even events beyond any possibility to experiment.

Instead, the numerical modeling of the underwater blast and the structural response and the calculation of pressure loading on the deforming structure showing the FSI effect could be extended and applied to various design problems , the well-established numerical process considering the FSI approach shows many useful features which may be engaged in this type of problem solving. This method can be extended to various design problems such as non-linear aero-elasticity problems, especially for morphing wings, low Reynolds number unmanned air vehicles (UAVs) or structural analysis in which unsteady response is a dominant effect.

This application of the FSI analysis is also a good example for taking advantage of parallel processing since the flow field domain can be divided by the flexible structure and so the application of parallel processing for the divided flow fields can save the computational time needed for the iterative FSI analysis.

6. REFERENCES

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THE EXERGY ANALYSIS FOR MARINE DIESEL ENGINES USING BIODIESEL AS FUEL

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ABSTRACT

Ships are important air pollution sources since on board high powered engines usually run with heavy fuels. There are two types of engines on board the ships: main engines and auxiliary engines. Usually, the main engines are a slow speed or medium speed diesel engine. The awareness of energetic and environmental problems pushed investigations towards the search of alternative fuels.

This paper analysis chemical and physical properties of biodiesel. An exergy analysis carried out on diesel engines using this kind of alternative fuel, for a power rating from 60–480 kW, enables to evaluate quantitatively the causes of thermodinamical imperfections.

Keywords: *biodiesel, engine, exergy analysis.*

1. INTRODUCTION

Diesel engines belong to the family of internal combustion engines. A diesel engine is a kind of heat engine that use the internal combustion process to turn the energy stored in the chemical bonds of the fuel into useful mechanical energy. It happens in two stages. First, the fuel burns (reacts chemically) and releases energy under form of heat. Due to the heat, gasses trapped in the cylinder expand moving the piston. This reciprocating motion of the piston is then turned into rotational motion by the crankshaft.

In order to convert the chemical energy of the fuel into useful mechanical energy, in internal combustion engines must take place the following events: intake, compression, power and exhaust. Different kind of engines depends on the timing of these events and how they occur Diesel engines fall into one of the types: two–stroke or four–stroke cycle engines. The word "cycle" refers to any operation or series of events that repeats itself. When speaking about four–stroke cycle engine asks four strokes of the piston (intake, compression, power and exhaust) to complete one full cycle. That is why, are needed two rotations of the crankshaft, or 720^o of crankshaft rotation (360^ox2) to complete one cycle. In the case of the two–stroke cycle engine, above mention events take place during only one rotation of the crankshaft, meaning 360^o.

From many points of view, shipping presents environmental advantages. The infrastructure requirements are very small compared to land–based modes and comparatively a small amount of energy is asked for the ship propulsion. Marine engine pollutants contribute to global warming, acid rain and to air quality degradation in cities near crowded shipping lanes and sea terminals.

The use of alternative fuels can decrease the amount of exhaust emissions and also can reduce reliance on diminishing oil reserves. While shipping is efficient when assessing CO_2 emissions per tonne–km, the large engines are responsible of releasing high NO_x emissions. Ships also tend to burn fuels presenting a high sulphur content.

2. BIODIESEL AS ALTERNATIVE FUELS FOR DIESEL ENGINES

In the last years, the environmental concern led researchers to the field of searching substitutes for traditional fuels. Biodiesel is one of the alternative fuels now in trend. It is obtained from different vegetable oils, like sunflower, soybean or rapeseed. Used in internal combustion engines, requires minor adjustments, being registered only a small decrease of performances. It is seen a small CO_2 combustion when a life cycle assessment is done.

Having in view that the properties of the biodiesel are very close to the ones of the diesel fuel, this alternative fuel might be used in Diesel cycle engines. The properties of the biodiesel are given in Table 1, while a comparison between fuels characteristics revealed values given in Table 2.

Considering the rate of oxygen (11%), the ones of carbon (77%) and hydrogen (similar to the one of Diesel oil), the value of LHV is lower for the biodiesel (≈37 MJ/kg respective to ≈43 for the Diesel oil). SO_x emissions can be neglected and the temperature of the flue gases at the stack can be considerable reduced to low values, since acid condensation is not significant. There are no aromatic compounds. In comparison to the Diesel oil, the biodiesel fuel presents a higher density and a superior cetane number. It is usually more than 50, due to the long linear acid chains which reduce the delay for the ignition of the fuel–air mixture. A flash point higher than 100^oC turns storage and transportation into less important processes. Due to the fact that biodiesel is miscible with Diesel oil, in applications is possible the usage of resulting blends.

The amount of carbonious residue from the hot decomposition of the vegetable compounds with high molecular weight is greater than that of Diesel oil, biodiesel being used in new advanced injection systems.

Table 1. European Standard for Biodiesel (EN 14214)

Property	Unit	Limits		Test method
		Minimum	Maximum	
Ester content	% (m m^{-1})	96,5	-	pr EN 14103
Density at 15°C	kg m^{-3}	860	900	EN ISO 3675 EN ISO 12185
Viscosity at 40°C	mm^2 s^{-1}	3,5	5	EN ISO 3104
Flash point	°C	120	-	ISO/CD 3679
Carbon residue (on 10% distillation residue)	% (m m^{-1})	-	0,3	EN ISO 10370
Acid value	mg KOH g^{-1}	-	0,5	pr EN 14104
Cetane index	-	51	-	EN ISO 5165
Sulphur content	mg kg^{-1}	-	10	-
Sulphated ash content	% (m m^{-1})	-	0,02	ISO 3987
Water content	mg kg^{-1}	-	500	EN ISO 12937
Total contamination	mg kg^{-1}	-	24	EN 12662
Copper strip corrosion (3hr at 50°C)	Rating	1	-	EN ISO 2160
Oxidation stability, 110°C	hr	6	-	pr EN 14112
Iodine value	-	-	120	pr EN 14111
Linolenic acid methyl ester	% (m m^{-1})	-	12	pr EN 14103
Polyunsaturated (≥4 double bonds) methyl esters	% (m m^{-1})	-	1	-
Methanol content	% (m m^{-1})	-	0,2	pr EN 14110
Monoglyceride content	% (m m^{-1})	-	0,8	pr EN 14105
Diglyceride content	% (m m^{-1})	-	0,2	pr EN 14105
Triglyceride content	% (m m^{-1})	-	0,2	pr EN 14105
Free glycerol	% (m m^{-1})	-	0,02	pr EN 14105 pr EN 14106
Total glycerol	% (m m^{-1})	-	0,25	pr EN 14105
Alkaline content (Na + K)	mg kg^{-1}	-	5	pr EN 14108 pr EN 14109
Phosphorus content	mg kg^{-1}	-	10	pr EN 14107

Oxidation products originated in biodiesel have impact on storage life and contribute to deposits development in tanks, fuel systems and filters. A better decomposition means a better biodegradability, an important issue when the fuel is reaching the environment. Also, biodiesel presents good lubricant properties compare to the Diesel oil, especially diesel with a low amount of sulphur. Results wear reduction in the engine at the injection system.

Table 2. Comparison of properties of biodiesel and Marine diesel oil

Fuel characteristics	Biodiesel EN 14214	Marine diesel
Density, 15°C	860 – 900 kg/m^3	< 900 kg/m^3
Viscosity at 40°C/50°C	3,5 – 5 cSt	< 11 cSt
Flashpoint	> 120°C	> 60°C
Cetane no	> 51	>35
Ash content	< 0,01%	<0,01%
Water content	<500 ppm	< 300 ppm
Acid no CTAN	< 0,5	-
Sulphur content	< 10 ppm	< 20000 ppm
Calorific value	≈ 37,5 MJ/kg	≈ 42 MJ/kg

3. EXERGY ANALYSIS

Exergy is a measure of the maximum useful work that a system can perform on its environment. Second law analysis, based on the notion of exergy, is intensively applied due to its advantages when an energy assessment is made. Exergy analysis is effective in design, optimization and performance evaluation of the system.

An exergy analysis of a complex thermodynamic system is used to identify which components of the system are responsible for irreversibilities because of the lost work, being possible to make improvements after such an analysis.

The exergy balance for a control volume at steady–state, considering the physical exergy (ex_{ph}) and the chemical exergy (ex_{ch}), is given below:

$$\left(\sum_i \dot{m}_i \left(ex_{Ch} + ex_{Ph}\right)_i\right)_{in} + Ex_{heat} = \left(\sum_i \dot{m}_j \left(ex_{Ch} + ex_{Ph}\right)_i\right)_{out} + \dot{W} + \dot{I} \quad (1)$$

The left side of this equation gives the exergy associated to the mass entering in the system, and to heat transfer. The right side of the equation refers to the mass leaving the system, the work transfer and the exergy destroy due to irreversibility.

For a given reference environment, the values of "ex_{ch}" are tabulated for many substances. If the mixture is a real solution, its chemical exergy can be found out according to:

$$ex_{Ch,mix} = \sum_i y_i \, ex_{i\,Ch} + \overline{R} T_0 \sum_i y_i \ln\left(\gamma_i y_i\right) \quad (2)$$

Where:
y – molar fraction,
T_0 – temperature at reference state, K,
$\overline{R}$ – ideal gas constant, kJ/(kmol K),
γ – activity coefficient.

The exergy due to the heat exchange is defined by:

$$Ex_{heat} = \left(1 - \frac{T}{T_0}\right) \cdot \dot{Q}_{vc} \quad (3)$$

In the above equation, $\dot{Q}_{vc}$ is the heat flow getting out of the volume of control.

For organic compounds whose elemental compositions are known, the chemical exergy is written depending on the lower heating value (LHV) as:

$$ex_{Ch} = \beta \, LHV \quad (4)$$

Above, the coefficient "β" for liquid fuels is:

$$\beta = 1{,}0401 + 0{,}1728 \frac{Z_{H_2}}{Z_C} + 0{,}0432 \frac{Z_{O_2}}{Z_C} \quad (5)$$

where Z_{H_2}/Z_C and Z_{O_2}/Z_C are the mass fractions between the elements of the fuel.

The physical exergy of the mass flow is calculated according to:

$$ex_{Ph} = \left(h - h_0\right) - T_0\left(s - s_0\right) \quad (6)$$

Where:
h – specific enthalpy, kJ/kg,
s – specific entropy, kJ/(kg K).

In every component of a system, the exergetic balance can be expressed by:

$$Ex_P = Ex_F - I - Ex_D \quad (7)$$

In this equation, subscripts refer to product (P), resource (F), destruction (D).

4. RESULTS OF THE EXERGY ANALYSIS

Entrance parameters for a diesel engine are as follows:

Power = 60 ÷ 480 kW

Air Temperature = 298 K

Fuel Temperature = 298 K

Exhaustion Temperature = 1800 K.

For the power rating from 60 to 480 are founded exergy values when biodiesel fuel is used.

Table 3. Exergy values for different powers of biodiesel engines

Power, kW	Ex_{in}, kW	Ex_{out}, kW	Ex_{heat}
60	113,86	97,57	0,15412
120	227,86	178,9	0,57812
180	341,86	260,23	1,27208
240	455,86	341,56	2,2356
300	569,86	422,89	3,469
360	683,86	504,22	4,9726
420	797,86	585,55	6,745
480	911,86	666,88	8,7878

The fuel mass flow depends on the power (P) and the fuel specific consumption (F_{SC}), as shown in the equation:

$$\dot{m}_f = P \cdot F_{SC} \quad (8)$$

Table 4 gives values of fuel exergy and exhaust gas exergy in the mention power rating.

Table 4. Fuel exergy and exhaust gas exergy for 60 – 480 kW power rating

P, kW	Ex_{fuel}, kW	Ex_{gas}
60	130	110
120	240	190
180	390	315
240	450	400
300	540	485
360	700	550
420	790	675
480	910	755

5. CONCLUSIONS

Exergy analysis is a powerful tool that provides solutions to analyse processes and to determine environmental impact. The shipping emissions presents global, regional and local environmental effects.

The first aspect discussed in the paper was diesel engine as an internal combustion engine. Biodiesel seems to be a promising solution for diesel engines, that is why was payed attention to biodiesel qualification.

The exergy analysis revealed values of exergies being seen that for the minimum power considered (of 60 kW), were found minimum exergy values and for the maximum power considered (of 450 kW) were found the maximum exergy values.

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THE IMPACT OF HCFC PHASE-OUT ON MARINE REFRIGERATION AND AIR CONDITIONING

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ABSTRACT

Concerns related to the environmental impact of synthesized refrigerants have seriously affected the marine refrigeration industry. Recently, the focus is on global warming aspect. This paper examines the alternatives at the hand of ship owners connected to the HCFC 22 replacement.

It is developed a heat transfer analysis for R407C, a refrigerant suitable for water chillers on board of fishing vessels. Results show that heat exchange performances are lower than that of HCFC 22.

Keywords: *marine refrigeration, environment, heat exchange analysis.*

1. INTRODUCTION

The transport of the food is one of the most important use of refrigeration. Food transport demand will increase in the future due to the fact that world population, which in present means 7 billion inhabitants, will met about 9 billion inhabitants in 2050. To be more specific, this increase will be mostly registered in developing countries.

Marine transport of goods doesn't refer only to non-perishable products, perishable commodities need also to be transported on board the ships. These might get spoiled during voyage if proper measures are not taken in terms of temperature control. Mentioned products could be anything like meat, fish, vegetables, fruits, dairy products and so on. Marine transport of refrigerated goods may be one of the two types: containerized transport and conventional refrigerated shipping.

There are currently 715000 TEUs worldwide. In 1998, sales of TEUs reached a level of 96500, more specific 500 insulated containers and 96000 refrigerated containers. The trend is towards self-contained refrigerated containers. They can transport perishable products for weeks, or even months, under very stable temperature, humidity and controlled atmosphere conditions. For the maritime transport of chilled products, is used R134a (HFC 134a) as a refrigerant. For the maritime transport of frozen products, either R 134a is used or R 404 A (HFC 404 A) can be employed. On reefers, besides R 22 (HCFC 22), the main refrigerants used are R 410 A (HFC 410 A), R 407 C (HFC 407 C) and R 404 A. In 1993, five refrigerating ships using ammonia were built. Since then, ammonia has no longer been used, except on fishing boats.

In developing countries, R 22 will be phased out soon. The service life of older ships is being extended to 10 to 12 years by retrofitting them with better plants, equipments, instruments and machines. R 12 systems are being replaced by R 22 systems because the plant size is smaller compared to an R 134a replacement system. For new ships, environmentally friendly R 134a is preferred.

2. THE ENVIRONMENTAL ISSUE

The vast majority of marine refrigerating equipment is vapour compression systems that use ozone depleting substances like CFCs and HCFCs. Refrigerants like CFCs, HCFCs and HFCs are potent greenhouse gases.

About the ozone layer

Since 1974 was observed the depletion of the stratospheric ozone layer that protects the Earth from harmful ultraviolet solar radiation. Some of the refrigerants traditionally used on board the ships, like CFC 12 and HCFCF 22, were found among responsible substances.

The Convention signed in Vienna (1985) pointed out the need of the progressive phase-out of ozone depleting substances, contributing to the signing of the Montreal Protocol, in 1987. In the following 15 years, this Protocol was signed by several stakeholders, being quickly implemented due to the involvement of governments, industrial stakeholders, manufacturers and users of refrigerants.

The Protocol started research works in order to be found new refrigerants, the so called "green refrigerants", having no impact on the ozone layer (like HCFCs). Also, some works focused on the rediscover of forgotten refrigerants (like NH_3 and CO_2), that might be successfully used with some technical improvements.

HCFCs are mild Ozone Depleting Substances as compared to CFCs. Their ODS potential is only about 5% of that CFCs.

HCFCs phase out helps ozone layer protection as well as climate change, but more than that it helps the economy. The impact of some refrigerants on the ozone layer is given in Table 1.

Global warming

Rising global temperature measurements and their correlation with the increase in CO_2 in the atmosphere led researches to observe that human activity release gases that significantly increased the natural greenhouse effect around the Earth. This situation led to the signing of the Rio Convention, in 1992, then the Kyoto Protocol in 1997. Refrigerants used in marine transportation,

belonging to CFCs, HCFCs or HFCs have a global warming potential that is about 100-10000-fold that of CO_2.

CFCs have been replaced by HCFCs. These also have an ozone depleting and a global warming potential, but much lower. Other substitutes are HCFCs. These have only a global warming potential (GWP), very close to the GWP of HCFCs, on the average. These replacements revealed a diminishing of more than 25% of global greenhouse emissions compared to 1990. The main concerns of the marine refrigerating sector might be resumed to the reduction of the direct effect of refrigerant emissions and the reduction in the energy consumption of the refrigeration systems. The impact of some refrigerant on the global warming is given in Table 2.

Table 1. Refrigerants' impact on the ozone layer

Family of refrigerants	Main refrigerants	ODP
CFCs	CFC 11 (R 11)	1
	CFC 12 (R 12)	1
HCFCs	HCFC 22 (R 22)	0,05
HFCs	HFC 134 a (R 134 a)	0
	HFC 404 A (R 404 A)	0
	HFC 407 C (R 407 C)	0
	HFC 410A (R 410 A)	0
Natural refrigerants	NH_3 (R 717)	0
	CO_2 (R 744)	0
	Hydrocarbons	0

Table 2. Refrigerants' impact on the global warming

Family of refrigerants	Main refrigerants	GWP
CFCs	CFC 11 (R 11)	4750
	CFC 12 (R 12)	10890
HCFCs	HCFC 22 (R 22)	1810
HFCs	HFC 134 a (R 134 a)	1430
	HFC 404 A (R 404 A)	3900
	HFC 410A (R 410 A)	2100
Natural refrigerants	NH_3 (R 717)	< 1
	CO_2 (R 744)	1
	Hydrocarbons	20
	Water	0

For the two widely spread R 12 and R 22 in marine refrigeration, the time schedule of Montreal Protocol is as follows:

Table 3. Regulations of the Montreal Protocol

Refrigerants	Industrialized countries	Developing countries
CFC 12 (R 12)	Forbidden since 1996	Forbidden in 2010
CFC 22 (R 22)	Forbidden in 2020	Forbidden in 2030

3. SOLUTIONS FOR THE REPLACEMENT OF HCFC 22

Marine refrigeration and air conditioning industry is facing a great challenge due to the European Legislations regarding the use of HCFC 22 in existing marine refrigerating plants. In Europe, after January 1st, 2015, HCFC 22 will be banned. It must be found the most effective and economic solution for this substitution.

The options should be known by the ship owners because the choosing depends on the age of the system, needs, type or financial disponibility.

Options at the hand of ship owners facing the HCFC 22 replacement are:

- to carry on using HCFC 22, but to control the tightness of the plant by minimizing all leakage,
- to envisage retrofitting in order to use another refrigerant,
- to replace the plant.

Some features of available refrigerants are given in Table 4, while a comparison with HCFC 22 is shown in Table 5.

Solution 1 – to carry on using HCFC 22 in existing marine refrigeration plants

The solution might be adopted only for systems close to the end of their lifespan.

Solution 2 – replacement of HCFC 22

For flooded installations (applications under a temperature of the 0^oC), are recommended R 404 A and R 507. Result a slightly better refrigerating capacity and a lower COP. Also, the capacity of the condenser and the compressor unit may be not satisfactory. Is needed a POE oil.

For direct – expansion installations (applications below 0^oC) are shown R404 A and R507. The use of R422 A might ask installation for additional refrigerating capacity.

For direct – expansion installations for temperatures above 0^oC, is indicated R407 C for water chillers.

When is considered ammonia as a substitute, it is important to use materials compatible with this refrigerant. During such kind of retrofitting, the plant must be stopped for a period of time, in order to enable flushing to be performed.

Table 4. Characteristics of available refrigerants

Refrigerants	Composition	Evap. Temperature (^oC)	Glide	Critical Temperature (^oC)	Critical Pressure (bar)	Global Warming Potential (GWP)
R 134 a		– 26	0	101	40,6	1300
R 404 A	R 125/134a/143a	– 46	0,8	72	37,4	3800
R 507	R 125/R 143 a		0,1	0	0	3800
R 407 C	R 32/125/134 a	– 44	7,2	87	46,3	1600
R 410 A	R 32/125	– 51	0,5	72,5	49,5	1900
R 422 D	R 125/134a/600	– 44	4,8	80	39	2230
R 417 A	R 125/134a/600	– 39	5	90	42,4	1950
R 422 A	R 125/134a/600a	– 47	3	72	37,5	2530
R 290 (propane)		– 42	0	97	42,5	3
R 600 (butane)						3
R 600a (isobutane)		– 12		135	36,4	3
R 717 (ammonia)		– 33,3		132	113,3	0
R 744 (CO_2)		– 78		31	73,8	0
R 718 (water)		100		374	221	0

Table 5. Comparison with HCFC 22

Refrigerant	Temperature – 40^oC/– 10^oC		Temperature – 10^oC/+ 35^oC	
	Refrigerating capacity	COP/COP HCFC 22	Refrigerating capacity	COP/COP HCFC 22
R 22	100	1 (6,95)	100	1 (4,71)
R 134 a	53	0,95	62	0,98
R 404 A	108	0,88	99	0,86
R 507	113	0,91	101	0,89
R 407 C	85	0,89	92	0,9
R 410 A	154	0,94	146	0,95
R 422 D	70		83	0,9
R 417 A	62		75	0,94
R 422 A	84	0,8	92	0,87

R 717 (ammonia)	83	0,96	107	1,03
R 744 (CO_2)	696	0,9		

Solution 3 – replacement of the plant

It is radical and expensive solution, asking a significant work time. Despite this, solution three is a good one due to the fact that the resulting equipment will answer to the new energy policies and to the environmental issues.

4. RESULTS OF HEAT TRANSFER ANALYSIS FOR R 407 C

R 407 is a zeotropic mixture (as shown before). R407 C is an option in zones where an accelerated phase-out of R 22 doesn't permit the adoption of R410A (Spatz and Soffientini, 2000).

As mentioned above, R407C is indicated for water chillers. These systems are ideal for commercial fishing. Instead relying on ice, the system chills the sea water (to about 28 F). Colder than ice and removing heat at a faster rate, bacterial action is practically non existent. Also, there is no risk of freezing the fish. An analysis on evaporative heat transfer and on condensing heat transfer carried on 9,5 mm O.D. tubes without internal enhancements leads to the results given below.

Table 6. Results of evaporative heat transfer

Mass flux, kg/(sec·m^2)	Avg. heat transfer for R22, W/(m^2·K)	Avg. heat transfer for R407C, W/(m^2·K)
150	2500	1700
200	3100	2000
250	3700	2400
300	4200	2780
350	4730	3000
400	5140	3160
450	5500	3400

Table 7. Results of optimizing mass flow in the evaporator

Mass flow rate, g/s	Evaporator outlet temp. for R22, °C	Evaporator outlet temp. for R407C, °C
5	8	6,4
6	8,2	6,6
7	8,3	7,1
8	8,4	7,3
9	8,3	7,4
10	8,2	7,45
11	8,1	7,4
12	8,0	7,2

Table 8. Results of optimizing mass flow in the condenser

Mass flow rate, g/s	Inlet condenser temp. for R22, °C	Inlet condenser temp. for R407C, °C
20	42,45	43,6
25	42,4	43,4
30	42,45	43,2
35	42,6	43,2
40	43,2	43,3

5. CONCLUSIONS

Every refrigerant has its own specific features.

In the paper were shown the options at the hand of ship owners dealing with equipments operating on HCFC 22. Before the replacement, an analysis must be developed. The solution for the HCFC replacement are summarized as: ammonia, hydrocarbons, CO_2, HCFs. The replacement of existing HCFC systems with a new one is one of the best possibilities, but also the most expensive.

An analysis on heat transfer revealed heat exchange performances of R407C poorer than that of R 22.

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FOUNDATIONS REALIZED IN PUNCHED HOLES WITH LOW IMPACT UPON THE ENVIRONMENT

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ABSTRACT

The paper deals with a new solution for realizing foundations, having a lower impact upon the environment than classical foundation solutions. The proposed solution consists of realizing foundation holes punched with the help of a spherical tamper. A semi-spherical foundation will be introduced in the obtained hole.

The presented foundation is easy to realize and efficient. It aims at avoiding a more expensive and hard to realize indirect founding system needing special, high capacity equipment. That would block the respective location for a long time altering the environment.

This solution for the realization of foundation holes pays a great part in reducing the volume of digging and of materials used in the foundations, the quantities of materials needing transportation (soil, concrete, steel-concrete, wood for formworks, etc.) as well as the shortening of the construction period. All these factors have favorable impact upon the environment, the investment costs being finally much smaller than in the case of other known solutions.

Keywords: *environment, foundation, punching holes, impact.*

1. INTRODUCTION

Through their shape and technology of execution, the foundations in punched holes represent both a foundation solution and the improvement of the soil around the foundations, increasing their bearing capacity.

In the case when, following the analysis of the foundation ground, its physical and mechanical characteristics show a weak foundation ground, the use of classical foundation solutions may lead to costs representing 30…40 % of the total construction cost .

This is why, for building on weak ground, research has been and is performed concerning the modernization of the technologies of improving foundation soils, as well as in drawing up new technologies to improve and execute foundations.

A new founding technology in the case of weak foundation soils is based on executing foundation holes through punching. This technology ensures a rational use of the ground's bearing capacity reserves, realizing in the same time an improvement of its physical and mechanical characteristics.

The punching technology of foundation holes can be applied both to civil and industrial buildings and to agricultural constructions such as temporary storing halls and shelters for agricultural machinery. The finally adopted building solutions differ depending on the stratification of the foundation ground and the type of resistance structure.

The punching technology has less impact on the environment than the indirect founding solutions which should be applied when the soil appropriate to founding is found deeper than 5 m. This method of realizing foundation holes contributes to reducing the excavated volume and the quantity of materials used in the foundations, to lowering the quantities of materials needing transportation (soil, concrete, formworks wood, etc.) as well as to shortening the execution period. All these elements impact favorably upon the environment, finally the investment costs being much lower than in the case of other known solutions.

2. THE PROPOSED SOLUTION

An efficient foundation solution in these circumstances, both technically and economically, is represented by the foundations in punched holes, with or without bulb, realized in granular materials with high mechanical resistances.

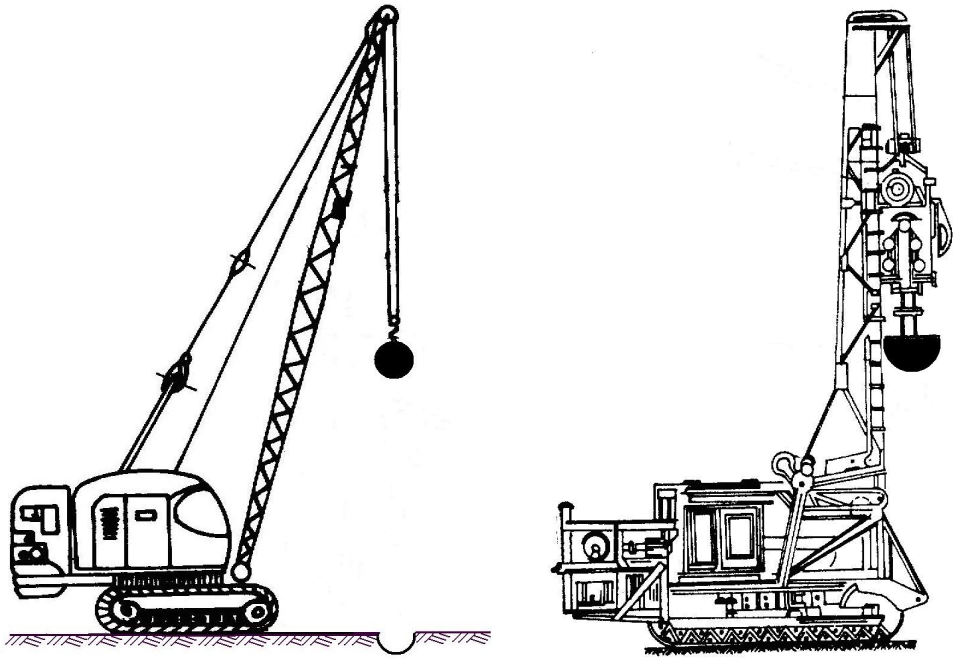
The proposed solution consists of realizing foundation holes punched with the help of a spherical tamper. A semi-spherical precast foundation or a monolith semi-spherical foundation will be introduced in the obtained hole. The spherical punching element cooperates better with the foundation ground leading to the uniform improvement both in depth and laterally wise of the foundation ground [2].

In the case of such foundations, the increase of the bearing capacity in the foundation ground is due to the area of packed soil (with improved physical-mechanical characteristics), occurring around the foundation as a result of punching the soil in order to realize the hole.

Specific punching equipment is used for the technology. The punching by beating offers the advantage of allowing the use as carrying devices of a large range of existing lifting equipment from the stock of the construction units. The beating device can be attached to these equipments without altering them.

Figure 1 presents the principle plans of punching

equipment through beating or vibration.

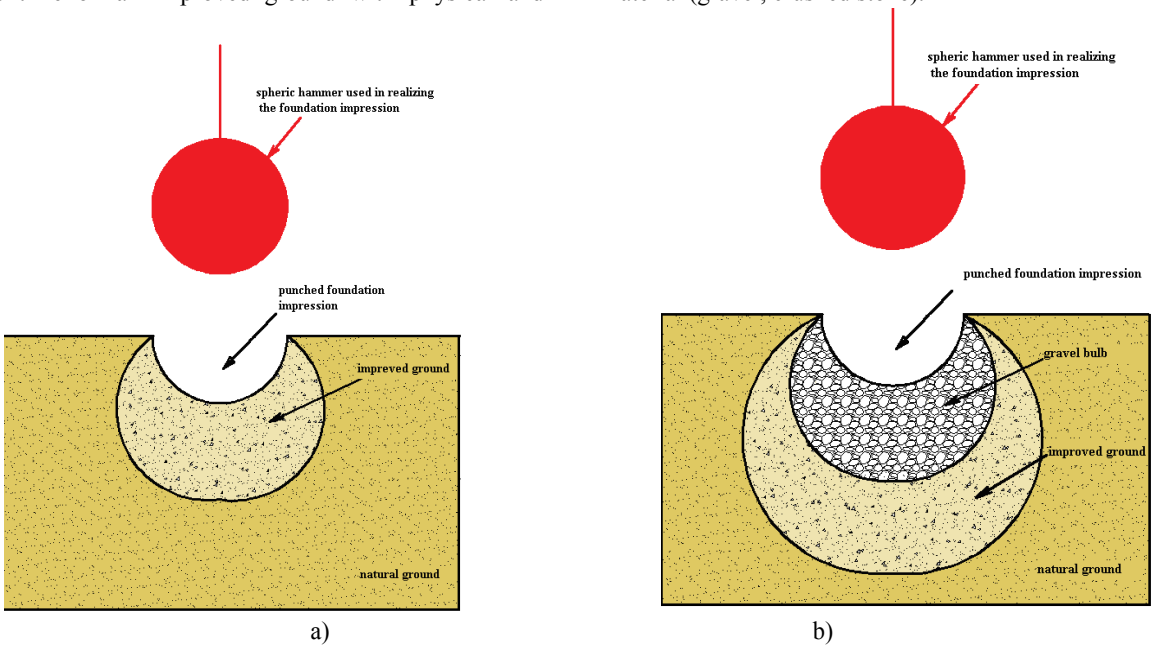


a) b)

Figure 1 Punching equipment: a) by beating; b) by vibration

The shape of the punching equipments is spherical if used punching by beating or semi-spherical for punching by vibration.

As beating punching element there can be used a metal ball from the demolition works. In this case, the repeated free falling of this ball from a certain height, on the same spot, creates on the ground an impression which constitutes the so-called foundation hole, placed this time on an improved ground with physical and mechanical characteristics clearly superior to those of the natural ground, that is a much higher bearing capacity (figure 2 a). In the case when this impression, after punching, will be filled with coarse addition material, by the repeated free falling of the spherical hammer, a new print ill be realized to be turned into the foundation hole - figure 2 b. This time the foundation will be placed on improved soil with additional granular material (gravel, crushed stone).



a) b)

Figure 2 Realization of foundations in punched holes: a) realization of the foundation hole; b) realization of the granular bulb

a) b)

Figure 3 Foundations in punched holes: a) with bulb; b) without the granular bulb

In the holes realized in this way, semi-sphere foundations with or without anti-pressing plate at he top will be placed (fig. 4).

In order to determinate the bearing capacity of the foundations realized in this way, laboratory experimental testing [1] on models has been performed (semi-sphere and semi-sphere with anti-pressing plate) on a 1:4 scale (fig. 3, fig. 4). The models have been introduced in the ground (non-cohesive soil) through vibration punching.

In order to emphasize the favorable effect of the anti-pressing plate, it was determined and compared from a quality point of view the increase in the bearing capacity of the semi-sphere foundation element equipped with anti-pressing plate with the semi-sphere element in simply punched holes and respectively in punched holes with ballast bulbs. The prefabricated models realized in C16/20 concrete were subjected to vertical compression stress.

During the laboratory testing, the yielding modality of the foundation ground under the circular elements has been studied [2] (fig. 5).

The values of the bearing capacities of the analyzed models have also been determined theoretically with a method resulting from a research concerning the calculation of the bearing capacity for the proposed foundations [3].

Finally, the results obtained from the experimental tests were subsequently compared to those determined theoretically.

a) b)

Figure 4 Research models: a) semi-sphere; b) semi-sphere with anti-pressing plate

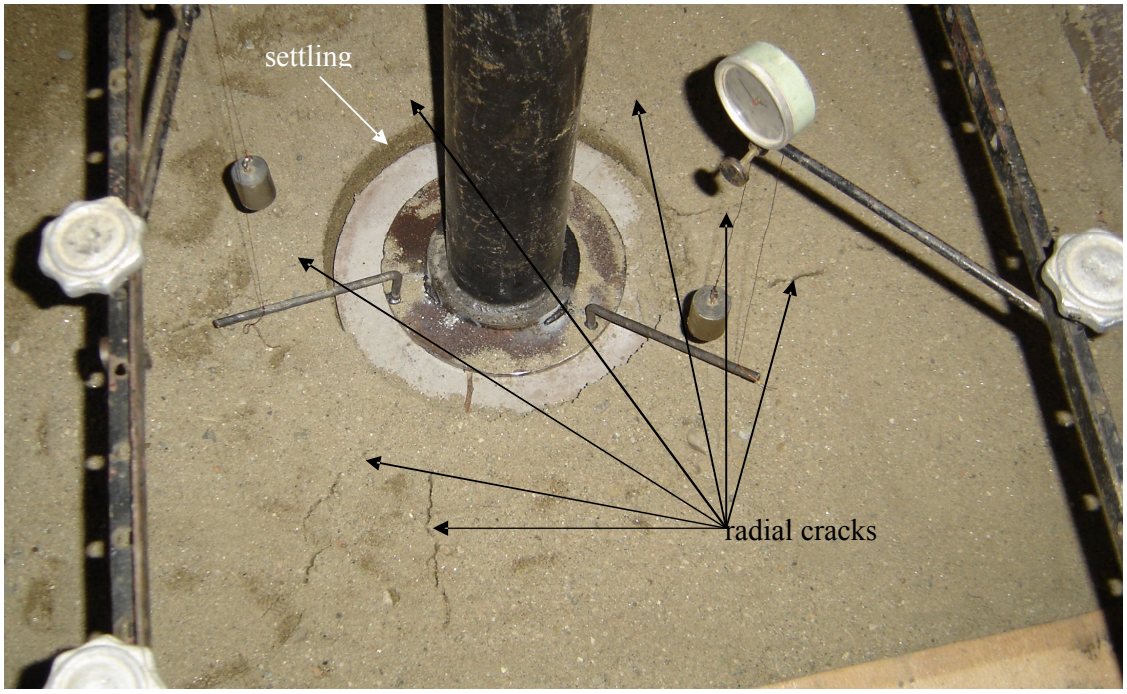
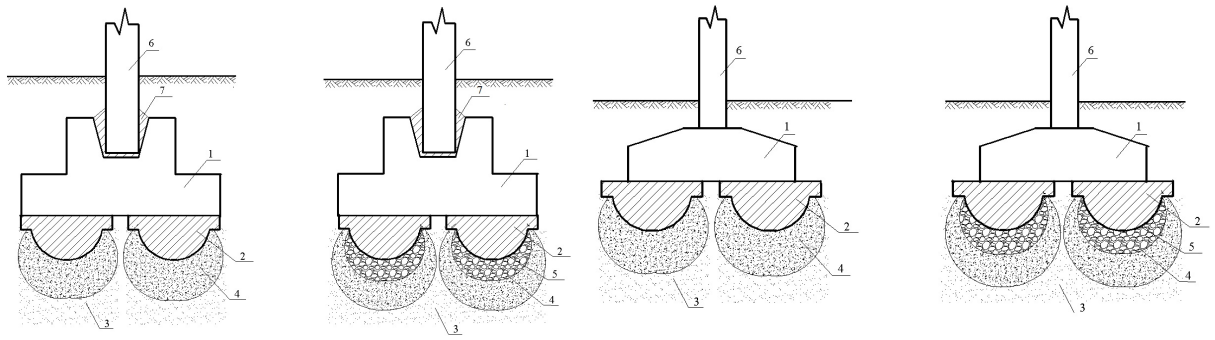


Figure 5 Yielding through radial cracking of the ground around the foundation

The semi-sphere or semi-sphere with anti-pressing plate foundations, realized in punched holes, can be used as insulated foundations under poles (figures 6) or as continuous foundations – figure 7 (or discontinuous – figure 8) under walls for civil, industrial or agricultural buildings placed on weak foundation soils down to 2 – 4m. Also, in the same situation, these elements can be used to realize insulated foundations under poles when these are tied through reinforced concrete girdles.

The solution will have an impact both theoretical and practical, having numerous applications and opening new horizons in the improvement of the foundation ground by using the punching procedure, since this procedure ensures the realization of buildings on weak soils, through direct, surface foundation. The subsequent deformations under the construction loadings are minimal.



a) b)

Figure 6 Classical insulated foundations under poles, unloading on punched foundations with or without bulbs (1- classical foundation, 2- semi-sphere with anti-pressing plate, 3 – natural soil, 4 – improved soil, 5 - bulb, 6 - pole, 7 - monolith): a) glass foundations; b) elastic foundations

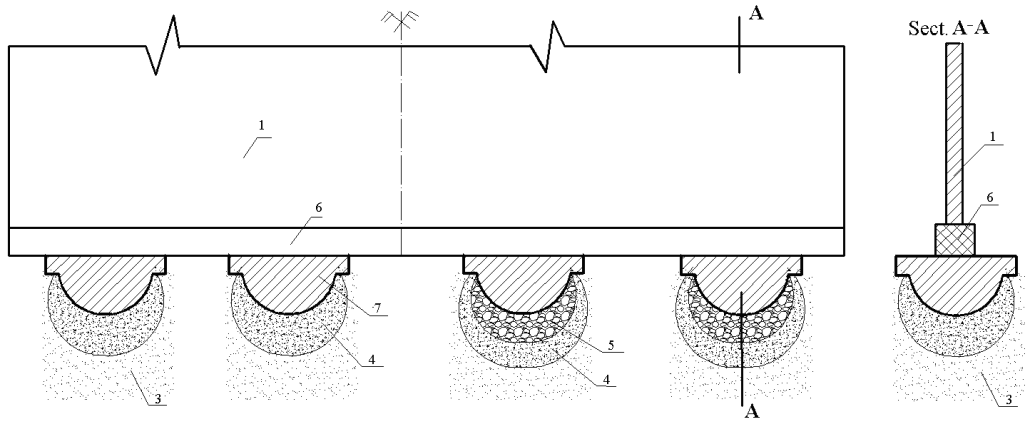


Figure 7 Semi-sphere punched foundations used for continuous foundations under walls
(1- wall, 3 – natural soil, 4 – improved soil, 5 - bulb, 6 - girdle, 7 – semi-sphere with anti-pressing plate)

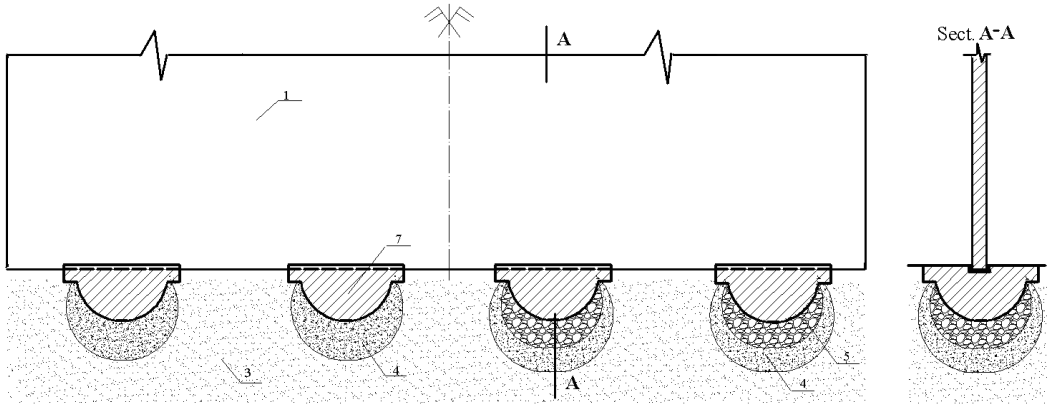


Figure 8 Semi-sphere punched foundations used in discontinuous foundations under walls
(1 - wall, 3 - natural soil, 4 - improved soil, 5 - bulb, 7 - semi-sphere with anti-pressing plate)

3. CONCLUSIONS

The solutions of realizing foundations in punched holes consist in forcing into the ground certain spherical, truncated cone, truncated pyramid shaped equipments (tampers) through striking or vibration.

As a result of this mechanical thrust, an area of packed soil is formed around the foundation, within whose limits the mechanical strength of the ground increases and the deformability characteristics decrease. Due to the reduction of the ground deformability, the foundations realized in punched holes can transmit vertical and horizontal loadings in the conditions of small size foundations.

The solution of realizing punched foundation holes is easy, efficient and aims at avoiding the use of an indirect foundation system which is much more expensive and difficult, needing special equipment of high capacity (pile drivers, drills), that would block the location for a long time altering the environment, both by phonic and by air pollution for the residents. Also, the classical technology of realizing surface foundation holes through digging, storing ands transporting the resulting soil produces both air and phonic pollution of the neighbouring area (the noise produced by engines and emissions of exhaust gases from the machines used, the dust resulting from digging the earth). The room occupied by the site organisation in the case of punching the foundation holes is much smaller than in the case of the other variants, since this method only requires the beating or vibration punching equipment.

The advantages of this solution consist in the significant reduction of the expenses in comparison with the deep foundation systems, the elimination of the seasonal character of the foundation process for buildings placed on soils inadequate for direct foundation and in the case of compaction works for road earthworks.

The analysis of the operational behavior of buildings with foundations realized in punched holes we can draw the conclusion showed a better time behavior. The registered settlings were much lower than the admissible values and their stabilization was quickly realized whereas the differentiated settlings were not important. Therefore, these punched foundation solutions are modern and ensure a high degree of mechanization of the foundation works, representing in the same time an efficient way of improving the foundation ground.

The prefabricated or monolith foundations realized in punched holes, especially the prefabricated ones, ensure a high degree of industrialization and

mechanization of the foundation works.

By punching the foundation holes, the improvement of the foundation soil is realized both in depth and laterally, leading to the increase of the bearing capacity of the foundations realized in punched holes.

The improving effect depends also on the shape of the hammer used in punching the hole. The use for the first time of a vibration hammer (vibro-hammer) with a spherical shape presents the advantage of a more uniform improvement of the foundation ground, both vertically and horizontally, as compared to the other shapes of truncated pyramid or truncated cone used up to now. Therefore, the spherical hammers have the best results in the compaction of the foundation ground through punching, this being also influenced by the mass of the hammer and the height from which it falls.

The semi-spherical shape is easy to realize and has advantages both concerning the thrusting of the hammer into the ground and mainly in its extraction, ensuring in the same time the stability of the hole's walls at the extraction of the equipment. This shape ensures a better cooperation with the foundation soil leading to a higher bearing capacity of the foundations in compaction with other shapes of hammer.

The presence of the anti-pressing plate in the semi-sphere foundations realized in punched holes increases significantly their bearing capacity.

The punching with granular bulb also leads to the increase of the bearing capacity of the foundations.

The use of spherical or truncated cone punching equipment represents a new and original element nationwide.

The solution will have an impact both theoretical and practical, having numerous applications and opening new horizons in the improvement of the foundation ground by using the punching procedure, since this procedure ensures the realization of buildings on weak soils, through direct, surface foundation. The subsequent deformations under the construction loadings are minimal.

The values of the bearing capacity obtained experimentally compared to those determined theoretically showed a good agreement, the differences ranging between 14 – 18%.

This solution for the realization of foundation holes contributes to the reduction of the digging volume and of the materials used in foundations, the decrease of the quantity of materials needing transportation (soil, concrete, steel-concrete, wood for shuttering, etc.) as well as to shortening the execution period. All these reflect favourably upon the environment, the costs of the investment being finally lower than in the case of other known solutions.

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DESIGN AND CONSTRUCTION OF A RTT PNEUMATIC MANIPULATOR FOR DIDACTIC USE

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ABSTRACT

The paper will present the process of building a pneumatic RTT manipulator for use in educational activities at the University of Oradea, Faculty of Management and Technological Engineering. The manipulator is useful for a series of activities related to teaching PLC programming, sensors and pneumatics. The manipulator is controlled by a PLC, which allows for a certain degree of flexibility of the manipulator's movement.

Keywords: *manipulator, pneumatic, PLC, educational, programming.*

1. INTRODUCTION

A manipulator is relatively widely used in industry, combining some of the advantaged of an industrial robot while having a major advantage, the low implementation costs. The manipulators are used for repetitive tasks such as extracting finished products from a plastic injection mould, moving different components from a conveyor to another. The main advantage of a manipulator over an industrial robot is the low cost for building, implementing and use. Also a manipulator includes a significantly lower number of components which significantly reduces the possibility of malfunction. All this advantages come with a significant disadvantage, the low flexibility of a manipulator. Due to the fact that manipulator are build to perform one task, this including the mechanical structure, speeds and programs when the task is no longer needed the manipulators can't be reused. In certain condition the manipulators can be reused by major structural modifications. Also a major disadvantage is the precision of the manipulators, which makes them unusable in areas where precision is a must, such as electronics industry, fine mechanics, laboratories etc. The goal for building an RTT manipulator at the University of Oradea is an educational one, the RTT manipulator resulted at the end of this project being successfully used in teaching PLC programming, pneumatics and sensors.

2. SECTION TITLE

When starting the project the main questions which needed answer where the type of the manipulator and the power source. Regarding the type of the manipulator, due to the fact that the project was developed for educational purposes the RTT choice was the obvious one since is a simple structure and it is made up of both types of cinematic couples. Also the work space of the RTT manipulator is a large one, easy to understand by the students learning the concept of work space in robotics.

The second major question regarding the manipulator was the power source to be used for the project. There were three options, electric, pneumatic and hydraulic. The hydraulic power source haze a series of disadvantages which makes them suitable only for machines where high mechanical power is a must such as heavy industrial machinery. The two viable alternatives where the electric power and pneumatic power. The main advantages of the electric power are the wide availability of the power source, easy methods of controlling the characteristics of the electric motors. The main problems was that the manipulator had a RTT structure which signified that for two elements of the manipulator the rotary movement obtained from the electric motors had to be converted in linear movement

This would have significantly raised the number of components needs for the project, with direct impact on the costs. There is also the option to use linear electric motors, but the cost of this type of electric motors makes them a nonviable option for manipulators. The other option was the pneumatic power. This option is the most suitable since trough pneumatic power both linear and rotary movement are easily obtained and pneumatic power is safe, clean and easy to obtain. Another advantage of the pneumatic power is that the components needed are inexpensive, reliable and easy to use.

The major disadvantages of the pneumatic power are the need for a brake system at the end of each piston, especially where high speed is used. Also sudden relaxation of compressed air in pneumatic cylinders is accompanied by lowering of air temperature, a phenomenon that causes the separation and dropping water on the walls, which promotes corrosion pneumatic elements. Water separators, filters and proper choice of materials reduce or even eliminate this deficiency. The major deficiency of pneumatic power which makes them unsuitable for most industrial robots, but can be disregarded in manipulators is the possibility of stopping the linear pneumatic motor in an intermediate position with high accuracy.

The available work space for placing the manipulator led to the choice of the useful cylinder length. This was possible only because the manipulator is an educational one. In an actual application the length of the mechanical elements are determined by the task the manipulator should perform. The pneumatic rotary motor situated at the base of the manipulator makes a 270o rotation, the linear movement pneumatic motor,

mounted horizontally haze a useful length of 250mm, and the pneumatic motor for the gripper haze a length of 200mm.

In figure 1 the structure of the pneumatic manipulator is presented.

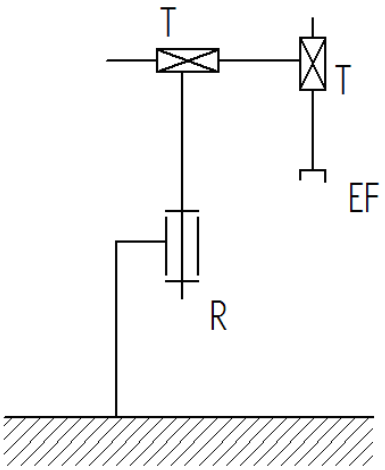

Fig. 1 The structure of the pneumatic manipulator.

The work space of the pneumatic manipulator is shown in figure 2.

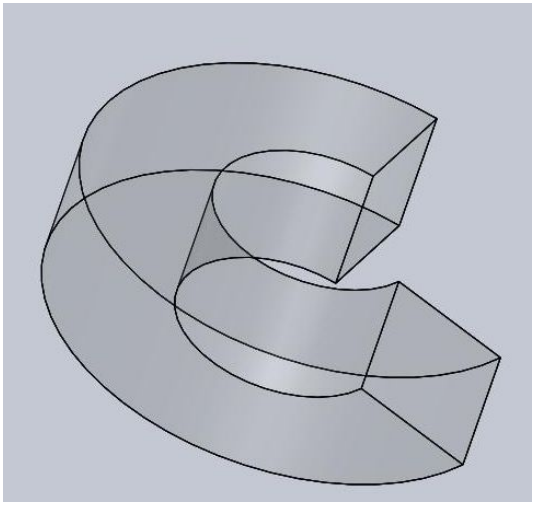

Fig. 2The shape for the theoretical work space of the pneumatic manipulator

For the mechanical structure of the manipulator, standardized extruded aluminum profiled where chosen. This type of elements have a series of advantages among which we mention the fact that aluminum has a low specific weight which leads to a reduced weight of the manipulator and with aluminum the corrosion problem is eliminated and also the need of protective coating.

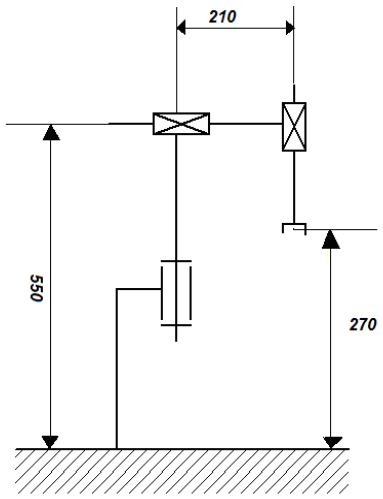

Fig. 3 - The dimensions of the manipulator in disengaged state.

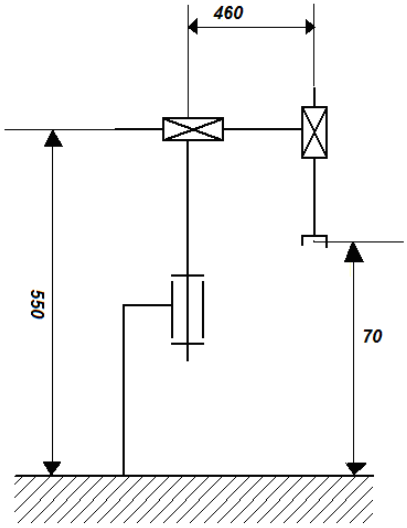

Fig. 4 The dimensions of the manipulator in engaged state.

Each pneumatic cylinder was fitted with two sensors (Reed relay type) to determine at which end of the piston the piston rod is. This information is used as information for the PLC that is controlling the flow of compressed air by means of 3 pcs of 5/2 valve. All valves used to build the manipulator are manufactured by SMC and are type SY5220-5YO-01F-Q and fitted with, 24 V DC solenoid.

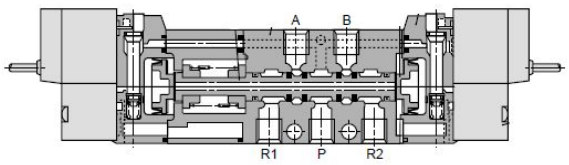

Fig. 5 Electro-valve SMC SY5220-5YO-01F-Q

In figure 3 is presented the pneumatic diagram of the manipulator.

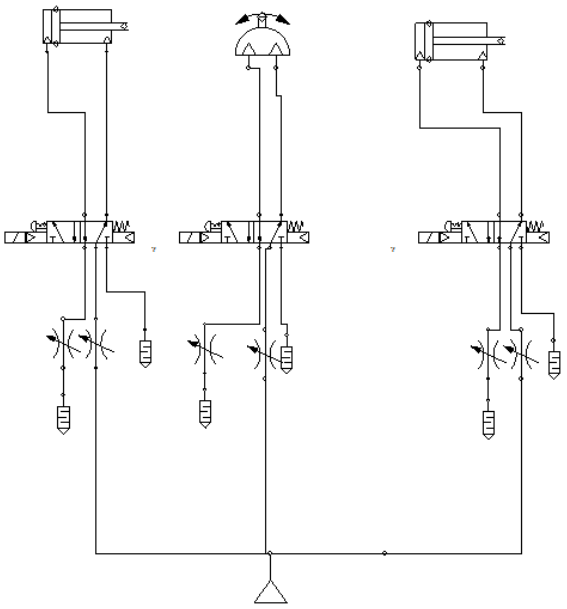

Fig. 6 Pneumatic diagram of the manipulator.

Using an adequate software, the characteristics of the manipulator's pneumatic circuit haze been simulated.

Fig. 7 Fig. 4- Software simulation of the pneumatic system

Where:

1-Rotary actuator – input flow.
2-Double acting cylinder1-Liniar speed.
3-Double acting cylinder2-Liniar speed.

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The gripper used for the pneumatic manipulator is a pneumatic gripper made by

The manipulator is controlled by an OMROM PLC (fig.5) which haze as input information the signals received from the sensors mounted on the pneumatic cylinders. This information is processed.

Fig. 8 Omron PLC series CMP2A

3. CONCLUSIONS

The manipulator was realized at the University of Oradea for didactic purposes. It is being used for teaching in several courses especially in the courses involving sensors, pneumatics and PLC programming.

In figure 6 is presented the pneumatic manipulator.

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PLASTICITY CRITERIA - RESIDUAL STRESSES AND DEFORMATIONS AT RING – SHAPED DISKS IN THERMAL FIELD I

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Abstract: - The present paper presents the theoretical method for determination of the deformations and the loss of stability of the disk stressed by an axial – symmetric thermal field, variable according to disk radius and thickness, superposed with a field of membrane tensions given by the rotational motion. The experimental results confirm the theoretical hypothesis. This paper also presents the tension and deformation state of the disks being in a non – stationary field of temperature. The study is done until the plastic deformations occur.

Key-Words: - disk, thermal field, stress, membrane tension, stability, non – stationary field

PART I

1 Introduction. Problem Formulation

From the equilibrium element of disk and using the hypothesis that the load is zero, between tensions exists the following relation:

$$\frac{d(r\sigma r)}{dr} - \sigma_\varphi = 0 \qquad (1)$$

where σ_z=0. It is assumed that the disk stress given by the thermal field is realized inside of the elastic domain. There are to be used the known relations between tensions σ, deformations ε and temperature T as well as the relations between deformations u and specific deformations ε. We know that:

$$\begin{cases} \varepsilon_{re} = \frac{1}{E}(\sigma_r - \upsilon\sigma_\varphi) + \alpha T \\ \varepsilon_{\varphi r} = \frac{1}{E}(\sigma_\varphi - \upsilon\sigma_r) + \alpha T \\ \varepsilon_{ze} = -\frac{\upsilon}{E}(\sigma_r + \sigma_\varphi) + \alpha T \end{cases}$$

The next calculation relation is obtained:

$$\frac{d^2u_e}{dr^2} + \frac{1}{r} * \frac{du_e}{dr} - \frac{1}{r^2} - \alpha(1+\upsilon) * \frac{dT}{dr} = 0 \qquad (2)$$

with the solution of

$$u_e = A\frac{1}{r} + Br + \alpha\frac{1+\upsilon}{r}\int rTdr \qquad (3)$$

Finally there are obtained the calculation relations for tensions:

$$\begin{cases} \sigma_{re} = \frac{1}{1-\upsilon^2}[-A\frac{1}{r^2}(1-\upsilon) + B(1+\upsilon) - \\ \alpha(1-\upsilon^2)\int rTdr]; \\ \sigma_{\varphi e} = \frac{1}{1-\upsilon^2}[A\frac{1}{r^2}(1-\upsilon) + B(1+\upsilon) + \\ \alpha(1-\upsilon^2)(\frac{1}{r^2}\int sTdr - T)] \end{cases} \qquad (4)$$

The integration constants A and B will be determined with the mean of limit conditions, respectively with the mean of continuity conditions at the limits between the elastic domain and plastic domain.

In the plastic domain there should be satisfied the plasticity criteria as well.

In the case of ring – shaped disks the unified fields criterion is adequate. Essentially this criterion is based on the hypothesis which stipulates that the plastic yielding is checked by the action and combination of two shear stresses.

The mathematical expression of the unified fields criterion is given by the following equations:

$$\begin{aligned} &\tau_{13} + b\tau_{12} = c, \quad when \quad \tau_{12} \geq \tau_{23} \\ &\tau_{13} + b\tau_{23} = c, \quad when \quad \tau_{23} \geq \tau_{12} \end{aligned} \qquad (4')$$

where *b* is a weight coefficient which shows the influence of the shear stresses τ_{12} or τ_{23} on the material and *c* is a material coefficient.

The equations are valid in the following conditions:

→ $\sigma_1 \geq \sigma_2 \geq \sigma_3$ are main stresses;

→ (σ_1, σ_2); (σ_2, σ_3) and (σ_3, σ_1) ar shear planes;

$$\tau_{12} = \frac{\sigma_1 - \sigma_2}{2}; \quad \tau_{23} = \frac{\sigma_2 - \sigma_3}{2} \text{ and } \quad \tau_{13} = \frac{\sigma_1 - \sigma_3}{2}$$

represents the shear stresses.

With this explanation, Eqs. (4) become:

$$\begin{cases} \sigma_1 - \frac{1}{1+b}(b\sigma_2 + \sigma_3) = \sigma_r & for \frac{\sigma_1+\sigma_3}{2} \geq \sigma_2; \\ \frac{1}{1+b}(\sigma_1 + b\sigma_2) - \sigma_3 = \sigma_0 & for \frac{\sigma_1+\sigma_3}{2} < \sigma_2 \end{cases} \quad (5)$$

where σ_r is the tensile rupture limit of the material. Eqs. (5) have a general feature. One mention that:

- for b = 0 one come to the TRESCA criterion;
- for b = 0.5 one come to the MISES criterion;
- for b = 1 one come to the unified fields criterion.

In hypothesis of Huber, Mises, Hencky plasticity criteria, there should be fulfilled the condition expressed through relation:

$$\sigma_{\varphi p}^2 - \sigma_{\varphi p}\sigma_{rp} + \sigma_{rp}^2 = \sigma_c \quad (6)$$

where σ_c – flowing limit of the material at the uniaxial test of lengthening. From the above:

$$\sigma_{\varphi p} = \frac{\sigma_{rp}}{2} \pm \sqrt{\sigma_c^2 - \frac{3}{4}\sigma_{rp}^2} \quad (7)$$

On the inner edge of the ring-shaped disk, from where actually the plasticity process starts, in the case they will be treated, $\sigma_{rp}(a)=0$. In front of the square root, the minus sign will be chosen at heating because of the negative tangential tension and at cooling there will be chosen the positive sign. Utilizing index1 for heating and index 2 for cooling it is obtained:

$$\frac{d\sigma_{rp1}}{dr} = -\frac{\sigma_{rp1}}{2} - \frac{1}{r}\sqrt{\sigma_c^2 - \frac{3}{4}\sigma_{rp1}^2} \quad (8)$$

This equation may be solved, in the case of a variable flowing limit $\sigma_c(r)$, by the mean of Runge-Kutta method, and the obtaining tensions will be approximated through parabola. For the mean flowing limit, constant:$\sigma_c=\sigma_m$, equation (8) may be integrated and therefore results:

$$\sigma_{rp1} = \frac{-2\sigma_{m1}}{\sqrt{3}}\sin\left(\upsilon - \frac{2}{3}\pi\right) \quad (9)$$

$\sigma_{\varphi p1}$ value results from plasticity criteria:

$$\sigma_{\varphi p1} = \frac{2\sigma_{m1}}{\sqrt{3}}\sin\left(\upsilon - \frac{2}{3}\pi\right) \quad (10)$$

In the same way, for he root case, the radial and tangential normal tensions will have their values given by the next relations:

$$\sigma_{rp2} = \frac{2\sigma_{m2}}{\sqrt{3}}\sin\left(\upsilon - \frac{2}{3}\pi\right)$$

$$\sigma_{\varphi p2} = -\frac{2\sigma_{m2}}{\sqrt{3}}\sin\left(\upsilon - \frac{2}{3}\pi\right) \quad (11)$$

In several cases is advantage the utilization of Tresca's plastic condition. Usually deviations that result against the obtained results using the Mises's condition are insignificantly. The main advantage of Tresca's plastic criteria consists of the fact hat it offers relations much simplified and thus mathematical operations may be used. In this case the plasticity criteria may be wrote as follow:

$$\begin{cases} (\sigma_{rp} - \sigma_{\varphi p})^2 - \sigma_c^2 = \phi_z \\ (\sigma_{\varphi p} - \sigma_{zp})^2 - \sigma_c^2 = \phi_r \\ (\sigma_{zp} - \sigma_{rp})^2 - \sigma_c^2 = \phi_\varphi \end{cases} \quad (12)$$

flowing appears when one of the three plasticity forces disappears. In the studied cases, $\sigma_{\varphi p}$ and σ_{rp} have the same sign and thus because $\sigma_{zp}=0$, plasticity criteria takes the following form:

$$\begin{cases} \phi_r = 0 \\ \sigma_{\varphi p} = \pm\sigma_c \end{cases} \quad (13)$$

The negative sign is valid for heating and the positive sign is valid for cooling the ring-shaped disk. Therefore:

$$\frac{d(\sigma_{rp} r)}{dr} = \pm\sigma_c \quad (14)$$

Taking in consideration the limit conditions $\sigma_{rp}(a)=0$, after the integration operation there will be obtained:

$$\sigma_{rp} = \pm\frac{1}{r}\int_a^r \sigma_c(\bar{r})d\bar{r} \quad (15)$$

Up to now, there have been determined the relations regarding to the elastic domain and plastic one. Next, the coupling of the two domains take place, through some binding relations. It may be assumed that the plastic domain is limited by the inner radius of the ring-shaped disk "a" and a radius of an elastic-plastic limit R_1. Therefore:

$$a \leq r \leq R_1$$

The above relation is valid at heating. In the case of cooling there will be a similar relation, but having another radius limit:

$$a \leq r \leq R_2$$

Because the temperature may be lowered only to the value of ambient temperature; always:

$$R_2 < R_1$$

The integration constants A and B as well as the limit radius R result from the following reason: radial tension disappears at the outer radius level:

$$\sigma_{re}(b) = 0 \quad (16)$$

From equilibrium reasons, radial tensions from the plastic domain and elastic domain should have the same values for the limit radius between domains:

Table

Plate on mandrel

- The table contains the values on ΔT_{cr}
- $\gamma = 30$ (coefficient from the temperature's law of distribution)
- $\Delta T = 10°C$
-

	Nr. cercuri nodale / Nr. diametre nodale	d=0	d=1	d=2	d=3	d=4
$\frac{R_i}{R_e}=0$	C=0	37,92	41,522	79,99	127,118	184,61
	C=1	90,22	147,78	219,18	300	392,156
	C=2	227,70	311,688	422,535	533,33	659,34
	C=3	427,04	533,333	685,714	833,33	991,73
	C=4	689,655	810,81	1016,949	1188,118	1384,08
$\frac{R_i}{R_e}=0,2$	C=0	42,44	63,707	89,55	134,378	194,174
	C=1	62,49	82,19	247,933	318,302	410,95
	C=2	192,926	209,05	483,87	571,42	693,64
	C=3	413,793	431,65	799,99	902,25	1043,47
	C=4	727,27	745,34	1212,12	1307,189	1458,08
$\frac{R_i}{R_e}=0,4$	C=0	66,2	70,28	118,8	162,16	224,71
	C=1	86,33	95,23	363,63	416,66	493,827
	C=2	322,58	332,4	759,49	821,91	902,25
	C=3	714,28	727,27	1318,68	1312,99	1463,41
	C=4	1263,157	1276,59	2023,6	2205,88	2185,79
$\frac{R_i}{R_e}=0,6$	C=0	78,9	128,7	226,41	269,05	332,409
	C=1	193,86	202,02	794,7	851,06	923,076
	C=2	754,716	764,33	1276,61	1788,37	1877,934
	C=3	1678,32	1690,14	3030,3	3092,78	3199,99
	C=4	2970,29	2985,07	4743,08	4780,87	4897,95
$\frac{R_i}{R_e}=0,8$	C=0	160,8	260,52	307,9	1034,48	1142,85
	C=1	916,03	930,23	967,74	3703,7	3870,96
	C=2	3519,06	3539,82	3603,6	8003,69	8275,86
	C=3	7843,13	7843,13	7947,01	14051,52	14302,74
	C=4	13793,103	13808,97	13904,98	21857,92	22140,22

Table

- Disk on mandrel
- Number of nodal circles: C = 0
- $\gamma = 1$ (coefficient from the temperature's law of distribution)
- $\Delta T = 10°C$; n = 1000 rot/min

C=0	DIAMETRE NODALE	$T_{cr}=\frac{\Delta T}{\lambda}$	$\omega_{cr}^2=-\frac{1}{\lambda}\cdot 10^6$	$\dot{T}_0$ (calculat)
$\frac{R_i}{R_e}=0$	d=0	35,211	+13,03 · 10^6	59,531
	d=1	112,032	+35,001 · 10^6	140,84
	d=2	316,555	+6,106 · 10^6	741,39
	d=3	683,15	+20,66 · 10^6	980, 789
	d=4	1154,25	+41,684 · 10^6	1403,464
$\frac{R_i}{R_e}=0,2$	d0	25,846	+11,36 · 10^6	46,206
	d1	92,592	+4,325 · 10^6	285,268
	d2	301,93	+6,958 · 10^6	692,468
	d3	467,126	+18,69 · 10^6	692,955
	d4	672,992	+37,03 · 10^6	836,560
$\frac{R_i}{R_e}=0,4$	d0	23,207	+12,007 · 10^6	40, 602
	d1	70,62	+7,209 · 10^6	158,784
	d2	526,37	+8,598 · 10^6	1077,22
	d3	693,77	+16,44 · 10^6	980,63
	d4	739,86	+28,97 · 10^6	969,709
$\frac{R_i}{R_e}=0,6$	d0	27,247	+18,737 · 10^6	40,33
	d1	74,204	+14,93 · 10^6	119,079
	d2	1594,13	+15,335 · 10^6	2517,46
	d3	1714,97	+20,53 · 10^6	2466,78
	d4	1772,04	+28,571 · 10^6	2330,24
$\frac{R_i}{R_e}=0,8$	d0	46,772	+56,915 · 10^6	54,168
	d1	120,26	+55,61 · 10^6	139,723
	d2	1312,33	+56,18 · 10^6	1522,56
	d3	13.073,04	+60,42 · 10^6	15 021,398

Table

- Disk on mandrel
- Number of nodal circles: C = 1
- $\gamma = 1$ (coefficient from the temperature's law of distribution)
- - $\Delta T = 10°C$; n = 1000 rot/min
-

C=1	DIAMETRE NODALE	$T_{cr}\ (\frac{10}{\lambda})$	$\omega_{cr}^2=(-\frac{1}{\lambda}\cdot 1000^2)$	$\dot{T}_0$ (calculat)
$\frac{R_i}{R_e}=0$	d=0	169, 692	+69,252 · 10^6	191, 745
	d=1	300, 12	+110,399 · 10^6	324,586
	d=2	559, 28	+66,44 · 10^6	635,04
	d=3	1025, 85	+104,36 · 10^6	1114, 31
	d=4	1593, 168	+149,58 · 10^6	1689,026
$\frac{R_i}{R_e}=0,2$	d=0	187, 65	+85,103 · 10^6	207, 194
	d=1	266, 737	+70,323 · 10^6	300, 874
	d=2	680, 272	+77,579 · 10^6	759, 19
	d=3	1018, 453	+100,59 · 10^6	1109, 55
	d=4	1395,069	+134,64 · 10^6	1488, 34
$\frac{R_i}{R_e}=0,4$	d=0	437, 629	+227,324 · 10^6	455, 162
	d=1	492, 125	+181,06 · 10^6	516, 587
	d=2	1489,86	+156, 10 · 10^6	1575, 75
	d=3	1830,59	+151,60 · 10^6	1939,26
	d=4	2380, 95	+159,31 · 10^6	2515, 45
$\frac{R_i}{R_e}=0,6$	d=0	1602, 564	+1093 · 10^6	1615, 759
	d=1	1663, 89	+835,42 · 10^6	1681, 815
	d=2	5162, 62	+616, 52 · 10^6	5237,98
	d=3	5571, 24	+485,67 · 10^6	5680, 59
	d=4	6426, 735	+410, 34 · 10^6	6567, 69
$\frac{R_i}{R_e}=0,8$	d=0	1879, 18	+61625,28 · 10^6	14136, 33
	d=1	14240, 95	+12881, 6 · 10^6	14250, 89
	d=2	16186, 46	+8733, 6 · 10^6	16203, 14
	d=3	45269, 35	+6013, 23 · 10^6	45337, 10

Table

- Disk on mandrel
- Number of nodal circles: C = 2
- $\gamma = 1$ (coefficient from the temperature's law of distribution)
- $\Delta T = 10°C$; n = 1000 rot/min

C=2	DIAMETRE NODALE	$T_{cr}=\frac{\Delta T}{\lambda}$	$\omega_{cr}^2=-\frac{1}{\lambda}\cdot 10^6$	$\dot{T}_0$ (calculat)
$\frac{R_i}{R_e}=0$	d=0	405,56	+168,01 · 10^6	407,253
	d=1	576,76	+224,87 · 10^6	699,843
	d=2	913,24	+165,43 · 10^6	962, 923
	d=3	1485,35	+224,06 · 10^6	1545, 013
	d=4	2182,92	+290,59 · 10^6	2250, 544
$\frac{R_i}{R_e}=0,2$	d=0	371,42	+268,131 · 10^6	391, 343
	d=1	640,61	+232,34 · 10^6	665, 424
	d=2	1271,61	+230,62 · 10^6	1321, 234
	d=3	1650,16	+248,31 · 10^6	1709, 73
	d=4	2209,94	+284,33 · 10^6	2279, 89
$\frac{R_i}{R_e}=0,4$	d=0	1491,04	+774,59 · 10^6	1509, 173
	d=1	1542,02	+607,28 · 10^6	1562,2189
	d=2	3132,83	+607,53 · 10^6	3179, 24
	d=3	3460,20	+550,66 · 10^6	3516, 75
	d=4	4338,39	+516,25 · 10^6	4414, 92
$\frac{R_i}{R_e}=0,6$	d=0	5656,10	+3866,97 · 10^6	5678, 28
	d=1	5714, 29	+3414, 13 · 10^6	5729, 343
	d=2	11.539, 349	+2873, 56 · 10^6	11.575, 49
	d=3	11.900, 51	+2988, 34 · 10^6	11.945, 344
	d=4	12.841, 91	+1997, 80 · 10^6	12.899, 169
$\frac{R_i}{R_e}=0,8$	d=0	50.607, 26	+61.652, 28 · 10^6	50.614, 607
	d=1	50.709, 93	+54.555, 37 · 10^6	50.713, 296
	d=2	58.761, 31	+44.909, 69 · 10^6	58.773, 082
	d=3	102.880, 65	+35.893, 76 · 10^6	102.906, 446
	d=4		+98.344, 67 · 10^6	

$$\sigma_{rp}(R) = \sigma_{re}(R) \tag{17}$$

The plasticity criteria is satisfied in both domains for limit radius R. Therefore:

$$\sigma_{\varphi p}(R)_e = \sigma_{\varphi e}(R) \tag{18}$$

Next, it is assumed that before heating there were no residual tensions in the plate. Therefore $\sigma_r=0$ and $\sigma_\varphi=0$. The hypothesis that there existed residual tensions is also used. For heating the value of final stationary temperature T is introduced. Through an accordingly mathematical development the tensions expressions result:

$$\begin{cases} \sigma_{\varphi e1}(r) = \frac{1}{2}(\sigma_{rp1}(R_1) + \sigma_{\varphi p1}(R_1) + E\alpha T_1 \\ (R_1))(1 + \frac{b^2}{r^2}) - E\alpha \frac{1}{r^2}(\int^b rT_1 dr - \\ \int rT_1 dr) - E\alpha T_1 \\ \sigma_{re1}(r) = \frac{1}{2}(\sigma_{rp1}(R_1) + \sigma_{\varphi p1}(R_1) + E\alpha T_1 \\ (R_1))(1 + \frac{b^2}{r^2}) + E\alpha \frac{1}{r^2}(\int^b rT_1 dr - \\ \int rT_1 dr) \end{cases} \tag{19}$$

For numerical development there will be utilized for T_1 a thermal stationary field using the approximated relations 15 (from the paper "RING - SHAPED DISKS IN NON – STATIONARY THERMAL FIELD").

Determination of residual tension state is done in the same way but taking in consideration that before beginning the process of cooling there are the following tensions σ_{r1} and $\sigma_{\varphi 1}$. Knowing these values is only important for elastic domain.

Tensions from plastic domain σ_{rp2} and $\sigma_{\varphi p2}$ may be calculated, independently of thermal tensions, for constant flowing limit at ambient temperature $T_2=0$.

In the case of first ratio, the following approximate relation is obtained:

$$\frac{\overline{T}}{T} = e^{-2350\left(\frac{ls}{t}\right)^{1.1}\left(\frac{r}{a}-1\right)}[0.0748 + \\ + 0.925e^{-1.920\left(\frac{r}{a}-1\right)}] \tag{20}$$

Representations from Fig. 5-6 (from the paper "RING - SHAPED DISKS IN NON – STATIONARY THERMAL FIELD"), had been done based on the following relations:

$$\begin{cases} \frac{\overline{T}}{^\circ C} = 30.64 + 2510.7 * e^{-5.75\frac{r}{b}} \\ \frac{\overline{T}}{^\circ C} = 45.96 + 3766 * e^{-5.57\frac{r}{b}} \end{cases} \tag{21}$$

where T_0=400 and 600 C and a/b=1/3. If calculations are made for a/b=1/10 ratio and temperatures T^1_0 equals with 400 and 600 C, the following relations are obtained:

$$\begin{cases} \frac{\overline{T}}{^\circ C} = 9.07 + 734 * e^{-6.3\frac{r}{b}} \\ \frac{\overline{T}}{^\circ C} = 13.61 + 1101 * e^{-6.3\frac{r}{b}} \end{cases} \tag{22}$$

The above relations are particularization of relations (15) (from the paper "RING - SHAPED DISKS IN NON – STATIONARY THERMAL FIELD"). We specify that the above relation is an approximated relation of thermal field; in this way a simplification of numerical calculation is obtained, in the way that the tensions state can be determined. It is emphasize that the determined thermal fields using this method differs very little of those considered to be exact (thermal accepted without any reserves).

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[3] Furdac, Fl., Radu, N.Gh., Comanescu, I. *Study of residual stresses due to the thermal tensions*, 12pages, CDM 2001, Machine dynamic, Series A-Mechanics, 2001, ISSN 1223-96361.

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PLASTICITY CRITERIA - RESIDUAL STRESSES AND DEFORMATIONS AT RING – SHAPED DISKS IN THERMAL FIELD II

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Abstract: - The present paper presents the theoretical method for determination of the deformations and the loss of stability of the disk stressed by an axial – symmetric thermal field, variable according to disk radius and thickness, superposed with a field of membrane tensions given by the rotational motion. The experimental results confirm the theoretical hypothesis. This paper also presents the tension and deformation state of the disks being in a non – stationary field of temperature. The study is done until the plastic deformations occur.

Key-Words: - disk, thermal field, stress, membrane tension, stability, non – stationary field

PART II
Problem Solution. Conclusions.

In Fig.1. are presented the residual tensions values for the case of b=1 m, T_0=600°C and ratios of a/b=1/3 and a/b=1/10.

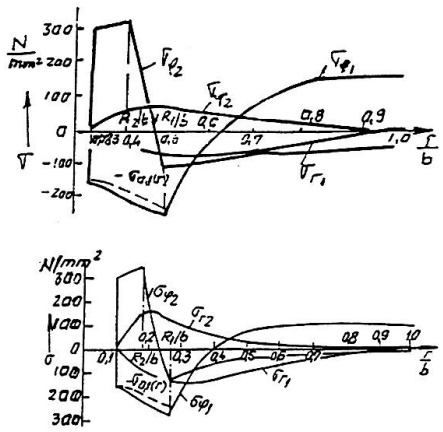
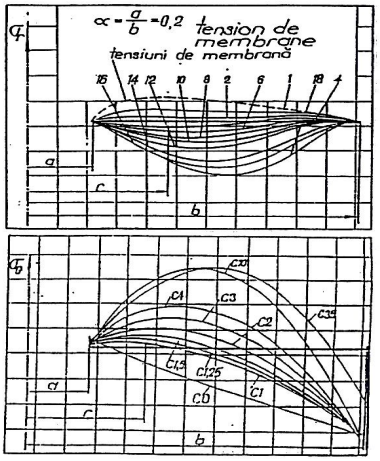


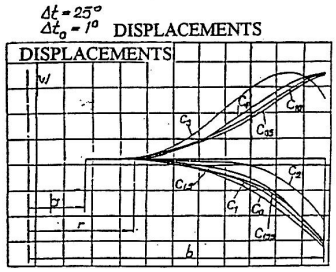
Fig. 1

In Fig. 2 are shown some diagrams, which show the deformation state (rotations and movement) and tension state for thin rotating disks in a thermal axial-symmetric state.

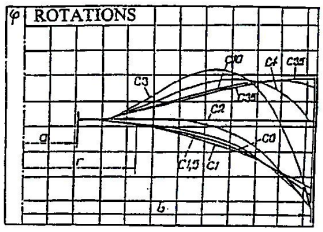
In Fig. 3 is shown the thermal and residual tensions variation for a ring-shaped plate with b=1 m, a/b=1/3 and T_0=400°C. With continuos line were presented the calculated variations using Tresca's criteria, and with dashed line were presented the calculated variations using Mises's criteria. There are no differences for σ_r tensions.



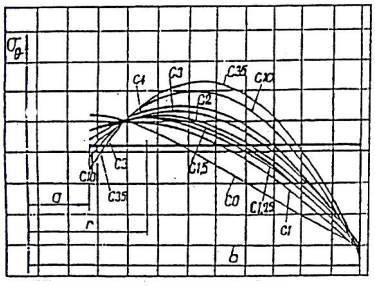
BENDING STRESSES
Bending stresses variations according to the temperature distribution's changes on the radius



Displacement's *w* variation according to the temperatures' changes on the radius



Rotation's variation according to the temperature's changes on the radius
Fig.2



MEMBRANE STRESSES
Membrane stresses' variation according to the temperature's distribution changes on the radius

Fig. 2 (sequel)

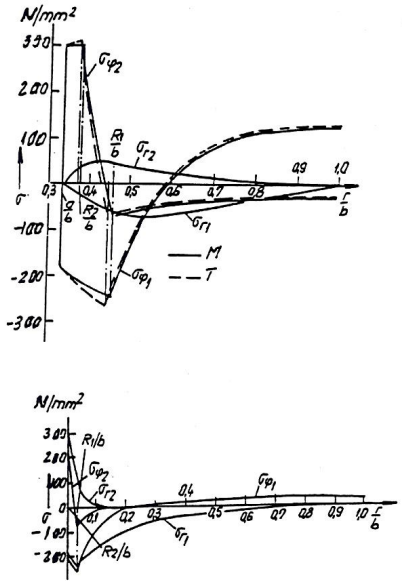


Fig. 3

Conclusions are very important and very useful in practice. If curves from Fig.8.b. (from the paper "RING - SHAPED DISKS IN NON – STATIONARY THERMAL FIELD") are compared with those from Fig. 2. and 3. there should be seen great similitude.
This may be explained by the correct way in which the temperature effect for planar plates had been seen and approached.
In conclusion we may say that the elastic stability problems are necessary, their study being as necessary as the static one. In this way it is shown which are the "reserves" of a structure, finishing with a design based on new considerations.
The study of behavior and stability for thin rotating disks in thermal axial-symmetric state, done in the hypothesis of bending stresses as well as membrane stresses, are decoupled (linear theory-first rank calculation), as well as in the hypothesis inter-independence study between this (non-linear behavior-second rank calculation) are necessary. If the disk's thickness is big enough and disks are placed in a non-stationary thermal field, then is taking account of apparition of local plastic deformation, which lead to the apparition of residual tensions (is a natural consequence of dynamic character of thermal processes).
The Unified Fields Criterion can also be named "the uniform yielding criterion" and it is suitable for thin disks.

The previous mentioned criterion contains a "family" of cases, which are obtained by variation of parameter *b* between the values 0 and 1.
For the specific cases when b = 0; b = 0.5 and b = 1, the unified fields criterion allows the checking and analysis with maximum efficiency of all structures which are subjected to the TRESCA and MISES criterion. This criterion offers the advantage of allowing the analysing of complex situations, numerical applications which can be solved with help of "linear programming methods".
The disk cannot be perfectly planar; it always has small geometrical flaws. In this situation, the field of membrane tensions produces displacement w perpendicular to the median surface of the disk, even if the field level is bellow the stability loss value. This dependence is not linear.
According to the nature and size of inhomogenies, loss of stability may take place by "axial-symmetrical modes"(with nodal circles) or "axial unsymmetrical modes" (with nodal diameters).
Table 3.2. presents also the temperature distribution for the studied case, with help of FEM and FDM.
Both from fig. 6 and table 3.1. one observes that the different combinations C = 0, D = 0; C = 1, D = 1, the critical temperatures are much increasing and from practical point of view, are not interesting.

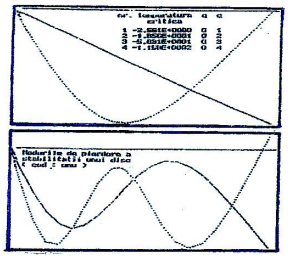
Table 3.1

C=0	DIAMETRE NODALE	$T_{cr}=\frac{\Delta T}{\lambda}$	$\omega_{cr}^2=-\frac{1}{\lambda}\cdot 10^6$	T_0 (calculat)
$\alpha=\frac{R_i}{R_e}=0$	d = 0	35,211	$+13,03\cdot 10^6$	59,531
	d = 1	112,032	$+35,001\cdot 10^6$	140,84
	d = 2	316,555	$+6,706\cdot 10^6$	741,39
	d = 3	683,15	$+20,66\cdot 10^6$	980,799
	d = 4	1154,25	$+41,684\cdot 10^6$	1403,464
$\alpha=\frac{R_i}{R_e}=0,2$	d0	25,846	$+11,38\cdot 10^6$	46,286
	d1	92,592	$+4,325\cdot 10^6$	285,268
	d2	301,93	$+6,958\cdot 10^6$	692,468
	d3	467,726	$+18,69\cdot 10^6$	692,955
	d4	672,992	$+37,03\cdot 10^6$	836,560

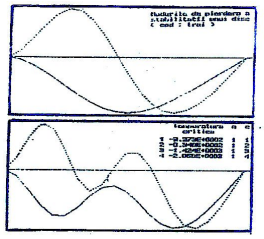
CRITICAL TEMPERATURES OF DISKS STABILITY LOSS
h=1.2 mm; n=1000 rot/min

Table 3.2.

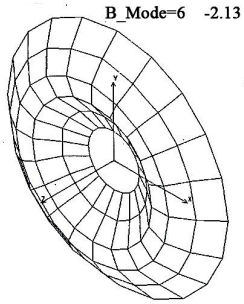
α	MODUL DE PIERDERE A STABILITĂŢII	PROGRAM MEF	PROGRAM DIFERENŢE FINITE	EXPERIMENTAL
0.2	D=0; c=0	46,286	47,062	48
	D=0; c=1	201,494	208,12	
0,4	D=0; c=0	40,602	42,04	44
	D=0; c=1	455,162	456,83	
0 [n=0]	D=0; c=0	35,211	36,8	34
	D=0; c=1	169,692	171,06	



Inner supported disk
W = 0, M = 0 at r = a
M = 0, Q = 0 at r = b



Fixed disk at r = 0 and supported at r = b
W = 0, φ = 0, W = 0, M = 0
Fig. 4



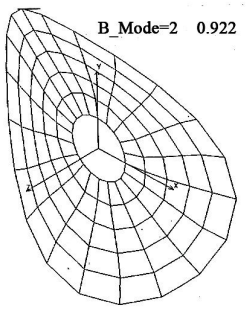
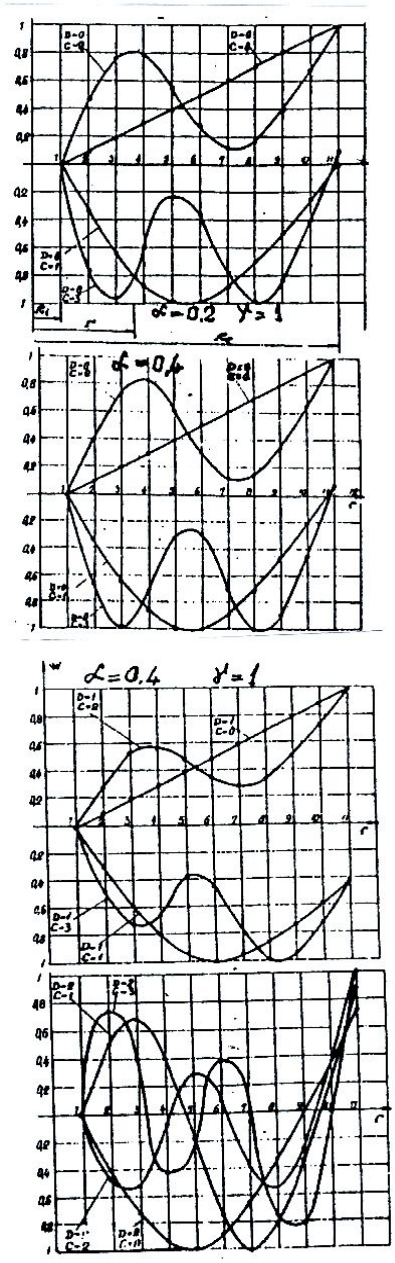


Fig. 5



Deformations *w*
α - variable value

Fig. 6

The temperature's distribution upon the disk radius are:

- FEM software: $T = T_0\left(\frac{r}{R_e}\right)^{\gamma}$;
- FDM software:

$$T = \Delta T\left[\frac{r - R_i}{r - R_e}(1 + C) + \left(\frac{r - R_i}{R_e - R_i}\right)^2 C\right]$$

- $\alpha = \frac{R_i}{R_e}$; D – nodal diameters; c – nodal circles;
- From the experimental records, it has been found that C = -0.65…+0.6. The value of the dimensionless coefficient C is strongly affected by many factors, such as: temperature difference $\Delta T = T_2 - T_1$ and disk velocity.

Generally one can assume that the two (membrane and bending) loads are independent and can be studied separately. If the plate is thin, the membrane tensions exert a strong influence on flexures; this influence is also notable on natural frequencies and
buckling tensions. Theoretically the study has been carried out with von Karman's equations, which represent a dynamic version of the non-linear theory of plates.

Karman's equations describe the behavior of thin disks subjected to membrane tensions, flexion tensions as well as the reciprocal influence of the two types of tensions (second rank calculation).

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A FUZZY LOGIC APPROACH ON MULTIPLE CRITERIA EVALUATION OF THE VOTING PROCESS THROUGHOUT AN ELECTORAL CYCLE

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ABSTRACT

This paper aims to present a study of how techniques of analysis used in designing the fuzzy controllers can be applied to Multi-Criteria distribution problems. As a case study, the repartition of the mandates for a county conference of a Romanian political party was analyzed. The distribution of mandates takes into account three criteria, namely: the number of votes, the percentage obtained and the positioning of each local organization in an election cycle. In fact, according to these three criteria, each organization is evaluated. The mandates are finally distributed in relation to the evaluation results. Evaluation is made using three methods. The first one analyzes the situation in which fuzzy rules contain three criteria. The second examines the situation in which fuzzy rules take into account only two criteria. The third one consider the situation when multi-criteria evaluation is done without resorting to fuzzy logic. Finally, one presents an analysis of the limitations imposed by each method..

Keywords: *Multi-Criteria Decision Analysis; Multi-Criteria Evaluation.*

1. INTRODUCTION

It is well known that the electoral process - a process where a large part of the population of a region or a country is participating - is largely supported by the local organizations of the parties participating in. On the other hand, reality shows that even within a party, involving of local organizations occurs on different levels. Based on this truth, existing mainstream parties in Europe and beyond, have developed various ways of evaluating the performance of local organizations. Evaluation of these performances can be made considering only one criterion, namely the percentage of votes cast at election time or, taking into account several criteria. This involves the combination of criteria such as number of voters drawn into the electoral process, or the establishment of majority actual results. It is obvious that there are different electoral strategies in case of a village with 2,000 inhabitants or a city with 300,000 inhabitants. Moreover, one is to obtain a satisfactory rate but do not win elections, or if the elections are won, the type of majority obtained becomes important. From this point of view, the problem of assessing local party organizations is included in the multi-criteria evaluation problem. It is well known as Arrow's Theorem (Voting Theorem) [1] shows the impossibility of such assessment, if the hypothesis of this theorem (unrestricted domain, non-dictatorship, Pareto efficiency, independence of irrelevant alternatives are met. On the other hand, given that the said assumptions are not met, one can imagine various solutions for multi-criteria evaluation. "Generic Methods for Multi-criteria Evaluation" [2] by Niklas Davidsson and Paul Lavesson shows a comprehensive review of solutions - existing in textbooks - to this problem. It must be said that, in terms of this work is interesting, the hybridization of fuzzy logic and evolutionary algorithm to address multiple objectives that has been proposed by ABIDO, M.A. and BAKHASHWAIN, J.M., in [3] and PIRJANIAN, P in [4]. Currently, this type of analysis was extended to areas such as Multi-Criteria Decision Analysis and Multi-Criteria Resources Allocation Analysis. Thus, this approach is useful in economic or technical field (theory of automatic systems).

2. PROBLEM FORMULATION

Consider $Cr_k \quad k \in \{1.2 \cdots r\}$ a number of "r" criteria (percentage obtained in the elections, the number of voters attracted by the organization, number of party members, obtain Staff.) that can be used in the evaluation of local party organizations. Each criterion is given a number "n_k" won in the electoral process. A rating factor - noted "$C_{eval.}$"- must be evaluated.

3. PROBLEM SOLUTION

The proposed solution uses fuzzy logic formalism. Figure 1 shows the simplified methodology applied for this type of analysis.

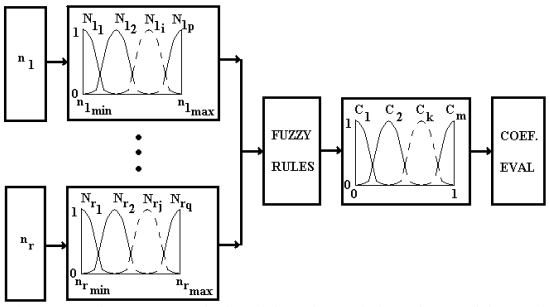

Figure 1 The proposed algorithm for solving the problem of multi-criteria evaluation

where:

$N_{1i} \quad i \in \{1,2,\cdots p\}$ membership functions for "n_1" input

N_{rj} $j \in \{1,2,\cdots q\}$ membership functions for "n_r" input

C_k $k \in \{1,2,\cdots m\}$ membership functions for "C_k" output

n_{1min}, n_{1max} limit values for "n_1" input

$n_{r\,min}$, $n_{r\,max}$ limit values for "n_r" input

n_1 dataset criterion "1"

n_r dataset criterion "r"

Figure 1 reveals the fact that the results obtained by a local organization for each criterion are the input data sets. The output of the algorithm is the evaluation factor. The fuzzy rules statement is:

$$\text{If} \quad n_\alpha \in N_{\alpha i} \quad \text{and} \quad n_\beta \in N_{\beta j} \quad \text{then} \quad C_{eval} \in C_k \qquad (1)$$

Where:

n_α, n_β input value for α-criterium, respectively β-criterium;

N_α, N_β membership function for α-criterium, respectively β-criterium;

C_k. membership functions for C_{eval}.

The evaluation of the fuzzy rules is made by min-max method [5]. The defuzzification is made using the centroid method [5]. In fact, the proposed algorithm develops the function:

$$C_{eval.} = C_{eval.}(n_1, n_2, \cdots n_r) \qquad (2)$$

There is also an additional condition, namely:

$$\frac{\partial C_{eval}}{\partial n_k} > 0 \quad k \in \{1.2.\cdots r\} \qquad (3)$$

4. CASE STUDY

Problem Statement

Find the number of mandates, allocated to any local organization at Constanta County Conference, depending on the results:

1. *County Council Elections,*
2. *Deputies Chamber Elections,*
3. *European Parliament Elections,*
4. *Election for President.*

The criteria used for evaluation are:

1. *Number of votes obtained by the organization (noted "N");*
2. *The percentage obtained by the organization (noted "P");*
3. *Actual result of the organization after evaluating the results of elections (noted 'B'), namely:*
   - *Election victory (<50%) bonus 5%;*
   - *Election victory (simple majority) bonus 10%*
   - *Election victory (qualified majority) bonus 15%*

Problem Solution

Given the algorithm proposed in Section 3, solving problem requires two steps:

1. Calculation of the according to mentioned algorithm;
2. Calculating the number of mandates implying a type d'Hondt algorithm [6].

The calculus of the evaluation factor is made using three methods:

1. Fuzzy rules involve three criteria. In this situation it is estimated:
   $$C_{eval.} = C_{eval.}(N, P, B) \qquad (4)$$
2. Fuzzy rules take into account only two criteria, namely, percentage obtained by the organization and actual outcome of the organization after evaluating election results. In this situation one evaluates:
   $$C_{eval.} = N \times C'_{eval}(P, B) \qquad (5)$$
3. Multi-criteria evaluation is done without resorting to fuzzy logic. In this situation one evaluates:
   $$C_{eval.} = N \times P \times B \qquad (6)$$

4.1 CALCULUS OF THE EVALUATION FACTOR USING THREE CRITERIA IN FUZZY RULES

Figure 2 shows the simplified algorithm used in this situation

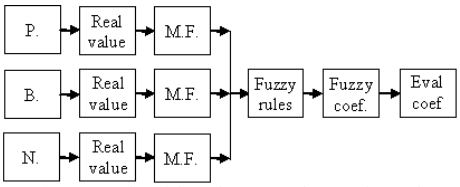

Figure 2 Algorithm that uses the (4) formula

Fuzzy universe of discourse associated with the input parameters and the evaluation factor is {SMALL, MEDIUM, HIGH}. In these conditions were used 27 fuzzy rules. For example, the first rule has the form:

If $P \in$ SMALL **and** $B \in$ SMALL **and** $N \in$ SMALL **then** $C \in$ SMALL

The remaining 26 rules were obtained by combination of the three logical values existing in the universe of words of input parameters. It is interesting to note that, according to sociological analysis, the process of voting in a city with over 300,000 inhabitants should be treated differently from that place in a village with 3,000 inhabitants. For this reason, this type of analysis was applied in three stages. In the first stage, the city of Constanta was analyzed. In the second stage, the the county towns were analyzed and finally the villages.

4.2 CALCULUS OF THE EVALUATION FACTOR USING TWO CRITERIA IN FUZZY RULES

As was noted, in this situation analysis focused on the percentage obtained using fuzzy techniques of organization and the actual result of the organization, after evaluating the results of elections. Figure 3 shows the simplified algorithm used in this situation:

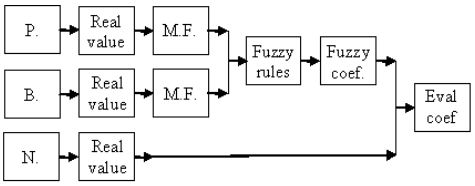

Figure 3 Algorithm that uses the (5) formula

The analysis - in this case - was done for two situations:

1. Using the Gaussian membership functions. Figures 4 and 5 reveal these features:

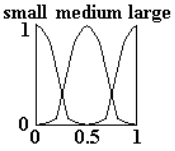

Figure 4 Gauss input m.f.

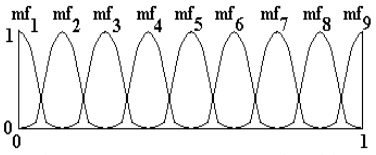

Figure 5 Gauss output membership

2. Using the triangle Gaussian membership functions. Figures 6 and 7 reveal these features:

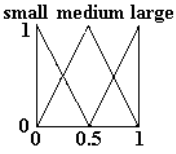

Figure 6 Triangle input m.f.

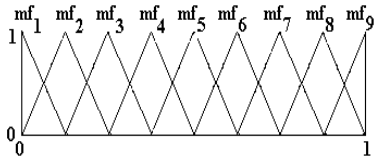

Figure 7 Triangle membership function used for output parameter

Fuzzy universe of discourse for input parameters was {SMALL (P_1 orB_1), MEDIUM (P_2 orB_2), LARGE (P_3 orB_3) }. Fuzzy universe of discourse for output parameters was {EXTRA SMALL (C_1), VERY SMALL (C_2), SMALL (C_3), ALMOST SMALL (C_4), MEDIUM (C_5), ALMOST LARGE (C_6), LARGE (C_7), VERY LARGE (C_8), EXTRA LARGE (C_9)}. The fuzzy rules were:

If $P \in P_1$ **and** $B \in B_1$ **then** $C \in C_1$
If $P \in P_1$ **and** $B \in B_2$ **then** $C \in C_2$
If $P \in P_1$ **and** $B \in B_3$ **then** $C \in C_3$
If $P \in P_2$ **and** $B \in B_1$ **then** $C \in C_4$
If $P \in P_2$ **and** $B \in B_2$ **then** $C \in C_5$
If $P \in P_2$ **and** $B \in B_3$ **then** $C \in C_6$
If $P \in P_3$ **and** $B \in B_1$ **then** $C \in C_7$
If $P \in P_3$ **and** $B \in B_2$ **then** $C \in C_8$
If $P \in P_3$ **and** $B \in B_3$ **then** $C \in C_9$

4.3 CALCULUS OF THE EVALUATION FACTOR WITHOUT USING FUZZY RULES

In this case, the figure 8 shows the algorithm used.

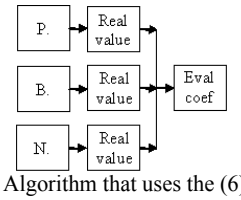

Figure 8 Algorithm that uses the (6) formula

5. RESULTS

Table 1 shows the summarized results by applying the methods presented above.

Table 1

Loc.	C_1	C_2	C_3	C_4
23 August	3	0	0	1
Adamclisi	4	8	8	7
Agigea	5	6	5	5
Albeşti	4	1	2	2
Aliman	4	4	4	3
Amzacea	4	6	6	5
Băneasa	8	2	2	3
Bărăganu	3	2	2	2
Castelu	5	3	3	3
Cerchezu	4	4	5	4
Cernavodă	13	13	12	12
Chirnogeni	4	8	8	6
Ciobanu	4	3	3	2
Ciocârlia	4	7	7	6
Cobadin	5	9	8	8
Cogealac	4	1	1	2
Comana	3	2	2	2
Constanta	291	263	256	286
Corbu	4	1	1	2
Costineşti	3	1	1	1
Crucea	4	7	7	6
Cumpana	7	23	25	22
Cuza Vodă	4	6	6	4
Deleni	4	10	11	7

Loc.	C_1	C_2	C_3	C_4
Dobromir	4	8	9	8
Dumbrăveni	2	2	2	2
Eforie	12	6	7	6
Fântânele	4	4	5	4
Gârliciu	4	7	7	7
Ghindăreşti	3	1	1	1
Grădina	3	3	3	2
Hârşova	11	7	7	7
Horia	3	2	1	2
Independ.	4	6	6	5
Ion Corvin	3	5	5	4
Istria	3	1	1	1
Limanu	3	0	0	1
Lipniţa	5	8	8	7
Lumina	5	11	9	9
Mangalia	15	24	23	18
Medgidia	20	23	27	30
Mereni	3	0	0	1
M. Viteazu	2	0	0	0
Kogălnicean	5	7	7	7
Mircea V	5	12	11	10
Murfatlar	11	3	2	4
Năvodari	17	21	25	26
N. Vodă	7	6	5	5

Loc.	C_1	C_2	C_3	C_4
N.Bălcescu	4	3	3	3
Oltina	4	2	2	2
Ostrov	5	7	6	5
Ovidiu	11	4	5	5
Pantelimon	4	9	9	7
Pecineaga	4	1	2	2
Peştera	4	11	11	10
P.Albă	4	1	1	1
Rasova	4	2	2	2
Săcele	3	0	0	1
Saligny	4	4	5	4
Saraiu	3	3	3	2
Seimeni	3	1	0	1
Siliştea	4	6	5	4
Târguşor	3	3	3	3
Techirghiol	10	4	4	4
Topalu	4	8	7	7
Topraisar	5	13	13	12
Tortomanu	4	4	4	3
Tuzla	5	3	4	4
V. Traian	5	1	1	2
Vulturu	2	1	1	1

where:

C_1 $C_{eval.} = C_{eval.}(N, P, B)$ Fuzzy evaluation for the three input parameters (triangular distribution for the membership function);

C_2 $C_{eval.} = N \times C'_{eval}(P, B)$ Fuzzy evaluation for two input parameters (triangular distribution for the membership function);

C_3 $C_{eval.} = N \times C'_{eval}(P, B)$ Fuzzy evaluation for two input parameters (Gauss distribution for the membership function);

C_4 $C_{eval.} = N \times P \times B$ Evaluation without fuzzy logic for the three input parameters

6. CONCLUSION

It must be said - as it was mentioned above - that the results presented were obtained in conditions in which fuzzy rules were evaluated using the min-max method. The defuzzification process was done by applying the centroid method. In these conditions has been observed:

1. The estimated evaluation factor of each local organization – related to the cases that are using fuzzy rules – does not follow the (3.3) condition;
2. The analysis of the mandates distribution using Gauss membership functions or triangle membership functions shows that the distribution of the mandates is similar;
3. The estimation of the evaluation factor – without using fuzzy logic - fully satisfies the (3.3) condition.

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NEW SOFTWARE TECHNOLOGIES FOR E-LEARNING

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ABSTRACT
In this paper we present a range of arguments in favour of integrating social software tools within e-learning system and to emphasize the advantages of socialization forms on student's education. Social software includes a wide range of different technologies, such as: social networking sites, weblogs, wikis, RSS feeds and social bookmarking. It's based on Web 2.0, a term associated with web applications that allows interactive information sharing, interoperability, user-centred design. The rigorous academic style of learning systems is necessary to be completed with social software tools to have a better impact on the student. Even wikis, social sites and blogs have a lot of fans (students and teachers) in higher education, it seems they have not been used to their full potential for e-learning.
As educators, we would like to be less boring, much more flexible and open and to have a better communication with our students. For this purpose, we tried to include the social software technologies in our courses, to achieve a deeper implication of the students in learning activities, to share knowledge, ideas and thoughts.
In respect of truth, it would be very misleading to define the social software as the best practice used in higher education, but we insist on idea to include its tools in learning systems.

Keywords: *Social software, E-learning, Web 2.0*

1. INTRODUCTION

Universities all over the world are using their own learning management system, generally considered traditional and inflexible by the students. As the authors of this paper belong to the teaching community, we would like to be less boring, much more flexible and open and to have a better communication with our students. For this purpose, we tried to include the social software technologies in our courses, to achieve a deeper implication of the students in learning activities, to share knowledge, ideas and thoughts.
There's no doubt, there are a considerable number of educational institutions who seem to ignore the advantages of Information Technology and especially Web services in the learning process and prefers using these tools for administrative services (registration, information, fee payment, admissions).

The term „social software" is used in many different contexts, and the different technologies covered by the term are not developed for educational purposes. The concept of educational social software was introduced by Terry Anderson [1] within a context of distance education as *networked tools that support and encourage individuals to learn together while retaining individual control over their time, space, presence, activity, identity and relationship*.
Social software is a concept difficult to define not only because it includes a wide range of different technologies, but also because the social application often emerges from a combined use of these technologies. They include discussion forums, social networking sites, weblogs, wikis, RSS feeds and social bookmarking.

In this paper we present a range of arguments in favour of integrating social software tools within e-learning system and to emphasize the advantages of socialization forms on student's education. This approach allows teachers to provide instructions for students (courses, resources), to review and check their work step-by-step and on the other hand, allows students to engage in joint work, share resources and information within university environment and make it available to others.

2. SOCIAL SOFTWARE TECHNOLOGIES - NEW EDUCATIONAL TOOLS FOR STUDENTS

From our point of view, the following social software technologies are the most relevant in the context of the teaching and learning processes:

1. *Social Networking Services* (SNS) - can be defined as internet-based social spaces, designed to facilitate communication, collaboration and content sharing across networks of contacts. The social networking sites allow individuals to build a public profile within a bounded system, articulate a list of other users with whom they share a connection, and view their list of connections and those made by others within the system. Significant examples of social networking services include Facebook, MySpace, LinkedIn, and Twitter. Social networking sites are websites used to support such type of *individual networks*, called also "networks developed on the basis of individual relations" [3]. The basis for social interaction in SNS is the personal profile, usually a webpage created by the individual. Choosing the look and the content information such as texts, pictures, videos and links, the individual uses the opportunities for *personalization*, his own representation on the web. The profile page is personal, but *not private*, in the sense that it can be made public in the individual's network. Also, the personal profile provides a basis and a starting point for *socialization* that begins when an individual's personal page is connected to other personal pages, building his own network of personal relations ("friends") [7]. The communication in social networks is achieved by classic ways (sending messages, adding comments on personal page) or by the new way of notification, meaning the announcement of friends whenever a personal page is modified or a person performs an action within the social site. This indirect form of communication by editing,

developing and updating personal services shows that the SNS works based on *transparency* principle.

Social networking systems allow users to describe themselves and their interests, connect and communicate with others, and set up groups on dedicated topics. Since in October 2007, there were over 250 million profiles on social networking sites, recent surveys in the US found that 55% of US online teens have created personal profiles online, using social networking sites like MySpace or Facebook. Also, is interesting to know that the findings indicated that education related topics were the most commonly discussed, with 60% of the young people surveyed talking about education-related topics and 50% discussing their schoolwork [8].

Beyond the criticism, the extension of SNSs is more and more important. Thus, *Facebook* increased its dominance of the online social networking market and recorded in December 2009 about 110 million unique visitors. *MySpace* is the second-most popular SNS, having 50 million of visitors that represents a decrease in comparison with 2008. *Twitter* recorded 18 million visitors in December 2009, a considerable growth from 3 million visitors in comparison with previous year. The evolution of the SNSs visitors is shown in figure 1 [12].

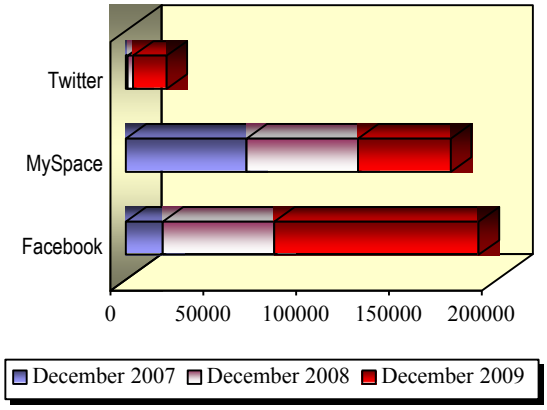

Fig. 1 The US visitors of Social Networking Sites

2. *Wikis* are websites that allows users to collaboratively add, remove, and change content. The original wikis idea are that any user of the World Wide Web could read and write in the same time using their browser, therefore simplifying the web editing process.

Being an open source technology, the community of users establishes a set of rules for calling a wiki [9]:

- *No authorship allowed*: a wiki is owned by its community, meaning that anybody who posts something on a wiki must do it freely, even if it means that the next user will erase or rephrase everything that has been posted.
- *Simplified markup language:* wiki markup language is easier and more automated than HTML; the URLs are linked automatically;
- *Focus is on content, not on format:* wikis look like plain HTML pages and their quality is in its content, not in the way it looks;
- *Version tracking:* the history of every single tiny change of every wiki page is available to anybody, which means that a page can travel back in time to a previous state at any moment;
- *The structure is defined by the community:* there is no need to create a wiki architecture or to have a group leader who imposes the way of organizing content; wiki rules will emerge from consensus when needed.
- *The community ensures wiki security:* if the community is engaged in the wiki and because of the version tracking feature, getting rid of erroneous entries is fast and efficient; therefore, there is no need for any kind of security procedure or for a user registration process.

Wikis are used to support a large number of different activities, but the most important example is Wikipedia, a collaboratively, created online encyclopaedia. Since its beginning in 2001, Wikipedia has grown rapidly into one of the largest reference websites, having more than 700 million visitors in 2009. There are about 75,000 active editors working on more than 10,000,000 articles in more than 250 languages. All these articles have been written by the Wikipedia community, which is composed of ordinary web users that generating a longer debate around authorship and peer-review, and denying also its value for education as a knowledge source [11].

But, even the critics can't deny that Wikipedia gave wikis a publicity sphere that makes them a widespread tool that changes the ways to communicate online.

3. *Blogs or Weblogs* - are online public writing environments, which enable a single author or a group of authors to write and publicly display articles (also called posts), organized in reversed chronological order [13]. Weblogs have become increasingly popular over the last three years, spreading to all spheres of activities: cultural, academic, professional, political and commercial. One of the main benefits of weblogs is that the content is published on the web at the time the content is written.

At first sight, weblogs seem to be rather individual then social tools, but they allow interaction with readers by their comments and they are also connected with other weblogs, creating this way communities and networks and become social.

The great number of individuals engaged in blogging created the term of blogosphere, which means a whole world of bloggers operating in their own environment, using free automated web publishing tools, such as: WordPress, Blogger, Pita, Manila, Big Blog Tool.

The most popular and influential blogging tool is Blogger which hosts several hundred thousand users. It has many features that simplify the way in which users may build and work with weblogs, such as: the web interface, the opportunity to choose a predefined style of web page and the addition a button to the toolbar of your browser, that may easing the connection between online reading and writing.

The authors of this paper have their own weblog on Blogger, having the topic related to the influence of social software in e-learning systems (figure 2).

Fig. 2 The paper author weblog about social software and its implications in educational environment

4. *RSS feed* ("Really Simple Syndication") is a family of web feed formats used to publish frequently updated works, such as blog entries, news headlines, audio, and video, in a standardized XML format. An RSS document includes full or summarized text, plus metadata such as publishing dates and authorship. Web feeds benefit publishers by letting them syndicate content automatically. They benefit readers who want to subscribe to timely updates from favourite websites or to aggregate feeds from many sites into one place.

Social software tools are not created for educational purposes, they can be used to support learning, because they better supports self-governed, problem-based and collaborative activities.

3. FROM WEB 1.0 TO WEB 2.0

The social software is based on Web 2.0 which is commonly associated with web applications that facilitate interactive information sharing, interoperability, user-centred design, and collaboration on the World Wide Web (Boyd et al., 2007). A Web 2.0 site allows its users *to interact with other users or to change website content*, in contrast to non-interactive websites where users are limited to the passive viewing of information that is provided to them. Although the term suggests a new version of the World Wide Web, it does not refer to an update of any technical specifications, but rather to cumulative changes concerning the ways to use Web 1.0 for both categories: software developers and end-users.

Figure 3 presents the major components of Social Software, which is Web 1.0 based.

Other examples of Web 2.0 include web-based communities, hosted services, web applications, video-sharing sites.

The client-side/web browser technologies typically used in Web 2.0 development, called RIA (Rich Internet Applications), are:

- Asynchronous JavaScript and XML (Ajax),
- Adobe Flash and the Adobe Flex framework,
- Microsoft Silverlight applications,
- HTML 5 (recently defined components).

Ajax programming uses JavaScript to upload and download new data from the web server without undergoing a full page reload. To permit the user to continue to interact with the page, communications such as *data requests going to the server are separated from data coming back to the page (asynchronously)*. Otherwise, the user would have to wait for the data to come back before they can do anything else on that page, just as a user has to wait for a page to complete the reload. This also increases overall performance of the site, as the sending of requests can be completely independent of blocking and queuing required sending data back to the client. The data fetched by an Ajax request is typically formatted in XML or JSON (JavaScript Object Notation), two widely used structured data formats.

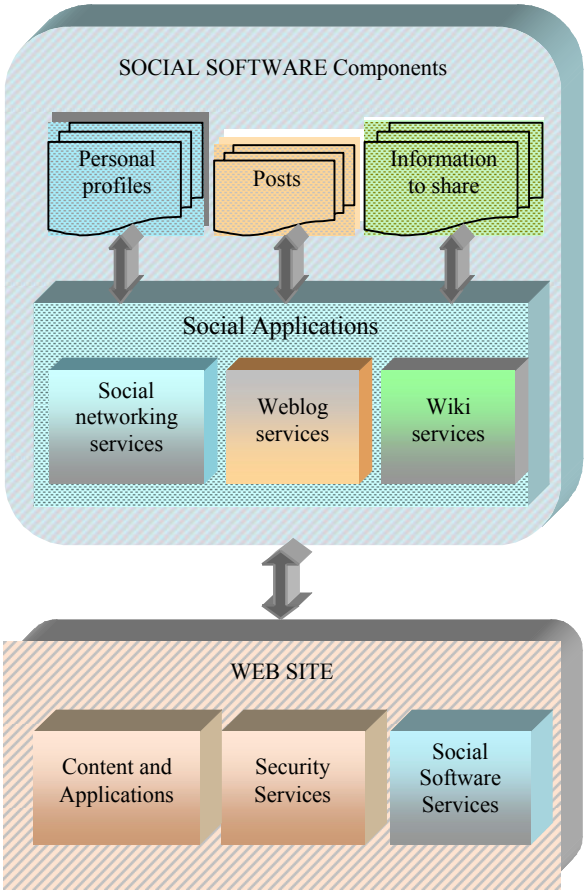

Figure 3.The Social Software components used in e-learning systems

Since both of these formats are understood by JavaScript, a programmer can easily use them to transmit structured data in their web application. When this data is received via Ajax, the JavaScript program then uses the Document Object Model (DOM) to dynamically update the web page based on the new data, allowing for a rapid and interactive user experience. Using these techniques, Web designers can make their pages function like desktop applications [4].

The critics of the term claim that Web 2.0 does not represent a new version of the World Wide Web, giving two arguments:

- The techniques such as AJAX do not replace underlying protocols like HTTP, but add an additional layer of abstraction on top of them.
- Some ideas of Web 2.0 had already been featured in implementations on networked systems well before the term Web 2.0 emerged. For example, Amazon.com has allowed users to write reviews and consumer guides since its launch in 1995, in a form of self-publishing.

In terms of Web 2.0's social impact, critics such as Andrew Keen argue that Web 2.0 [10] has created a cult of digital narcissism and amateurism, which undermines the notion of expertise *by allowing anybody, anywhere to share* – and place undue value upon – *their own opinions about any subject* and post any kind of content regardless of their particular talents, knowledge ability. The core assumption of Web 2.0, that all opinions and user-generated content are equally valuable and relevant, is misguided and is instead *"creating an endless digital forest of mediocrity: uninformed political commentary, unseemly home videos, embarrassingly amateurish music, unreadable poems, essays and novels"*.

4. THE IMPACT OF SOCIAL SOFTWARE TOOLS IN UNIVERSITY ENVIRONMENT

The rigorous academic style of learning systems is necessary to be completed with social software technologies to achieve a real student centred learning.
In the last years we assist to a whole new orientation on teenagers' life which is reflected also in their education: a step-by-step isolation from the real world and a powerful socialization in the newly-created virtual worlds. In this paper we try to define this migration and to emphasize the advantages of socialization forms on student's education.

Learning cannot be managed, however can be facilitated. The educational potential of social software is to facilitate self-governed, problem-based and collaborative activities by supplying with personal tools for personal projects, and by engaging them in social networks. In this context it's essential for students, a major segment of social software users, to formulate and find answers to a major question: what is the educational potential of social software technologies within a university environment?
To find some answers, we have two starting points: first, we consider that they change academic communication and translate into the need for new software, both for teachers and for students and second, we must look at this subject from two sides: the different roles in teaching and learning for instructors and for the students.

The approach to include social software technologies in e-learning systems empowers students in their self-governed activities. Students are directed at solving a problem, and the purpose is to provide them with tools they can use to solve problems on their own and in collaboration with other students. A student involved in a project, working on dealing with a task, can use a weblog to communicate ideas and thoughts. Further, the student can use wikis or other kinds of Web pages to develop the project.

a. Social networking sites can be an enhancement from the traditional class to an interesting online class and a challenge of flexible education to a collaborative students work. The three main characteristics of social networks (personalization, socialization and transparency) are relevant for education [2]. Transparency in student relations offers flexibility to education with continuous enrolment and examination. Transparency means that students are visible to each other as potential partners and resources. Further, the starting point is the problem-oriented individual or a group working together on a common project.
To follow the outlined socio-cultural approach, an important objective is to support an individual's consciousness and awareness of activities of others. This can be achieved by development and use of personal tools, which first support the activities of the individual or group. It's now possible to use the personal tools as the basis of social networks. *Students can connect to and subscribe to personal tools of other students.* The result is a different kind of transparency than in discussion forums. Whereas discussion forums and other tools for direct communication and collaboration focus on direct sharing, social networking can support students' indirect sharing of resources, thoughts, ideas, productions, writings, notes, etc. This kind of sharing can provide students with insights into the workings of other students, and, thus, give them an increased awareness of the activities of other students [8].

So, it's obviously that the educational potential lies within developing social networks, where students share their individual or group activities. The potential is to support transparency through a combination of personalization and socialization.
Social networks also allow teachers to follow and participate in the student work. Such networks are supported by weblogs connection between students and teachers.

b. *Weblogs* are another recent technology trend that has been introduced in higher education. Empirical research regarding weblog use to support different types of thinking and activities in higher education is insufficient. Some areas of research regarding weblogs deal with student perceptions of sharing their online journaling practices.
The use of weblogs can help teachers to require students to interact and study on a daily, weekly, or monthly basis, rather than leaving all the study to the time of the final examination. Moreover, it also creates a challenge for time management, because instructors that use web-enhanced or online courses report large increases in the time it takes to mange online/web-enhanced courses compared to traditional courses.

The use of weblogs in education can be evaluated in different dimensions with regard to who writes the weblog, who reads the weblog and what is the objective of the weblog.
From the point of view of blog writers, they can be [14]:
- Teachers, who may write weblogs to provide instructional advices and instructions for students, to offer additional material (links, downloadable material), and to provide a place for comments past the school day.

- Students, who may write weblogs as learning logs (a log that documents their learning), as project logs (a log kept for the duration of the project that reflects the progress and findings), or as a medium aimed at learning web technology.

Concerning to the readers of the weblog, they can be:

• Teachers, who can read students' weblogs as coursework and to keep their work in a specific knowledge field.

• Students, who may read weblogs as a coursework and others' weblogs as group work.

From the beginning each weblog has an objective likewise: a collaborative learning activity, a way of knowledge sharing, for reflection and debate, a medium to link to other resources.

c. In higher education, there are three ways in which *wikis* can be useful: teaching, research, and administration. We analyze only educational area, so we focus on teaching and learning processes.

First, teachers can work together using a wiki to write curriculum and lesson plans for courses, to develop assignments. If the faculty has multiple teaching sections of a course and the teachers need to teach from the same materials, they have a central space to which they can collaboratively contribute material [11].

For students, wikis are beneficial primarily as a collaborative tool for things like group assignments in courses. Using the wiki, a group of students can do some experiments and share the results. Teams would work on common projects, and when they wrote their report, each student being responsible for a different section.

The other benefit that comes out of that, especially with group work, is to see periodically what students are doing, help them to keep a project on course towards success, versus failing because there are problems in the group we don't know about until the end of the project, when they come with a substandard result.

Having Wikipedia as example, one of the greatest successes of the wiki technology, we consider that is useful to encourage the students to work with such tools. Thus, we see in that site a starting point to introduce the concept of the value of information, and we advise our student to check the facts on other sources.

But, there are a lot of educators which categorically refuse any citation coming from wikis, warning students to stay as far away as possible from that source, including numerous educational institutions.

Since a wiki is a collaborative space, owned and edited by anyone, there are some conditions to be followed [9]:

1) Users are registered: it is possible to track changes and associate a user with them; that way, if a user changes a page or a section that is reserved to some other users, it is possible to revert that change or take some actions against that user.

2) Content can be viewed by everyone: wiki tools don't have a feature that hides some pages from a registered user, which means that even if a user is not allowed to make a change, the content is still viewable.

Other initiatives are trying to bring peer-review and authorship back into online knowledge initiatives. Google announced a new project called *Knol* that will emphasize the value of having identified authors for each article, a process that would bring back the idea of reputation in online encyclopaedias.

5. CONCLUSIONS

Trying to keep the academic distance built into traditional learning systems and common forms of social software technologies, it's possible to imply a greater loss of rich involvement in communication and collaborative activities between teachers and students.

In the academic environment articles are drafted, revised, rewritten, edited, proofread, finalised in comparison with unedited, spontaneous, most of them recent and concise expression of thoughts, ideas published on blogs or wikis. A blog, a wikis or a SNS profile is a trail, a visible trace of the process of individual research, and an expectation of linking, often a comment on other writing and be linked to it.

Even wikis, social sites and blogs have a lot of fans (students and teachers) in higher education, it seems they have not been used to their full potential for learning. One of the reasons that have been evoked in several articles is the fact that they are usually associated with the concept of actual work, and not learning, which is associated with the more formal and traditional classroom training.

The adoption or the failure of the social software depends in great part of the original design of the intended learning activity and its fit with the university philosophy. Every implementation of learning system depends on the chosen pedagogical approach. A discussion of the educational potential of social software, and other tools, needs to be started from the point of view of an understanding and description of specific learning activities [5].

Problem-based activities describe a learning process in which students are directed at solving a specific problem. It's important for a social network approach that a student tries to solve the problem him or herself. Students' self-governed and problem-solving activities are considered the focal point of a learning process. This concept of a learning process means that it's not possible to structure or pre-determine the students' activities in a learning activity – the activities must develop on the basis of the student's own problem-solving abilities.

With the increasing flow of and access to information, academic communication is changing. Though being aware of new communication technologies the academics can be part of the new writing and take part in the development of these emerging genres, instead of marginalizing themselves.

In order to have a better impact on the student, the learning experience must be active, social, contextual, engaging and student-centred. To achieve this goal, the social software provides many advantages:

- encourages contact and cooperation among students;
- develops active learning;
- gives prompt feedback;
- emphasizes time on task activities;
- communicates student and teacher expectations;
- respects individual ideas and his chosen ways of learning.

As a faculty member, a student might choose or not to use a wiki in his course or a social network site for a project. But students are now empowered in the use of web 2.0 technologies. They are using Facebook or Google Docs to create study groups, they are using their computers to keep in touch with their colleagues through social networking applications, they are accessing the web to find the information they need, just in time.

In this paper, we try to prove the opportunity to integrate such tools in educational activities because they facilitate the transition from the theory to practice, they encourage the expression of original ideas and the discussions. Also, we must underline the major social significance of these new technologies.

As educators, it is our duty to reflect on these technologies and behaviours in order to detect and implement innovative ways to enhance student learning and develop their 21st century skills, the ones they will need to survive professionally in a highly networked environment.

In respect of truth, it would be very misleading to define the social software as the best practice used in higher education, but we insist on idea to include its tools in learning systems.

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OPTIMIZATION OF ENERGY SYSTEMS MODELING WITH PETRI NETS

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ABSTRACT

Traditional tools used for modeling and simulation of power systems have certain limits in representing the problem and addressing the dynamics of events. This paper proposes using Petri network to optimize time to conduct an aerial electrical lines. In this sense, an extension of classical Petri network, transport network Petri T - timer shaped electric line construction problem. Critical path method is applied to this network has the advantage of its properties - in our case transition invariants. The algorithm used to determine road network and the network generates and compiles the program during the transition sequences provides a simple and flexible technique for real-time optimization of the project.

Keywords: *modeling, simulation, optimization, Petri nets*

1. INTRODUCTION

All energy sectors (construction, operation, management and maintenance of energy facilities) aimed at addressing systemic and fundamental decision in order to achieve optimal parameters of the best economic and operational safety. Solving optimization problems that arise in power systems is done using methods and operational research models.

One of the problems that require optimization in a power system is overhead lines construction so that the duration of works to be making minimum.

Currently, such a question is addressed to resolving critical drmului method (CPM). This is a critical path analysis technique in which only one parameter is analyzed and graphical representation of network time to take into account the following conventions:

- Each activity is assigned a segment called oriented arc defined by its ends, thus identifying each activity as a spring;
- Each arc is assigned a value equal to the duration of the activity that is.

Conditioning of the two activities are represented by the sequence of two adjacent arcs. Nodes will be moments characteristic graph representing stages of project implementation activities (complete one or more activities and / or start one or more activities). CPM process is based on a bipartite matching between the elements of a project (activities, events) and a graph elements (arcs and nodes). Obtain a relationship model - object. This tool provides a means to obtain a timetable for various work tasks associated with a network project. Shortcomings of this method are numerous and have been documented in many publications [1].

This study suggests a programming paradigm shift by adopting the Petri net and the vertebral column, the system of planning. As a graphical tool, they can be used as a visual communication aid. As a mathematical tool, it is possible to set up state equations, algebraic equations and other mathematical models governing the behavior of a system.

Mathematical theory is well developed Petri net theory and invariants, especially, is very useful for analyzing and verifying a system modeled by the network [2], [3]. To make reading the paper more accessible as we make a review of basic definitions and notations related to Petri nets with timing the transition, then we explain the use of Petri net T - timed to determine the minimum period of a network overhead.

Conclusions and recommendations are provided in the last section of the paper.

2. OVERVIEW T-TIMED PETRI NETS

Petri nets are graphical and mathematical tools that can be used for static and dynamic modeling of existing or new systems. At this time there are many extensions of Petri nets used for performance evaluation of industrial systems [2] but, in this paper, timed Petri nets to stop.

In these networks, each transition Ti is assigned a delay di, constant and positive value, possibly null . A brand located in a position can be reserved or not. Thus, if a position Pk, located on the entry transition You are contributing to the validation mark and T_i transition at a certain time t, decides transition execution mark is reserved all the time [t, t + d_i), which can run time after the transition in question.

For example, if T-timed Petri network of Fig. 1, initially in the position P1 is not no mark. Assuming that at time t_1, T_1 transition execution occurs, the transfer mark position P_1 (Fig. 1,b). Mark is unreserved, although the transition T_2 became valid. If at time t_2, deciding the implementation of transition T_2 from time t_2 mark is reserved. After the delay time to equal D_2, T_2 transition can be executed. The implementation of the transition T_2 is moved to the position mark P_2 (Fig. 1, d) and becomes non-reserved until it decides the execution of transition T_3.

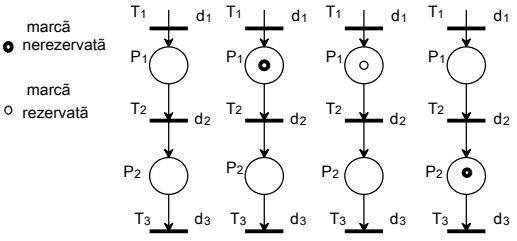

Fig. 1 Dynamics of a Petri T - timed

It appears that for a Petri T - delay, a transition can become valid only when each position located upstream unreserved marks the transition number is large enough to validate that transition. At baseline, all marks are reserved. Booking respectively validates a transition occurs only decided that the transition implementation. When, in a Petri T - timed, each transition is executed with proper timing, as soon as it becomes valid, it says that the network operates at maximum speed. Definitions, classifications, Matrix description of timed Petri nets and their application examples are given topical works in [4] [5]. In [6] is proposed, developed and tested an extension of Petri nets called Petri transport network which is addressed in efiență optimization problems in shipping systems. In this paper I propose now associating the transmission timing of the transitions going to use this model in a critical path problem for a otimizări in power systems.

3. CRITICAL PATH IN A TIMED TRANSPORTATION PETRI NETWORK

A transportation Perti network (RPt) ,a directed graph where $P_i \in P = \{P_0, P_1, P_2, ...P_n\}$ positions are connected by arcs of pure transitions $T_k \in T = \{T_1, T_2, ...T_m\}$, where $P_0 \in P$ is a unique position, having just downstream transitions, called the input (source) network and $P_n \in P$ unique position, having only the input transitions, called output (destination) network. Each is assigned a number $ck \geq 0$, k = 1, ... m, called the transition capacity. Because Petri nets offer a transport T - delay, the capacity of the transition will mean the transition period (during execution of an action).

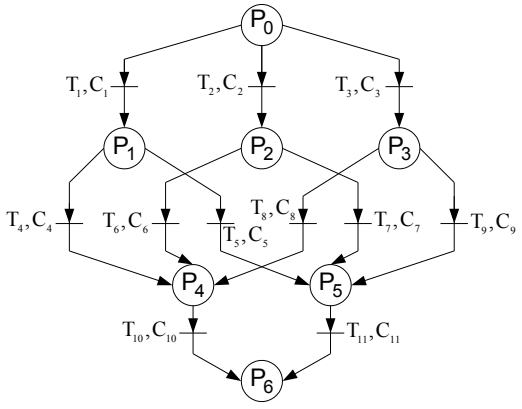

Fig. 2. Transportation Petri network (RPt)

Figure 2 is a transportation Petri network for which $P = \{P_0 P_1 ... P_6\}$, $T = \{T_1 T_2 ... T_{11}\}$. Transitions may be assigned crowd capacity vector C = (C_1, C_2, ... C_{11}) or a vector of transition times D = (d_1, d_2, ... D_{11}).

One transportation Petri network properties is the execution invariants [3], [7]. These are sequences of executable transitions between the position of entry and exit, which restores the mark in the transmission network. Shift to the property (invariants), because we use to determine critical path in a network.

Call path in a Petri network transport, a sequence of transitions, run between source and destination.

To create an algorithm for determining the road network is required matrix representation of the network.

Define the incidence matrices Pre (W^-) and Post (W^+) and the matrix within the network (W).

$[W^-] = [w^-_{ij}]$ unde $w^-_{ij} = Pre [P_i, T_j]$ (2.1)

$[W^+] = [w^+_{ij}]$ unde $w^+_{ij} = Post [P_i, T_j]$ (2.2)

Incidence matrix is defined:

$W = W^+ - W^- = [w_{ij}]$, unde $w_{ij} = w^+_{ij} - w^-_{ij}$ (2.2)

For a transportation Petri network, this graph can be reconstructed using only the incidence matrix, it is a suggestive description of entries and exits of positions. Moreover, roads are expressed as sequences of transitions determined RPt_0 - complemented by a network transition T_0 to restore the initial marking. If we note by T (S) set of transitions that occur in a sequence S, ie:

$$T(S) = \{T_i \in T | s_i \neq 0, unde..i = 0,1,...m\} \quad (2.3)$$

Then, a subset of transitions T 'is a repetitive element in RPt that restores initial marking if and only if there is a sequence S such that:

$$T(S) = T' \square i\, [W_e] \cdot [S] = [0] \quad (2.4)$$

where [0] is the matrix column dimension n with all elements zero.

It follows that, in determining repetitive sequences, is necessary and sufficient to determine the characteristics vectors S verifies the equation:

$$[W_e] \cdot [S] = [0] \quad (2.5)$$

If we translate equation (2.5), we obtain:

$$[S]^t \cdot [W_e]^t = [0]^t \quad (2.6)$$

3.1. Invariants of the algorithm execution

From equation (2.6) is observed that, in determining execution invariants of a Petri net transport is necessary to resolve a positive integer matrix, with coefficients whole form:

$$[X] \cdot [A] = [0] \quad (2.7)$$

Where: $[A] = [W]^t \square i\, [X] = S^t$ characteristic vectors.

The algorithm consists of the following steps:

Step 1**:** Construct the extended matrix [B, A], where initial [B] = [t]. Unit matrix [I] has order equal to the number of matrix lines [A];

Step 2**:** For each column j a matrix [A] is executed next steps:

Step 2.1: Every line has the matrix [B, A] collects a linear combination of other lines, so as to cancel the

item, the matrix [A] located on the line i and column j. The linear combination lines are multiplied by positive integers;

Step 2.2: Delete the matrix [B A] lines in matrix [A], the column j, participated in obtaining null elements;

Step 3: Invariants are given by lines matrix [B] associated with all elements zero lines of matrix [A].

4. OPTIMIZATION BY MODELING WITH PETRI NETS THE TIME CONSTRUCTION LEA

Given these modeling tools can address the above construction of a 400 kV LEA with two conductors per phase and two conductors such as duration of protection works to be making minimum.

It is known that track construction operations, during operations, their sequence and conditionality. They say the operation B is conditional operation A when B can not start operation before the operation has to be done. This data line are shown in Table 1 mentioned

Tabelul 1. Project operations and their conditionalities

Operation name	Symbol	duration [days]	Operation directly linked
Digging holes	SG	0,75	MF
Transport material for foundations	TF	0,40	MF
Foundation installation	MF	0,50	RS, MP
Transportation to the picket pole	TS	1,00	AS
Pole assembly	AS	0,66	RS
Lifting pole	RS	0,66	IC, VS
Conductor extent	IC	1,00	MD
Spacers mount	MD	1,00	-
Ground mounting socket	MP	0,50	-
Pole painting	VS	1,00	-

In order to construct Petri nets model type will determine the set of positions and set transitions. Transitions are modeled construction operations that comprise the LEA, and state positions will shape operations (Start - End). Each operation in Table 1 confer a transition such that the set of transitions is: $T = \{T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}\}$.

Based on the table is set conditionalities set positions: $P = \{P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9\}$.

Each operation has a duration included in Table 1, vector delay is $D = (d_1, ..., d_9)$.

With this data matrix is built by PRE incidence, W^-, POST incidence matrix, W^+ and the difference of the two resulting network incidence matrix W :

Matrix W is:

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
P_1	-1	-1	-1	0	0	0	0	0	0	0
P_2	1	0	0	-1	0	0	0	0	0	0
P_3	0	1	0	-1	0	0	0	0	0	0
P_4	0	0	1	0	-1	0	0	0	0	0
P_5	0	0	0	1	0	-1	-1	0	0	0
P_6	0	0	0	0	1	-1	0	0	0	0
P_7	0	0	0	0	0	1	0	-1	-1	0
P_8	0	0	0	0	0	0	0	1	0	-1
P_9	0	0	0	0	0	0	1	0	1	1

A graphical user interface [8] builds on the incidence matrix, Petri network (fig.3).

Incidence matrix extends the cycling transition (restores the original mark). To establish road (invariants) network, the algorithm whose steps were outlined above.

Invariants are obtained:

$S_1 = (T_1, T_4, T_6, T_8, T_{10})$, $S_2 = (T_1, T_4, T_7, T_9)$;
$S_3 = (T_1, T_4, T_6, T_9, T_{10})$; $S_4 = (|T_2, T_4, T_6, T_9, T_{10})$,
$S_5 = (|T_2, T_4, T_6, T_8, T_{10})$; $S_6 = (T_2, T_4, T_7)$;
$S_7 = (T_3, T_5, T_6, T_8, T_{10})$;

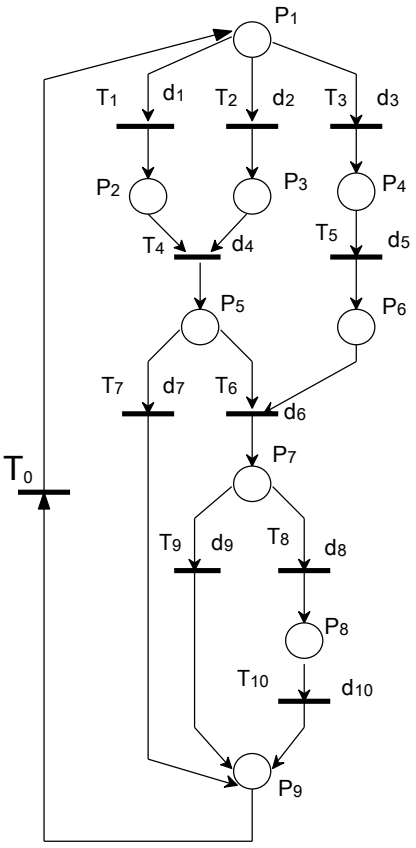

Fig.3. RPt model of LEA project

By replacing transitions with their execution times are obtained Dj's timing vectors. Is a vector sum of transition durations during the road network.

$D_1 = (0,75; 0,50; 0,66; 1,00; 1,00) \Rightarrow D_1 = 3,91$
$D_2 = (0,75; 0,50; 0,50; 1,00) \Rightarrow D_2 = 2,75$

$D_3 = (0,75; 0,50; 0,66; 1,00; 1,00) \Rightarrow D_3 = 3,91$
$D_4 = (0,40; 0,50; 0,66; 1,00; 1,00) \Rightarrow D_4 = 3,56$
$D_5 = (0,40; 0,50; 0,66; 1,00; 1,00) \Rightarrow D_5 = 3,56$
$D_6 = (0,40; 0,50; 0,50) \Rightarrow D_6 = 1,40$
$D_7 = (1,00; 0,66; 0,66; 1,00; 1,00) \Rightarrow D_7 = 4,32$
$D_8 = (1,00; 0,66; 0,66; 1,00) \Rightarrow D_8 = 3,32$

Critical path network construction shaping power line (LEA) 400 volts, has the value 4.32 - the highest term of a sequence of execution of entry and exit from the network.

5. CONCLUSIONS

Petri transport network is a modeling tool that provides a clear and suggestive of a construction project, eliminating some disadvantages of classical methods of modeling and optimization.

Optimization of construction time performance energy can be tackled with ease by using timed Transportation Petri network transmission. Critical path method based on Petri network transmission delay is a simple and effective method that assist constructors managers in determining the real time execution of works. Create algorithms, computer programs that generate network that determines road network and its value will produce quick results but also the progress of the system when data changes occur. It is appropriate to introduce the techniques of modeling and optimization in the optimization of energy systems.

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SIGNAL VOLTAGE ELECTRICITY NETWORKS

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ABSTRACT

Harmonics are sinusoidal voltages or currents whose frequency is a multiple of the fundamental frequency of the source. Unlike them, voltage or current interharmonics have a sinusoidal variation with a frequency that is not a multiple of the frequency source.

Keywords: *Current curves, interharmonic frequency, fluctuations, flicker.*

1. INTRODUCTION

Harmonics are sinusoidal voltages or currents whose frequency is a multiple of the fundamental frequency of the source.

Unlike them, voltage or current interharmonics have a sinusoidal variation with a frequency that is not a multiple of the frequency source. Knowledge associated electromagnetic pertubations interharmonics are still under development and currently, there is growing interest in studying this phenomenon. Although they were always present in power systems, the interest for interharmonics became greater with increasing their amplitude due to the wide spread of power electronics in electrical installations.

Interharmonics harmonics and a curve of voltage or current consideration are defined by the corresponding spectral components functioning quasi-stationary steady state

2. FULL CONTROL OF THE OPERATING CYCLE SWITCHING THYRISTOR

This command controls a current completed using a semiconductor switch. In this way the current is not distorted as a result of command - he is either sinusoidal (for linear load) is zero.

An example of using a semiconductor switch three-phase configuration is shown in Fig. 1

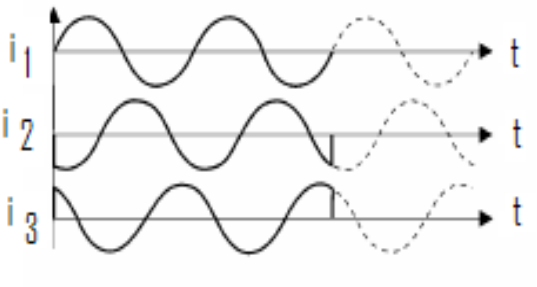

Figure 1 - Current curves in a three-phase configuration with neutral Order degree of filling of a full cycle

Switching to a three-phase loads at the zero crossing of phase voltage has the effect of running a current through the neutral conductor in a system with four conductors.

If simultaneous switching of phases and if the load is resistive, the current is not neutral but, if the load is inductive, there are transient processes associated with switching.

Analysis of configurations as in Figure 2a (the neutral) may be restricted to a single-phase equivalent circuit (Figure 2b). Next will be considered a single-phase resistive load, as usual in most applications.

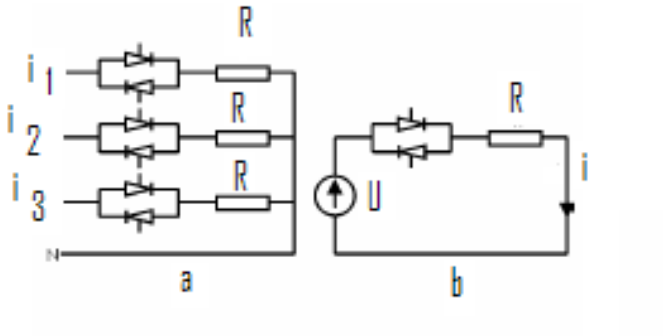

Figure 2 - Controller in AC

a) three-phase configuration and
b) single-phase configuration

A completed work includes N T conduction period covered by a whole number of periods M (Figure 3). Average power transferred to the load is controlled by ratio (filling degree) N / M As a basis for Fourier analysis, repeatability during the current form should be Mf1 -1, where f1 is the frequency power supply and M is number of periods T.

The first component is interharmonic frequency (1/ M) F1 is the lowest frequency component of current. In the example in Figure 3, where N = 2, M = 3, value is one third of the subharmonic frequency supply voltage. The other components are multiples of its frequency.

This method of control is a source of subharmonic and interharmonic, but not a source of higher harmonic. When N = 2, M = 3, as shown in Figure 3, the amplitude of harmonics is zero for n = 6, 9, 12, …

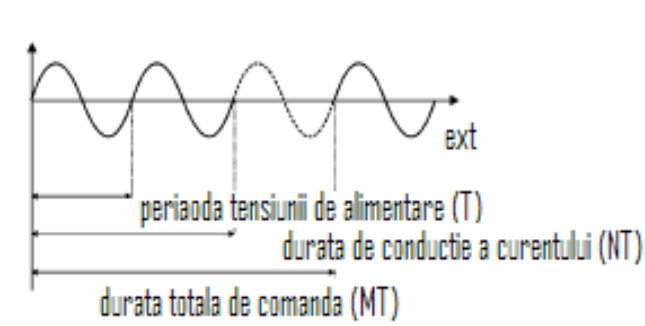

Figure 3 - Type of load current in a full cycle of the system command: N = 2, M = 3

Current spectrum for this case is given in Figure 4. As the figure shows, the major components are harmonics of the fundamental frequency of the supply voltage and subharmonic frequency (2f)/3.
Harmonic amplitudes are zero.

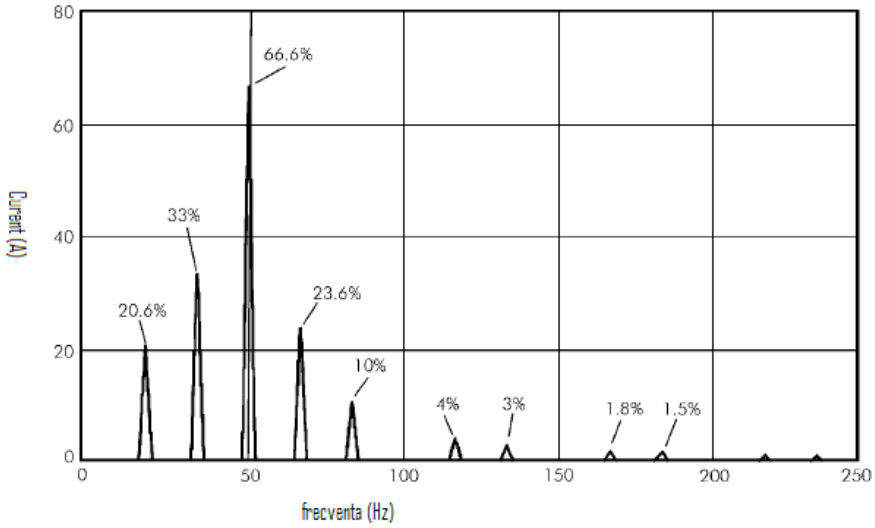

Figure 4 - Current spectrum for N = 2, M = 3

Major components are harmonics of the fundamental frequency of the supply voltage and subharmonic frequency (2f)/3. Harmonic amplitudes are zero.

Public electricity grid is designed primarily to supply electricity consumers. Network operator uses to control signals, eg to control certain types of pregnancy (street lighting, change tariff, remote switching tasks, etc.) or for data transmission.

From a technical standpoint these signals are a source of inter-duration 0.5 - 2 s (up to seven seconds in older systems) repeated at intervals of 6-180 s. In most cases the pulse duration is 0.5 s and during the entire sequence is about 30 s.

Predetermined voltage and frequency signal, the signal being sent to certain times, specified.

Figure 5 is an example of the tension spectrum for a system use the data to 175 Hz frequents (U_{ih} = 1.35%). In this example there are other inter-harmonic frequencies generated by the interaction.

Upper second harmonic components are unimportant (they will not disturb the task), while below 200 Hz interharmonics problems can occur.

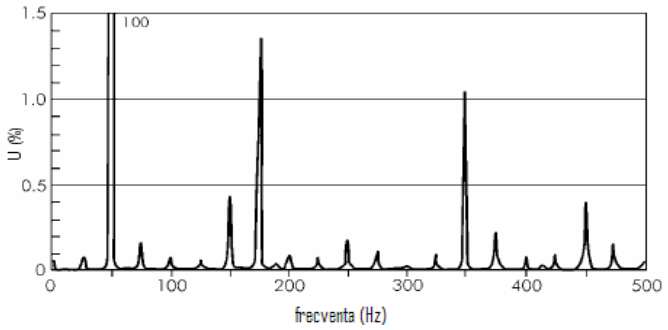

Figure 5 - FFT analysis results in during transmission voltage data signal (U_{ih} = 1.35%, f (U_{ih}) = 175 Hz)

3. VOLTAGE FLUCTUATIONS AND FLICKER

Voltage can be written:

$$u(t) = U_1 \sin(\omega_1 t)\left[1 + m\sin(\omega_i t)\right] + \sum_h U_h \sin(\omega_i t) \quad (1)$$

$$u(t) = U_1 \sin(\omega_1 t) + \left[\sum_h U_h \sin(\omega_h t)\right]\left[1 + m\sin(\omega_i t)\right] \quad (2)$$

where $\omega_1 = 2\pi f_1$ and m factor for signal with pulse modulation $\omega_i = 2\pi f_i$.

Should they be taken into account only fundamental blood component, the relationship becomes:

$$u(t) = U_1 \sin(\omega_1 t)\left[1 + m\sin(\omega_i t)\right] = U_1 \sin\omega_1 t + \frac{mU_1}{2}\left[\cos(\omega_1 - \omega_i)t - \cos(\omega_1 + \omega_i)t\right]$$

In this relationship, next fundamental component, are highlighted whose two frequency components are associated with the signal modulator, which are symmetrically placed on either side, toward fundamental frequency. Periodic variations in blood could be seen as changes in actual value (or maximum) or as a result of its presence modulate interharmonics lateral voltage.

The interharmonics influence, with a frequency greater than twice the frequency fundamental influence is smaller compared with the frequency interharmonics under this value (100 Hz).

Interharmonics there is a risk in the presence of voltage fluctuations occur which can cause flicker if, for a certain frequency, it exceeds a limit value.

If $b_e \leq f_1$ and, in particular, to be neighborhood fundamental frequency ($f_i = f_1 \pm 15$ Hz) fundamental component modulation produces variations in the effective value of voltage supply, become a source of flicker.

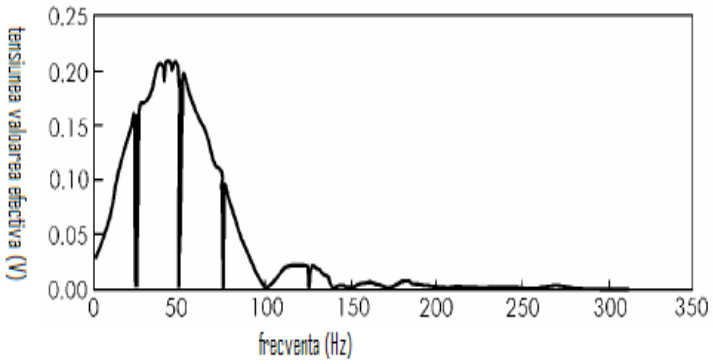

Figure 6 - Dependence maximum effective value of voltage variation in frequency of constant amplitude interharmonics

A flicker a particular beacon signal system on the lines represent previously.

Although smaller amplitude, these signals may create conditions for the occurrence of lamp flicker sensitive as economic compact fluorescent lamps.

This mode of disruption is rarely lamps with electronic ballasts.

4. CONCLUSIONS

The above interharmonics the existence, their main sources of generation and shape characteristics in continuous and discrete spectrum, allowing the formulation of conclusions general appearance.

First, the vast majority of cases interharmonics values and frequencies of current and voltage is dependent on many sizes stochastic parameters of the complex transitional process.

Second, assessing the value and frequency interharmonics is possible for a particular process, taken into account.

Thirdly, there is still no standardized rules on interharmonics, although there is a need for this practice.

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METHODS FOR LIMITING AND REDUCING THEIR EFFECTS INTERHARMONICS

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ABSTRACT

Harmonics are sinusoidal voltages or currents whose frequency is a multiple of the fundamental frequency of the source. Unlike them, voltage or current interharmonics have a sinusoidal variation with a frequency that is not a multiple of the frequency source.

Keywords: *Harmonics, passive filters, load, distortion to voltage*.

1. INTRODUCTION

Harmonics are sinusoidal voltages or currents whose frequency is a multiple of the fundamental frequency of the source. Unlike them, voltage or current interharmonics have a sinusoidal variation with a frequency that is not a multiple of the frequency source.

Knowledge associated electromagnetic pertubations interharmonics are still under development and currently, there is growing interest in studying this phenomenon.

Although they were always present in power systems, the interest for interharmonics became greater with increasing their amplitude due to the wide spread of power electronics in electrical installations.

Interharmonics harmonics and a curve of voltage or current consideration are defined by the corresponding spectral components functioning quasi-stationary steady state.

Corresponding mathematical formulations:

Harmonica	**$f = nf_1$ where n is an integer greater than zero**
Continuous component	$f = nf_1$ for n= 0
Interharmonic	$f \neq nf_1$ where n is an integer greater than zero
Subharmonic	$f > 0$ Hz and $f < f_1$

f_1 = fundamental frequency voltage (basic harmonic)

The first interharmonic source is generating this component in side bands of fundamental frequency and supply voltage harmonics as a result of changes in amplitude and / or their phase. They are caused by rapid changes in current drawn by equipment and facilities, which are also sources of voltage fluctuations.

Disturbances are caused by transient electrical loads, long or short, or, in many cases, when there are amplitude modulation of currents and voltages. These disturbances have largely random in nature, depending on the variation inherent electrical load during the different processes.

The second source is switching asynchronous (not synchronized with the supply voltage frequency) of semiconductor devices in static converters. A typical example provides converters with pulse width modulation (pulse width modulation - PWM). Interharmonics generated they can be located anywhere in the spectrum analyzed in relation to the supply voltage harmonics.

The major interharmonics sources are:

- ♦ electric charge with electric arc
- ♦ electric motors with variable load
- ♦ static converters, in particular direct and indirect frequency converters
- ♦ remote systems (“ripple controls”).

Effects presence interharmonics:

Interharmonics current may occur the distortion to voltage depending on the amplitudes of voltage and current components of the power system impedance, pertinent to these frequencies. The frequency components of current rank is higher the greater the risk of unwanted resonances that will cause increased distortion and overload or disturbances in the functioning of equipment and consumer.

The most important interharmonics direct effect is:

- ♦ thermal effects
- ♦ low frequency oscillations in mechanical systems
- ♦ disturbance in the functioning of fluorescent lamps and electronic devices. In practice, operation any equipment that is synchronized with zero crossing or maximum supply voltage can be perturbed (Figure 1).
- ♦ interference signals on the control and protection of power lines. It is currently most harmful effect of interharmonics
- ♦ passive filters loading parallel case of senior spectral components
- ♦ telecommunications interference;
- ♦ acoustic disturbances
- ♦ saturation of current transformers.

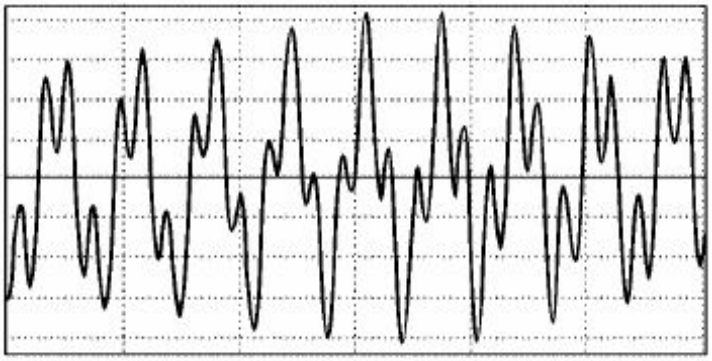

Figure 1 - Multiple zero crossings of the voltage curve as a result of distortion

2. MEASUREMENT

Fundamental analysis tool is the Fourier Transform (TF). In practice, the signal is analyzed on a limited time (measuring time window Tw) using a limited number of samples (M) the real signal. Results of Discrete Fourier Transformation (DFT - Discrete Fourier Transformation) values depend on the choice of M and Tw. Tw is the inverse of the Fourier fundamental frequency signal is applied to real-FF DFT time window within; signal outside this window is not processed, but it is assumed that it is the same within its. In this way, the real signal is replaced with a virtual one, periodically, with period equal to the width of the window.

On a regular curve analysis arises no problem of synchronization time for analysis with curve fundamental period (even if its has harmonics). If curve contains interharmonic the analysis becomes more difficult. The frequency by interharmonics components are not integer multiples of the fundamental frequency and often they change over time, making it even more difficult measurements.

Because of both harmonic components and those interharmonics, Fourier frequency, which is the greatest common divisor of all frequency components contained in the signal fundamental frequency is different from the supply voltage is usually very small.

Two problems arise:

♦ minimum sampling time must be long and large number of samples

♦ is difficult to assess the Fourier fundamental frequency since all frequencies that signal components are known.

This can be illustrated by the following examples:

Signal to be analyzed is the sum of the fundamental component (50 Hz), an interharmonics (71.2 Hz) and harmonic (2500 Hz). Fourier fundamental frequency is 0.2 Hz, much lower than fundamental frequency component.

Corresponding period is five seconds and therefore the minimum sampling is also 5 s. If the sampling frequency is 10 kHz, which in practice is worth applicable minimum resulting from the Nyquist criterion, the required minimum number of samples is M 50 000. If there were no inter-component (71.2 Hz), the minimum measurement time would be 20 ms and number of samples would be 200.

Signal to be analyzed is the sum of the fundamental component (50 Hz) and harmonic (2500 Hz), their amplitudes with frequencies ranging from 0.1 Hz to 5 Hz. The effect of these is the emergence of four inter-modulations with frequencies 49.9 Hz, 50.1 Hz, 2495 Hz and 2505 Hz. Fourier fundamental frequency is 0.1 Hz and minimum sampling time is 10 s and M = 100 000

In practical applications, due to limitations of equipment and software, the number of samples M can not exceed a certain value and, consequently, measurement time is limited. Using a different measurement for the fundamental Fourier period causes a discontinuity in the signal at the beginning and end of the measurement window. This leads to errors in identification of components, known as dispersion spectrum.

A possible solution to this problem is to use a window of time "weighted" signal that varies over time applied before FFT analysis. In practice, using two measurement windows: rectangular window and Hanning window.

3. INTERHARMONICS METHOD LIMITING AND REDUCING THEIR EFFECTS

Methods include eliminating the effects interharmonics:

♦ emission reduction

♦ reducing sensitivity pregnancy

♦ reduce coupling between production equipment and load.

The methods used are the same as for harmonic.

Additional factors must be considered to designing passive filters. For example, interharmonics resonance between the filter circuit of the power grid can be amplified and lead to significant distortions and voltage fluctuations. Filter circuits must be designed to have a high damping factor.

Impedance characteristics of a passive filter (harmonics 3, 5, 7 and 12) seen from the input terminals of the converter supplying an extensive installation of electric arc furnace are shown in Figure 2.

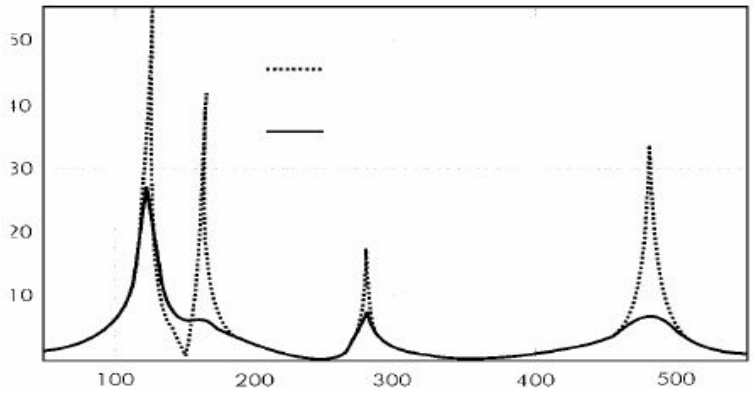

Figure 2 - Multiple zero crossings of the voltage curve as a result of distortion

Dotted line corresponds unamortised filter. There is a real risk interharmonics adjacent resonance 120 and 170 Hz. If depreciation is used for harmonic 3 and 7, to reduce the risk occurrence of resonance. When designing a filter is necessary to achieve a compromise between accuracy and granting power losses to be taken into account in choosing the filter quality factor.

Frequency deviation of normal supply network can be important, especially when combined with changes in frequency of agreement, determined by component tolerances, aging, temperature variation and change of power network impedance.

Results of resonance frequency variations of the filter can significantly reduce the efficiency of filtration, even if the change is small. If it is necessary to choose a lower quality factor, resulting in widening the band Filter, a clear advantage in terms of filtration interharmonics.

Harmonic values used as a basis for determining the levels of interharmonics compatibility [5] are presented in the table below:

Harmonic order	**5**	**7**	**11**	**13**	$17 \le h \le 49$
effective value (% of fundamental component)	6	5	3,5	3	$2.27 * (17/h) - 0,27$

Table 2 - Values of harmonics used as a basis for determining the levels of compatibility interharmonic [5]

4. CONCLUSIONS

The above interharmonics the existence, their main sources of generation and shape characteristics in continuous and discrete spectrum, allowing the formulation of conclusions general appearance.

First, the vast majority of cases interharmonics values and frequencies of current and voltage is dependent on many sizes stochastic parameters of the complex transitional process.

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ALTERNATIVE ENERGY RESOURCES: FOUNDATION SOLUTION FOR WIND TURBINES

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ABSTRACT

The use of the wind energy represents a modern and efficient solution for alternative energy consumption. The production of electrical energy using the wind power can be performed only by using modern equipments based on updated technologies. The electrical power generator and the steel upper structure of a wind turbine are equipments where were implemented the latest state of the art technology. The foundation solutions for this type of structure consist mainly into a huge block of reinforced concrete, this solution ensuring a great weight at the level of the base of the tower necessary to ensure the equilibrium of the upper structure. The paper will analyze the effect of a reduced number of piles below the foundation base. Those piles must ensure a reduction of the pressure transmitted to the soil by the foundation base and simultaneously to ensure a better equilibrium of the foundation and of the superstructure. The aim of the piles use is also to ensure a reduction of the dimensions of the foundation, having as consequence important savings in steel and concrete quantities.

Keywords: *wind energy, wind turbine, foundation, energy consumption.*

1. INTRODUCTION

Until about 300 years ago, the majority of human energy needs were supplied by human and animal labour, water power, wind and wood and other burnable matter such as agricultural waste, dung and peat.

With the beginning of the Industrial Revolution in the late 18th and early 19th century, water power remained important, but fossil fuels (mainly coal) began to be used on a large scale. Over the course 20th century petroleum products assumed a major role in supplying the energy needs.

Even casual observation of hurricanes and tornadoes reveals that the wind has power. Sails and windmills have been used to harness the energy from lesser winds for centuries.

The production of wind energy creates no air pollution and, if the turbines are sited properly, has minimal environment impact. Wind energy became a major source of power supply.

2. WIND TURBINES

Modern wind turbines for generation of electrical power are placed on towers ranging from 30 to 90 m in height in "wind farms". Each wind turbine generates till 2.5 M W.

A turbine and switchgear are mounted at the top of each tower in a casing called nacelle, and blades are attached to the turbine. The turbines use moving air to produce power by transferring the wind's pressure to the rotor blades and localizing that energy in a single rotating shaft. The larger turbines rotate at about 15 revolutions per minute.

The force of the wind on a plate held normal to it is expressed as:

$$F = \frac{1}{2} \cdot A \cdot \rho \cdot v^2 \qquad (1)$$

where:

F – force, in N;
A – area of plate, in m^2;
ρ – density of air, in kgm^{-3};
v – wind speed, in ms^{-1}.

Energy is generated when the wind speed reaches about 16.00 km per hour, and a speed of 40.00 km per hour allows the turbines to generate at their rated capacity. They shut down when the wind exceeds 90.00 km per hour. Although wind speed varies according to the time of day, season, height above ground, and terrain. The proper placement of a wind turbine in a breezy location away from large obstructions enhance its performance.

Large modern turbines are very quiet. At distances of more than 200.00 m, the swishing sound of the rotor blades is usually masked completely by wind noise in the leaves of trees or shrubs. The turbine sites will be distant enough from neighbours so that people won't hear any sound at all unless they are standing close to the towers.

The turbine blades are made not of metal but of glass-reinforced epoxy (a material similar to fibreglass), and the turbines are equipped with asynchronous (brushless) generators that do not create any electrical disturbance. The turbines used in green power program will cause no electromagnetic interference and do not disrupt radio or television signals.

The wind-turbine-foundation design relies on determining site conditions and selecting the option most economically appropriate for the site. Working together, the geotechnical and structural engineers conduct a

subsurface investigation program, analyze the results, and design a foundation system suited to each site.

The analysis includes evaluation of bearing capacity, amount of settlement, stress levels, deformation levels, overall stability, ground improvement, and dynamic ground behaviour.

3. EFFICIENT FOUNDATION SOLUTIONS FOR WIND TOURBINES

The foundation solutions for this kind of structures consist in a massive circular foundation or of a foundation with the shape of octagon, from reinforced concrete, with a great surface resting on the ground.

The foundation has also the purpose to improve the equilibrium conditions of the superstructure that transmits very large bending moments to the level of foundations.

The structural behavior of wind turbine foundation slabs can be analyzed with various numerical and analytical models. The methods include models suitable for hand-calculations, finite element models with plate elements resting on springs as well as three dimensional models of both the foundation slab and the soil.

Linear elastic as well as nonlinear behavior, including cracking of concrete and the complex load transfer from the tower into the foundation respectively from the foundation to the soil, can be considered.

The global dimensions of a wind turbine foundation slab are all governed by normative regulations regarding safety against overturning. As a rule, the foundation slabs are always subjected to extremely eccentric loading and have to be designed as such.

In these conditions, according to the principles of bearing capacity calculus of the foundation ground, established by K. Terzaghi, must be determined the so-called reduced surface of the foundation base:

$$A_{reduced} = L' \cdot B' \qquad (2)$$

In the case of circular foundations, specific for these kinds of structures, the dimensions of the reduced area are determined by a graphical construction function of foundations dimensions and function of the value of the load eccentricity (Figure 1).

The structural design of a foundation slab is above all governed by the distribution of soil pressure under it. As the purpose of a foundation slab is to distribute the more or less concentrated load into a larger area, respectively volume of the soil, so that soil can carry it without negative consequences, e.g. bearing failure of the soil, excessive settlement and so on. The form and the pressure distribution at the foundation base level have a decisive impact on the stress distribution inside the reinforced concrete foundation block.

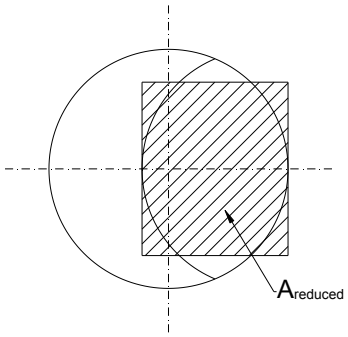

Figure 1 Theoretical pressure distribution on the soil for a circular shape foundation

An efficient foundation solution, from the point of view of material consumption (concrete, reinforcement) consists in realization of some piles placed symmetrically under foundation base.

The purpose of the piles in this case is double. First, they will represent discrete support points under the foundation base, having a greater stiffness than that of the foundation ground. Second, in the case of some loads that determine great eccentricities of the resultant under the foundation base, some piles can be subjected to tension.

These tension forces can improve the equilibrium conditions of the foundation, respectively can reduce significantly the pressures transmitted through the foundation base to the foundation ground.

In this situation, the calculus of the loads that are transmitted to the foundation ground must be approached differently.

The foundation slabs can be modelled as linear elastic plate structures. The finite element mesh consists of rectangular 4-node plate elements. A spring surface support with a modulus of subgrade reaction is assumed for this analysis.

The determination of the value for the subgrade modulus has to be assumed, the chosen value for the stiffness of the springs will model the behaviour of the deformation properties of the real soil.

So, the foundation block was modelled as a finite elements mesh, resting discretely in the nodes of the mesh. In plan, the model has an octagon shape.

This shape is more used than a circular shape for wind turbines foundations (Figure 2), due to the fact that a circular shuttering is more difficult to be realized and the reinforcement placement in a circular shape creates some problems with the different length of each bar.

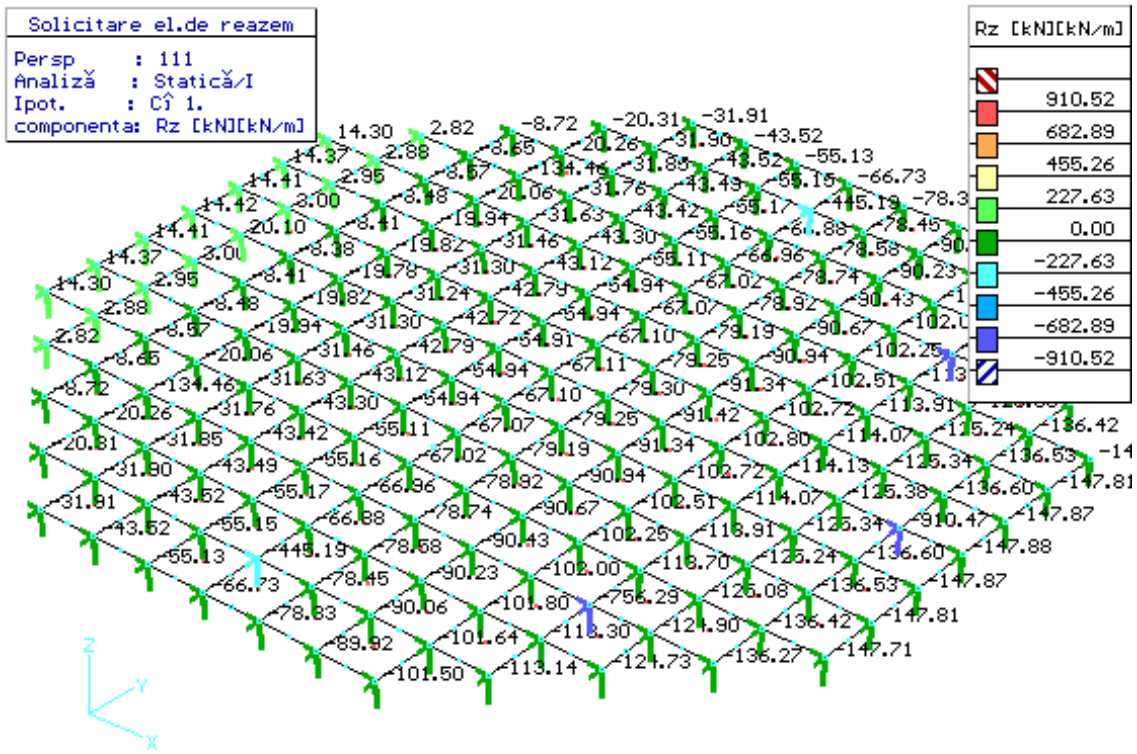

Figure 2 Load distribution into the mesh nodes

In the calculus of the studied model was considered a number of eight piles, distributed each near the sides of the octagon. Modifying successively the stiffness of the supporting points, corresponding to the piles bearing capacity, were compared the results obtained for piles with increasing bearing capacity, from values of 300 kN to 1000 kN.

In the conditions in which the piles overtake a greater part of the loads, the pressure distributed on tl ground was modified substantially, the effect being reduction of the pressure with approximately 23 %.

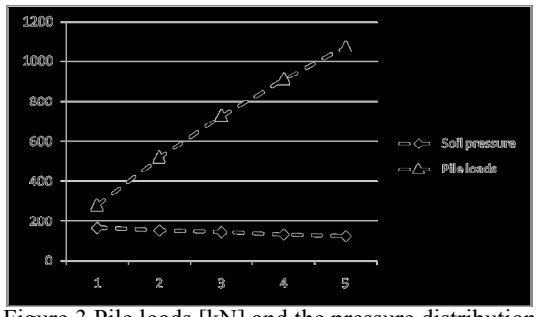

Figure 3 Pile loads [kN] and the pressure distribution [kN/m^2] on the foundation base

The Finite Element Method (F.E.M.) provides a means to model the behaviour of foundation-soil interaction more accurately than other methods. Instead of just issuing a one-dimensional stiffness of the soil, the soil medium itself can be modelled with discrete elements.

Even if just elastic, isotropic soil behaviour is assumed, the structure-soil-interaction can be described more realistically than with the modulus of subgrade reaction.

The same foundation was analyzed using a 3D F.E.M. calculus. In this model, there are a number of 16 piles which can be activated totally (16 piles) or partially (8 piles), considering the symmetry of the foundation.

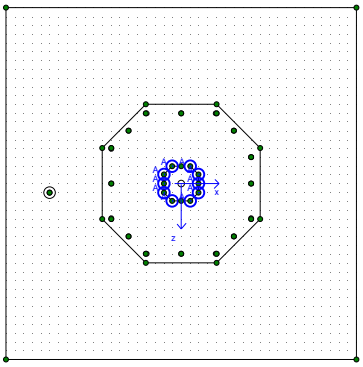

Figure 4 Plane view of the 3D F.E.M. model

The calculus using F.E.M. allows to determine the deformations of the structure and also to determine the stress distribution into the elements of the structure. So, can be determined the settlement of the foundation for the applied load due to the self-weight of the tower and the wind loads.

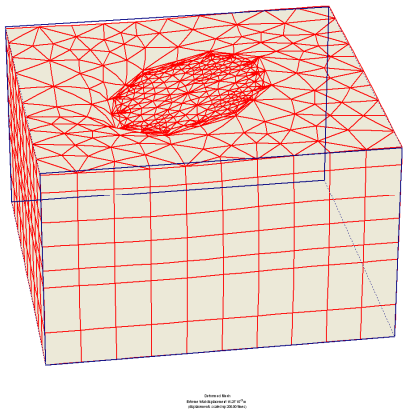

Figure 5 3D representation of the F.E.M. model

Figure 6 presents the deformation of the structure together with the foundation block and the piles.

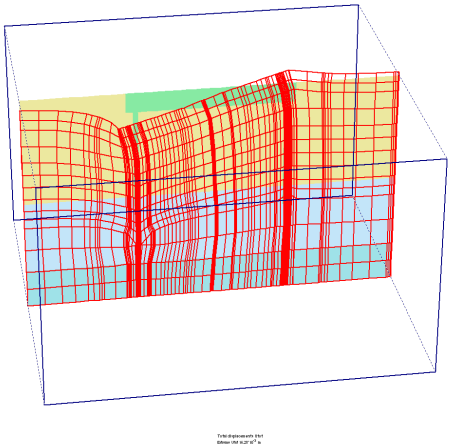

Figure 6 Cross-section representing the deformation of the foundation-piles system

The characteristics of the used software allow determining the stress distribution into the foundation block and along the piles shaft to calculate the necessary reinforcement of the reinforced concrete elements.

The stress distribution into the soil mass can be compared with the resistance characteristics of the soil, so that the bearing capacity conditions should be fulfilled.

4. CONCLUSIONS

The analysis shows, that the presence of some rigid support points can improve significantly the behavior of the foundation under the eccentric loads.

The use of the Finite Element Model, outcome interesting results which can be used for an efficient, technically and economically, design of this kind of massive structure.

A 3-D analysis improves the results and it could be conducted for a more detailed understanding of the behavior of the wind turbine foundations.

The number and the distribution of the piles under the foundation, is also a future subject to be studied because the necessary bearing capacity of the piles must be established. This bearing capacity of the piles can be obtained, function of the foundation ground, with different lengths and different diameters of the piles.

Considering all these elements we can see that the design of wind turbine foundations can be improved and it must be found the most suitable solution, from the point of view of the material consumption, technological possibilities and of the costs.

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SOME ASPECTS REGARDING THE ACTIVATOR LAYER DESTRUCTION AT THE HID LAMPS ELECTRODES-PLASMA INTERACTION

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ABSTRACT

In this paper some aspects regarding the activator layer destruction are presented. Function of various external conditions, like current intensity, electrodes shapes, and surface electrode un-homogeneities, the electrode functioning mode of high intensity discharge lamps (HID) can be diffuse or hot-spot. The two modes are extremely different from the emissive layer evaporation and sputtering point of view. In the diffuse mode, the surface temperature distribution is relatively constant and low. The vaporization rate of the barium layer is small. Contrary, in the hot-spot case, the local spot core temperature can be higher than of the tungsten melting point temperature (3663 K) and the activator layer is rapidly destroyed. The work function increase and the discharge spot are moving to another zone more convenient from the electron emission point of view. This permanent spot movement determine a strong vaporization of the emissive layer and the lamp life-time reduction.

Keywords: *diffuse mode, hot-spot mode, emissive mixture.*

1. INTRODUCTION

The high-pressure mercury or sodium lamps (usually called HID lamps) need high value of the discharge current. The thermal electron emission mechanism is not enough to assure this current value. The electrode must be covered with thin activator layer in order to decrease the electron work function. Currently, is used barium or thorium activator. The thermionic enhanced emission mechanism is specific for HID lamps. This mechanism is described by Richardson–Duchmann formula corrected by Schottky effect of charge image. During the lamp ignition the emissive layer is heavily destroyed by the sputtering due to the ionic impact with the electrode surface. In the stationary regime the activator layer is destroyed by the vaporization. Both of the two processes determine a reduction of the activator and consequently, the lamp life-time is diminished.

The outline of this paper is to calculate the cathode emissive material evaporation rate for various external parameters for a better electrode design. In section 2 the governing equations of the model are given together with corresponding boundaries condition. Some results of the calculation are given in section 3 and discussed in section 4.

2. THEORY

2.1. Activator layer.

The HID lamp cathodes are made from tungsten road over which is wrapped one or two coil layers from the same material. The role of wrapped layers is twofold: first to increase the radiant surface, and second to allow the storage of the emissive material between the coil interstitions. Usually, the most frequently used emissive mixtures are made of barium oxide (BaO) and barium carbonate ($BaCO_3$). By sinterisation barium tungstanat (Ba_3WO_6) and barium atoms (Ba) in excess are generated in accordance with the reaction:

$$6BaO + W \rightarrow Ba_3WO_6 + 3Ba \qquad (1)$$

The barium tungstanat remain localized at tungsten-mixture interface and the barium atoms migrate at the electrode surface where the emissive layer is formed. The Ba atoms monolayer has the role to decrease the electron work function from 4.5eV (case of pure W) to 2.61eV (case of Ba).

2.2. Sputtering and vaporization of emissive layer

The emissive material loss is due to sputtering and vaporization phenomena. Both processes are depending from the ionic bombardment at the electrode surface and from the electrode temperature.

The barium tungstanat can release barium atoms following the reaction:

$$5Ba_3WO_{6(s)} + W_{(s)} \rightarrow 6Ba_2WO_{5(s)} + 3Ba_{(g)} \qquad (2)$$

where "*s*" and "*g*" symbolise the solid state respectively the gaseous state of materials.

An important loss of the emissive material is made through $Ba_{(g)}$ evaporation (resulted from reaction (2))

The flux density of atoms leaving the cathode due to evaporation is described by Hertz-Knudsen formula [1]:

$$G_v = p(T)\sqrt{\frac{M}{2\pi k_B T}} \qquad (2)$$

where T is the local cathode surface temperature, $p(T)$ the cathode material vapor pressure that corresponds to local temperature T, M is the atom mass of cathode material (137 *m.a.u.* for Ba) and k_B is the Boltzmann constant.

Generally, the metal vapor pressure is given by Clapeyron-Clausius equation:

$$\ln(p) = -\frac{\Delta H_T^0}{RT} \quad (3)$$

where ΔH_T^0 is the free enthalpy.

A formula for barium vapor pressure measured in torr was given by Rutledge and Rittner [2]:

$$\lg(p_{Ba}) = -17200/T + 8.56 \quad (4)$$

In our computation we have used more recent formula [3]:

$$p_{Ba}(T) = 2.87\times10^9 \exp\left(-1.9188\times10^4/T\right) \quad (5)$$

This formula fit the best the experimental existing data in the literature [4].

2.3. Electrode temperature distribution

Two mode of cathode operation exist at the same electric voltage drop and current discharge. The first mode, called "hot-spot", exist where the cathode electric field is higher ($E > 10^8 V/m$) with very high-density current ($j > 10^8 A/m^2$). The second mode, called "diffuse mode", occur for lower field ($E < 10^7 V/m$) with lower current density.

Starting from the MacKeon equation, a relationship between electric field intensity E_k, cathodic voltage drop V_k and electrode surface temperature is obtained for the electric discharge stationary regime [5]:

$$V_k T^4 - a_1\left(\frac{1-\beta\gamma}{\beta}\right)^2 E_k^4 \cdot \exp\left(\frac{b_1 - c_1 E_k^{1/2}}{T}\right) = 0 \quad (6)$$

where the constants are $a_1 = \frac{e\varepsilon_0^2}{8 m_i A^2}$, $b_1 = \frac{2e\varphi_0}{k_B}$, $c_1 = \frac{2e^{3/2}}{k_B\sqrt{4\pi\varepsilon_0}}$. Here e is the electron charge, ε_0 is the free space dielectric constant, A is the Richardson-Duschman constant, m_i is the mercury ion mass, $e\varphi_0 = 2.61\text{eV}$ is the barium work function, β is the Waymouth coefficient and γ is the secondary Townsend emission coefficient.

In the model is supposed that the discharge presents a cylindrical symmetry (Figure 1), the coils layers being replaced by a material heaving different barium atoms coating, and consequently, different work functions.

From vaporization point of view, the rate of barium atoms vaporization in the case of hot-spot operating cathode mode is higher than vaporization rate in the diffuse mode. So, considering that the active surface temperature in the diffuse mode is around $T_{diff} \sim 1500K$ and higher than $T_{hs} \sim 3663\ K$ in hot-spot mode functioning (which reach the tungsten melting point) [6], we have:

$$\frac{G_v^{hs}}{G_v^{diff}} = \sqrt{\frac{T_{diff}}{T_{hs}}} \exp\left(\frac{19188}{T_{diff}} - \frac{19188}{T_{hs}}\right) \cong 1200 \quad (7)$$

Consequently, in our analysis we suppose the cathode operating in hot-spote mode, with the spot localized in front of the electrode on the symmetry axis [7].

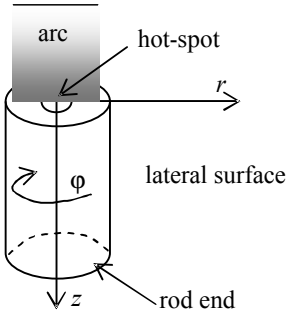

Figure 1. Electrode geometry (in cylindrical coordinates).

The temperature distribution of the electrode surface and inside electrode is obtained by the solving the heat transfer equation. As it was show in other papers [8], the Joule heat generation inside the cathode body is negligible in rapport of another heating mechanism. The major cathode heating is done by the ionic bombardment.

So, in stationary regime, the heat transport equation become:

$$\nabla\left[k_w(T)\nabla T\right] = 0 \quad (8)$$

The temperature dependence of tungsten thermal conductivity is the analytical function, which fit the literature data [9]:

$$k_w(T) = \frac{776}{T^{0.256}} \quad (9)$$

The spot size is obtained by solving the energetic flux conservation equation at the electrode surface [10].

For a current intensity I passing through the circular spot area with r_0 radius the following equation is obtained:

$$\frac{I}{\pi r_0^2(1+\beta)}\left[\beta\left(V_k + V_i\right) - \varphi(1+\beta) - \frac{2k_B T_{hs}}{e}\right] - \sigma\varepsilon_w\left(T_{hs}\right)\left[T_{hs}^4 - T_{plasma}^4\right] = k_w\left(T_{hs}\right)\left(\frac{\partial T}{\partial z}\right)_{z=z_{spot}} \quad (10)$$

where $V_i = 10.434\ V$ is the mercury ionization potential, σ is the Stefan-Boltzmann constant, T_{plasma} is the plasma arc temperature (5800K) and $\varepsilon_w(T_{hs})$ is the tungsten thermal emissivity at the melting point.

This equation allows the calculation of the hot-spot radius dependence on the discharge current.

In order to solve the partial differential equation (8), we need to know the electrode boundary conditions. All these conditions are summarised in table I (see also the figure 1)

Table I. Electrode boundaries conditions.

Frontier	Type of condition	Expression
Rod end	Dirichlet	$T_{end} = 650\ K$
Lateral surface	Neumann	$k_w \frac{\partial T}{\partial n} = q$
Front rod	Neumann	$k_w \frac{\partial T}{\partial n} = g$

In the table I the quantity $\frac{\partial T}{\partial n}$ represent the temperature derivative in the normal direction ($\vec{n}$) of the cathode surface.

The functions q and g represent the heat flux change by the cathode trough convection and thermal radiation mechanism. There are respectively:

$$\vec{n}q = \vec{n}k_w\left(\frac{\partial T}{\partial n}\right) = \vec{n}\zeta\left(T - T_{amb}\right) \quad (11)$$

$$\vec{n}g = \vec{n}k_w\left(\frac{\partial T}{\partial n}\right)_b = \vec{n}\varepsilon_w(T)\sigma\left(T^4 - T_{plasma}^4\right) \quad (12)$$

where $\zeta = 25\ Wm^{-2}K^{-1}$ is the convection transport coefficient and $T_{amb} = 300\ K$ is the ambient temperature and $T_{plasma} = 5800\ K$ represent the core plasma discharge temperature. The function $\varepsilon_w(T)$ represents a polynomial fit of literature data [9].

3. RESULTS

The numerical solution of the eq (9) with boundaries conditions from table I is obtained using commercial software COMSOL Multiphysics, version 3.0.

Knowing the surface and bulk electrode temperature distribution, other physical quantities can be determinated such as ionic flux or barium atom vaporization rate.

The computations were performed for different external parameter: electrode radius, jumped current, or various values for Waymouth or Townsend coefficients.

As example, in Figure 2 are presented the bulk electrode temperature distributions for three values of the current intensity. The electrode radius is 1 mm and the electrode height is 5 mm.

In Figure 3 are presented the temperature distribution at the cathode surface for different discharge current. Also, in the legend are marked the maximal surface temperature T_0 (on the symmetry axis) and the spot size r_0 obtained from energetic flux conservation equation (10).

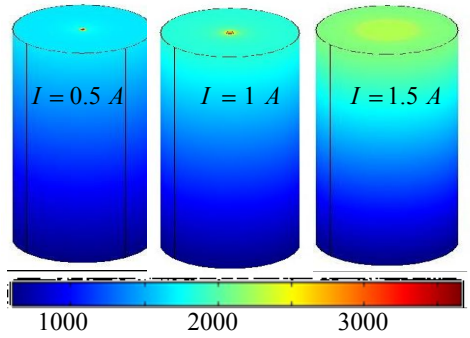

Figure 2. Temperature distribution in the cathode bulk for 0.5, 1.0 and 1.5 A intensity current discharge.

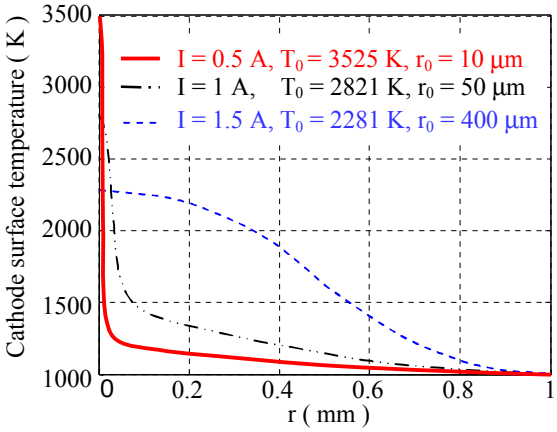

Figure 3. Temperature distribution on the active cathode surface

When the total current diminishes the electric spot became small. That means that in this case the cathode bulk heating is small and the emission is produced at big current density on the small area. When the current intensity increase, the bulk cathode heating increase too, and the thermionic emission cover a large part of the cathode front area. The cathode passes in diffuse mode functioning.

The electrode density current emission is given by:

- field-enhanced thermionic emission (FEE) process using the Richardson-Duschman equation corrected by Schottky effect of charge image:

$$j_e^{th} = AT^2 \exp\left(-\frac{e\varphi}{k_B T}\right); \quad \varphi = \varphi_0 - \left(\frac{eE_k}{4\pi\varepsilon_0}\right)^{1/2} \quad (13)$$

- secondary electrons emission by γ-Townsend process:

$$j_e^{sec} = \gamma j_i \quad (14)$$

Considering that the total current density is $j = j_e + j_i$ and taking into account the Waymouth relation between ionic and electronic density current, the current distribution on the cathode active surface can be found. In Figure 4 the electronic and ionic

current density distribution of the active electrode surface are presented.

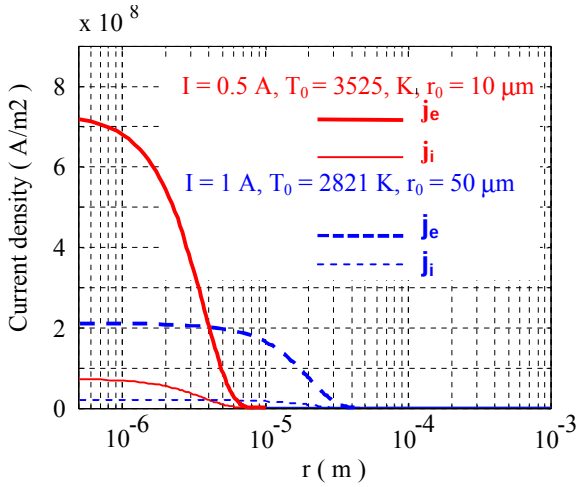

Figure 4. Density current distribution on the cathode active surface.

If the total current is calculated as an integral surface of the current density, the value obtained is very close to the input value of the model. So, the integral:

$$I = 2\pi\int_0^{r_0} j_{spot}(T_{hs})rdr + 2\pi\int_{r_0}^{R} j(T(r))rdr \qquad (15)$$

give the values, 0.50065A respectively 1.0049A for the input value of the current intensity 0.5 A and 1.0 A respectively.

These means that the model is self consistent with an error of 0.31 % respectively 0.49% .

The damage of the emissive layer is produced also by sputtering atoms. This process depends by the ionic current density which become bigger where the discharge cathode mode passe from diffuse mode to hot-spot mode. So, the two modes functioning are very different from vaporization and sputtering of emissive layer point of view.

Figure 5 shows an example of calculation for the barium atoms evaporation rate on the cathode front surface for a current intensity equal of 1 A.

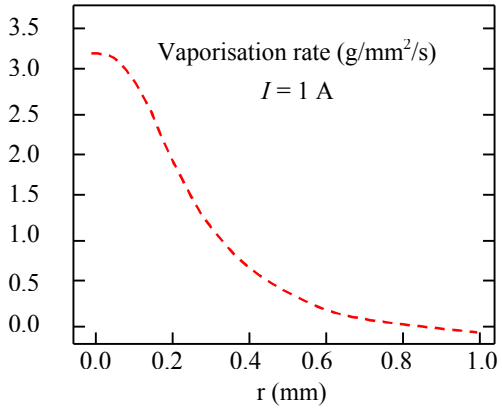

Figure 5. Barium atoms evaporation rate.

A fraction of the barium vaporised rate is returning from plasma arc to the cathode and as result, the net vaporisation rate is lower than the one given by Hertz-Knudsen formula. There is no model for this mechanism and therefore it is difficult to estimate the number of the barium atom which is coming back to the plasma and are adsorbed on the electrode surface.

The damage of the emissive layer is very high in the core of the spot. The rapid vaporization of the layer it is not instantly repaired by reaction (2) or by the plasma barium atom adsorption. Consequently, the work function increase locally and the spot are moving to the other zone more convenient from energetic point of view.

4. CONCLUSIONS

Axially symmetric cathodes heated by dc arc plasmas are considered. A 3D model has been developed in order to calculate the temperature distribution on the active area surface. The rate of emissive material vaporization on the active surface is carried out. The vaporization rate of barium atom is three order of magnitude gather in the case of hot-spot functioning. This leads to a shorten lamp life-time. Contrary, in the case of diffuse cathode mode functioning, the emissive mixture is less destroyed.

The sputtering is very important but is hard to calculate this rate. Also the rate of the barium atoms which comeback from the plasma to electrode surface is the future goal of physicist.

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MODELLING THE STACK TYPE STRUCTURES BY USING THE PETRI NETS

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ABSTRACT

In the present paper is presented a model generated with the Petri Nets for a stack type structure. Each level of the stack (i.e. the bottom, an intermediate level and the top of the stack) is modelled with a Petri Net, the stack's model being obtained by combining all of them. The number of levels is unlimited.

Keywords: *Discret Event System, Modelling, Petri Nets, data structures.*

1. INTRODUCTION

Stack is a data structure very often encountered in practice. Thus, in a computer certain information is stored in stack. For some industrial processes, the palletized, containerized, etc. goods are arranged in stacks during transportation, handling and storage as well. The problems of loading and unloading a stack at different stages have many applications. Many particular problems of loading and unloading a stack through a sequence of handling operations appear; each handling operation consists in removing from the top of the stack a given subset of elements and then inserting at the top of it another subset of elements.

The stack is said to have "last in, first out" behavior. It means that for a multi-level stack, new elements are inserted at the 'top' of stack and elements are also deleted from the 'top' of the stack

2. THE STACK STRUCTURE

The theoretical framework for stack modeling is based on the stack structure. Figure 1 presents the block diagram of a multi-level stack. Whenever we add some elements into the stack, the first level (BOTTOM) is occupied the first; afterwards the upper levels will be occupied. The last filled level is the TOP of the stack.

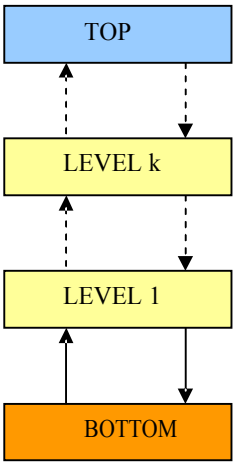

Figure 1. The block diagram of a multi-level stack.

Theoretically, there may be any number of intermediate levels. To simplify consideration, without losing generality, we will consider only one intermediate level.

Below, after completing the Petri Net type models for the BOTTOM (B) of the stack, an INTERMEDIATE level (I) ant the TOP (T) of the stack, for a three-levels stack, the model will be obtained by connecting them according the block diagram shown in figure 1.

3. THE MODEL FOR THE BOTTOM OF THE STACK

For the BOTTOM of the stack, the model presented in figure 2 is proposed.

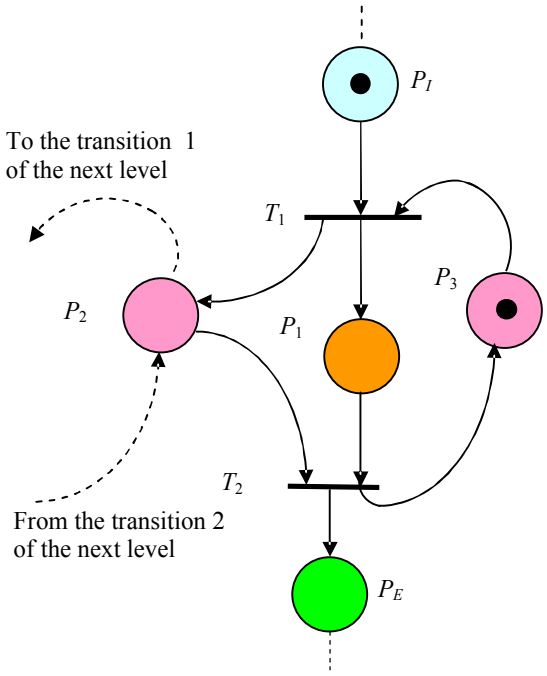

Figure 2. The model for the BOTTOM of the stack

The significance of the BOTTOM level model positions is shown in table 1.

Table 1. The significance of the BOTTOM model's positions

POSITION	SIGNIFICANCE
P_I	Stack's entry object
P_1	Stack's BOTTOM object
P_2	The BOTTOM level may be vacated or the next level may be occupied
P_3	The BOTTOM level may be occupied
P_E	Stack's exit object

The execution of the BOTTOM model transitions is associated to the actions shown in table 2.

Table 2. The significance of the BOTTOM model transitions

TRANSITION	ACTION
T_1	An object enters in stack on the BOTTOM level
T_2	An object leaves the stack from the BOTTOM level

4. THE INTERMEDIATE LEVEL MODEL

For a stack's INTERMEDIATE level, the model is shown in figure 3.

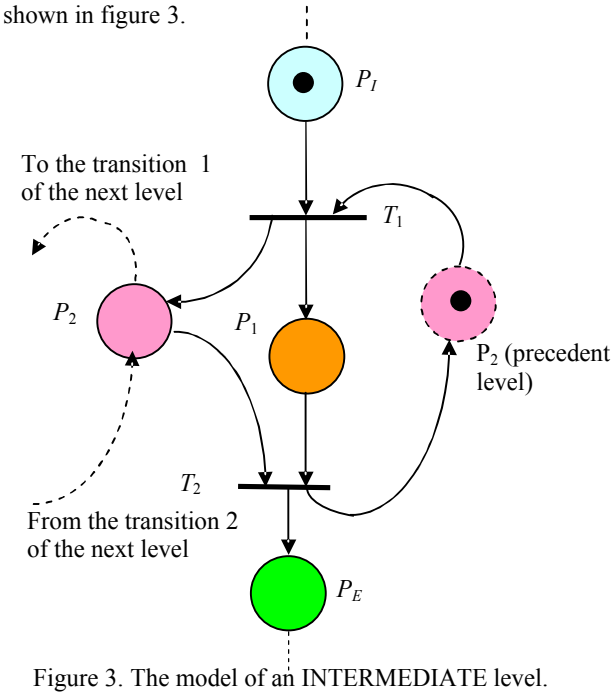

Figure 3. The model of an INTERMEDIATE level.

When a mark reaches a position, the significance of the positions is shown in table 3.

Table 3. The significance of the level I model's positions

POSITION	SIGNIFICANCE
P_1	An object is situated on the level I
P_2	The current level I may be vacated or the next level may be occupied
P_2 (precedent level)	The precedent level is occupied and may be vacuated or the current level may be occupied.

The execution of the INTERMEDIATE model's transitions is associated to the actions shown in the table 4.

Table 4. The significance of the INTERMEDIATE level model's transitions

TRANSITION	ACTION
T_1	An object enters in stack on the INTERMEDIATE level
T_2	An object leaves the stack from the INTERMEDIATE level

5. THE STACK'S TOP MODEL

For the stack's TOP level, the model is shown in figure 4.

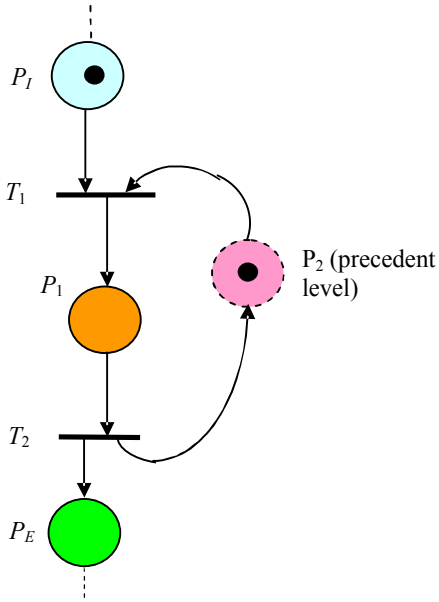

Figure 4. The stack's TOP model.

When a mark reaches a position, the significance of the positions is shown in table 5.

Table 5. The significance of the TOP model's positions

POSITION	SIGNIFICANCE
P_1	An object is situated on the TOP of the stack
P_2 (precedent level)	The precedent level is occupied and may be vacuated or the TOP of the stack may be occupied.

The execution of the TOP model's transitions is associated to the actions shown in the table 6.

Table 6. The significance of the TOP model's transitions

TRANSITION	ACTION
T_1	An object enters in stack on the TOP level
T_2	An object leaves the stack from the TOP level

6. THE STACK'S MODEL

Starting from the block diagram shown in figure 1 for a stack with a single intermediate level, the model shown in figure 5 is obtained.

As it can be seen, the position P1 for each model (BOTTOM, INTERMEDIATE, TOP) is related to its level status (free level or occupied level) while the position P2 for each model validates the vacancy of the respective level or the ocupancy of the next level. The position P3 of the BOTTOM model validates the occupancy of the first level.

An object (mark in figure 5) may occupy a level inside the stack only if the respective level is vacant and the precedent level (excepting the BOTTOM) is occupied – condition validated by a mark existing in position P2 of the precedent level.

An object may vacate a certain stack's level (excepting the TOP) only if the respective level is occupied and the next level is vacant - condition validated by a mark existing in position P2 of the respective level.

If M(P) is the marking (number of marks) of a position P, for the Petri Net shown in figure 5, the marking vector M and the initial marking vector M_0 are:

$$M = \begin{bmatrix} M(P_1) \\ M(P_{1B}) \\ M(P_{2B}) \\ M(P_{3B}) \\ M(P_{1I}) \\ M(P_{2I}) \\ M(P_{1T}) \\ M(P_E) \end{bmatrix} \qquad M_0 = \begin{bmatrix} 3 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Because there are positions numbered by the same index, we also used the B, T and I index for BOTTOM, TOP and INTERMEDIATE level.

The marking graph shown in figure 6 is obtained.

Markings of each level inside the marking vector are in an coloured area (each colour related to respective level).

Markings reffering to the objects being at the stack's entrance, at the stack's exit or onto the stack's levels are red coloured inside the marking vector.

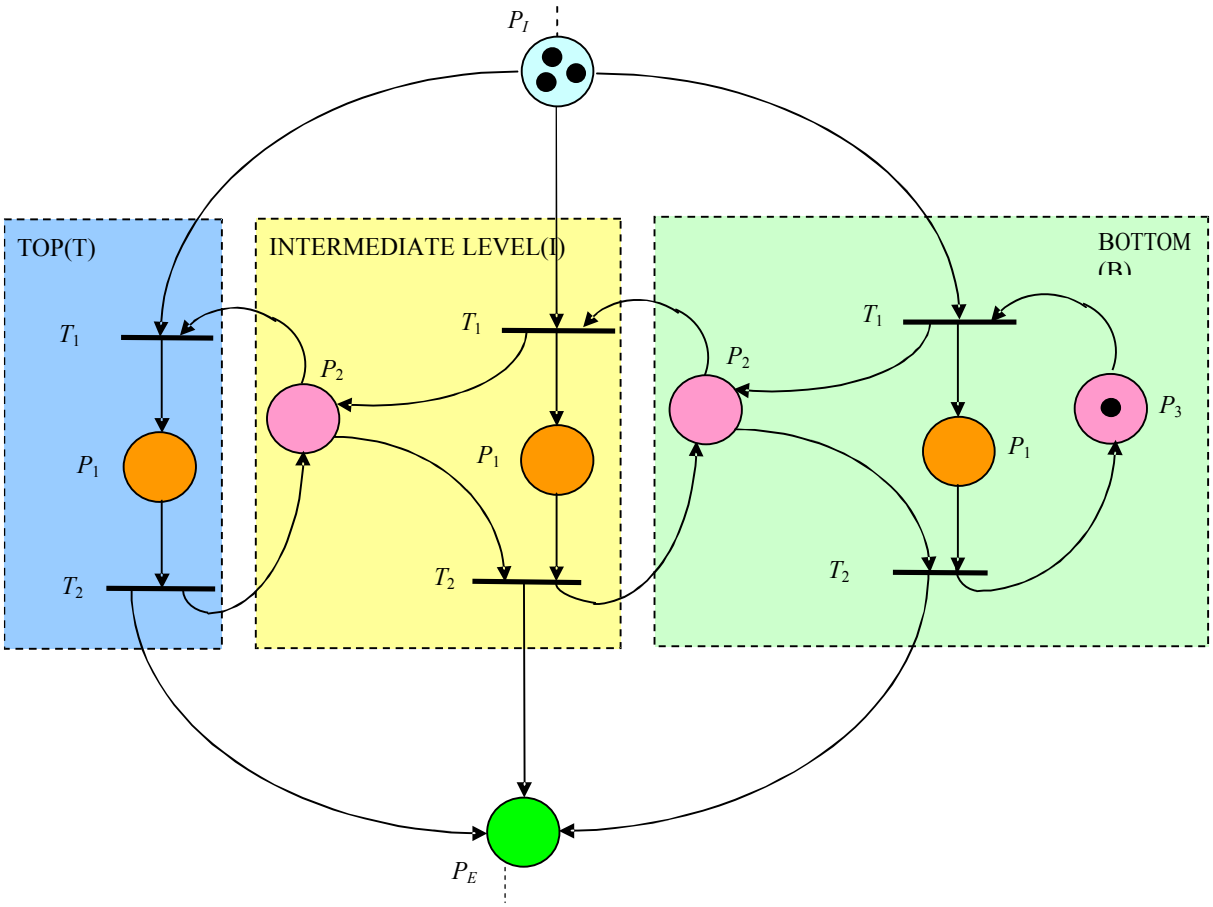

Figure 5. 3-levels stack Petri Net – type model.

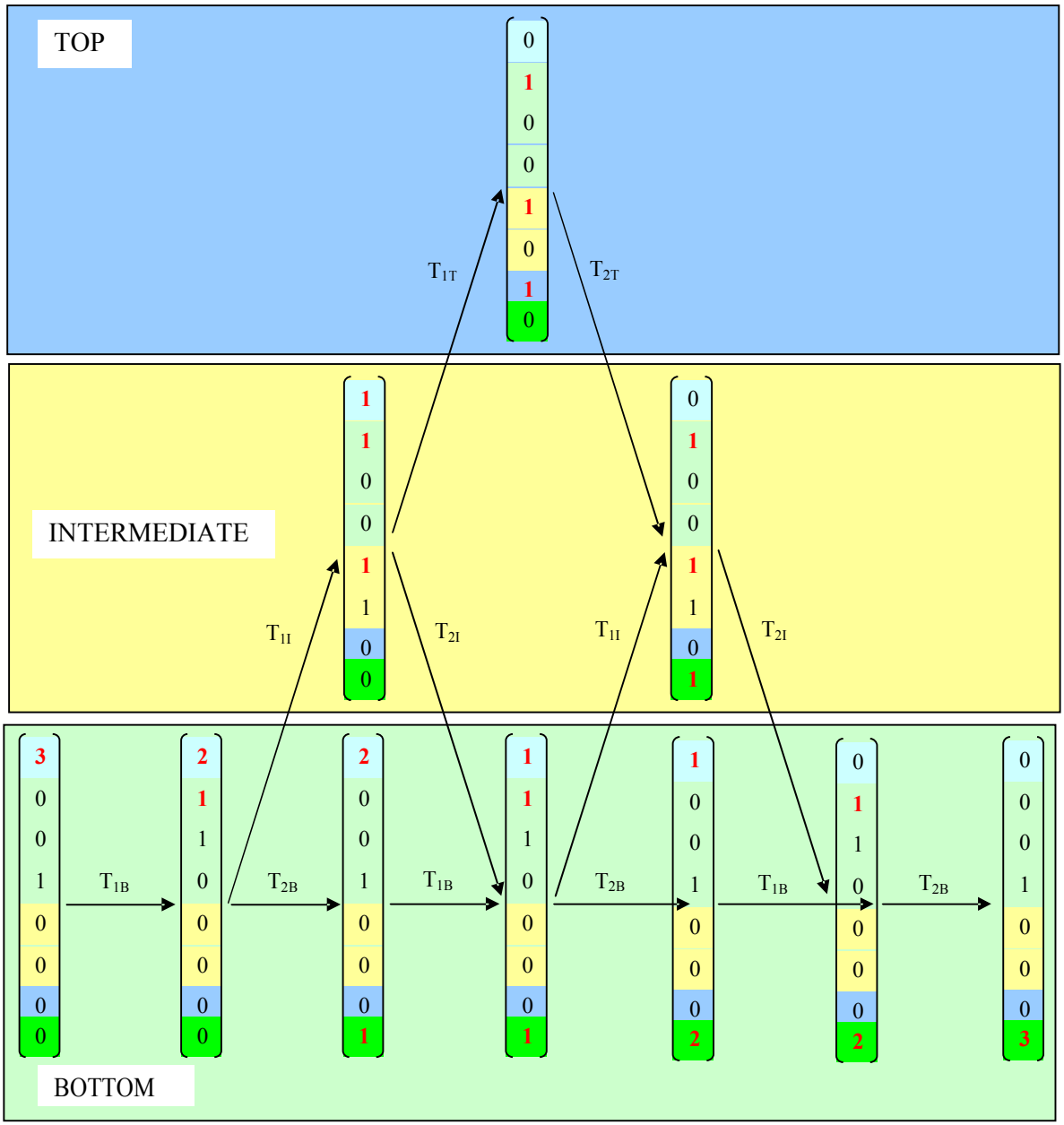

Figure 6. The marking graph for the PETRI NET in figure 5.

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PROPORTIONAL STEERING SYSTEM

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ABSTRACT

This article presents a naval steering system with continuous action having a proportional control. The power electro hydraulic comprises a controlled debt pump actuated by means of an electric torquer. Studying this assembly behavior, with regard to the classic discontinuously steering operation, it is important to observe that the ship's rudder motion is smoother [1], [2], [4], [5].

Keywords: *proportional control, power electro hydraulic, controlled debt pump, torquer*

1. INTRODUCTION

The ideea to install and to use a proportional steering system on board of a ship is to eliminate the rough regime of the rudder machine imposed by the rudder inertia.

Different types of steering systems architecture are imposed by choosing the type of rudder machine imposing in this way the adequate power electro hydraulic which require suitable electronic and electric control equipments [5].

1.1. Classification of naval steering systems

There are two manners to steer a ship: by actuating continuously or discontinuously the rudder blade. There for exist two types of naval steering control systems:

- continuous acting control (proportional type)
- discontinuous acting control (ON – OFF type)

It is to be mentioned that the rudder machines are of two kinds:

- Hydraulic cylinders machines (fig 1.a) [8]
- Hydraulic rotary machines (fig 1.b). [8]

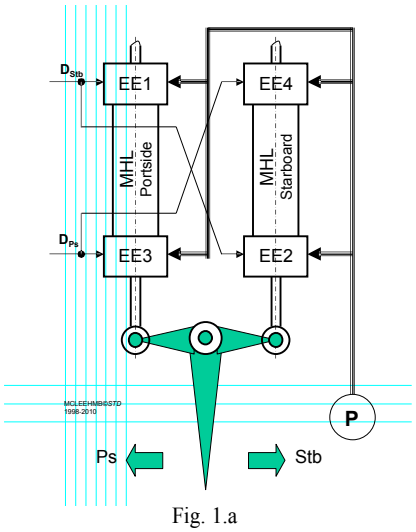

Fig. 1.a
Hydraulic cylinders rudder machine

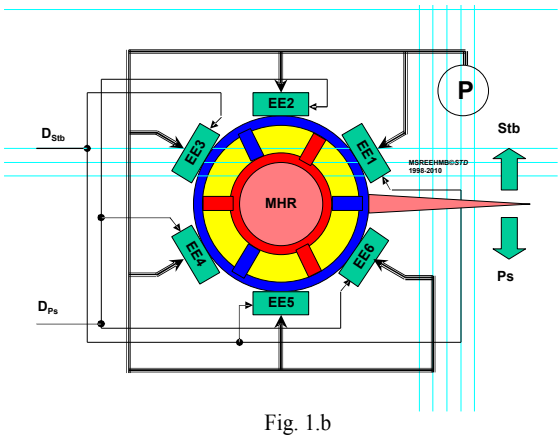

Fig. 1.b
Hydraulic rotary rudder machine

1.2. Classification of power electro hydraulics

The main two types of pumps included in the architecture of the ship's power electro hydraulics are:

- Variable debt pumps activated by means of torquers or electro hydraulic proportional valves
- Constant debt pumps activated by means of electro hydraulic ON – OFF valves

1.3. Classification of low power proportional electric executors

There are tree categories of the above mentioned executors:

- PWM valves (such are proportional valves and torquers)
- Step by step proportional actuated valves supplied by means of synthetic wave (fig.3) [1], [3], [5]
- Digital proportional multichannel valves

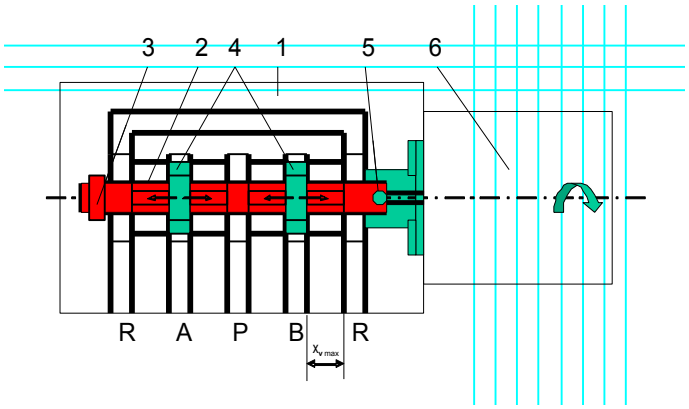

Fig.2
Step by step proportional 4-way valve activated by means of step by step motor

Legend:

1 – casing of the hydraulic distributor
2 – shaft
3 – (ball) bearing
4 – proportional variable enclosures
5 – shaft of the step motor
6 – step by step electric motor

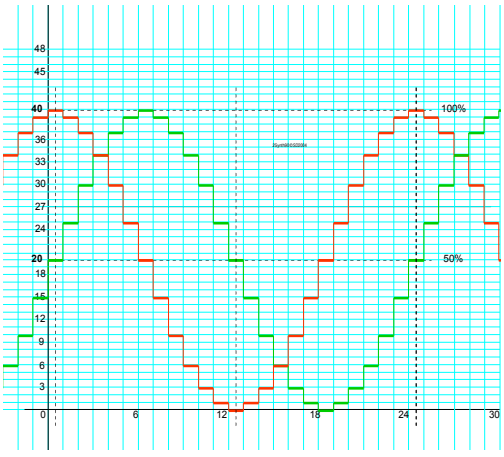

Fig. 3
Synthetic sine waves on the electric step actuator [10]

2. THE SYSTEM

Figure 4 shows the entire steering system.

The steering amplifier accepts an input signal from the steering wheel or from the autopilot, representing the desired rudder angle and compares it with a further signal from the rudder. Any difference between both, results in a corresponding output, controlling the discharge of the pump by means of solenoid valves (proportional valves) or a torque motor.

Torque motors normally require a position control with an additional feedback transmitter. The amplifier is able to accept this signal, too, and to provide the corresponding position control.

Definitions

- δ_{set} = desired rudder angle
- δ_{act} = actual (achieved) rudder angle
- $\Delta\delta$ = control deviation angle
- a_{act} = actual torquer position
- q_{act} = actual debt
- $u_{\delta\ set}$ = desired rudder angle voltage
- $u_{\delta\ act}$ = actual (achieved) rudder angle voltage
- $i_{\Delta\delta}$ = current activating the torquer
- $u_{\alpha\ act}$ = actual torquer position transferred voltage
- $u\ q\ act$ = actual debt transferred voltage

Transfers

The transfer through the Wheel Transmitter is

$$\chi_{W\delta set} = \frac{u_{\delta set}}{\delta_{W set}}\left[\frac{Volt}{\deg ree}\right] \quad (1)$$

The transfer through the Automatic Pilot is

$$\chi_{AP\delta set} = \frac{u_{\delta set}}{\Delta\Psi_{AP\delta set}}\left[\frac{Volt}{\deg ree}\right] \quad (2)$$

The transfer through the Steering Amplifier is

$$\chi_{SA\Delta\delta} = \frac{i_{\Delta\delta}}{u_{\Delta\delta}}\left[\frac{Ampere}{Volt}\right] \quad (3)$$

The transfer through the proportional device (Torquer) is

$$\chi_{torq} = \frac{\alpha_{\Delta\delta}}{i_{\Delta\delta}}\left[\frac{\deg ree}{ampere}\right] \quad (4)$$

The transfer through the Controlled Debt Pump is

$$\chi_{VDP} = \frac{q_{act}}{\alpha_{act}}\left[\frac{m^3}{\deg ree}\right] \quad (5)$$

The transfer through the Rudder Machine is

$$\chi_{AP\delta set} = \frac{\delta_{act}}{q_{act}}\left[\frac{\deg ree}{m^3}\right] \quad (6)$$

The transfer through the Rudder Angle Transmitter is

$$\chi_{R\delta act} = \frac{u_{\delta act}}{\delta_{act}}\left[\frac{Volt}{\deg ree}\right] \quad (7)$$

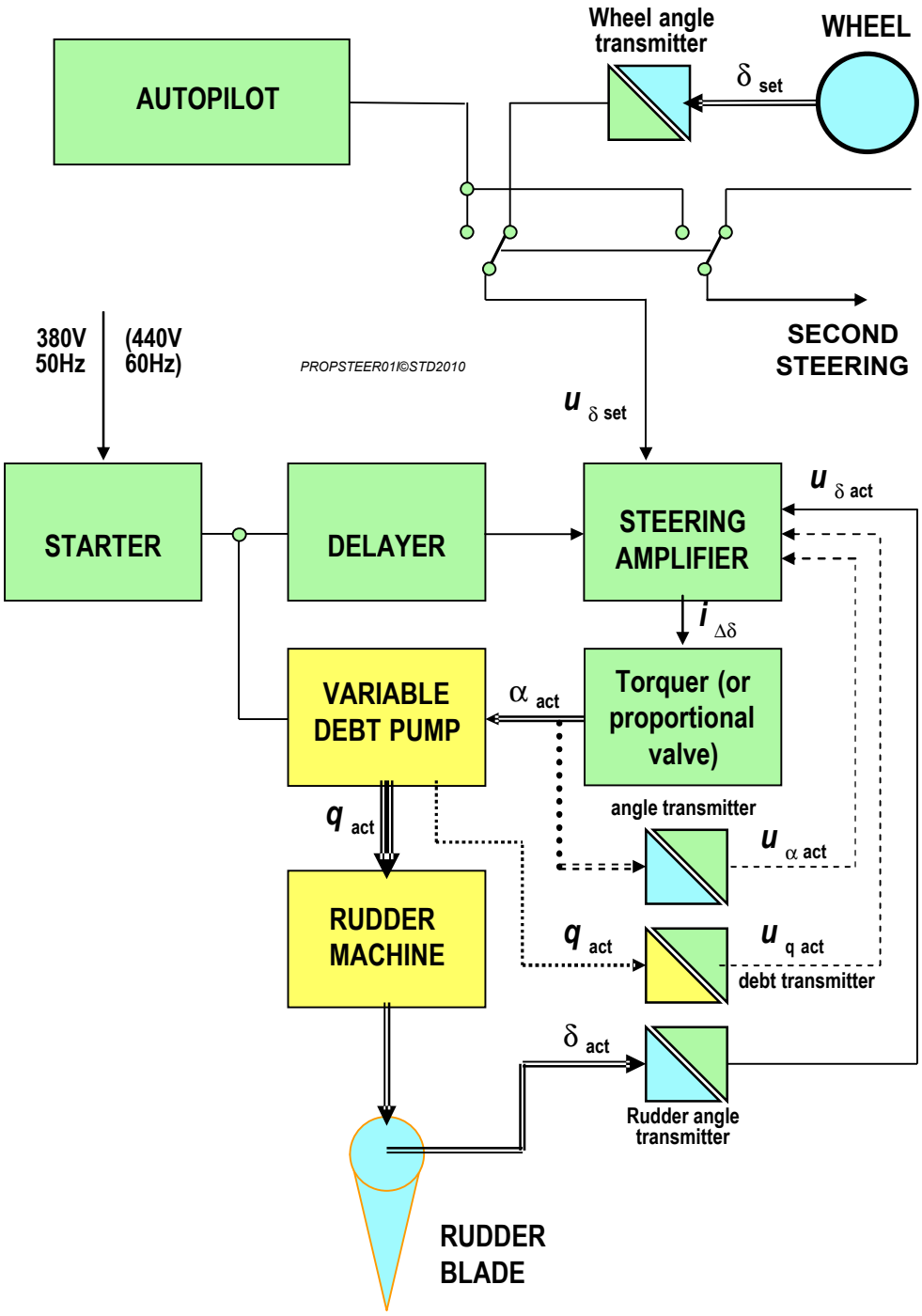

Fig.4
The entire Naval Proportional Steering System

3. THE CONTROL

The input voltage representing the rudder command $u_{\delta set}$ (desired rudder angle) is applied to the **INPUT SELECTOR** and the voltage achieved by the feedback unit $u_{\delta act}$ (actual rudder angle) is applied to a feedback input. As the polarity of these voltages is inverse, the difference between both ($u_{\Delta\delta}$) can be measured at the output. *STATUS* defines the chosen source: ***AUTOPILOT*** or ***WHEEL***

In the next stage (**DIFF AMPLIFIER**), the above mentioned difference signal $u_{\Delta\delta}$ is combined with the position feedback signal $u_{\alpha act}$ from the torque-motor. Is to be mentioned that the ratio *rudder difference signal* $u_{\Delta\delta}$ / *torque-motor position signal* $u_{\alpha act}$ is adjustable.

The resulting output of **DIFF AMPLIFIER** is limited to ±10V, to prevent that the output current of the connected power amplifier exceeds the set limit for extreme input signal conditions to the input board.

Transfers

$$\chi_{R\delta act} = \frac{sign[u_{\Delta\delta\alpha}]}{sign(u_{\Delta\delta} - u_{\alpha act})}\left[\frac{Volt}{Volt}\right] \quad (8)$$

$$\chi_{R\delta act} = \frac{sign[i_{\Delta\delta\alpha}]}{sign(u_{\Delta\delta\alpha})}\left[\frac{Ampere}{Volt}\right] \quad (9)$$

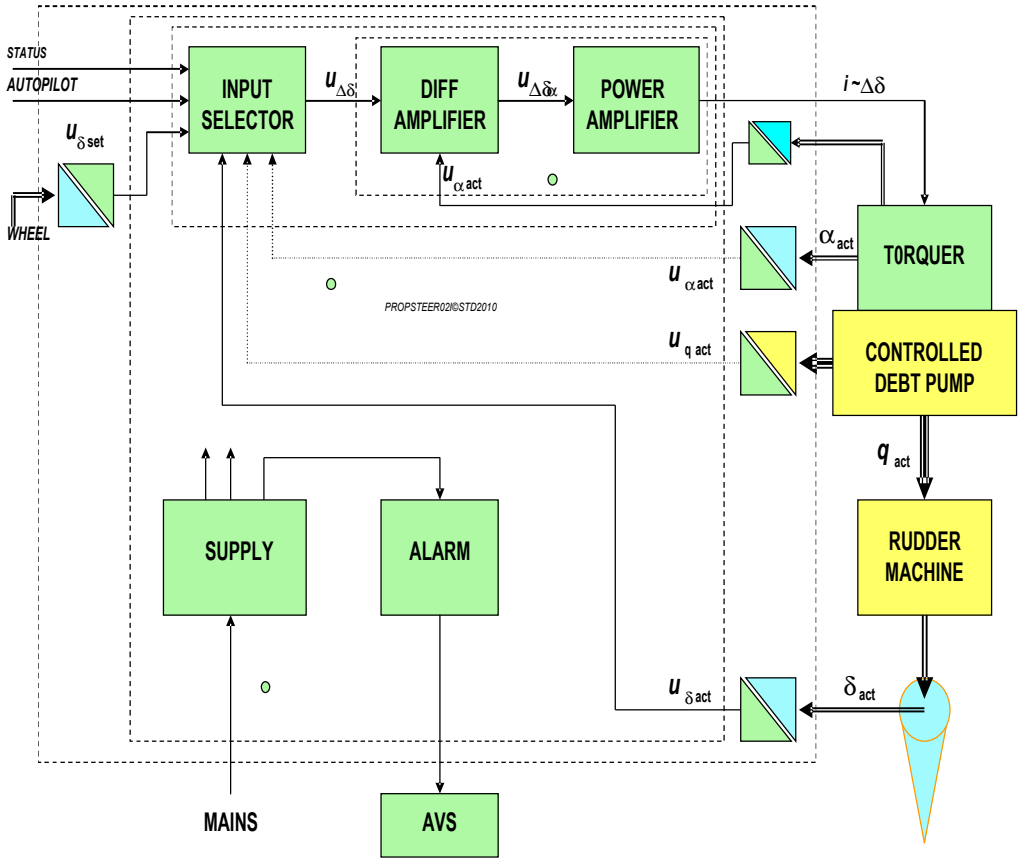

Fig. 5
Steering control

4. MEASUREMENTS

A diagram

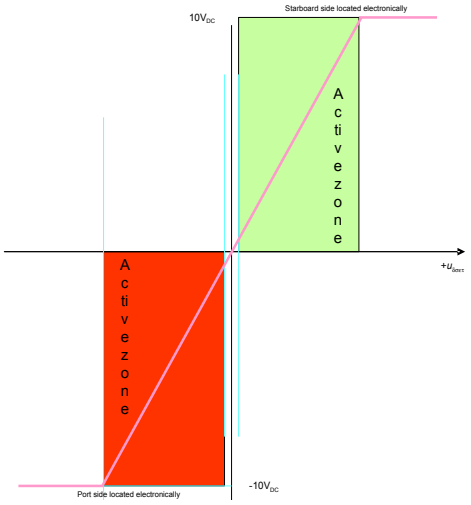

Fig.6
The Control

On the right side the chart gives the corresponding values

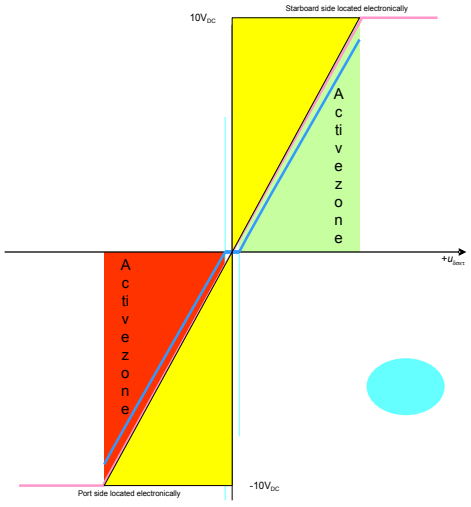

Fig. 7
The Rudder response

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Anti – Hunt Control System

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ABSTRACT

The anti-hunt control system performs a better behavior than a classical On-Off one. The rudder moves softly and also the rudder machine. The derivative reactor ensures a component compensating the hyper transition one so the entire system will behave smoothly protecting the steering gear life.

Keywords: *anti-hunt control system, stroke, overshoot.*

1. INTRODUCTION

Conventionally designed steering gears are controlled by simple ON/OFF signals, which results in a certain overshoot and rough operation (fig.1.1).

There are two ways to remove this inconvenient, by using:

- a hunting compensation, for the ON-OFF types;
- an analog steering control.

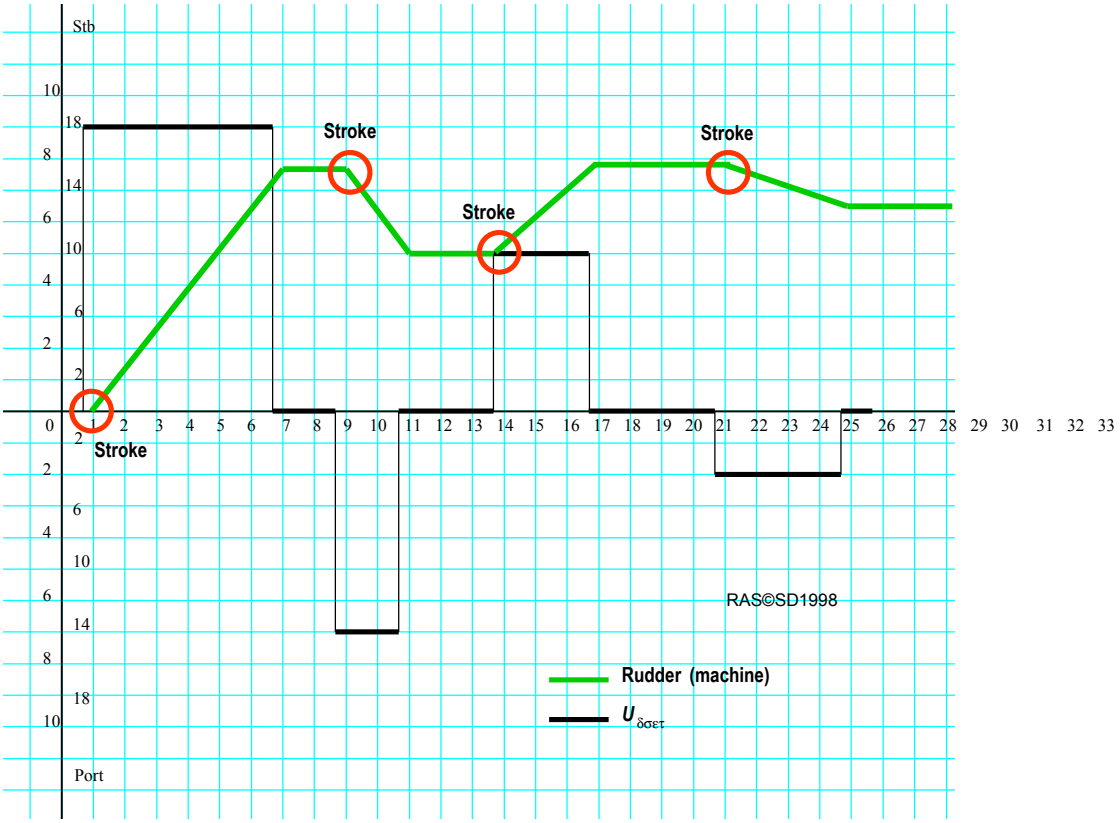

Figure 1.1[9]
Steering gear controlled by simple ON/OFF signals

The hunting compensation permits to avoid overshooting of the rudder blade (usually called "rudder hunting") – which results from inertia of the steering gear – over the preselected desired position.

At the input (see the block diagram shown in fig.1.2), pre-selection of the desired rudder angle signal $u_{\delta set}$, is to be made by the handwheel or by the autopilot. The servo electronics activates the steering gear until the actual rudder angle δ_{act}, is equal to the desired rudder angle, i.e. the control deviation

$$\Delta\delta = \delta_{set} - \delta_{act} = 0$$

Thus the servo electronics is no longer activated.

The servo electronics operates as a three-point controller; its output is of the ON - OFF type.

By differentiation of the rudder feedback signal, is formed a rudder rate-of-turn signal $d\delta/dt$, which is added to the control deviation $\Delta\delta$.

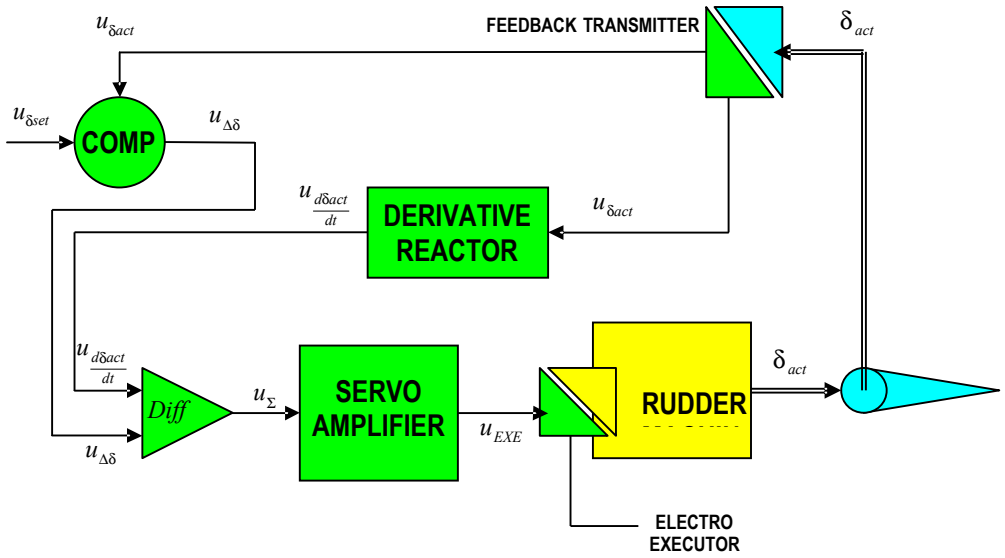

Figure 1.2.
The ANTI-HUNT Steering System

The transfers

The transfer through the Wheel Transmitter is

$$\chi_{W\delta set} = \frac{u_{\delta set}}{\delta_{Wset}}\left[\frac{Volt}{\deg ree}\right] \quad (1)$$

The transfer through the Automatic Pilot is

$$\chi_{AP\delta set} = \frac{u_{\delta set}}{\Delta\Psi_{AP\delta set}}\left[\frac{Volt}{\deg ree}\right] \quad (2)$$

The transfer through the *Diff* Amplifier is

$$\chi_{Diff} = \frac{u_{\Sigma}}{sign\left(u_{\Delta\delta} + u_{\frac{d\delta act}{dt}}\right)}\left[\frac{Volt}{Volt}\right] \quad (3)$$

The transfer through the proportional device (Torquer) is

$$\chi_{torq} = \frac{u_{EXE}}{u_{\Sigma}}\left[\frac{Volt}{Volt}\right] \quad (4)$$

$$\chi_{CONV} = \frac{I_{EXE}}{u_{EXE}}\left[\frac{Ampere}{Volt}\right]$$

The transfer through the Controlled Rudder *EXE* Machine is

$$\chi_{RM} = \frac{q_{act}}{I_{EXE}}\left[\frac{m^3/\sec}{Ampere}\right] \quad (5)$$

The transfer through the Rudder Machine is

$$\chi_{AP\delta set} = \frac{\delta_{act}}{q_{act}}\left[\frac{\deg ree}{m^3/\sec}\right] \quad (6)$$

The transfer through the Rudder Angle Transmitter is

$$\chi_{R\delta act} = \frac{u_{\delta act}}{\delta_{act}}\left[\frac{Volt}{\deg ree}\right] \quad (7)$$

The block diagram shown in the fig.1.2 gives a detailed functional description.

Signal electronics

The comparator **COMP** forms the static output error $u_{\Delta\delta}$ from the desired-value signal $u_{\delta set}$ and from the actual rudder signal $u_{\delta act}$.

Rudder limitation

The command signal (24V DC) for rudder limitation to 1/2 the maximum rudder angle, which is fed in over, reaches the input of an opto-coupler.

Status input "AUTO / HAND"

The desired-value take-over can be changed over by means of the status input "AUTO / HAND". Control takes place by use of the steering mode selector switch.

There has to be a hysteresis covering the control zone as shown in fig.1.3.

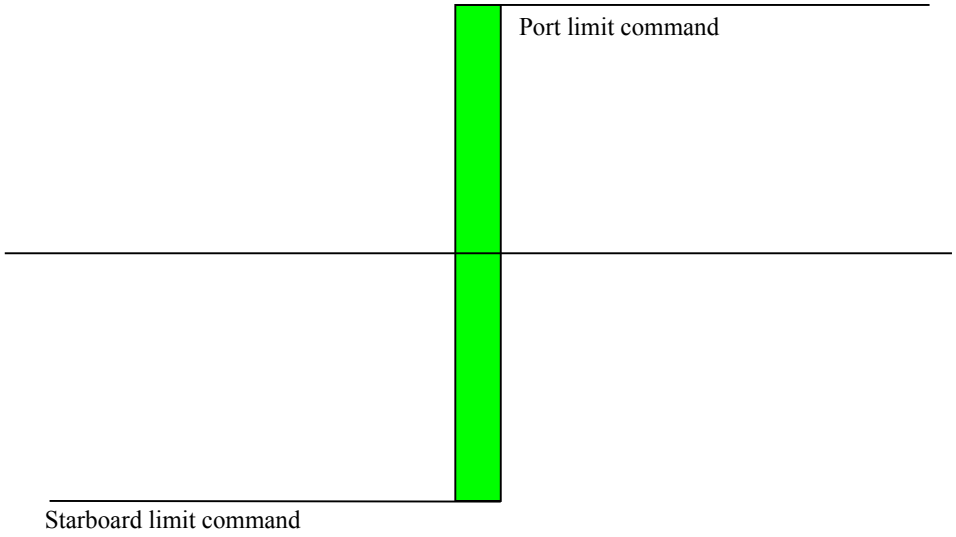

Fig. 1.3.
A digital hysteresis covering the control zone

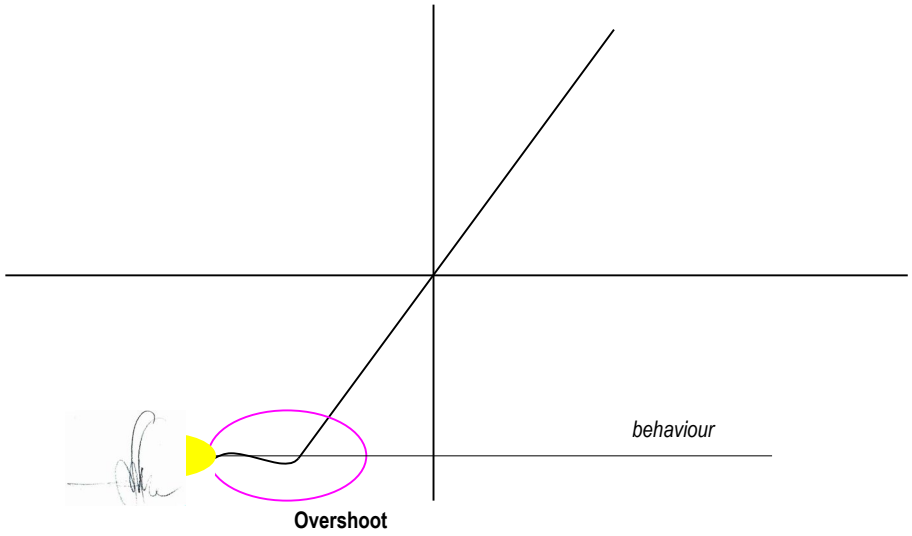

Figure 1.4
Mechanical stroke flowed by an overshoot

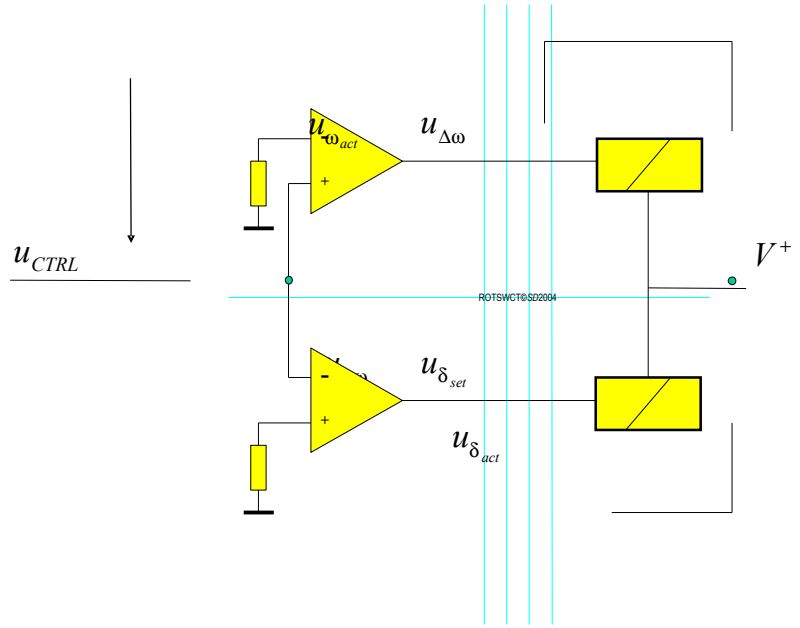

Fig. 1.5.
ON-OFF partition on boards

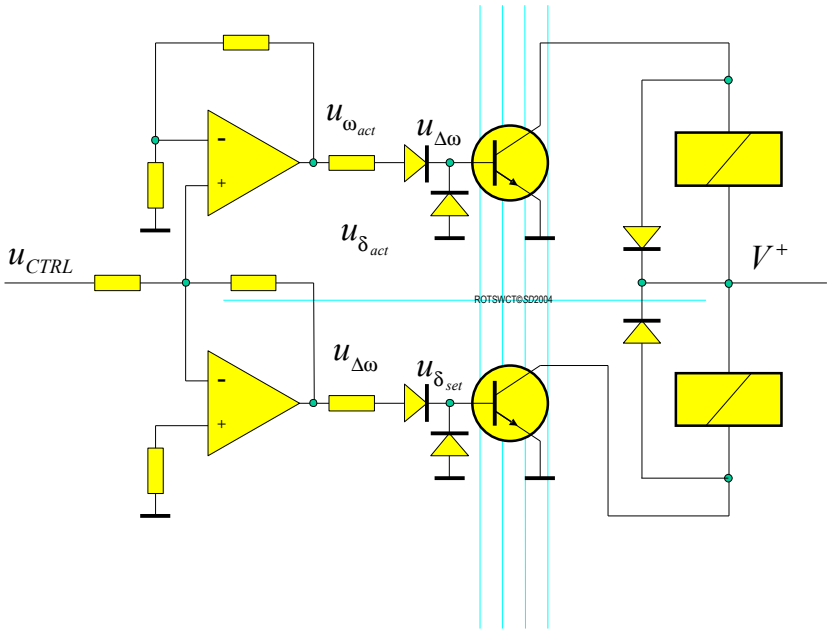

Fig. 1.6.
Discontinuously follow up amplifier

1. DEAD ZONE ADJUSTMENT

Depending on the type of the motors or hydraulic control elements connected, hunting may be experienced after switching off the equipment.

By adjusting the dead zone (neutral zone), the rudder is prevented from swinging.

Adjustment is effected by means of the transmitter (fig. 1.6), whose shaft is provided in the opening of the cover. For adjusting the dead zone, turn the transmitter shaft to the left or to the right, in order to obtain a dead zone as small as possible.

Adjustment of Follow-up Steering Control

For adjustment, cause to be in mid-position:

a) the handwheel coupled with the course transmitter adjusting the desired rudder angle;
b) the rudder (telemotor receiver) with the feedback transmitter.

As regard the mid-positions of the transmitters, coarse adjustment has already been done. Accurate adjustment necessitates an electrical measurement.

The electronic steering control enables the rotary or thrust motions of electric steering gears or electro-hydraulically operated power units to be controlled by simple ON/OFF-signals. Any sensible difference between the desired rudder angle signal and the achieved rudder angle signal activates the steering control, which delivers the ”ON” signal.

The follow-up steering control is made up of one amplifier and two transmitters (one of them is activated by the steering wheel and the other one is activated by the rudder – see fig. 1.2).

The rectified voltage supplied by the operating transformer (supply transformer) is applied to both transmitters. If their positions are identical, the voltage between both wipers will be zero. As one of the transmitters is displaced, a voltage arises, the magnitude and polarity of which being dependent upon the angular displacement and direction of displacement, respectively. This voltage is applied to the amplifier.

The input of the amplifier is provided with a differential amplifier (see fig. 1.2) in which a small transmitter is inserted to enable the minimum operating voltage to be adjusted. The variable response threshold accounts for a variable “dead zone”(neutral zone) within which there is no output from the amplifier (see fig. 1.6).

The voltage applied is amplified and fed into two Schmitt trigger circuits, each one actuating the associate output transistor.

In the fig. 1.6., displacement of the handwheel transmitter makes, via the amplifier/trigger, one of the two relays pulls up. Via the contacts of that relay (which is energized), servomotors are controlled or valves of hydraulic power units actuated electromagnetically. The rudder begins the motion toward port or starboard side, actuating the rudder transmitter coupled to the control unit.

This transmitter performs the feedback function. The control unit continues to operate until the transmitter connected to it has assumed the same angular position as the one connected to the handwheel. The voltage between the wipers being small enough to situate the output of the differential amplifier inside the “dead zone”, the energized relay will drop out and the rudder will stop.

Action of the non-contacting control elements is similar.

Displacement of the handwheel transmitter in opposite direction results in the alternative relay being energized and the reversed motion of the rudder.

The amplifier assembly, the relay group, the spark suppressors, the 24v relay group and the thyristor control units are mounted on separate pcb of their own which are capable of being slid into the chassis. Connections are made by multipoint connectors.

Transmitters (fig. 1.2)

Each of them is usually accommodated in sheet-metal casing filled with oil. Drive is either via a driver plate or gear wheel.

5. CONCLUSIONS

The anti-hunt control system is a better solution in order to obtain an non oscillation response. The life time of a rudder machine is embaded by the steering process.

6. ACKNOWLEDGMENTS

The anti-hunt control system is designed to avoid the premature oldering of the steering gear (including the rudder machine and the rudder asembly). It must to be known that the rotary machine has a lower usage than the cylinder one. The electronics of the control system includes integrative elements such delaying by capacitors.

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CROSSTALK INFLUENCE IN THE EFFICIENT USE OF SPECTRUM FOR DSL NETWORKS

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ABSTRACT

This paper deals with practical issues associated to the adoption of dynamic spectrum management (DSM) in order to mitigate the crosstalk influence in digital circuits subscriber lines (DSL) access networks. Through dynamic adaptation and utilization of frequency spectrum, such as power control, bit loading or vectored transmission, Dynamic Spectrum Management (DSM) allows maximum flexibility in allocating ratindg among flows, achieves much higher total data rates, and extends the reach of broadband acccess.

To extract information associated to the crosstalk, information used by the DSM (Dynamic Spectrum Management) system, was utilizate a procedure named „crosstalk estimation".

The DSM level 2 performance is evaluated based on the achievable data rates obtained through experiments.

Keywords: *crosstalk, Dynamic Spectrum Management, Power Spectral Density, DSL*

1. INTRODUCTION

Broadband communications performances on the digital subscriber lines (DSL) are severely limited by crosstalk interference induced in the adjacent pairs of the network access cable. Crosstalk generally represents an undesirable influence between useful signals sent by neighbor channels and is considered one of the most dominant causes of DSL systems performances limiting.

Static Spectrum Management (fixed spectral masks) ensures that DSL lines in the same cable are spectrally compatible under worst-case crosstalk assumptions. Dynamic Spectrum Management (DSM) increases capacity utilization by adapting the transmit spectra of DSL lines to the actual time-variable crosstalk interference .

For this reason, according [3,5] dynamic spectrum management (DSM) has been proposed as a multi-user resource management approach for crosstalk mitigation.

The DSM solutions optimize the transmission by coordinating the transmit spectra to the slowly time–varying crosstalk channel conditions [3,5] .

Since the presence of the crosstalk estimation error impacts the final solution of the DSM algoritms, the DSM performance is evaluated based on the achievable data obtained through network simulations. For these simulations, network scenarios consisting of real twisted–pair cables are considered and in adition, both crosstalk estimates and references measurements are used for the comparison. The crosstalk reference measurements are conducted in a laboratory using a network analyzer and ordinary twisted-pair cables.

In this paper will be introduced the system model considered, defined notation and described general bit loadig formulation of a general DSM algoritm.

2. SYSTEM MODEL

DSL broadband access networks were analyzed from the perspective of the system with a single user.

Our analysis requires a multiuser model (multiple input and multiple output) MIMO type.

In this analysis, DSM algorithms are introduced on an acess link with N users using a cable of copper (Cu) equipped with DSL transceivers.

Each transceiver has a discrete multiton modulation (DMT) and operates over a twisted–pair line with k parallel subchannels (tones), which are free of intersymbol interference [1] .

This means that the signal vector received by the tone (frequency) k can be modeled according to [1,5],

$$\bar{y}^k = H^k \bar{x}^k + \bar{z}^k, \text{ for } k=1,2,...k \quad (1)$$

where:

(i) $\bar{x}^k = \left[x_1^k, x_2^k, ..., x_N^k\right]^T$ is the transmitted signal vector on the tone k for all N users;

(ii) $\bar{y}^k = \left[y_1^k, y_2^k, ... y_N^k\right]^T$ is the received signal vector on the tone k for all N users;

(iii) $\bar{z}^k = \left[z_1^k, z_2^k, .., z_N^k\right]^T$ is the additive noise vector on tone k including the extrinsec network impairment, for example impulse noise, radio freqency interference (RFI), thermal noise and alien crosstalk [1].

(iv) H^k coresponds to an NxN matrix containing the channel transfer function on tone k.

The DMT transmission for the tone k in a cable binder represented by (1) is illustrated in Figure 1. Typically, in the DSL network are present two crosstalk types: the far-end or FEXT and the near-end or NEXT.

Considering a DMT (discrete multiton modulation) transmission with duplex division of frequencies where upstream and downstream frequency bands does not interfere, crosstalk NEXT can be neglected.

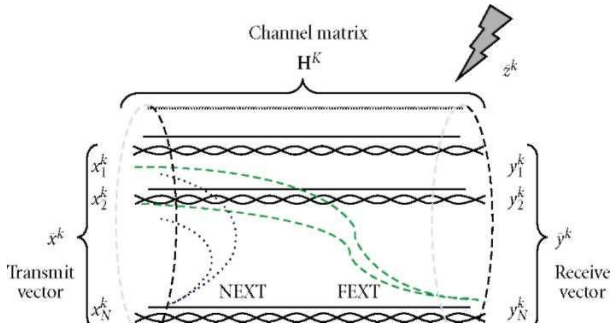

Figure 1. DMT transmision and occurring NEXT and FEXT interference on a copper access binder.

Each channel vector $\overline{h_{n,m}} = \left[h^1_{n,m}, h^2_{n,m}, ..., h^k_{n,m}\right]^T$ represents the transfer function of the channel from transmitter m to receiver n over the tones. For $m = n$, the vectors $\bar{h}_{1,1}, \bar{h}_{2,2}, ...\bar{h}_{N,N}$, correspond to the direct transfer functions of the twister pair lines. Similarly, the off-vectors $\bar{h}_{n,m}$, for $n \neq m$, correspond to the FEXT transfer functions between the lines.

DSM levels 1 and 2 employ PSD (Power Spectrum Density) level optimization aiming to assign a transmit PSD for each user in order to minimize the crosstalk interference. The PSD level optimization allows transmitter to adaptively vary the number of trasmitted bits per tone according to the characteristics of the channel [5,7]. This allocation of bits per tone is performed for each subchannel and can be expressed as follows [9]:

$$b^k_n = \log_2\left[1 + \frac{s^k_n \left|h^k_{n,n}\right|^2}{\Gamma\left(\sigma^k_n + \sum_{m \neq n} s^k_m \left|h^k_{n,m}\right|^2\right)}\right] \quad (3)$$

where:

- b^k_n is the achievable bitloading on tone k for user n;
- s^k_n denotes the power allocate for user n at tone k;
- σ^k_n represents the background noise power on tone k at the receiver n and contains the thermal noise, alien crosstalk and RFI (radio freqency interference);
- Γ denotes the signal-to-noise SNR ratio *gap*. The *gap* is an indicator of how closely the bit rate comes to the theoretical channel capacity [1,2]
- $\left|h^k_{n,n}\right|^2$ represents the square-magnitude of the direct channel gain for user n at tone k.
- $\left|h^k_{n,m}\right|^2$ denotes the square-magnitude of the far-end crosstalk channel from transmitter m to receiver n at tone k.

3. CROSSTALK ESTIMATION

Assuming [12], this section describes the method of channel crosstalk estimation. Estimator executes sequential measurements of power spectral density PSD at the far-end circuit terminal considering the situation where only a transmitter is active at the near-end per measurement sequence.

Using a procedure for the loop measuring on which we will call „Loop diagnostic" [13], measurements can be performed and coordinated by a network management system. Using matrix formulation, was defined the sequential estimation method for a system with a single-input and multiple-outputs (SIMO) expressed through m sequences where only the sequence m is active at a time as follows,

$$y(m) = x(m)H(m) + z(m) \quad (4)$$

$y(m) = \left[\bar{y}_1(m)\bar{y}_2(m)..\bar{y}_N(m)\right]$ is the KxN matrix containing the received signals in all K subchannels and for all N, receiver and $H(m) = \left[\bar{h}_{1,m}\bar{h}_{2,m}.....\bar{h}_{N,m}\right]$ is the SIMO matrix KxN. The known transmitted $Kx\,K$ signal matrix from transmitter m yields

$$x(m) = \begin{pmatrix} x^1_m & 0 & 0 & 0 \\ 0 & x^2_m & .. & 0 \\ .. & .. & .. & .. \\ 0 & .. & .. & x^K_m \end{pmatrix}$$

În (4), added noise is denoted by the KxN matrix :

$$z(m) = \left[\bar{z}_1(m)\bar{z}_2(m).....\bar{z}_N(m)\right]$$

The PSD (Power Spectral Density)– based estimate of the FEXT attenuation matrix for sequence $m = 1,2, ..., N$ can be formulated as [12]:

$$\left|\tilde{H}\right|^2(m) = P_x(m)^{-1}\left(P_y(m) - P_z(m_0)\right), \quad (5)$$

Where $P_y(m), P_x(m) and P_z(m)$ are the correspondig PSD matrix by taking the absolute-squared value of the elements $y(m), x(m)$ and $z(m)$ respectively.
In (5), $P_z(m_0)$ is the background noise measured with no active transmitters to the start of sequence m. From (4) – (5) follows that $\left|\tilde{H}\right|^2(m)$ becomes unbiassed if $P_z(m) \approx P_z(m_0)$. This presumption of (temporary) stationarity can be reasonable from two aspects: in the SIMO case no other active disturber is present, and twisted–pair channel is non time-varying.

4. DSM FRAMEWORK

This section is dedicated to the discription of a DSM application framework [9,10]. This framework is analyzed in order to obtain and evaluate the DSM performance results.

The frequency dependence of crosstalk transmission function has a random character. The knowledge of crosstalk transfer function between all pairs of binder cable will be necessary for Dynamic Spectrum Management (DSM).

In case of static spectrum management (SSM) the transmit PSDs (Power Spectral Density) cannot exceed the spectral masks as defined in the standard. Examples are margin adaptive (MA) and rate adaptive bit loading. In the MA case , all available power is used to maximise the noise margin. This increases the SNR (Signal to Noise Ratio) on this line, but also increases the crosstalk noise on the other lines in the binder.

DSM Level 2 adds a "politeness" capability allowing each DSL modem's power to be set on a frequency-agile basis to avoid noises and reduce the generation of frequency-dependent crosstalk to other DSL lines.

DSM can be achieved over ordinary copper phone lines network by reducing or eliminating crosstak interference and near-far problem within a DSL network especially affecting the DSL phone lines that are close together in a binder.

The DSM technique involves multiple methods:

- continuously monitoring the status of interfering signal levels using current bit-loading compared to maximum achievable bit rate, number of errored seconds, number of severely errored seconds, number of FEC (forward error correction) and making decisions about the underperforming scenarios cause and forcing the link to train in a specific way.
- identifying the neighborhood cables in the binders that may be causing unwanted crosstalk and lowering their upstream transmission power till bit-rates are optimized for the network.
- increasing or decreasing the amount of forward error correction overhead applied to the signal propagating on the cable in response to the severity of the correlated interferers or jammers.
-modifying the limits on the power levels allowed on cable, the masks of the tones on which bits can be loaded or the masks for Power Spectral Density to allow for minimization of the interference caused due to excess SNRs (Signal to Noise Ratio) racausing degradation of SNR on other lines.
- modem hardware CPE (consumer premises equipment) adjusting transmission settings in order to achieve the optimized DMTsignal (this is not exactly DSM and can be achieved even without DSM). This hardware adjustment being forced from a central monitoring location applied to a network of consumer premises equipment on the whole to optimize the network performance as a whole.

Most DSM algoritms do not work together with the physical level, for instance, modems used in practice can not arbitrarily modify PSD (Power Spectral Density) during operation. Although the PSD cannot be modified in operation, there is a set of spectrum modeling parameters transmitter spectrum shaping (tss_i) which allow the PSD modeling to be made by ADSL2 and ADSL2 + standards [13,14]. Using these parameters is possible to define a mask (a profile) of limitation which cannot be exceed by the modems in charge.

In autonomous DSM operation, the service provider (DSL Operator) sets data rates for the DSL services they will provide.

Each modem is configured to run in one of three modes:

RA – rate adaptive, maximize data rate,

MA – margin adaptive (use all available power at given fixed data rate)

FM – fixed margin (use only power needed to guarantee high-quality services.

A flowchart [9] of the developed DSM framework is illustrated in Figure 2.

The framework execution is as follows:

- First, the direct and crosstalk channel information is estimated and retrieved according to previous section method. While, the crosstalk transfer function measurements may be performed using a network analyzer.
- A DSM algorithm is used to calculate a set of optimized PSDs.
- The PSDs results are modified [15] to generate a set of valid control parameters (tss_i values) to be applied at the Central Office (CO) modem, at the DSL access multiplexer (DSLAM).
- After PSD mask application the framework request feedback from the network (bit rates, bit load, output power), in order to evaluate the performance.

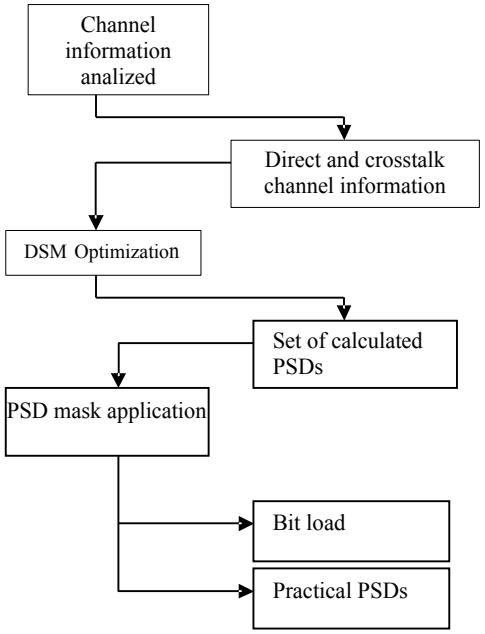

Figure 2 Fowchart:The main steps of framework

Iterative spectrum balancing (ISB) [7,9] is the DSM algoritm in the optimization.

5. EVALUATION AND RESULTS

This section presents a comparision of the practical DSM performance, applying measured estimated crosstalk channel information in the DSM application.

The Crosstalk Estimator presented is applied on access network scenarios shown in Figure 3.

The DSM simulations uses the measured direct channel gains and the PSD of the background noise, obtained with a network analyzer (NA) and with the Loop Diagnostic procedure [9,10].

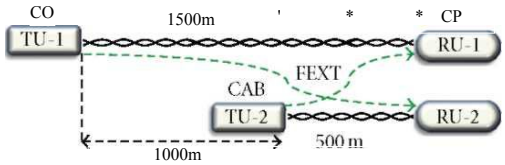

FIGURE 3: Near-far topology with diferent legs

The comparison is made by assessing the rates provided by the same DSM algoritm having as imput two information sources as drawn in Figure 3.

Figure 4 show the optained rate regions (a set of bit rates that can be achieved in a DSL network, in this work, the rate region represents the combination of bit rates obtained from hardware using PSD masks calculated by DSM methods) using the algorithm ISB (Iterative Spectrum Balancing).

The results plotted in Figure 4 show that the FEXT channel estimates are accurate enough to provide values close to the reference (measurement) value.

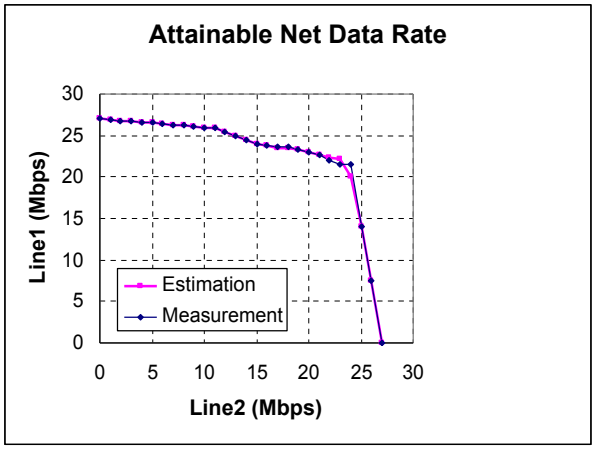

Figure 4: Practical DSM level 2 performance when using measurated and estimated channel information.

6. CONCLUSIONS

Crosstalk is the type of noise which occurs when pairs of wires in a bundle couple electromagnetically with each other. This interaction produces noise that varies slowly with time and causes significant problems at high frequencies. Severe crosstalk noise can cause either link drops or acute performance degradation resulting in service disruptions.

Once the crosstalk channels information have been accurately estimated, one tehnique for combating crosstalk is Dynamic Spectrum Management (DSM). DSM -level 2 analyzed optimizes channel capacity by adapting the transmit spectra of all DSL lines to the actual time-variable crosstalk interference. DSM has expanded in scope to include techniques for crosstalk mitigation and cancellation by jointly processing signals from multiple DSL lines.

The next solution of Dynamic Spectrum Management Level 3 (DSM3), also called vectoring, reduces crosstalk and effectively increases capacity on copper lines by taking advantage of advanced mathematical algorithms and signal processing principles related to those used in noise cancellation.

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A DIFFERENT APPROACH OF THE RIJNDAEL-AES ALGORITHM

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ABSTRACT

This paper presents a different approach of the Rijndael-AES symmetric algorithm, based on the addition of Mix Columns transformation, which originally belongs to the AES standard algorithm, before/after/before&after the Rijndael-AES encryption/decryption block and to the secret encryption/decryption key, resulting a new symmetric algorithm, in 3 different versions (M -AES, AES-M, M -AES-M), which the author of this paper generically called the AES PLUS algorithm. This paper also presents some aspects regarding the hardware (FPGA) implementation of the standard and proposed algorithms. The NIST statistical tests both applied to the AES-128 algorithm and to the new one proved that the M -AES-M version has a better statistical behavior than the original AES-128 standard algorithm.

Keywords: *Rijndael-AES symmetric algorithm, MixColumns transformation, hardware (FPGA) implementation, statistical tests.*

1. INTRODUCTION

The specifications for the Rijndael-Advanced Encryption Standard (AES) symmetric algorithm, as [1] and [2], stipulate a final encryption/decryption round without its most complex transformation, that is the Mix Columns transformation. This is a finite field (Galois Field (2^8)) multiplication between the data block (organized in 4x4 binary matrix, with 8 bit numeric coefficients, which is called State) and a constant matrix operand (e.g. in case of the AES-128 version of the standard algorithm, organized in 4x4 binary matrix, with 8 bit constant coefficients). The author of this paper did not find any explanation for this fact, so he had the idea to add the missing transformation before/after/before& after the Rijndael-AES encryption/decryption block, together with the same transformation of the secret encryption/decryption key, resulting a new symmetric algorithm, in 3 different versions (M -AES, AES-M, M -AES-M), which the author of this paper generically called the AES PLUS algorithm.

This paper also presents the hardware (FPGA) implementations of the standard and of the proposed algorithm, all in iterative loop configurations, which will provide corresponding cryptographic modules.

Finally, the resulted cryptographic modules are statistically tested, using a special designed FPGA test unit and the NIST statistical test suite.

The improved algorithm (AES-128 PLUS), that is the modified AES-128 version of AES, will be presented, but the other versions of AES can be similarly modified.

2. A DIFFERENT ARCHITECTURAL APPROACH

The architecture of the AES block encryption/decryption algorithm contains, as shown in Fig. 2.1, an initial round where on its input a 128 bits plaintext/ciphertext is applied, consisting of 4 columns with 4 bytes each, or else, 4 words with 32 bits each. The plaintext/ciphertext is XORed with the initial key, also represented as a data block consisting of 4 words with 32 bits each.

The algorithm specification contained by [2] mentions 3 possible versions for the AES encryption/decryption algorithm, respectively N_k = 4, 6, 8 (the number of 4 bytes columns, or 32 bits words, of the key) corresponding to AES-128, AES-192 and AES-256 versions, also uniquely N_b = 4 (the number of 4 bytes columns, or 32 bits words, of the plaintext/ciphertext), namely 128 bits. The architectures presented by Figure 1 refer to the AES-128 version. For the 3 constructive versions we have 3 different round numbers, as shown in Table 1.

After the initial round, AES-128 contains 9 encryption/decryption rounds. Each of these rounds has a corresponding round key supplied by the key schedule mechanism which starts the key generation process with the secret initial key.

Table 1. AES versions characteristics

AES version	Key Length (N_k words)	Block Size (N_b words)	Number of Rounds (N_r)
AES-128	4	4	10
AES-192	6	4	12
AES-256	8	4	14

For the encryption process, every round consists of 4 main operations: Shift Rows (every row of the State is shifted by a specific number of positions), Sub Bytes (the substitution of every byte of the State using a special substitution table), Mix Columns and the Add Round Key (the round key is XORed with the resulted State of the previous operation, namely Mix Columns). This sequence of operations is 9 times iterated.

Mix Columns is a Galois Field (2^8) multiplication between the State, each of its columns being polynomials over GF(2^8), and a fixed polynomial given by:

$$a(x) = \{03\}x^3 + \{01\}x^2 + \{01\}x + \{02\} \qquad (1)$$

$$\text{or} \quad \begin{bmatrix} S'_{0,c} \\ S'_{1,c} \\ S'_{2,c} \\ S'_{3,c} \end{bmatrix} = \begin{bmatrix} 02 & 03 & 01 & 01 \\ 01 & 02 & 03 & 01 \\ 01 & 01 & 02 & 03 \\ 03 & 01 & 01 & 02 \end{bmatrix} \begin{bmatrix} S_{0,c} \\ S_{1,c} \\ S_{2,c} \\ S_{3,c} \end{bmatrix}, \quad 0 \le c < N_b \quad (2)$$

The final round differs from the others by the lack of the Mix Columns operation. Thus, this round only consists of Shift Rows, Sub Bytes and an Add Round Key operation. Finally, the result of this last round is the ciphertext State, which is a matrix with 4 words, exactly like the plaintext State.

For the decryption process, every round consists of 4 main operations: Inv Shift Rows (every row of the State is right shifted by a specific number of positions, which is the inverse transposition of those made in the encryption case), Inv Sub Bytes (the substitution of every byte of the State using an inverse substitution table), Inv Mix Columns (which produces the two variants of implementation) and the Add Round Key (the round key is XORed with the resulted State of the previous operation). This sequence of operations is also 9 times iterated.

The Inv Mix Columns function is a Galois Field (2^8) multiplication between the operand (described above), each of its columns being polynomials over GF(2^8), and a fixed polynomial given by:

$$a^{-1}(x) = \{0B\}x^3 + \{0D\}x^2 + \{09\}x + \{0E\} \quad (3)$$

$$\text{or} \quad \begin{bmatrix} S'_{0,c} \\ S'_{1,c} \\ S'_{2,c} \\ S'_{3,c} \end{bmatrix} = \begin{bmatrix} 0E & 0B & 0D & 09 \\ 09 & 0E & 0B & 0D \\ 0D & 09 & 0E & 0B \\ 0B & 0D & 09 & 0E \end{bmatrix} \begin{bmatrix} S_{0,c} \\ S_{1,c} \\ S_{2,c} \\ S_{3,c} \end{bmatrix}, \quad 0 \le c < N_b \quad (4)$$

The hardware (FPGA) implementations of the decryption use a decomposition of the inverse affine matrix, in two matrix terms, given by [3]:

$$\begin{bmatrix} 0E & 0B & 0D & 09 \\ 09 & 0E & 0B & 0D \\ 0D & 09 & 0E & 0B \\ 0B & 0D & 09 & 0E \end{bmatrix} = \begin{bmatrix} 02 & 03 & 01 & 01 \\ 01 & 02 & 03 & 01 \\ 01 & 01 & 02 & 03 \\ 03 & 01 & 01 & 02 \end{bmatrix} \begin{bmatrix} 05 & 00 & 04 & 00 \\ 00 & 05 & 00 & 04 \\ 04 & 00 & 05 & 00 \\ 00 & 04 & 00 & 05 \end{bmatrix} \quad (5)$$

The final round differs from the others by the lack of the Inv Mix Columns operation. Thus, this round only consists of Inv Shift Rows, Inv Sub Bytes and an Add Round Key operation. Finally, the result of this last round is the plaintext State, which is a matrix with 4 words, exactly like the input ciphertext State.

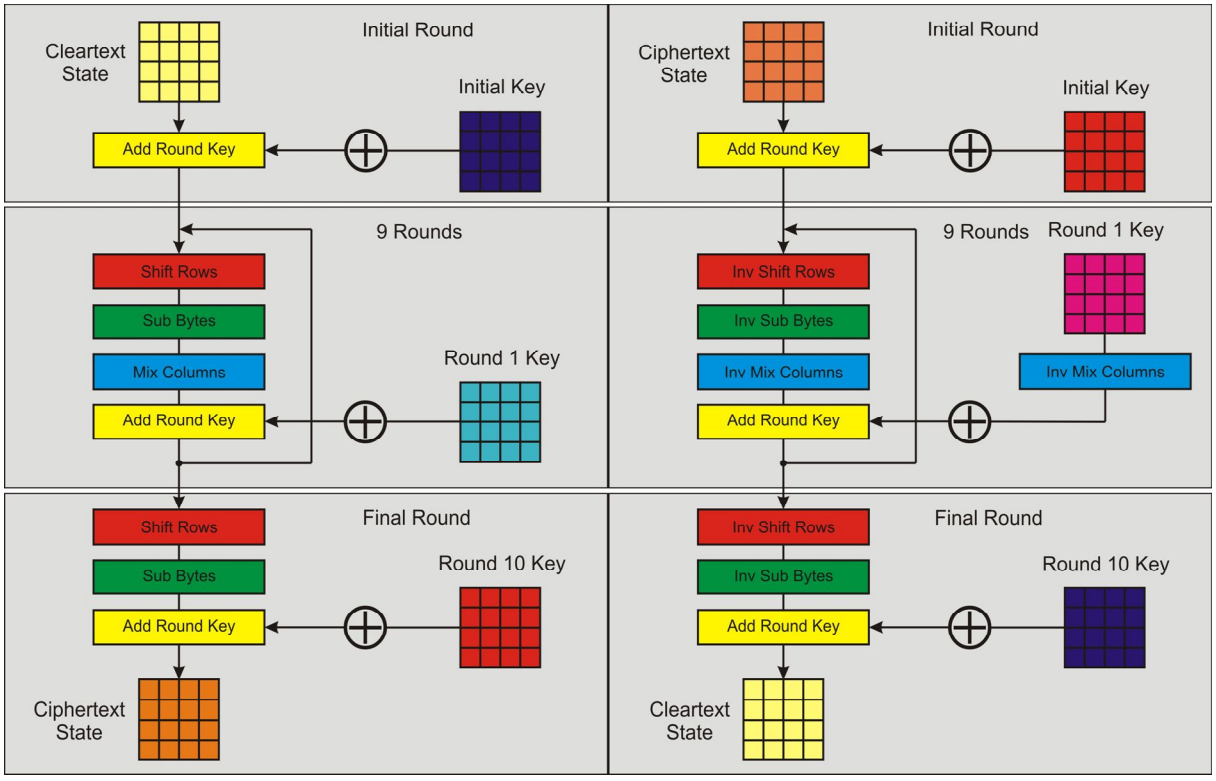

Fig.2.1. Basic AES-128 encryption/decryption architecture (the encryption block - left picture, the decryption block - right picture)

The key schedule uses a key expansion routine which provides the encryption algorithm with N_b (N_r + 1) words, namely 44 key words, or 11 round keys, for the AES-128 encryption version. The resulting key schedule consists of a linear array of 4 byte words, denoted $[w_i]$, with i in the range $0 \le i < N_b(N_r + 1)$. The expansion routine uses some specific functions, like SubWord(), which takes a 4 byte input word and applies the substitution S-box to each of the 4 bytes to produce an output word, and RotWord(), which takes a word $[a_0,a_1,a_2,a_3]$ as input, performs a cyclic permutation, and returns the word $[a_1,a_2,a_3,a_0]$. The round constant word array, Rcon[i], contains the values given by $[x^{i-1},\{00\},\{00\},\{00\}]$, with x^{i-1} being powers of x, where x is denoted as {02} in the GF(2^8) field. Every following word, w[i], is equal to the XOR of the previous word, w[i-1], and the word N_k positions earlier, w[i-N_k]. For words in positions that are a multiple of N_k, a transformation is applied to w[i-1] prior to the XOR, followed by a XOR with a round constant, Rcon[i]. This transformation consists of a cyclic shift of the bytes in a word (RotWord()), followed by the application of a table lookup to all four bytes of the word (SubWord()).

The inverse key schedule uses the same key expansion routine as in the encryption case, with the difference from the encryption of the reverse order of the keys. Another difference from the encryption key expansion is the reverse order of the applied round constant (Rcon[i]) values ([4]).

For the purpose of security improvement, the author of this paper had the idea to add the missing transformation to the input/to the output/to both the input&output of Rijndael-AES encryption/decryption block, together with the same transformation of the secret encryption/decryption key. A new symmetric algorithm is obtained, in 3 different versions (M -AES, AES-M, M -AES-M), generically called by the author the AES-128 PLUS algorithm. The 3 versions are presented in Figure 2 (the encryption algorithm) and Figure 3 (the decryption algorithm). It can be easily noticed that the Mix Columns transformation, that is applied to the input of the AES-128 encryption (called the M -AES version), will have a corresponding Inv Mix Columns transformation that is applied to the output of the AES-128 decryption. Similarly, the Mix Columns transformation, that is applied to the output of the AES-128 encryption (called the AES-M version), will have a corresponding Inv Mix columns transformation that is applied to the input of the AES-128 decryption. For the case of M -AES-M version of the AES-128 PLUS algorithm, the Mix Columns transformation will be applied both to the input and output of an AES-128 encryption/decryption block.

In order to prove the functionality of the new AES-128 PLUS algorithm, the 3 versions, including both encryption and decryption, together with the AES-128 algorithm, were implemented using a reconfigurable hardware device, namely a Xilinx FPGA platform model XC4VFX12 - FF668-10C, that is a low resource platform, with 5472 slices, 320 I/O blocks, 10944 LUT components with 4 inputs each.

All implementations used the VHDL programming language, which nowadays is a well-established commonly used language for FPGA devices. The design & simulation software was Xilinx ISE 10.1, a complete version of this software being provided by the producer's website for evaluation purpose.

These implementations refer to the case of Electronic Code Book (ECB) mode of operation for the AES-128 and AES-128 PLUS encryption/decryption.

In Figure 4 (AES-128) and Figure 5 (AES-128 PLUS), the encryption block (left block) and the decryption block (right block) are represented, where the main signals used by the corresponding implementations are shown.

In theory there are 2 main types of hardware implementations of the block ciphers: iterative and pipelined implementations, as in [3]. Some characteristics of the iterative architectures are: knowing that the block ciphers are themselves of iterative nature (n iterations of the same algorithm are made for a single encryption/decryption, and n clock cycles are used for a single encryption/decryption), the iterative structure is a natural choice for implementation, occupying small areas of the FPGA devices, with the disadvantage of low throughput. Iterative architectures implement a reduced number of rounds, usually one, in an independent way. The iterative architectures would be useful for applications where hardware area is limited and speed is not critical, which is the case of our target FPGA device. A pipelined version of the AES implementation was not included because the target of this paper was not speed, but the functionality of this new algorithm ([4]).

The evaluation of the security provided by this implementation must take into consideration the security requirements for cryptographic modules stipulated by [5]. In fact, the security of the cryptographic module stands on the security provided by the cryptographic algorithm itself. In [6], a complex evaluation of the 5 finalists of the NIST's international contest concludes that using S-boxes as non-linear components, 'Rijndael appears to have an adequate security margin, but has received some criticism suggesting that its mathematical structure may lead to attacks. On the other hand, the simple structure may have facilitated its security analysis during the timeframe of the AES development process.' Even if some critiques were formulated (e.g. 'the key schedule does not have high diffusion'), Rijndael-AES was highly appreciated for the provided level of security. Regarding attacks on implementations, [6] remarks that 'the operations used by Rijndael-AES are among the easiest to defend against power and timing attacks' [4].

Another way to evaluate the security provided by the discussed implementations is the application of the NIST statistical test suite, version 1.7 (including 15 tests), on the implemented algorithms (resulted cryptographic modules), as given by [7]. The support idea of these tests is based on the supposition of the equivalence between the output of each implemented encryption block (AES-128 and AES-128 PLUS) and a pseudorandom number generator. In case of AES-128, this equivalence is proven by the development process of AES and its evaluation, as mentioned by [6]. This paper includes the results of complete statistical tests

application on a well-known pseudorandom generator BBS (Blum-Blum-Schub), on the AES-128 encryption module and on the 3 versions of AES-128 PLUS encryption module.

The special built test unit is again based on the same Xilinx FPGA device, which applies an iteration loop (with 850.000 iterations) to each of the evaluated algorithms (this is an implementation using VHDL programming language which integrates each of the algorithms in the iteration loop). The initial cleartext message consists of 128 '0' bits, same as the initial key (the initial key is permanently of this form). The ciphertext output of the algorithm is connected to the module input for a new iteration. After all 850.000 iterations, 4 binary files will result, with 103 MB each, consisting of a continuous catenation of 128 bit output ciphertext blocks. The 15 statistical tests use 100 series of 1.024.000 bits each, that is the content of each single binary file. Each test provides 100 test points, included in the statistical test charts, that is considered by [7] to be enough for the test to be relevant.

After the application of the statistical test suite, firstly an evaluation of the statistical test charts was made (how close to the diagonal are the test points), resulting a classification based upon the synopsis of evaluated algorithms for each statistical test (e.g. for the Frequency Test, the hierarchy is: M -AES-M - 5 pts, AES-128 - 4 pts, AES-M - 3 pts, BBS - 2 pts, M -AES - 1 pt). The complete results of this evaluation are presented in Table 2, where the tests are: (1) The Frequency (Monobit) Test, (2) Frequency Test within a Block, (3) The Cumulative Sums (Cusums) Test, (4) The Runs Test, (5) Tests for the Longest-Run-of-Ones in a Block, (6) The Binary Matrix Rank Test, (7) The Discrete Fourier Transform (Spectral) Test, (8) The Non-overlapping Template Matching Test, (9) The Overlapping Template Matching Test, (10) Maurer's "Universal Statistical" Test, (11) The Approximate Entropy Test, (12) The Random Excursions Test, (13) The Random Excursions Variant Test, (14) The Serial Test, (15) The Linear Complexity Test.

Table 2. The Statistical Test Charts Evaluation

Test no.	BBS	AES-128	M-AES	AES-M	M-AES-M
(1)	2	4	1	3	5
(2)	3	4	1	2	5
(3)	3	2	1	4	5
(4)	4	1	2	3	5
(5)	1	5	4	3	2
(6)	4	1	2	3	5
(7)	3	2	1	4	5
(8)	3	4	1	2	5
(9)	3	4	1	2	5
(10)	4	5	2	1	3
(11)	2	3	1	4	5
(12)	3	5	1	4	2
(13)	2	1	5	4	3
(14)	2	4	5	3	1
(15)	4	3	1	2	5
Total no.	43	48	29	44	61

Secondly, an evaluation of the experimental results of the statistical tests was made, this time counting the number of "FAILURE" conclusions for each test and algorithm. Table 3 presents this evaluation with the same order of the statistical tests as before.

Table 4 presents 2 test charts, respectively for the Frequency (Monobit) Test and the Cumulative Sums (Cusums) Test.

Table 3.The Number Of "FAILURE" Conclusions

Test no.	BBS	AES-128	M-AES	AES-M	M-AES-M
(1)	0	2	2	1	1
(2)	1	0	1	0	1
(3)	0	4	4	1	2
(4)	1	2	0	2	1
(5)	1	0	1	0	0
(6)	0	3	2	2	3
(7)	2	3	3	1	1
(8)	153	148	139	158	181
(9)	4	0	0	1	0
(10)	0	1	2	0	0
(11)	0	2	2	1	1
(12)	1	4	2	3	7
(13)	6	11	9	8	10
(14)	5	1	1	1	3
(15)	1	2	0	1	0

3. CONCLUSIONS

The conclusion of these evaluations is that M -AES-M's behavior is much better than the AES's. The other 2 versions (M -AES and AES-M) of the proposed AES-128 PLUS algorithm are close to the standard algorithm, AES-128. In only one test, namely the Non-overlapping Template Matching Test, M -AES-M's behavior is worse than AES-128's, but with an acceptable percentage of "FAILURE" conclusions, that is 1,25%.

4. ACKNOWLEDGMENTS

I would like to thank to my PhD advisor, prof. Emil Sofron, for supporting me during these past 3 years, and also to my work and university colleagues, especially to doctor mathematician Emil Simion and doctor engineer Gabriel Iana.

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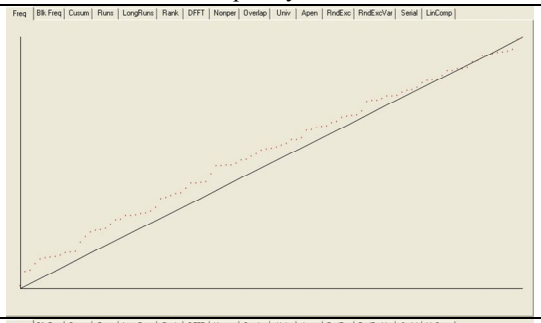
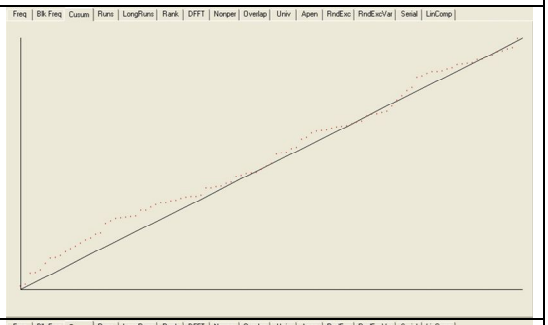
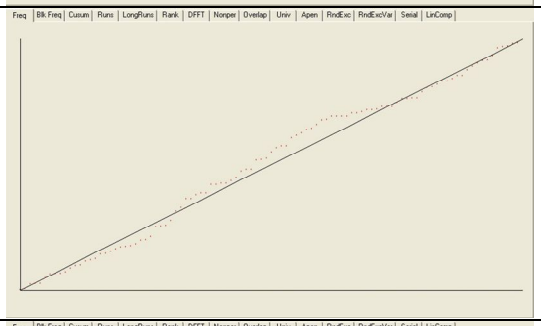
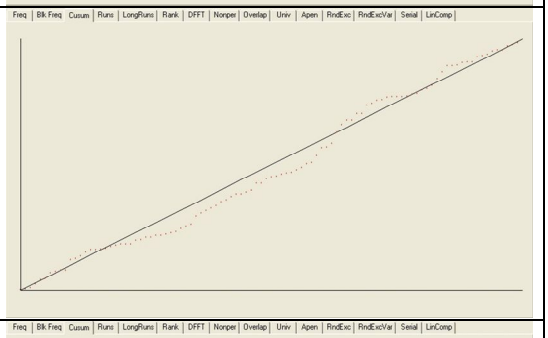
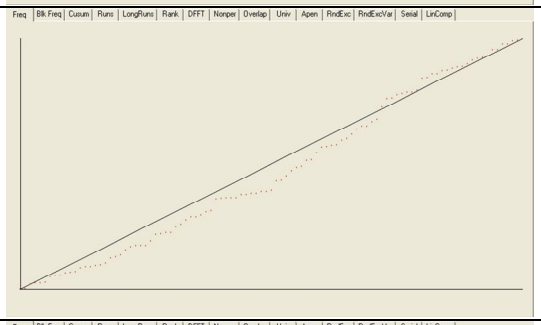
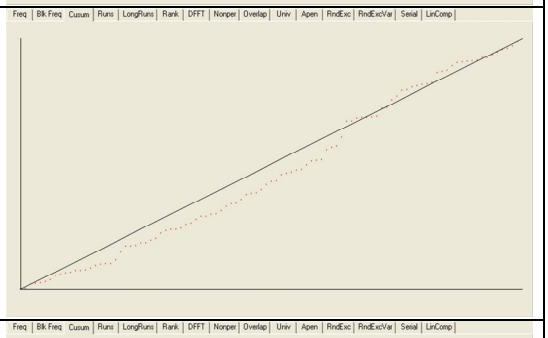
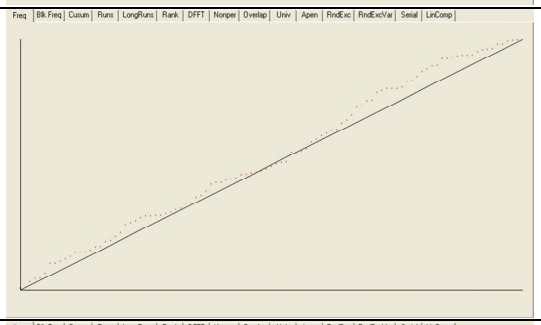
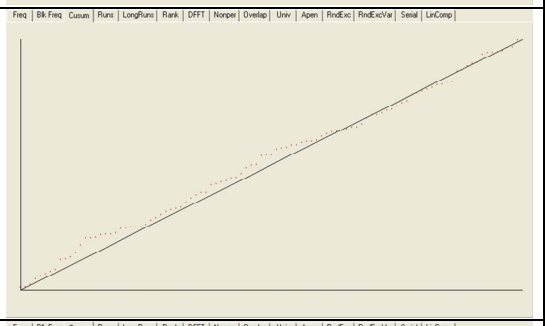
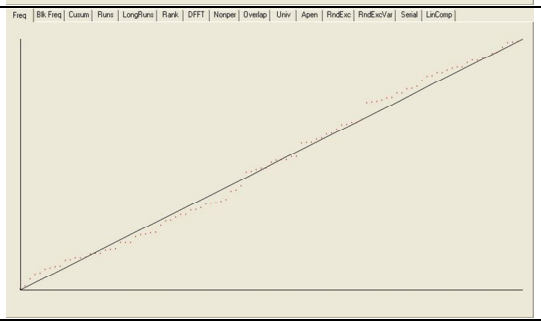
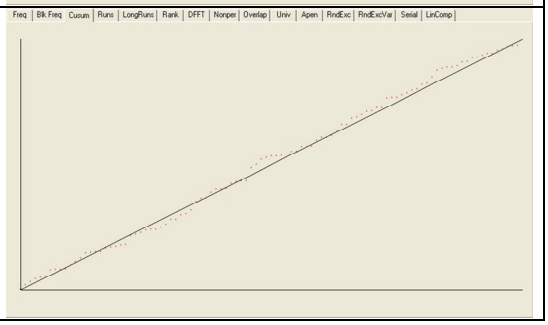
[7] NIST Special Pub 800-22 (revision 1), *A statistical test suite for random and pseudorandom number generators for cryptographic applications*, 2008

Table 4. NIST Tests Diagrams Of The Evaluated Algorithms

Algorithm	Frequency Test	Cumulative Sums Test
BBS		
AES-128		
AES-128 PLUS (M -AES)		
AES-128 PLUS (AES-M)		
AES-128 PLUS (M -AES-M)		

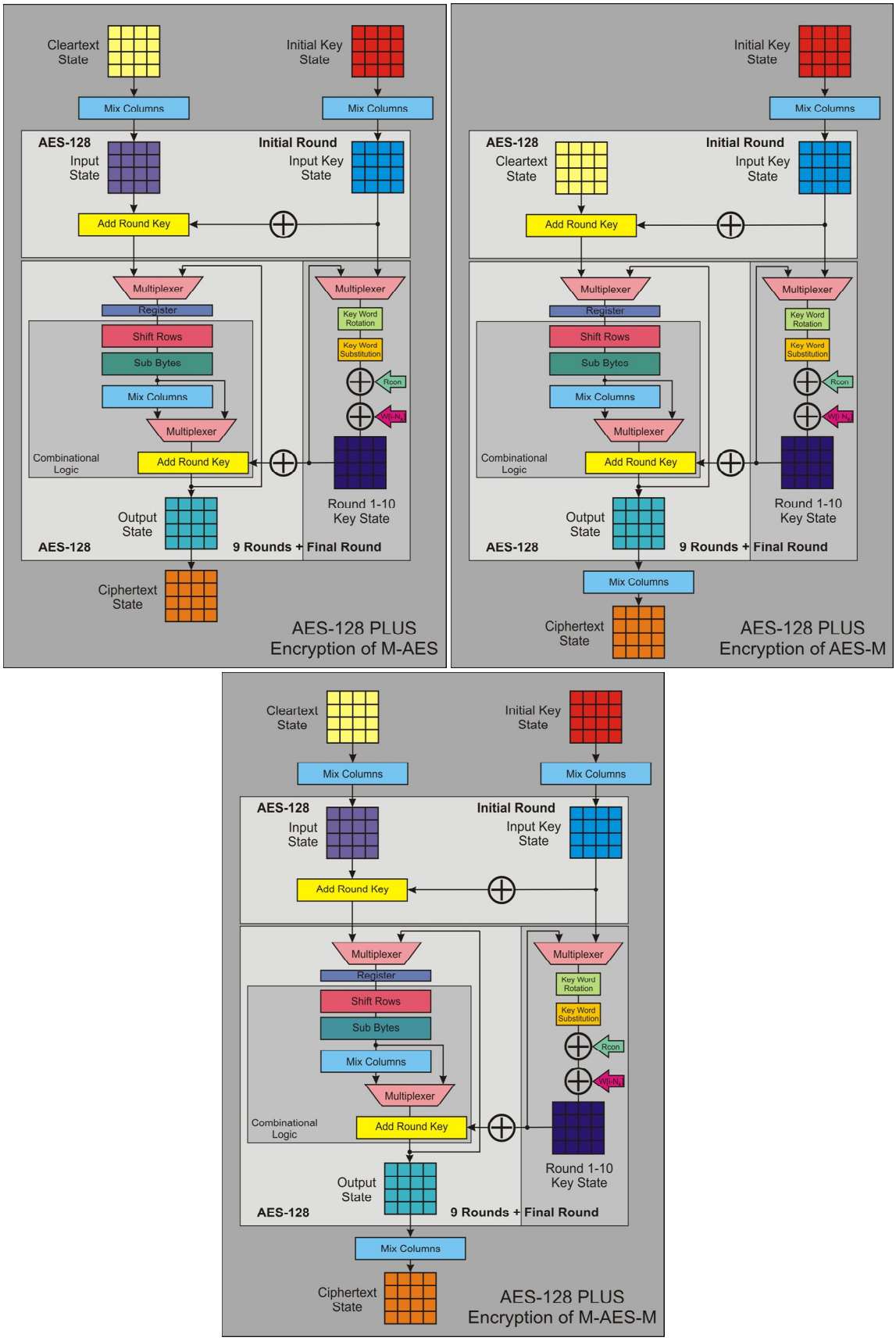


Figure 2. The 3 versions of AES-128 PLUS encryption

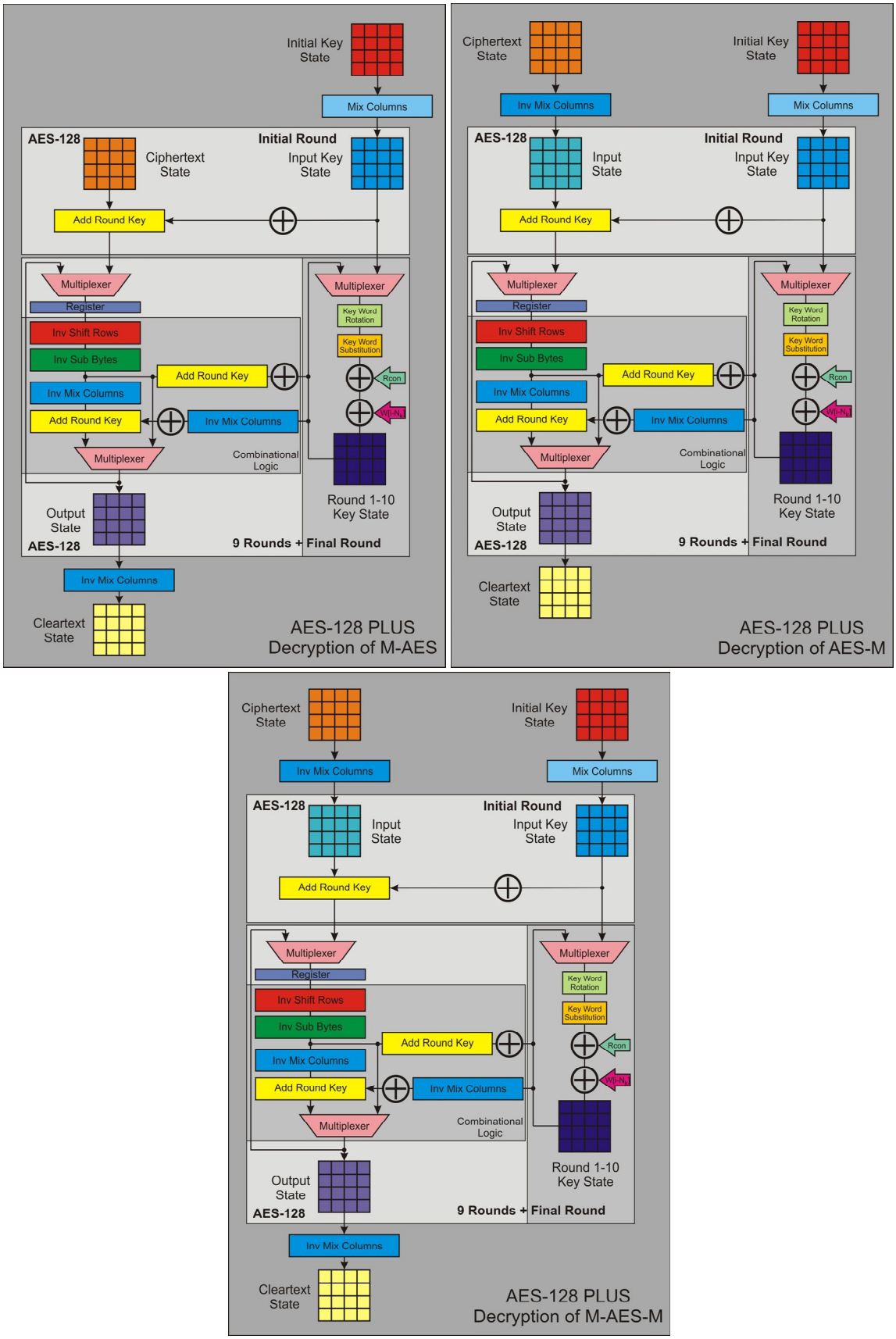


Figure 3. The 3 versions of AES-128 PLUS decryption

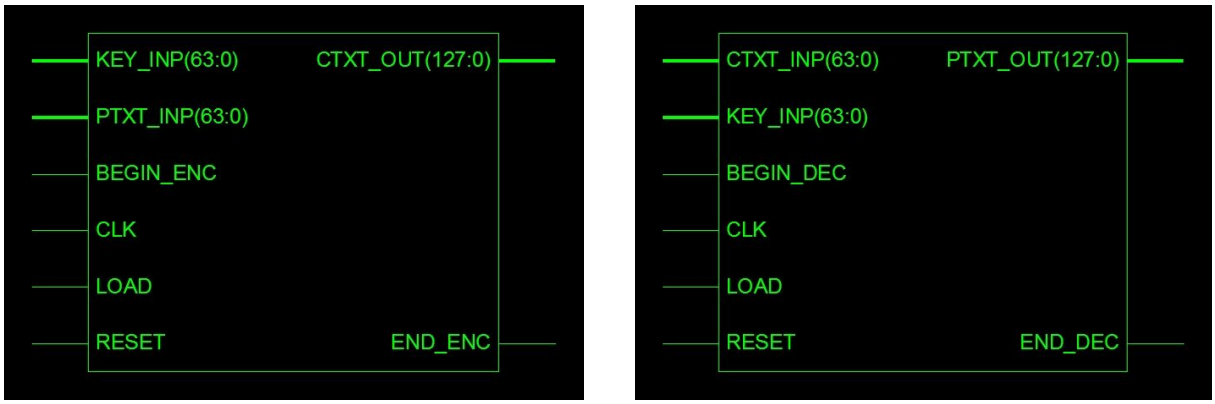


Figure 4. The encryption/decryption blocks of AES-128

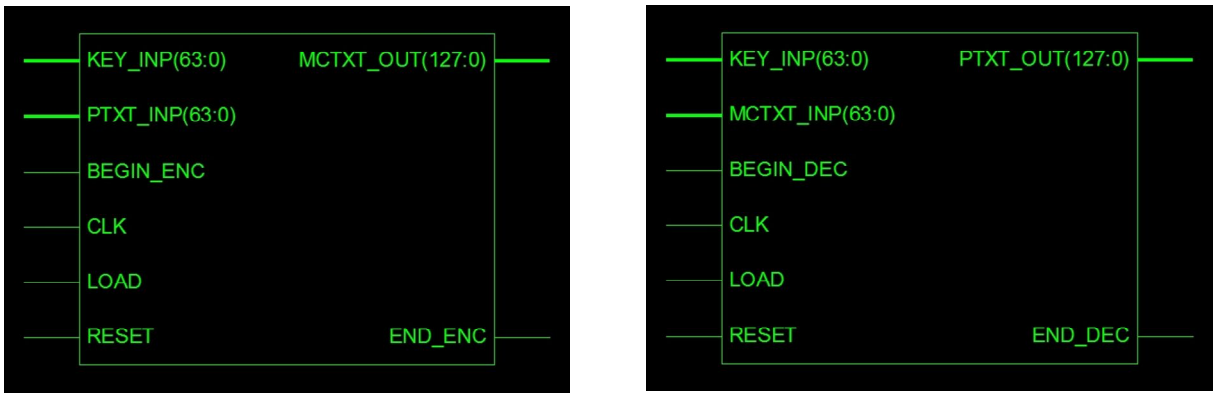


Figure 5. The encryption/decryption blocks of AES-128 PLUS

Again on semisimple infra-near-rings

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ABSTRACT

In some papers [6-9], M. Ştefănescu introduced and investigated the left infra-near-rings. In this paper we find out some properties of semisimple left infra-near-rings and we give characterizations for semisimplicity by using a kind of radical for a left infra-near-ring.

Keywords: *infra-near-rings, ideals, subgroups*.

The left infra-near-rings were introduced and investigated in [6-9], by M. Ştefănescu.

This algebraic system arises naturally during the study of the properties of the binary operations – pointwise addition and mapping composition – on the set of all affine transformations of a vector space V over a field k. Studying the structure of infra-near-rings, she arrived to the concepts of simplicity and semisimplicity (see [8]).

We have also studied weak near-rings [3]. Some properties of the simple and semisimple infra-near-rings defined in a way inspired by the situation for the near-rings (see Pilz [5]) were done in [8]. The theory becomes more interesting when in each minimal nonzero right N-subgroup of the infra-near-ring N there exists a left distributive element. This is the case of some abstract affine infra-near-rings ([7]).

We have to point that the theory of semisimplicity in Ω-groups does not hold for infra-near-rings, because generally in a left infra-near-ring $x \cdot 0$ is different from 0, while in Ω-groups all the operations in Ω are assumed 0-symmetric. Therefore we cannot define the prime ideals and k-prime ideals as in the case of rings, near-rings, algebras.

1. PRELIMINARIES

First we recall some definitions and properties.

Definition 1.1. A **left infra-near-ring** is a triple $(N,+,\cdot)$, where N is a nonempty set, "+" and "·" are binary operations on N, such that:

(i) $(N,+)$ is a group (not necessarily abelian);
(ii) $(N,\cdot)$ is a semigroup;
(iii) the multiplication is left infra-distributive with respect to the addition, i.e. the following condition holds for all $x, y, z \in N$:

(1.1) $x \cdot (y+z) = x \cdot y - x \cdot 0 + x \cdot z$.

If $x \cdot 0 = 0$ for all $x \in N$, then $(N,+,\cdot)$ is a left near-ring (there are some excellent monographs on this subject, see, for example, Pilz [5]).

The set $A(V)$ of all affine transformations of the vector space V over the field k is both a left infra-near-ring and a right near-ring with respect to the pointwise addition and the mapping composition.

If $x \cdot 0 = \varphi(x) + \psi(0)$ and $0 \cdot x = \varphi(0) + \psi(x)$, where $\varphi(\cdot) - \varphi(0)$ and $\psi(\cdot) - \psi(0)$ belong to the set of endomorphisms of the addituve group $(N,+)$, a right infra-distributivity law is also fulfilled on N while the addition is commutative, then we obtain the weak ring defined by Climescu ([1] and [2], in the first paper, $\varphi = \psi = 1_N$).

Other examples and properties of left infra-near-rings may be found in [6].

Definition 1.2. Let $(N,+,\cdot)$ be a left infra-near-ring. A **right N-group** is an additive group $(M,+)$ together with a right multiplication

$\mu : M \times N \to M$, $(m,x) \mapsto m \cdot x$, satisfying the following axioms for all $m \in M$ and $x, y \in N$:

(1.2) $m \cdot (x+y) = m \cdot x - m \cdot 0 + m \cdot y$;

(1.3) $m \cdot (xy) = (m \cdot x) \cdot y$;

(1.4) $0 \cdot x = 0$.

Assume also that N satisfies the condition $0 \cdot x = 0$ for all $x \in N$, such that N is itself a right N-group.

The concept of right N-subgroup of a right N-group M or particularly of N viewed as a right N-group is obvious.

Definition 1.3. A right ideal of N is a normal subgroup A of $(N,+)$ satisfying the property:

(1.5) $(a+x) \cdot y - x \cdot y \in A$, for all $a \in A$, $x, y \in N$.

A **left ideal of** N is a normal subgroup A of $(N,+)$ satisfying the property:

(1.6) $x \cdot a - x \cdot 0 \in A$, for all $a \in A$, $x \in N$.

It is obvious that a right ideal of N is also a right N-subgroup of N (take x = 0 in (1.5)), while the converse is not true.

The set of all right ideals of N forms a lattice with respect to the set-inclusion; the union is the sum: $A + B = \{a+b / a \in A, b \in B\}$ and the meet is the set intersection: $A \cap B$.

Moreover, if A is a right ideal of N and B is a right N-subgroup of N, then $A+B$ is a right N-subgroup of N, since, for all $a \in A$, $b \in B$, $x \in N$, we have:

$(a+b) \cdot x = ((a+b) \cdot x - b \cdot x) + b \cdot x \in AB$.

Definition 1.4. Let M be a nonzero right N-subgroup (right ideal)of N. If there is no other nonzero right N-subgroup (right ideal) of N different from M included into M, then M is called a **minimal** right N-subgroup (right ideal) of N.

Definition 1.5. Let M and M' be two right N-groups. A mapping $\varphi : M \to M'$ is called a **morphism of right N-groups**, if, for all $m, m_1, m_2 \in M'$ and $x \in N$, $\varphi(m_1 + m_2) = \varphi(m_1) + \varphi(m_2)$ and $\varphi(m \cdot x) = \varphi(m) \cdot x$.

$\mathrm{Im}\varphi$ is a right N-subgroup of M' and $\ker\varphi$ is a normal right N-subgroup of M, having the property, which generalizes (1.5):

(1.7) $(m_0 + m) \cdot x - m \cdot x \in \ker\varphi$,

for all $m_0 \in \ker\varphi$, $m \in M$ and $x \in N$.

We denote by

$D(M) = \{m \in M / 0 \cdot m = 0 \cdot 0\}$

the set of all left distributive elements of M and by

$W(M) = \{m \in M / 0 \cdot m = m \cdot 0\}$,

the set of all weakly left distributive elements of M, those which are invariant under the multiplication by 0.

By straightforward calculations, we verify that:

1. $(D,\cdot)$ is a subsemigroup of $(N,\cdot)$;
2. $(W,\cdot)$ is a two-sided ideal of the semigroup $(N,\cdot)$;
3. W has the property:

(1.8) $w \cdot x = w$, for all $w \in W$ and $x \in N$, which implies that W is a right near-ring (see [7], p.6). (Here we denote by D the set $D(N)$ and by W the set $W(N)$).

If D is a near ring with left distributivity law and $0 \cdot x = 0$ for all $d \in D$, if W is a left D-group, then their direct sum as groups $D \oplus W$ can be endowed with a multiplication of a left infra-near ring, namely:

(1.9) $(d_1 + w_1) \cdot (d_2 + w_2) := d_1 d_2 + (w_1 + d_1 w_2)$, with obvious notations.

If D is a ring and W a left D-module, then we obtain the abstract affine right near-ring (Gonshor [3]).

Take T a nonempty subset of a right N-group M. Then the **right annihilator of** T **in** N,

(1.10) $Ann_r(T) = \{x \in N / t \cdot x = t \cdot 0, \forall t \in T\}$, is a right ideal of N.

We prove two simple statements that we need in Section 2.

Proposition 1.1. Let N be a left infra-near ring with a left identity 1. If A is a right N-subgroup and B is a right ideal of N, such that $N = A + B$ and $A \cap B = \{0\}$, then there exists $e \in D(A)$, $e^2 = e$ and $A = e \cdot N$.

Proof. Let $1 = e + b$ be the decomposition of the left identity under A and B, $e \in A$, then $a = ea + ba \in A$ (B right ideal) hence $e \cdot a = a$ for all $a \in A$. Therefore $e \cdot e = e$, $e \cdot 0 = 0$ and $A = e \cdot N$ (we just use the inclusions $A = e \cdot N \subseteq e \cdot N \subseteq A$).

Proposition 1.2. If the element $0 \in N$ is right distributive that is $(m+m')\cdot 0 = m\cdot 0 + m'\cdot 0$, for all $m, m' \in M$, where M is a right N-group, then:

(i) $D(M)$ and $W(M)$ are subgroups of $(M,+)$;

(ii) M is the semidirect sum of these two subgroups.

Proof. The application $\varphi_0 : M \to M$, $\varphi_0(m) = m\cdot 0$ is a homomorphism of groups, for which $\ker\varphi_0 = D(M)$ and $\mathrm{Im}\varphi_0 = W(M)$.

We have $m = (m - m\cdot 0) + m\cdot 0$, where $m - m\cdot 0 \in D(M)$ and $m\cdot 0 \in W(M)$, $D(M)$ is a normal subgroup of $(N,+)$and

$$D(M)\cap W(M) = \{0\}.$$

2. SEMISIMPLE LEFT INFRA-NEAR-RINGS

Definition 2.1. If N is a left infra-near-ring satisfying the conditions:

(2.1) The descending chain condition for right N-subgroups;

(2.2) Each minimal nonzero right N-subgroup M of N contains a left distributive element d such that $d\cdot M \neq 0$,

then we call N a **semisimple left infra-near-ring**.

Putting together some results in [8], we obtain:

Proposition 2.1. If N is a semisimple left infra-near-ring, then the following conditions are fulfilled:

(i) N is a finite direct sum of minimal nonzero right N-subgroups.

(ii) N is a finite direct sum of nonzero minimal right ideals.

(iii) Each minimal nonzero right ideal of N is a minimal right N-subgroup of N.

(iv) N has a left identity.

(v) Each right ideal J contains a left identity e and $J = e\cdot N$.

Denote by $\mathcal{M}$ the set of all minimal nonzero right N-subgroups of N and consider the intersection of right N-subgroups of N:

$$(2.3)\quad R := \bigcap_{M\in\mathcal{M}} Ann_r(D(M)).$$

Proposition 2.2. R is a right ideal of N. For a left infra-near-ring which satisfies the condition (2.1), R is the ideal $\{0\}$ if and only if N satisfies also the condition (2.2), therefore N is semisimple.

Proof. If N is semisimple, for each $M \in \mathcal{M}$ there exists $d \in D(M)$ such that $d\cdot M \neq \{0\}$. As R is a right N-subgroup of N, being a right ideal of N, if $R \neq \{0\}$, then there exists a minimal right N-subgroup $M \in \mathcal{M}$ such that $M \subseteq R$ (we apply here the condition (2.1) to obtain the existence of the element M which is minimal in the subset of all nonzero right N-subgroups of N contained in R). But M does not have any $d \in D(M)$ such that $d\cdot M \neq 0$, since $M \subseteq R \subseteq Ann_r(D(M))$. Therefore R is the ideal $\{0\}$. Conversely, let $R = \{0\}$ and assume that there exists an $M \in \mathcal{M}$ such that for all $d \in D(M)$, $dM \neq 0$. Then, by assuming that there exists an $M' \in \mathcal{M}$ such that there is a distributive element of M', $d' \in D(M')$, for which $d'\cdot M \neq 0$, we define the mapping $\psi : M \to M'$, by $\psi(m) = d'\cdot m$, for all $m \in M$. This is a homomorphism of N-groups, which is surjective and injective because M and M' belong to $\mathcal{M}$. But then there exists an element $d \in D(M)$ such that $\psi(d) = d'\cdot d = d'$.

We have now that $d'\cdot M = (d'\cdot d)\cdot M = d'\cdot(d\cdot M) = d'\cdot\{0\} = \{0\}$ and $d'\cdot M \neq \{0\}$, a contradiction. Hence for all $M' \in \mathcal{M}$ and for all $d \in D(M)$ we have $d\cdot M' = \{0\}$, hence $M \subseteq R$ and $R \neq \{0\}$, a contradiction. Therefore N is semisimple.

Proposition 2.3. Let N be a left infra-near ring with a left identity. The following statements are equivalent:

(i) N is semisimple.

(ii) If M is a right N-group and M_1 is a right N-subgroup of M, if there exists an element $d \in D(M)$ such that $d\cdot N = M$, then there exists a normal right N-subgroup M_2 of M such that $M = M_1 + M_2$, $M_1 \cap M_2 = \{0\}$ and M_2 satisfies the condition:

(2.4) $(m_2 + m)\cdot x - m\cdot x \in M_2$, for all $m_2 \in M_2$, $m \in M$ and $x \in N$.

(iii) For every right N-subgroup A of N there exists a right ideal B of N such that $N = A + B$ and $A \cap B = \{0\}$.

Proof. (i) $\Rightarrow$(ii):

If N is semisimple, then $N=\bigoplus_{i=1}^{n} A_i$, where A_i are right ideals which are minimal and nonzero, as we remind in Proposition 2.1, ii. If $M=d\cdot N$, where $d\in D(M)$, we obtain $M=\sum_{i=1}^{n} d\cdot A_i$, and dA_i are normal right N-subgroups of M, as we can easily verify, taking into account that every $m\in M$ is of the form $m=d\cdot x$, for an $x\in N$.

By applying Zorn Lemma to the collection

$\mathsf{P}=\{P/P$ is a normal right N - subgroup of M such that $(p+m)\cdot x-m\cdot x\in P$ for all $p\in P$, $m\in M$ and $x\in N$ and $M_1\cap P=\{0\}\}$, partially ordered by set-inclusion, we obtain the existence of a maximal element M_2 in P, hence M_2 is a normal right N-subgroup of M and $M_1\cap M_2=\{0\}$. Let us show that $M=M_1+M_2$. If this is not true, then there exists A_i such that $d\cdot A_i\not\subseteq M_1+M_2$.

Take the mapping $f:A_i\to d\cdot A_i$, which is a surjective homomorphism of N-groups since $d\in D(M)$ and its kernel is $\{0\}$, hence f is an isomorphism. As f induces a bijection between the set of N-subgroups of A_i and the set of right N-subgroups of $d\cdot A_i$, we deduce that $d\cdot A_i$ is a simple right N-subgroup of M. But then $M_2+d\cdot A_i\in\mathsf{P}$ and it is a normal right N-subgroup of M containing strictly the maximal element of P, M_2. This is a contradiction, hence $M=M_1+M_2$.

(ii)$\Rightarrow$(iii):

Indeed, we apply (ii) to the N-group $N=1\cdot N$, as we have the existence of a right N-subgroup of N satisfying the condition of a right ideal and being normal.

In order to prove (iii)$\Rightarrow$(i), we need some lemmas:

Lemma 2.4. Let N be a left infra-near-ring with a left identity. If N is semisimple, then for any two right N-subgroups P and M, and for any injective homomorphism $f:P\to M$, there exists $g:M\to P$, such that $gf=1_P$.

Proof. If N is semisimple, then (iii) is true. Take $A=f(P)$ and let B be the right ideal of N such that $A+B=N$ and $A\cap B=\{0\}$.

The projection $\pi: N=A+B\to A$, $\pi(a+b)=a$, is an N-homomorphism of N to A. We restrict π to B, denote the restriction by π' and consider $g=f^{-1}\circ\pi'$: , which verifies the condition.

By applying the previous lemma to the inclusion $P\subseteq M$ for two right N-subgroups of N, we obtain:

Lemma 2.5. If N is a semisimple left infra-near-ring, then, for any two right N-subgroups P and M of N such that $P\subseteq M$ and for any right N-group M', each homomorphism of N-groups $h:P\to M'$ can be extended to an N-homomorphism $\bar{h}:M\to M'$.

Proof. Taking the inclusion $i:P\to M$ as f, we obtain the existence of $g:M\to P$ and then $\bar{h}=h\circ g$.

Corollary 2.6. In the hypotheses of Lemma 2.4, M is the semidirect sum of $f(P)$ and $\ker(g)$, where $f(P)$ is a right N-subgroup of N and $\ker(g)$ is a right ideal.

This corollary is an obvious consequence of the quoted lemma.

Proof of (iii)$\Rightarrow$(i):

Let $N\geq L_1\geq L_2\geq\ldots$ be a descending chain of right N-subgroups of N. For every sequence $0\to L_{j+1}\to L_j$, we have the existence of a right ideal K_{j+1} such that $L_j=L_{j+1}+K_{j+1}$ with $L_{j+1}\cap K_{j+1}=\{0\}$. Similarly, $N=L_1+K_1$, $L_1\cap K_1=\{0\}$. Then $K=\sum_{j\geq 1} K_j$ is a right ideal of N as we can easily verify, therefore K is a right N-subgroup of N and there exists an ideal T of N such that $N=K+T$ and $K\cap T=\{0\}$. Hence there exists the decomposition $l=k+t$, $k=\sum_{j=1}^{s} k_{i_j}$, with $k_{i_j}\in K_{i_j}$, for $j=1,2,\ldots,s$. If $i_1<i_2<\ldots<i_s<i_s+1$, we show that for any $x\in K_{i_s+1}$,

$x=1\cdot x=((k+t)\cdot x-k\cdot x)+k\cdot x$, and since

the first element belongs to $K \cap T$, we obtain $x = k \cdot x = \sum_{j=1}^{s} k'_{i_j}$. As $k \in K \cap$ [illegible] $_{-1}$, we have $k'_{j_1} = 0$ and so on, in the end, $x = 0$, hence $K_{i_s+1} = \{0\}$ and generally $K_i = \{0\}$ for all $i \geq i_s + 1$. Therefore $L_i = L_{i_s}$ for all $i \geq i_s + 1$. The condition (2.1) is fulfilled.

Now let A be a minimal nonzero right N-subgroup of N. By using Proposition 2.1, we obtain the existence of $e \in A$ such that $A = e \cdot N$ and $e \cdot e = e$, $e \in D(A)$. Therefore N is semisimple.

As we can see, the set R defines by (2.3) plays the role of a radical for the semisimplicity of left infra-near-rings in the sense of Definition 2.1.

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On multiplication on groups

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ABSTRACT

In this short note, we find some properties of the multiplications defined on additive (commutative or noncommutative) groups.

REZUMAT

În această scurtă notă, găsim câteva proprietăți ale multiplicărilor definite pe grupuri aditive (comutative sau necomutative).

Keywords: *generalized rings, ideals*.

We start with some necessary definitions.

Definition 1. Let $(G,+)$ be a group (commutative or not). A **multiplication** on G is a mapping $\mu : G\times G \to G$.

μ is **associative**, if it satisfies:

(1) $\mu(\mu(x,y),z)=\mu(x,\mu(y,z)),\forall x,y,z\in G$;

μ is **left distributive** with respect to "+" if it satisfies:

(2) $\mu(x,y+z)=\mu(x,y)+\mu(x,z),\forall x,y,z\in G$;

μ is **right distributive** with respect to "+" if it satisfies:

(3) $\mu(y+z,x)=\mu(y,x)+\mu(z,x),\forall x,y,z\in G$;

μ is **(two-sided) distributive** with respect to "+" if it satisfies (2) and (3);

μ is **left infra-distributive** over "+" if it satisfies:

(4) $\mu(x,y+z)=\mu(x,y)-\mu(x,0)+\mu(x,z)$, $\forall x,y,z\in G$.

If $(G,+)$ is abelian and μ satisfies (1), (2), (3), then $(G,+,\mu)$ is a ring.

If μ satisfies (1) and (2), then $(G,+,\mu)$ is a left near-ring.

If μ satisfies (1) and (4), then $(G,+,\mu)$ is a left infra-near-ring.

There are Abelian groups $(G,+)$ on which the only ring structure defined on it is the nilring (zero-ring), with:

(5) $\mu(x,y)=0$, for all $x,y\in G$.

First such groups have been investigated by T. Szele in 1949.

His results can be summarized by the following:

Proposition 2. Let $(G,+)$ be an Abelian group which is not torsion-free. Then the following statements are equivalent:

(i) G is a divisible torsion group.
(ii) G is associative nil.
(iii) The only two-sided distributive (eventually nonassociative) multiplication on $(G,+)$ is the 0-multiplication.
(iv) The only left right distributive multiplication with 0 a right-associative element is the 0-multiplication (See also: S. Feigelstock [2]).

Definition 3. We recall that an Abelian group is said to be **nil (quasi-nil)** if there are only one (finitely many) non-isomorphic associative ring structure(s) on it.

Investigating such groups, Feigelstock [2] found the following results:

Proposition 4. If G is a torsion group, then G is quasi-nil if and only is $G = B \oplus D$, where B is a finite group and D is a divisible torsion group.

Proposition 5. If G is a torsion-free group, then:

(1) G is the additive group of two non-isomorphic rings if and only if G is isomorphic with $(\boldsymbol{Q},+)$.

(2) G is the additive group of three non-isomorphic groups if and only if $G = \boldsymbol{Q} \oplus H$, where H is a nil rank 1 torsion free group.

(3) Otherwise G is either nil or the additive group of infinitely many non-isomorphic rings.

As for near-ring structures in $(G,+)$, some results have been obtained by:

- R.E. Williams (1967), on near-rings defined on vector spaces;
- J.R. Clay (1968), on near-rings defined on groups of low orders.

For infra-near-rings, a paper has been published in 1968 by M. Ştefănescu.

We discuss about some properties of a left infra-distributive multiplication μ on a group $(G,+)$.

Proposition 6. Let $(G,+)$ be a group and μ be a left infra-distributive associative multiplication on G.

Then defining:

(6) $\gamma_x(y) = \mu(x,y) - \mu(x,0) = \mu^{(1)}(x,y)$,

(7) $\mu^{(2)}(x,y) = -\mu(x,0) + \mu(x,y)$,

(8) $\eta(x) = \mu(x,0)$,

we have:

(i) $\gamma_x \in EndG$;

(ii) $\mu^{(1)}, \mu^{(2)}$ are left distributive (eventually nonassociative);

(iii) If μ is also right distributive, then:

a) $\mu(\eta(x), z) = \eta(x), \forall x, z \in G$;

b) $\mu(\eta(x), \mu(y,z)) = \mu(\eta(x), \mu(z,y)), \forall x, y, z \in G$;

c) $\eta \in EndG$ and $\eta \cdot \eta = \eta$;

d) $\eta(\mu^{(1)}(x,y)) = \mu^{(1)}(x, \eta(y))$;

e) $\mu(\eta(x), y) = 0$.

The proof is done by straighforward verifications.

Proposition 8. Let μ and τ be left infra-distributive multiplications. Then $\mu + \tau$ is a left infra-distributive multiplication if and only if $\mu^{(1)}$ and $\tau^{(1)}$ commute.

Proof. The infra-distributivity of $\mu + \tau$ gives :

$$(\mu+\tau)(x, y+z) = (\mu+\tau)(x,y) - (\mu+\tau)(x,0) +$$
$$+ (\mu+\tau)(x,z) = \mu(x,y) + \tau(x,y) -$$
$$- [\mu(x,0) + \tau(x,0)] + \mu(x,z) + \tau(x,z),$$
$$\forall x, y, z \in G$$

The commutativity of μ and τ gives:

$$\mu^{(1)}(x,y) + \tau^{(1)}(x,y) =$$
$$= \tau^{(1)}(x,y) + \mu^{(1)}(x,y), \forall x, y \in G$$

Therefore

$$\mu(x,y) - \mu(x,0) + \tau(x,y) - \tau(x,0) =$$
$$= \tau(x,y) - \tau(x,0) + \mu(x,y) - \mu(x,0)$$

The both implications in Proposition 8 are now clear.

Denote $Mult(G) = \{\mu : \}$.

Proposition 9. Let $(G,+)$ be a group and $\mu \in Mult(G)$ be a function $\mu : G \times G \to G$, such that $\mu(x,y) = f(x) + g(y)$, where $f, g \in Map(G)$. The multiplication μ is left infra-distributive if and only if g satisfies the condition:

(9) $g(y+z) = g(y) - g(0) + g(z), \forall y, z \in G.$

Proof. Indeed,

$$\mu(x, y+z) = f(x) + g(y+z) =$$
$$= f(x) + g(y) - g(0) + g(z)$$

and

$$\begin{aligned}&\mu(x,y)-\mu(x,0)+\mu(x,z)=\\&=f(x)+g(y)-g(0)-f(x)+f(x)+g(z)=\\&=f(x)+g(y)-g(0)+g(z)=f(x)+g(y+z)=\\&=\mu(x,y+z)\end{aligned}$$

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DISCRETE GROWTH MODELS FOR INTERACTING POPULATIONS

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ABSTRACT

The paper presents a study of the optimal solution, for the so called "predator-prey" type models, which have a non-zero stable state such that if the perturbation from it is sufficiently large, the population densities undergo large variations, before returning to the steady state.

Keywords: *threshold, population, steady, optimal, state.*

1. INTRODUCTION

The present paper contains a particularly point of view in the study of the systems of nonlinear differential equations of the general form:

$$\frac{dN_i}{dt} = N_i F_i(N_1, N_2, ..., N_n), i = 1,2,... \quad (1)$$

Here, N is the vector of populations. The systems (1) are the general form of the predator-prey models and sometimes and sometimes, they are referred as the "Kolmogorov equations" [2, p. 111] As it has been demonstrated, there are many species of trophic levels, where "energy" flows from one species to another, and the total number of individuals in a species is referred as "biomass", in this case being the population. Also, models involve interaction between several species.

Fuurther, we consider the interaction of only two species: for the prey (N) and the predator (P). The system of coupled equations is:

$$N_{t+1} = N_t f(N_t, P_t)$$
$$P_{t+1} = N_t g(N_t, P_t) \quad (2)$$

where *f* and *g* are functions which relate the predator-influenced reproductive efficiency of the prey and the searching efficiency of the predator respectively.

Let us take for example the so called "threshold" type systems:

$$N_{t+1} = N_t [F(N_t) - P_t],$$
$$P_{t+1} = P_t [N_t - G(P_t)] \quad (3)$$

in which, for convenience, all the parameters have been incorporated in $F(N_t)$ and $G(P_t)$, that is the per capita growth rate of the prey and the per capita mortality rate of the predators (real, continous differentiable functions).

- N_t= the prey density;
- P_t=the predators' density

2. THE MATHEMATICAL MODEL OF THE TWO SPECIES PREDATOR-PREY INTERACTION

The mathematical model (2) of J. D. Murray, published in "Mathematical Biology", describes the functionality of the nonlinear interaction between two species. The functions f and g involves parameters which characterize the various growth and interaction features of the system under investigation. The stability of the steady states is determined by linearizing about the steady states, say: $N^* = P^* = 0$.

From (2) the community matrix M for the zero steady state is:

$$M = \begin{pmatrix} \frac{\partial f}{\partial N} & \frac{\partial f}{\partial P} \\ \frac{\partial g}{\partial N} & \frac{\partial g}{\partial P} \end{pmatrix}_{N=0=P} = \begin{pmatrix} F(0) & 0 \\ 0 & -G(0) \end{pmatrix}$$

The eigenvalues are: $\lambda_1 = F(0) > 0$ and $\lambda_2 = -G(0) < 0$ (the initial conditions are: $F(0),\ G(0) > 0$) so (0,0) is a steady state point of instability.

We first consider a detailed analysis of a simple model . This is reflected in the system :

$$N_{t+1} = N_t [aN_t - P_t]$$
$$P_{t+1} = P_t [N_t - bP_t] \quad (4)$$
$$a,b > 0$$

With this system we are interested what the outcome of the stability analysis will be. In general if the result is not what we anticipated as a preliminary qualitative impression can often help in modifying the model to make it more realistic. The equilibrium values N^*, P^* of (3) are given by: $N^* = P^* = 0$

or : $1 = aN^* - P^*,\ 1 = N^* - bP^*$

and so positive steady state populations are:

$$P^* = \frac{1-a}{ab-1},\ N^* = \frac{b-1}{ab-1}$$

The linear stability of the equilibria can be determined in the usual way by writing:

$$N_t = N^* + n_t,\ P_t = P^* + p_t,$$

substituting into (3) and retaining only linear terms. For the steady state *(0, 0)* the analysis we are led to: a=b=1 and the system is:

$$n_{t+1} = p_t(n_t - bp_t),\ p_{t+1} = p_t(n_t - bp_t)$$

The positive steady state exists for:

- $ab > 1 \Rightarrow b > 1(p_t \uparrow), a < 1(n_t \downarrow)$ (4)
- $ab < 1 \Rightarrow b < 1(p_t \downarrow), a > 1(n_t \uparrow)$

For this positive steady state we have the system of equations:

$$\begin{cases} n_{t+1} = (aN^* - P^*)n_t - N^* \cdot p_t + (an_t^2 - n_t p_t + a(N^*)^2 - \\ - N^*P^* - N^*) = n_t - N^* \cdot p_t + (an_t^2 - n_t p_t) \\ p_{t+1} = (N^* - bP^*)p_t + P^* \cdot n_t + (-bp_t^2 + n_t p_t - b(P^*)^2 + \\ + N^*P^* - P^*) = p_t + P^* \cdot n_t + (-bp_t^2 + n_t p_t) \end{cases} \quad (5)$$

By linearization we obtain:

$$\begin{aligned} n_{t+1} &= n_t - N^* \cdot p_t \\ p_{t+1} &= p_t + P^* \cdot n_t \end{aligned} \quad (6)$$

The linear perturbation system (6) in matrix form is:

$$\begin{pmatrix} n_{t+1} \\ p_{t+1} \end{pmatrix} = A \begin{pmatrix} n_t \\ p_t \end{pmatrix} \quad A = \begin{pmatrix} aN^* - P^* & -N^* \\ P^* & N^* - bP^* \end{pmatrix} = \begin{pmatrix} 1 & -N^* \\ P^* & 1 \end{pmatrix} \quad (7)$$

We now look for the nontrivial solutions in the form: $n_t = A\lambda$.

$$\det(A - \lambda \cdot I_2) = 0 \Rightarrow \begin{pmatrix} 1-\lambda & -N^* \\ P^* & 1-\lambda \end{pmatrix} = 0 \quad (8)$$

It results the quadratic characteristic equation:

$$\lambda^2 - 2\lambda + 1 + N^* \cdot P^* = 0 \quad (9)$$

The solutions λ_1 and λ_2 are the eigenvalues of the matrix A in (8). This matrix approach is the discrete equation analogue of the one we used for the continuous interacting population models.

The stability of the steady state (N^*, P^*) is determined by the magnitude of $|\lambda_1|$ and $|\lambda_2|$. If either of $|\lambda_1| > 1$ or $|\lambda_2| > 1$ then n_t and p_t become unbounded as $t \to \infty$ and hence (N^*, P^*) is unstable since perturbations from it grow with time.

The discriminant of the quadratic equation (9) is:

$$-4 \cdot N^* \cdot P^* < 0 \quad (10)$$

The roots λ_1 and λ_2 are complex conjugates. Thus, the solutions (n_t, p_t) become unbounded as $t \to \infty$ and so the positive equilibrium (N^*, P^*) is unstable, and by growing oscillations since λ_1 and λ_2 are complex.

Let: $x_1 = n_t$, $x_2 = p_t$ The system (7) can be written as following:

$$\begin{pmatrix} n_{t+1} \\ p_{t+1} \end{pmatrix} = \begin{pmatrix} 1 & -N^* \\ P^* & 1 \end{pmatrix} \cdot \begin{pmatrix} n_t \\ p_t \end{pmatrix} \Rightarrow \begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} 0 & -N^* \\ P^* & 0 \end{pmatrix} \cdot \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} \quad (11)$$

in an unit of time (t).

2.1 *The state form of the model*

The entrance of the system is identified by u from now on, a command upon the prey, for example, in order to obtain an optimal predators' population. The last form (11) can be written in statement variables terms:

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} 0 & -N^* \\ P^* & 0 \end{pmatrix} \cdot \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix} \cdot \begin{pmatrix} u \\ 0 \end{pmatrix} \quad (12)$$

$$y(t) = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}, \quad x_1 = x_1(t), \quad x_2 = x_2(t) \quad (12')$$

$$u_1 = u(t), \quad u_2 = 0$$

The system has been rebuild in order to have all the system coefficients as quadratic matrices and the state variables terms are depending on the time t.

2.2 *The dynamical system of the two species predator-prey model*

Suppose that:

$$A(t) = \begin{pmatrix} 0 & -N^* \\ P^* & 0 \end{pmatrix}, \; B(t) = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}, \; C(t) = \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix} \quad (13)$$

Then the system represented by the above equations (12)-(12'), has the next form:

$$\begin{cases} \dfrac{dx}{dt} = A(t) \cdot x(t) + B(t) \cdot u(t) \\ y(t) = C(t) \cdot x(t) \end{cases} \quad (14)$$

where:

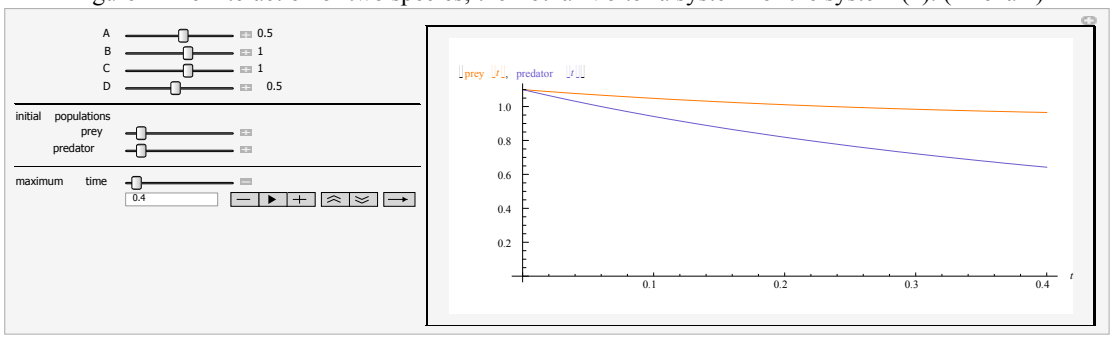
- y(t)= the response of the system;
- x(t)=the solution of the linear system

2.3 *The support of Wolfram_Mathematica*

For having the software support we use the algorithm in "anexa.nb": [5]

$$\begin{aligned} N'[t] &= N[t][a\, N[t] - P[t]], \\ P'[t] &= P[t][[N[t] - b\, P[t]], \\ N[0] &= N_0, \; P[0] = P_0, \\ a, b &> 0 \end{aligned} \quad (15)$$

Figure 1 The interaction of two species; the Lotka- Volterra system for the system (4). (Anexa 1)



3. ANALYTIC SOLUTION OF AN OPTIMAL CONTROL PROBLEM

Let $\Sigma =< (T_1, T_2), U, \Omega, X, Y, \varphi, \eta >$ be the dynamic smooth linear system and:

$$f(x,u,t) = A(t)\cdot x + B(t)\cdot u \quad \eta(t,x) = C(t)\cdot x \qquad (16)$$

In the finite dimensional case f is a positive symmetric matrix. The optimal control problem can be stated to the determination of the command $u(t)$ which minimize the quadratic cost $J(t_0, x_0, u(\cdot))$, for any initial pair $(t_0, x_0) \in (T_1, T_2)\times X$.

If $p : (T_1, T_2) \to L(X,X)$ is continuous differentiable, then $\omega(t,x) = \frac{1}{2} < x, p(t) >$ is also continuous differentiable. According to Kalman's theory, if a Hamilton-Jacobi solution $\omega(t,x)$ is found, then the optimal control problem can be solved. It is proved that $p(\cdot)$ is a Riccati solution of the Riccati equation formed with the system $\sum$ coefficients:

$$\dot{p}(t) = -p^*(t)\cdot A(t) - A^*(t)\cdot p(t) + p^*(t)\cdot S(t)\cdot p(t) - \rho(t)$$

with: $S(t) = B(t)\cdot \sigma^{-1}(t)\cdot B^*(t)$. (14)

For system $\sum$ problem with constant coefficients, ρ and σ are positive elements, so that: $t \to \sigma(t)$ is continuous and $t \to \rho(t)$ is regular on (T_1, T_2), the considerations led to the following: [4]

Theorem 3.1

For any fixed initial pair $(t_0, x_0) \in (T_1, t_1]\times X$, with $t_1 \in (T_1, T_2)$, the regulation problem of the system $\sum$ has a solution according to the state.

- The optimal command is: $u^0(t,x) = \sigma^{-1}(t)\cdot B^*\cdot p(t)\cdot x(t),$, with $p(\cdot)$ the unique solution for the Riccati equation which verifies: $p(t_1) = \Psi(t_1)\cdot\Psi^{-1}(t_0)$; we have considered $\Psi(\cdot)$ the fundamental matrix, in this case.
- The optimal trajectory is a solution of the differential equation: $\dot{x}(t) = [A - S(t)\cdot p(t)]\cdot x(t)$, with: $x(t_0) = x_0, S(t) = B\cdot\sigma^{-1}(t)\cdot B^*$.

4. OPTIMAL SOLUTION OF THE PREDATOR-PREY DYNAMICAL SYSTEM

The dynamic system of the mathematical model (14) is in the Kalman's theory conditions, with the coefficients in (13) and the initial conditions:

$$A, B, C \in M_2(R), X = Y, t_0 = 0, t_1 = 1, (t_0, t_1) \subset R,$$

$$\rho(t) = 0, \sigma^{-1}(t) = 1, x_0 = 1, p(t) = p^*(t), C_0 = e^A$$

Consequently, in order to solve the regulation problem of the system and obtain the optimal command for this particularly system, we have to solve a Bernoulli equation([3]) **:**

$$\dot{p}(t) + \begin{pmatrix} 0 & P^* - N^* \\ P^* - N^* & 0 \end{pmatrix}\cdot p(t) + \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}\cdot p^2(t) = 0_2 \quad (15)$$

with: $p(t_1) = p(1) = \Psi(t_1)\cdot\Psi^{-1}(t_0) = e^A = C_0$ (since $\Psi(t) = e^{At}$), where $p(t)$ is a self adjoint operator and continuous differentiable on (t_0, t_1).

$$\det A = -\left(P^* - N^*\right)^2 \neq 0$$

As $\det p(t) \neq 0$ and $\det A \neq 0$, we multiply with : $[p(t)]^{-2} \Leftrightarrow [(p(t))^2]^{-1}$:

$$\dot{p}(t)\cdot[p(t)]^{-2} + \begin{pmatrix} 0 & P^* - N^* \\ P^* - N^* & 0 \end{pmatrix}\cdot p(t)\cdot[p(t)]^{-1} - \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix} = 0_2$$

(17)

Let : $\dot{v}(t) = \dot{p}(t)\cdot[p(t)]^{-2}$ (18)

$$\dot{v}(t) - \begin{pmatrix} 0 & P^* - N^* \\ P^* - N^* & 0 \end{pmatrix}\cdot v(t) - \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix} = 0_2$$

$$\dot{v}(t) - (A + A^*)\cdot v(t) = S \qquad (19)$$

Solving the last equation:

$$v(t) = e^{(A+A^*)\cdot t}\cdot C_2 - C_1 \qquad (20)$$

$$C_1 = S\cdot(A + A^*)^{-1}$$

$$C_2 = -e^{-2\cdot A - A^*} + -e^{-A - A^*}\cdot S\cdot(A + A^*)^{-1}$$

(we know: $v(1) = -[p(1)]^{-1} = -e^{-A}$)

Consequently: $p(t) = [C_1 - e^{(A+A^*)\cdot t}\cdot C_2]^{-1}$.

As a result of the above theorem, the optimal trajectory is the solution for the differential equation:

$$\dot{x}(t) = [A - S\cdot p(t)]\cdot x(t) = M(t)\cdot x(t) \Rightarrow$$

$$\Rightarrow x(t) = E\cdot e^{\int_0^t M(v)dv} \qquad (21)$$

with the initial restriction:

$$x(0) = E = x_0 \Rightarrow x(t) = x_0\cdot e^{\int_0^t M(v)dv}.$$

The visualization of the optimal trajectory : (a=b=1/2) (with aid of M athematica 6.0)

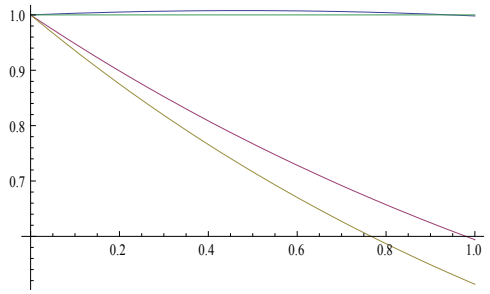


Figure 2. The optimal trajectory of the N and P

The analytic formula for the optimal command is the following:

$$u^0(t,x) = -\sigma^{-1}(t)\cdot B^*\cdot[C_1 - e^{(A+A^*)\cdot t}\cdot C_2]^{-1}\cdot x_0\cdot e^{\int_0^t M(v)dv} \quad (22)$$

The graphical representation of the optimal command: (a=b=1/2)

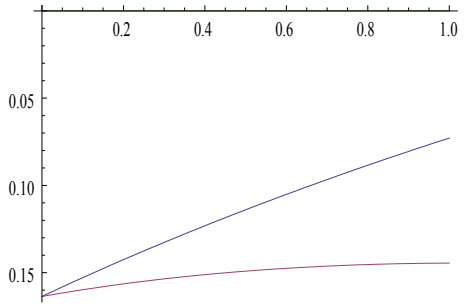


Figure 3. The components of the optimal command in the particularly case (Anexa 2).

6. CONCLUSIONS

The conclusion is that, the optimal solution is not possible so that the above example gives only a theoretical result. Even so, it is another way for studing the optimal control problem of the presented dynamic system .

7. REFERENCES

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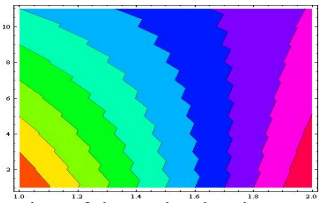
ANEXA 1(ANEXA 1.NB)

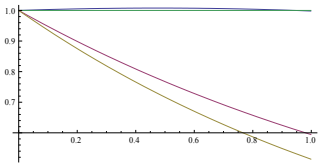
```
LotkaVolterra[{a_,b_,c_,d_},{x0_,y0_},t1_]:=Module[{
x,y,t},
  {x,y}/.Quiet[NDSolve[{
      x'[t]=a x[t] x[t]-b x[t] y[t],
      y'[t]=-c y[t] y[t]+d x[t] y[t],
      x[0]=x0,
      y[0]=y0
      },{x,y},{t,0,t1}]]//Flatten
  ];
Manipulate[
 Module[

{soln,col1=RGBColor[1,.47,0],col2=ColorData["HTML
","SlateBlue"]},

Plot[Evaluate[{#[[1]][t],#[[2]][t]}&[soln=Quiet@Lotka
Volterra[{a,b,c,d},{prey0,predator0},tmax]]],{t,0,Min[t
max,Min[#[[1,1,2]]&/@soln]]},

AxesLabel=TraditionalForm/@{t,{Style[prey[t],col1],St
yle[predator[t],col2]}},

PlotRange=All,AxesOrigin={0,0},PlotStyle={col1,col2}
,ImageSize={400,300},ImagePadding={{40,10},{10,25
}}]
  ],
 {{a,1,"A"},-
5,5,.01,ImageSize=Tiny,Appearance□"Labeled"},{{b,1,
"B"},-
5,5,.01,ImageSize=Tiny,Appearance□"Labeled"},{{c,1,
"C"},-
5,5,.01,ImageSize=Tiny,Appearance="Labeled"},{{d,1,"
D"},-
5,5,.01,ImageSize=Tiny,Appearance="Labeled"},Delimi
ter,
 "initial populations",
 {{prey0,3,"prey"},0,20,ImageSize=Tiny},

{{predator0,5,"predator"},0,20,ImageSize=Tiny},Delimi
ter,{{tmax,40,"maximum
time"},.01,50,ImageSize=Tiny},
 SaveDefinitions=True,ControlPlacement =Left]
```

ANEXA 2 (ANEXA 2.NB)

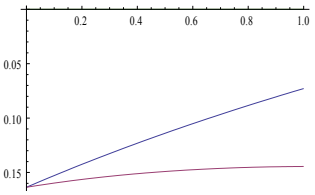
```
DifferentialEquations`InterpolatingFunctionAnatomy`

 INITIAL   INPUTS: a=1/2, b=1/2
matA=N[{{0,-2/3},{-2/3,0}}]
matA//MatrixForm
{{0.,-0.666667},{-0.666667,0.}}
( {
  {0., -0.666667},
  {-0.666667, 0.}
 } )
Transpose[matA]
{{0.,-0.666667},{-0.666667,0.}}
matX=matA+Transpose[matA]

{{0.,-1.33333},{-1.33333,0.}}
I0=-Exp[-matA-matX]
{{-1.,-7.38906},{-7.38906,-1.}}
S=N[{{1,0},{0,0}}]=matB.matB*
{{1.,0.},{0.,0.}}

C2=Exp[-matX].S.MatrixPower[matX,-1]-I0
{{1.,6.63906},{7.38906,-1.84525}}
C1=S.MatrixPower[matX,-1]
{{0.,-0.75},{0.,0.}}

solExp=NDSolve[V'[t]□matX.V[t]&&V[1]□-Exp[-
matA],V,{t,0,1}];
matrixExpX=V/.First[solExp]
InterpolatingFunction[{{0.,1.}},<>]

Table[matV,{t,0,1}]
{{{1.,7.38906},{7.38906,-
1.84525}},{{2.75004,7.65265},{6.90265,0.102483}}}

p=MatrixPower[-matV,-1]

Table[p,{t,0.0001,1}]
{{{-0.0326887,-0.130912},{-0.130911,0.0177201}}}

CALCUL OF THE OPTIMAL TRAJECTORY:
x0=matA-S.p (M (t), equation (21))
x0=matA-S.p
Integrate[x0,{u,0.,t}]
x=THE OPTIMAL TRAJECTORY (EQUATION (21))

x=Exp[Integrate[x0,{u,0.,t}]]
Table[N[x],{t,0.,1.}]
{{{1.,1.},{1.,1.}},{{0.998051,0.593916},{0.513417,1.}
}}

dat=Table[{t,Norm[N[x,t],"Frobenius"]},{t,0.,1,0.1}];

LogListPlot[dat,PlotJoined =True];
ListContourPlot[dat,ColorFunction= Hue]
```



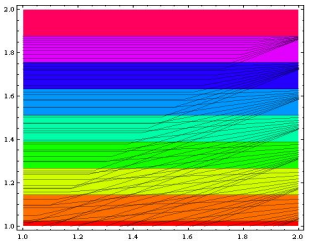
The representation of the optimal trajectory for the initial inputs:
Plot[x,{t,0,1}]



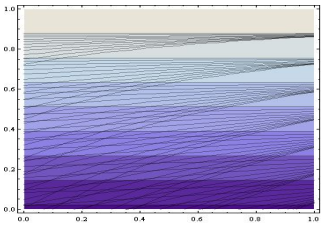
matB*=N[{{1,0},{0,0}}]
{{1.,0.},{0.,0.}}
THE OPTIMAL COMMAND (EQUATION (22))
u0=matB*.p.x
THE OPTIMAL COMMAND VALUES:
Table[u0,{t,0.,1.}]
{{{-0.163603,-0.163603},{0.,0.}},{{-0.0728319,-0.14449},{0.,0.}}}
THE REPRESENTATION OF THE OPTIMAL COMMAND FOR THE INITIAL INPUTS:
Plot[u0,{t,0,1}]



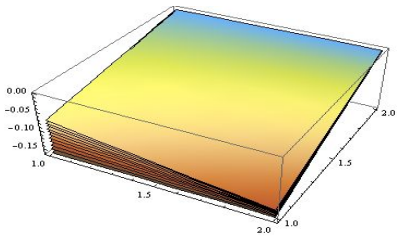
LISTING OF THE OPTIMAL COMMAND VALUES:
dat1=Table[u0,{t,0,1,0.1}]
{{{-0.163603,-0.163603},{0.,0.}},{{-0.152847,-0.159749},{0.,0.}},{{-0.142533,-0.156402},{0.,0.}},{{-0.132632,-0.153532},{0.,0.}},{{-0.123115,-0.151107},{0.,0.}},{{-0.113957,-0.1491},{0.,0.}},{{-0.105135,-0.147484},{0.,0.}},{{-0.0966294,-0.146236},{0.,0.}},{{-0.0884208,-0.145335},{0.,0.}},{{-0.0804931,-0.144759},{0.,0.}},{{-0.0728319,-0.14449},{0.,0.}}}



ListContourPlot[dat1,DataRange{{0,1},{0,1}},InterpolationOrder=1,PlotRange=All]



ListPlot3D[dat1,Mesh=None,InterpolationOrder=1,
ColorFunction= "SouthwestColors"]



PARONYMS IN ENGLISH LANGUAGE

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ABSTRACT

The subject of this paper is the study of paronyms in English language, an useful way of introducing special words with their definitions and their pronunciations, as well. The emphasis is laid on those paronyms that require large explanations; the studying and practising vocabulary items will help at decoding and absorbing information beyond the actual semantic significance of the words themselves. This is an approach of the linguistic variations in using English, taking into account the reliability of English as a language of communication, in written and oral form.

Keywords: *paronyms*, *grammatical and sense categories, diversified meanings, deceptive cognates.*

1. INTRODUCTION

In linguistics, a paronym may refer to:

– a word related to another word and derived from the same root - e.g. cognate words; this types of paronyms often lead to confusion - the deceptive cognates.

– words almost homonyms but having slight differences in spelling or pronunciation - different prefixes or suffixes and added word syllables can change stress and elements of pronunciation - and having different meanings.

Examples are essential to a through understanding of the different uses of words; they are useful in reinforcing the meaning given in the definitions. Some words having both denotative and connotative meanings, all the examples aid the comprehension of their function in combination with other words and structures. We have paid a great attention to showing the properties of words and the grammatical relations into which they can enter.

1.1. Noun

1.1.1. Noun-noun

allusion [ə□lu□□ən] n. – an indirect reference to someone or something
The letter is full of *allusions* to his business failure.
illusion [□□lu□□ən] n. – something that appears to exist but doesn't actually exist; a false belief or idea
What about your *illusion* of a perfect voyage?

berth [bə□θ] n. – a place where a ship anchors in a harbour
The seaman can't remember the number of the *berth*.
birth [bə□θ] n. – act of being born
The *birth* of her baby girl was a personal joy.
(fig.) social position
The old fisherman was a person of low *birth*.

clothes [klouðz] n. pl. – articles of dress
That day, the officer was wearing plain *clothes*.
cloths [kl□:θs] n. pl. – woven or knitted materials
For the summer collection, she has used only expensive *cloths*.

collision [kə□li□ən] n. – a collision occurs when a moving object crashes into something.
When coming back home, they saw a three-car *collision*, with five injured people.
- fig. (clash)
His play stands for the *collision* of two generations.
collusion [kə□lu□ən] n. – secret or illegal agreement, co-operation (between people, companies, countries)
There is no evidence of *collusion* between the Spanish company and this ship-owner.

copse [k□ps] n. – a small group of trees growing very close to each other
He won't forget the little *copse* of acacia trees in his grandparents' village.
corpse [k□:ʳps] n. – a dead body, usually of a person
The soldier's *corpse* was found after three weeks.

councillor [□ka□nsələʳ] n. – member of a council
His grandfather has been a *councillor* for for two years.
counsellor [□ka□nsələʳ] n. – someone who is trained to listen to people and give them advice about their problems
The college has a new *counsellor* to help students with their personal and work problems.

dairy [□deəri] n. – a place where milk is kept and where cheese and butter are made or sold
Fruit and *dairy* produce are carried in ships with refrigerated holds.
diary [□da□əri] n. – a (copy)book in which one writes down what happens each day; record of daily happenings
In my *diary* there were only three empty pages.

decease [d□□si□s] n. – a person's death
It was a hard life for them after their mother's *decease*.
disease [d□□zi□z] n. – an illness of people, animals, plants, etc., caused by infection
It was reported a sudden outbreak of a *disease* in the north of the harbour.

genius [□d□i□niəs] n. – very great and rare natural ability or skill, especially in a particular area such as science or art; a person who has this ability
They say that his brother was a writer of *genius*.
genus [□d□enəs] n. – a group (of animals or plants), that is smaller than a family but larger than a species
This *genus* of plants is characteristic of the African countries.

glacier [□glæsiə^{r}] n. – a large mass of ice which moves slowly
This year, during the voyage, they have seen a real *glacier*.
glazier [□gle□ziər] n. – a person who sells glass or fits it into windows
At that time, he was twenty-five years old and was working as a *glazier*.

price [pra□s] n. – the amount of money for which something is sold
The *price* of gold hasn't risen lately.
prize [pra□z] n. – something valuable, such as an amount of money, that is given to someone who succeeds in a competition or as a reward for doing good work
She has won a *prize* for the best suggestion made by an employee.

veracity [və□ræs□ti] n. – the quality of being true, honest or accurate
The police officer didn't have confidence in the *veracity* of their alibi.
voracity [v□ræsiti] n. – extreme gluttony, greediness
Everybody knows his *voracity* for old books and furniture.

1.1.2. noun-adjective

law [l□□] n. – rule made by the government or other authority; science or principles of laws or particular types of laws
The *laws* of the country are made by Parliament.
My son has been studying international *law* for three years.
low [lo□] adj. – not measuring much from the base to the top, or close to the ground or the bottom of something
The master of the ship is worried because the stocks are running *low*.

perspective [pəspekt□v] n. – a particular way of considering something
The death of his daughter has given him a new *perspective* of life.
prospective [prəspekt□v] adj. – people who are expected to buy something / employ someone; proposed, planned
Mark's *prospective* employer phoned to say that the job had been filled.

1.1.3. noun-adjective-verb

secret [□si□krit] n. – a piece of information that is only known by one person or few people
The design of this cruse liner must be a dead *secret.*
secret [□si□krit] adj. – hidden, concealed
The engineer is trying to keep the results of the research *secret.*
secrete [s□kri□t] vb. – to put something in a place where it is unlikely to be found
The new worker has *secreted* several lead bars from his chief.

1.1.4. noun-verb

breath [breθ] n. – the air that goes into and out of the lungs
To climb the stairs, he had to take a deep *breath*.
breathe [bri□ð] vb. – to move air into and out of the lungs
Because of the fog, I can hardly *breathe*.

1.1.5. noun-verb-noun

desert [□dezət] n. – an area, often covered with sand or rocks, where there is very little rain and not many plants
During that trip, they lost their way in the *desert*, for three days.
desert [d□zə:t] vb. – to leave the armed forces without permission and with no intention of returning
The lieutenant who *deserted*, was caught and punished.
Confidence and sense of humour never *desert* the real sea dogs.
dessert [d□zə:t] n. – sweet food eaten at the end of a meal
Se has homemade choc-ice for *dessert*.

1.1.6. noun-verb-noun-verb

excise [eksaiz] n. – tax that the government puts on particular goods – cigarettes and alcoholic drinks – produced for sale in its own country
Smokers will be hit by increases in taxes and *excise*.
excise [iksaiz] vb. – to remove something deliberately and completely
This is a personal crusade to *excise* racist references in newspapers.
exercise [eksə^{r}saiz] n. – practice, drill, training
Every morning, the old sailor does *exercises* on the beach.
exercise [eksə^{r}saiz] vb. – to train, to drill, to practise
Don't *exercise* after a large meal!

1.2. Adjective
1.2.1. adjective-noun

principal [□pr□ns□pəl] adj. – most important
Milan is one of the *principal* cities in Italy.
principle [□pr□ns□pəl] n. – 1. a basic idea or rule that explains or controls how something happens or works
My father's prosperous boat business was run on capitalist *principles*.

2. something that one believes in or follows as a rule
Lying is against my *principles*.

1.2.2. adjective-adjective

apposite [□æpəz□t] adj. – suitable and well-chosen
Congratulations! You made very *apposite* remarks at that important meeting.
opposite [□□pəz□t] adj. – completely different; reverse
Ken turned the car and drove off in the *opposite* direction.

bald [b□□ld] adj. – with little or no hair on the head; basic and with no unnecessary words; not detailed
At twenty-five he was already going *bald*.
There is just this *bald* statement of resignation – no extra explanation.
bold [bo□ld] adj. – brave, not fearing danger; rude, disrespectful
The young seaman was *bold* enough to answer back to the watch officer.

capable [□ke□pəbəl] adj. – able to do things effectively and skilfully, and to achieve results
She is a very *capable* judge.
capacious [kəpe□□əs] adj. – able to hold or contain much; having a lot of space
Ben's car has got a *capacious* boot.

contemptible [kəntempt□bəl] adj. – deserving contempt
Her behaviour was *contemptible*.
contemptuous [kəntemptjuəs] adj. – expressing contempt
Dan was very *contemptuous* of all the 'popular' writers, whom he described as having no talent.

eligible [□el□d□ibəl] adj. – having the necessary qualifications or satisfying the necessary conditions
My younger son might be *eligible* for a research grant.
illegible [□led□ibəl] adj. – (of writing or print) impossible or almost impossible to read because of being very untidy or not clear
My doctor's writing is almost *illegible*.

eminent [□em□nənt] adj. – famous, respected or important
Mr. Reed is a good politician because he is an *eminent* historian.
imminent [□□m□nənt] adj. – coming or likely to happen very soon
Things being as they are, a strike is *imminent*.

human [□hju□mən] adj. – relating to or concerning people
The *human* body is composed of about 60% water.
humane [hju□me□n] adj. – showing kindness, care and sympathy towards others, especially those who are suffering
It would be *humane* to bring that dog home from the pond.

temporal [□tempərəl] adj. – relating to practical matters or physical things, rather than spiritual ones; earthly
Unfortunately, their old leader has got only *temporal* powers.
temporary [□tempərəri] adj. – not lasting or needed for very long; passing
They made a *temporary* stop to repair the engine and then drove on.

1.2.3.. adjective-verb

loose [lu:s] adj. – not firmly fixed in place; (of clothes) not fitting closely to the body; not tight
There were some *loose* wires hanging out of the wall.
lose [lu□z] vb. – to fail to succeed in a game, competition etc.; to mislay
His favourite team *lost* to Arsenal.
I've *lost* my door key again.

1.2.4. adjective-verb-adjective

quiet [kwa□ət] adj. – making very little noise; silent
The stevedores were speaking in a *quiet* voice so as not to be heard by the foreman.
quiet [kwa□ət] vb. – to calm, to subdue
Though our chief was extremely angry at first, we *quieted* him with our explanation.
quite [kwa□t] adj. – 1. completely
Winter in Italy is *quite* different from winter in Switzerland.
2. rather; to some extent
At my party, my sister-in-law had *quite* a pretty dress.

1.3. Verb
1.3.1. verb-adjective

elicit [□□l□s□t] vb. – to get or produce something, especially response or a reaction
The student is hopeful that his request will *elicit* a positive response.
illicit [□□l□s□t] adj. – illegal or disapproved by society
They were arrested for using and selling *illicit* drugs.

1.3.2. verb-verb

adapt [ə□dæpt] vb. – to change something to suit different conditions or uses
You have to *adapt* your plans to fit Charlie's timetable.
adopt [ə□d□pt] vb. – to accept or start using something new
I think it's time to *adopt* a new strategy in my dealing with my students.

complement [□k□mpl□ment] vb. – to make something else seem better or more attractive when combining with it; to complete
The lights and the music, in the show, *complement* her way of dancing perfectly – and I'm not just complimenting her.

compliment [□k□mpl□ment] vb. – to say a polite remark that expresses approval, admiration or respect; to praise, to flatter
All her work mates *complimented* her on her new hair-style.

precede [pr□si□d] vb. – to be or go before something or someone in time or space
The Greek civilization *preceded* the Roman one.
proceed [prəsi□d] vb. – to move on / ahead, to progress
Let's *proceed* to the next house and interview the people there.

2. CONCLUSIONS

Ambiguity and homophony are the worst enemies of a safe communication, causing misunderstandings, both on the lexical and on sentences and discourse level.

Today, people who don't speak each other's language will very often use English as the instrument of communication: pilots communicating with control centres, seafarers in multilingual crew etc.; according to statistics, a lot of accidents have been caused by poor communication and lack of understanding – mistaken words and linguistic structures.

With this approach of paronyms, we have underlined the pragmatic implications of language use and the importance of an appropriate choice of words and phrases for particular purposes and in various contexts and situations.

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THE CAMPAIGN OF MARCUS ATILIUS REGULUS IN AFRICA. MILITARY OPERATIONS BY SEA AND BY LAND (256 – 255 B.C.)

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ABSTRACT

In 256 B.C., the Roman Senate decided to move the center of the operations against Carthage from Sicily to Africa. The Carthaginians encountered the Romans in the waters of Cape Ecnomus, but the fates smiled on the Roman's behalf, opening the way to Africa. In the winter of the years 256-255 B.C., only one consul, M. Atilius Regulus, remained in Africa. This actually triggered some negotiations between the two powers, but they were never completed. When diplomacy failed, the Carthaginians rebuilt their army recruiting African and Greek mercenaries. This new army was entrusted to a Spartan general, Xanthippus. In the early spring of 255 B.C., Atilius Regulus did not wait for his reinforcements to arrive and accepted the confrontation. The battle ended with the victory of the Carthaginians. In the same year, Rome sent ships to the North African coast in order to save the remaining expeditionary troops of Regulus. On the way back from Africa, the Roman fleet was caught in a strong storm near Camarina, which caused the loss of important troops. Instead of being a success, the African campaign turned into a great disaster in 255 B.C.

Keywords: *Rome, Carthage, M. Atilius Regulus, Xanthippus, Cape Ecnomus, Camarina, Polybius*

In 264 B.C., the first military conflict between Rome and Carthage, the most important powers in the Western Mediterranean area, broke out. Each of the two adversaries puted their hopes in a quick victory which was supposed to bring them new territories and international supremacy. But their expectations were not met and the war turned into a long one, with losses on both sides and changing odds.

In the winter of 258-257 B.C., the Roman Senate made a radical decision regarding the war. The Romans decided to move the war to Africa since their actions in Sicily did not come to expected result. The idea to open a battlefield in Africa was inspired by the strategy of the Syracusan tyrant Agathocles, who fought against Carthage on the North African coast, between 310-307 B.C. [1]. But the plan conceived by the Roman authorities was to be put into practice only at the beginning of 256 B.C. The necessity to build 200 quinqueremes explained the delay. According to Polybius, the Romans had 330 ships at the beginning of 256 B.C. [2]. Appian wrote instead that the Romans had 350 ships, a figure close to that stated by the historian from Megalopolis [3]. The number of soldiers the Romans embarked was about 140.000. The Carthaginians had 350 ships and 150.000 soldiers [4].

The modern researchers denied the value of Polybius information about the effective forces of the two adversaries. Firstly, given the fact that the Carthaginians had no intention to land, it is hardly believable that besides the 300 oarsmen on each ship they also embarked 120 soldiers. They were not interested in having such a great number of soldiers on board because their naval tactics involved the quick handling of the ships and the crew in excess would have reduced the speed considerably. Probably, Polybius assumed in a wrong way that the Carthaginians would have embarked the same number of soldiers on a single ship as their enemies [5].

In the summer of 256 B.C., the Roman quinqueremes left Ostia and sailed in the Tyrrhenian Sea, along the coast of the Italic Peninsula, to Messene. They embarked the land army in Sicily, so that the number of people on board increased from 40 to120. The invasion troops had been carefully selected, being made of the most combative soldiers [6]. The Roman forces were under the command of the two consuls, Lucius Manlius Vulso Longus and Marcus Atilius Regulus. The latter was *consul suffectus* because Manlius' colleague, Quintus Caedicius, had died during the exercise of function, little before the expedition [7].

With the troops on board, the Roman fleet raised anchor and sailed towards North-West, along the Southern shore of Sicily. At the Cape Ecnomus, the Romans met the Carthaginians fleet prepared for the battle. There is no doubt that the Carthaginians knew the Romans' plans and they waited for them in a place far enough from their base of operation in order to defeat them and destroy their fleet. The Carthaginians placed themselves in a simple battle line having the left flank on the Sicilian coast. The Romans placed their ships in a triangle shape. The admiral ships, two sexiremes, were placed in a frontal oblique line, followed by two squadrons, one on the right side and the other one on the left side. A third contingent was closing the angle and the ships carrying the cavalry horses were linked to it [8].

The Carthaginians organized a simple battle line, extended as an arc of a circle with the left flank on the shore of Sicily. All their ships had their bows directed towards the Roman ships. This placement showed the Carthaginians intention to surround the enemy. The Carthaginian right flank, made of quinqueremes, was under the command of Hanno, the one who had been defeated by the Romans at Acragas. The ships under his command were proper for surrounding the Roman flanks because of their fast and agile movements. The African

right flank was under the command of Hamilcar who had fought against the Romans by sea at Tyndaris [9].

The odds were changing during the battle of Ecnomus. Though, Rome gained the victory. The boarding-bridges that helped the soldiers to turn a sea war into a land one made a great contribution to Romans' victory [10]. According to Polybius, the Carthaginians losses were enormous: 30 sunk ships and 64 captured together with the crew. The Romans paid a smaller price for their victory: 24 ships sank and no one was captured [11]. Eutropius wrote about the same losses of the Carthaginians, while for the Romans he mentioned only 22 sunk ships [12].

This victory opened the way to Africa because it would have been hardly believable that the rest of 100 Carthaginian ships could stop the Romans from landing on the continent. However, the Romans did not cross the Mediterranean Sea immediately because they needed a time to recover. The oarsmen needed rest after the effort spent during the confrontation. Also, the Romans had to repair their destroyed ships and the captured ships to replace the sunk ones [13]. Literary resources do not state clearly the place where the Roman fleet was reorganized after the battle of Ecnomus. *The Histories* of Polybius keep silence in this matter. Zonaras assumed that the Roman ships came back to Messene for this purpose [14]. Still, it is most likely that the Roman ships rowed to Syracuse that was closer to the battle place than Messene and also had a larger harbour [15]. An interesting paragraph belonging to Cassius Dio states that while the Roman fleet was recovering, Hamilcar sent Hanno to the consuls with a peace offer. Unfortunately, the information is singular and it is not certified by any other source [16]. This information could still be true taking into account that the next target was Carthage.

When the fleet was ready, the Romans started for Africa with an effective of 350 ships [17]. The vanguard waited for the rest of the Roman fleet at the Hermean Promontory from where they left to Carthage. The Rome ships avoided the Carthaginian fleet that was waiting for them in the Gulf of Carthage, landing at Aspis (Clupea), South-East from the Cape Bon. The harbour offered the ships enough space and protection against storms and was seccured by the city placed on a hill like a shield. The Romans set up a naval camp with a defence mound and started to plunder the surrounding area. The courageous plan of the Romans succeeded with minimum losses. Their trust in success is proved by the fact that the Roman Senate called the consul Lucius Manlius Vulso back to Italy with the largest part of the fleet and half of the land army. The consul returned home from Africa with 27.000 prisoners. Once in Rome, he ostentatiously celebrated his victory from Ecnomus. Marcus Atilius Regulus remained in Africa with 40 ships, 15.000 infantrymen and 500 cavalrymen [18].

The Romans intended to attack Carthage both by sea and by land, but the arrival of winter delayed their plan. They sent back home most of the ships, part of the army and the prisoners because they were not able to feed a great number of seamen, soldiers and slaves in a completely hostile territory. In these conditions, the big attack against Carthage was postponed until the spring of 255 B.C. The Romans' intention to attack Carthage also by the sea could have been put into practice even if the Republic fleet had left the African sea in 256 B.C., because Rome was dominating the Western Mediterranean Sea as a result of the victory of Ecnomus [19].

The consul who remained in Africa had the mission to wage a war of attrition in winter, to weaken the Carthaginian army in order to defeat it for good during the spring campaign. Another purpose Regulus had in view was to start a rebellion among the subjects of Carthagae in the North of Africa [20]. The Roman commander managed to conquer Adys in spite of the opposition of the African army commanded by Hasdrubal, Bostar and Hamilcar, the last one just returned from Sicily with 500 cavalrymen and 5.000 infantrymen. The next location conquered by the consul's legions was Tunis, placed in the immediate neighbourhood of Carthage. Atilius Regulus organized here the winter camp hoping to start the attack against Carthage in spring and to conquer it. Polybius does not offer information about the Carthaginian losses in their confrontation with the Roman army [21]. Later sources present figures that are not trustful. Thus, Eutropius wrote in his breviary that the Roman army killed 18.000 soldiers, captured 5.000 together with 18 elephants and 74 cities allied with the invaders. Orosius states that the Romans killed 17.000 Carthaginians and that the number of cities that allied with the consul forces was 82 [22].

The literary sources offer contradictory information about the events that followed the conquest of the two important African cities. Polybius mentioned that Marcus Atilius Regulus proposed the Carthaginians the project of a peace treaty given the fact they were facing an important lack of food and also a powerful Numidian invasion. The historian from Megalopolis wrote that the consul's initiative was justified by his fear of losing the honours to put an end to this war in the favour of the consul from the next year. According to Polybius' *Histories*, the Carthaginians received well the news about the beginning of negotiations but they could not accept the conditions imposed by Regulus, finding them humiliating. However, Polybius did not mention anything about the terms of the supposed project of peace proposed by Regulus [23].

This piece of information is contradicted by Diodorus, Livy, Eutropius, Orosius and Zonaras. These authors mention that the Carthaginians had the initiative in starting the negotiations and not the Romans. Still they share a common point of view on certain aspect: the African government found the terms the consul stipulated unacceptable and therefore they turned them down [24]. Another record found in Livy's record contradicts the point of view expressed by Polybius. According to it, Atilius Regulus' consulship was prolonged against his will and no one was sent to replace him. In addition, the information of Livy is sustained by Frontinus [25]. Cassius Dio is the only one who wrote about what Romans required in exchange for putting an end to the war. According to him, the consul asked the Carthaginians to abandon Sicily and Sardinia, to free the Roman prisoners without claiming for damages, to ransom the Carthaginian prisoners, to pay for the war

expenses and to pay a yearly tribute in Rome's treasury. Also, the Africans were not allowed to make peace or declare war without Rome's consent. The peace project also stipulated the Carthaginians should give up their war fleet. These terms were meant to bring the Carthaginians at the same level with the citizens from Tarentum and Naples, but they were unacceptable for a state which still had an army and a fleet [26].

After rejecting the peace treaty, the Carthaginians turned their attention on rebuilding the army. They recruited a great number of mercenaries from Africa and Greece. The Spartan commander Xanthippus, who had good knowledge in the warfare, was among the ones interested in the gold the Africans were ready to pay to drive the Romans back in Italy [27].

In the early spring of 255 B.C., the Carthaginian army left the city walls and occupied their fighting positions in the open field, challenging the Romans. The African army was made of 12.000 infantrymen, 4.000 cavalrymen and 100 elephants. Both armies had an equal number of infantrymen, while the cavalrymen in the army under the command of Xanthippus outnumbered the Roman cavalry. The trap set by the Spartan commander worked. The Romans did not wait for reinforcements from Italy and started the battle in the April of 255 B.C. The tactics of the Spartan commander misled the Roman consul. He set the elephants in a single line in front of the whole Roman army. Regulus placed his forces as to counteract the first attack of elephants, neglecting the superiority of the Carthaginian cavalry. The Spartan commander firstly launched the cavalry against the enemy. The avalanche of the African cavalry spread the Roman cavalry placed as usual on flanks and surrounded it. The Roman legions did not give up yet and started the attack. The left flank managed to avoid the elephants, took the mercenary infantrymen by surprise and pushed them back. However, this first success divided the Roman fighting formation and the Republic forces were caught in a square. The elephants attacked them frontally, the cavalry from the flanks and from behind. The Carthage gained a great victory in this battle [28]. The literary sources offer information about the disaster of the Roman army. Many Roman soldiers remained on the battle field and 500 of them, among which there was also the consul Atilius Regulus, were made prisoners. Only 2.000 men managed to escape the disaster and to retreat in Clupea [29].

Xanthippus' victory entitled the Carthaginians to pin their hopes on putting an end to the conflict with the power over the Mediterranean or to break it concluding a truce. They sent the captured consul in front of the Roman Senate to start the peace negotiations or at least to get the redemption for the Roman prisoners. At Rome, Regulus did not plead for the Africans desires but for the continuation of the war until the final victory. To prove he was an honourable man, he returned to Africa because before he left the Carthage he had sworn he would be back in case the mission failed. Because he did not carry out his mission he was put in a barrel and thrown in the sea [30]. It is likely that the episode of Regulus being sent in front of the Roman Senate is linked more to Livy desire to diminish the importance of the failure suffered by the troops under the consul command and to offer an explanation for the cruelty deeds of his widow. She tortured two Carthaginian prisoners to death [31].

The crew members of the 40 ships anchored in the harbour added to the 2.000 soldiers who survived the battle against Xanthippus [32]. The loyalty and courage of the Roman soldiers is proved by a fragment from *Bellum Punicum* of Naevius, according to which the African suggested the Romans to surrender the city in exchange of the freedom to sail to Sicily. The soldiers chose to resist and not to surrender the Roman bridge end in Africa without fight [33].

The many mistakes made by the Roman consul led to the disaster under the walls of Carthage. Firstly, Regulus should have concluded a treaty of alliance with the rebel Numidian tribes as a means to provide the Roman army with the combative cavalry it missed at that moment. But the biggest mistake was that he agreed on starting a decisive battle before the reinforcement arrived from Italy [34].

The defeat of the Roman army in the North of Africa changed the initial battle plan that was to attack Carthage both by land and by sea. The Senate decided to embark the fleet to Africa in order to save the survivors blocked in Clupea [35]. According to Polybius, in 255 B.C., the Romans launched 350 ships under the command of the two consuls, Servius Fulvius Paetinus Nobilior and Marcus Aemilius Paulus, that were meant to cross the Mediterranean and to save the besieged soldiers in Clupea [36]. Eutropius recorded that the consular fleet was made of 300 ships and not 350 [37]. Though, according to the modern historians, it seems that the real number of ships sent to Africa to save the survivors did not exceed 210 [38]. According to Zonaras, the Roman fleet in its way to Africa was pushed by a storm towards the Cossyra island they plundered [39]. The Romans had left a small garrison on the island before they went on. The information Zonaras offered had been taken from the *fasti triumphales* according to which the naval triumph against the inhabitants of Cossyra was celebrated in the January of 253 B.C. [40].

The Carthaginians found out that Rome prepared a fleet in order to return to the African waters and they also prepared 200 ships in their turn. They waited for the Romans near the Hermean Promontory. The Romans gained the victory and according to Polybius they managed to capture 114 ships and their crew [41]. Polybius information was not confirmed by Eutropius, who stated that the Romans sank 104 ships and only 30 had been captured [42]. Regardless of the real figures, the victory was brought again to the Romans by the boarding bridges. A possible explanation for the defeat suffered by the Carthaginians can be the fact that some of the African oarsmen did not have the necessary experience to face a naval fight. This battle reduced the impressive Carthaginian fleet to only 70 ships [43].

Following their success at the Hermean Cape, the Roman ships anchored at Clupea, took the surviving soldiers from Regulus army on board and left for Sicily. Near the shore of Camarina, a heavy storm sank almost the entire Roman fleet. Only 80 ships of 364 survived this natural calamity while 25.000 soldiers and 70.000 oarsmen died in the sea [44]. The commanders were

guilty for this shipwreck because in order to demonstrate their force to some Sicily cities they neglected the steersmen advice to avoid sailing along the South-East coast of the island because of its rocky characteristics. In case of a storm, the ships would have been crashed against the rocks, which happened in fact [45].

The year 255 B.C. shattered the Romans' hopes. The great African invasion was a big failure and the army under the command of Marcus Atilius Regulus was destroyed. In the same year, the first Roman war fleet that faced all the battle up then was defeated by the natural hostile forces in the waters of Camarina.

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SPECIFIC MODALITIES TO APPLY THE MATHEMATICAL-STATISTICAL PROCESSINGS INSIDE THE OPERATIONAL RESEARCH, ACTING IN THE PROFESSIONAL AND SPORTIVE TRAINING OF THE NAVAL STUDENTS

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ABSTRACT

The present paper shows in short, the results of a larger research we made in Romania with the naval students who followed an experimental methodological plan for their specific physical training, in order to increase the level of their efficiency and their performances according to the physical and psycho-motional requests aboard ships, during good weather as well as when bad, stormy weather over the seas. The results we obtained, presented here in their short form, because we do not have room enough, showed that the improving experimental intervention proved to be extremely positive, modifying all previous concepts expressed so far, in the methodology of the naval students physical and pshycho-motional training.

Keywords: *Specific physical training, specific training, applicative swimming, testing, professional-applicative performance*,

1. INTRODUCTION

During the professional training of the naval students, the *specific physical* and *the psycho-motional training* has a main role to play.

In order to achieve from practical point of view this training, in order to face the specific needs and requests of the navigation activities we have to simultaneously realize a lot of tests. In the same time we also have to apply *true tests* involved in the field, as well as a thoroughfully and most adequate mathematical-statistical processing of the data we obtained, just in order to be able to direct the multiple task preparation, needed in the field.[1]

2. THE RESEARCH TASKS

The wide research we made on the naval.

First of all we studied the level and the directions of physical reqirements aboard ships, to understand the way to actin order to help and improve the training of the naval students and their officers, of the civilian and military fleets, as well. We also strongly objectivised the results obtained from the specific tests we used, processing in the statistical-mathematical way all those data gathered in every phase of this applied research.

3. THE RESEARCH METHODS

All the research methods were also multiple, including the special litterature study, the laws and the rules concerning the life and the activities aboard ships. Eventually, we tried to build up and apply specific tests in the field, we introduced new ideas to improve the methodology of the specific training, in the processing of the data and the mathematical-statistical analysis.

We established absolutely at random a witness-group and an experimental one, between the mechanical naval students. After the first test (T1), we applied the new methodology, on the experimental group of specific training, and the requests aboard, previously studied.

Because we do not have room enough in this paper we'll expose only the second part of our operational wide research in the field, the comparative evolution of the data and the statistical processing.

4. THE RESULTS OF THE RESEARCH

4. 1. The recults and the dynamics of the investigated parameter evolution in the first test of the specific physical training of the naval students

As you can seein table no.1, at the first test (T_1) the groups of students showed an uniform value of the physical training level, or better said the same missing points in this respect, in both groups, as the expressed differences between them, concerning the statistic term „t", were not significant.

At the second test (T_2) included in the first experimental stage, after applying the experimental specific professional training program, we may note in

[1] We have to mention the col. (rs.) *Dan Nicolau*, who had a role in supporting the realising of this paper.

this very phase, significant statistical differences to four from the six watched parameters (the situation is here presented in the table no. 2 and the figure no.1)

Table no. 1

The comparative analysis of the group contents, characterizing *The specific physical training* of the naval students involved in the pedagogical experiment (witness and experimental groups), in the innitial testing (T_1) of the experimental stage I.

No.	Compared parameters	$\overline{X} \pm m$		Statistical Criteria	
		Witness Group	Experimental Group	„t”	„p”
(Experimental stage I) The innitial testing (T_1) $\overline{X}1 \pm m$					
1	Pulling the rope in orthostatic position	21,20 ± 1,12	20,60 ± 0,96	- 0,4	> 0,05
2	Rowing the single person boat	364,07 ± 3,94	367,00 ± 3,86	0,41	> 0,05
3	Swimming equipped, 50 m (just blouse and trousers)	118,00 ± 3,53	117,27 ± 4,87	- 0,12	> 0,05
4	Pulling the rope when swimming	63,00 ± 3,07	65,00 ± 3,46	0,43	> 0,05
5	The carrying of the lifebuoy, an eqiupment set and the rifle when swimming for 50 m	163,2 ± 1,77	164 ± 1,63	0,33	> 0,05
6	Applicative ittinerary aboard ship	84,27 ± 1,22	85,07 ± 1,28	0,45	> 0,05

Table no. 2

The comparative analysis of the group contents, characterizing *The specific physical training* of the naval students involved in the pedagogical experiment (witness and experimental groups), in the second testing (T_2) of the experimental stage I

No.	Compared parameters	$\overline{X} \pm m$		Statistical Criteria	
		Witness Group	Experimental Group	„t”	„p”
(Experimental stage I) The second testing (T_2) $\overline{X}2 \pm m$					
1	Pulling the rope in orthostatic position	25,40 ± 1,39	27,27 ± 0,77	1,17	> 0,05
2	**Rowing the single person boat**	340,33 ± 2,53	275,07 ± 9,89	**- 6,39**	< 0,001
3	Swimming equipped, 50 m (just blouse and trousers)	107,07 ± 2,52	95,40 ± 4,73	- 2,17	< 0,05
4	**Pulling the rope when swimming**	85,13 ± 3,90	105,07 ± 3,65	**3,73**	< 0,01
5	The carrying of the lifebuoy, an eqiupment set and the rifle when swimming for 50 m	152,67 ± 1,77	147,4 ± 1,79	-2,09	> 0,05
6	**Applicative ittinerary aboard ship**	80,47 ± 1,4	75,4 ± 1,33	**-2,62**	< 0,05

Here it is, a clearer expression of their evolution:

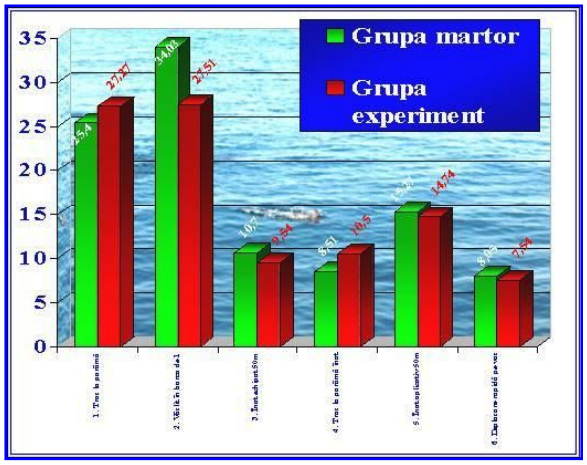
- at the specific test of *rowing in the single boat on a established ittinerary*, the experimental group, we used to apply our specific programme, outrun the witness group. We used for the witness group the traditional training system. Therefore we improved the group time (medium) with 65,26 seconds, the value of „t” = 6,39 > 4,14, a *very significant difference from statistical point of view* to „p” < 0.001 and n-1;

- at the *equipped swimming for 50 m in blouse and trousers* „t” = 2,17 > 2,14, a *significant difference from statistical point of view* to the treshold of statistic significance „p” < 0.05 and the liberty freedom degree of n-1;

- at the specific test of *pulling the rope during swimming* „t” = 3,73 > 2,97, the *significant statistic difference* to p < 0.01 and n-1;

- at the specific test of *quick run aboard ship on an established ittinerary*, the experimental group records at its second test, a time shorte with five seconds than the witness group, „t” = 2,62 > 2,14, representing a statistically significant difference at the treshold of the *statistic significance* „p” < 0.05 and liberty degree n-1.

Figure 1



The comparative analysis of the group contents, characterizing the specific physical training at the second testing (T2)

Continuing to apply to the experimental group the special programme of the training, containing an adequate level of professional requirements at the naval students level, as well as the professional navigators level, we noticed an even bigger difference (from positive point of view) between the results obtained by the students of the experimental group, compared to the ones of the witness group.

At the final test (T_f) of the groups of students, concerning the *specific physical training*, the experimental group recorded a spectacular difference, compared to the witness group at all tested parameters. (See table 3 and Figure2)

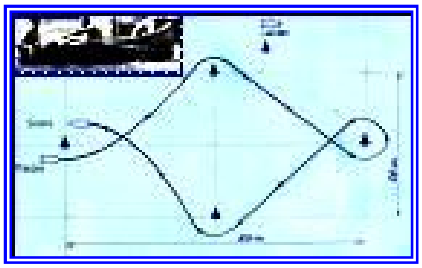
Table 3

The comparative analysis of the group contents, characterizing *The specific physical training* of the naval students involved in the pedagogical experiment (witness and experimental groups), in the final testing (T_f)

No.	Compared parameters	$\overline{X} \pm m$		Statistical Criteria	
		Witness Group	Experimental Group	„t”	„p”
(Experimental stage I) The final testing (T_f) $\overline{X}f \pm m$					
1	Pulling the rope in orthostatic position	29,20 ± 1,25	33,80 ± 0,67	3,24	< 0,01
2	Rowing the single person boat	327,93 ± 2,76	250,20 ± 8,58	- 8,6	< 0,001
3	Swimming equipped, 50 m (just blouse and trousers)	96,13 ± 2,49	84,60 ± 3,82	- 2,52	< 0,05
4	Pulling the rope when swimming	92,87 ± 3,36	137,00 ± 3,96	8,49	< 0,001
5	The carrying of the lifebuoy, an eqiupment set and the rifle when swimming for 50 m	148,00 ± 1,93	133,13 ± 1,44	- 6,17	< 0,001
6	Applicative ittinerary aboard ship	74,93 ± 1,07	67,00 ± 1,32	- 4,66	< 0,001

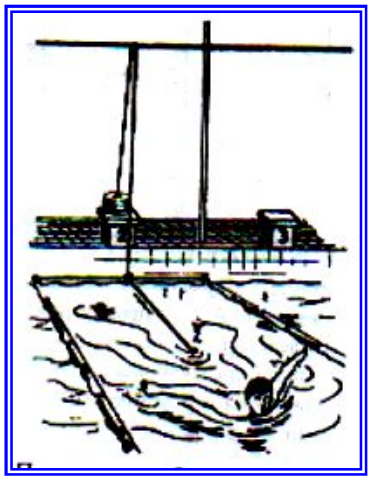
As can be seen in the table no 3 and the figure no 2, the test of heavyweight lifting by *pulling the rope when standing (orthostatic position)* the value of the statistical significance of the difference between the medium values of te groups „t” = 3,24 > 2,97, the difference is „*satistically significant*” at the significsnce threshold of „p” = 0,01 and the liberty degree n-1.

At the test of *rowing a single person boat* along an established ittinerary, the results recorded by the members of the experimental group were showing the most spectacular evolution, the statistical significance between the groups results, being of „t” = 8,6 > 4,14, the difference meaning being *„statistically, very significant”* to „p” < 0,001 and n-1.



At the test of *equipped swimming in blouse and trousers* for 50 m „t" = 2,52 > 2,15, the difference between the group average times, being „*statistically, significant*" to „p" < 0,05 and n-1.

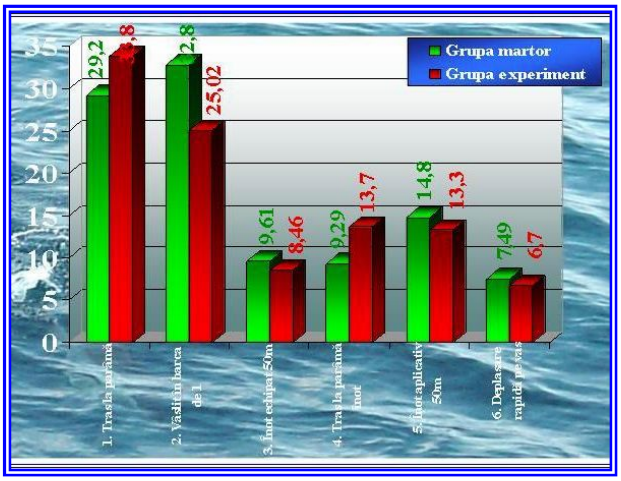
At the *specific endurance test* of *pulling the rope when swimming* in order to maintain a heavyweight at a constant level on an addapted helcometer, the statistical difference between the results of the groups was „t" = 8,49 > 4,14, another *„statistically, very significat"* differenceto „p" < 0,001 and n-1.



At the *applied swimming* test, very specific to the Naval Forces students, the statistical significance of the difference between the two groups was finally, „t" = 6,17 > 4,14, a „*statistically, very significant*" one to „p" = 0,001 and n-1.

At *the quick run aboard ship*, combined with *the jump in the water* and *the climbing back on the pilot ladder,* we got a difference, between the groups, of „t" = 4,66 > 4,14, „*statistically, very significant*" at „p" < 0,001 and n-1.

Figure no. 2



The comparative analysis of the groups results, characterizing *The specific physical training* of the naval students involved in the pedagogical experiment (witness and experimental groups), in the final testing (Tf)

5. CONCLUSIONS (I)

As we noticed before, in the experimental stage II, we concluded that the introduction of the specific physical and psycho- motional trainingadequated to the needs and requests aboard ships, we also influenced the level of the general physical training, in the final phase of this research, as the experimental group reached superior, better values, improved at seven from the nine investigated parameters. The differences between the groups was „statistically, very significant" according to Fischer's Table, at a statistical significance threshold of p<0.001 and n-1.

In the field of specific physical training, the evolution of the peremeters recorded in the final phase, clearly demonstrated the training programme is justified, aboard ships. The statistic evaluations results emphasized that the experimental group marked „statistically, very significant" differencies, at the most of the recorded investigated parameters at a significance threshold of p=0.01 and n-1. We are expressing in objective figures, as you can see. Thus, we can do the mathematic models of the training levels we followed, as well as the processing of the statistical-mathematical manner of understanding the results. It means we reached at a high level the task we proposed, in this pedagogical experiment.

6. FINAL CONCLUSIONS

1. After this study we decided the problem of the specific physical and psycho-motional training inside the naval education left no traces in the specific litterature. Not enough, we may say. The authors getting next to the problems of the naval training refers much more to the psychological and pedagogical area of the education in the field. But they still recognize the important roleplay, the physical activity and the sports activities have in maintaing a balanced person in the middle of the naval activities, aboard ships.

2. When analyzing *the educational plans*, an the other *planning documents* in the Navy, we first of all *noticed a too short schedule* (short number of hours) concerning the physical training of the naval students, they having been accorded the same number of physical training hours, as for the students in philosophy, litterature or ...theology, not at all correct with their status, with their future activity, the professional needs of the navigators. We also have to notice, that until the research we made, the schedule involved mostly, *general physical training*. The mentioned psycho-motional training having in these circumstances a very reduced presence, compared to the necessary training time, requested by the navigation activities.

3. When *analyzing the results of the sociological investigation questionnaire,* we learnt the scientists are very aware about the need of alloting a larger number of these training hours in the naval education, in order to improve their specific qualities in physical training.

We got the meaning of the same idea, when analyzing *the rules and the regulations,* generally coordinating the navigation activities. We concluded these rules were not supported by practical plans, they were somehow unefficient, therefore, just because they lack a scientific method to replace the traditional model of training, and improve the practical plan, including the legal rules approved until this moment.

4. In order to follow the ideas proposed by this task we use on one hand a pack of *traditional tests,* taken from the specific navigation litterature, but we also involved *new specific tests* studied and applied before, with concrete results in the field, having good evaluation and appreciation scales.

5. The results we obtained during the experimental stage II relieved very clear, and also experimentally demonstrated that the ***optimal model applied in the specific physical and psycho-motional training*** of the naval students was a brilliant one, a very successful one, deeply in accordance with the specificity of the physical and psycho-motional requests of the navigation activity. We demonstrated that the tudents reached the highest level of the parameters we followed, as they were asked to answer. We elaborated ***„a navigator's model"*** having figured parameters, objectives in every way, for all cathegories of age, experience and others, involved in the navigation activities. Such a thing, was first time realised by us in the Navy.

7. METHODICAL - PRACTICAL RECOMMENDATIONS

1. The results obtained optimizing the structure and the contents of the physical and psycho-motional training of the naval students demonstrated the true way we acted in the experiment, a valuable research and also, the need to generalize the new optimal system, to extend it and apply it to the whole naval personnel.

2. The structure of organizing the professional activities aboard ships has to compulsory include the training due to obtain the highest rate of results in the professional activities in the open sea, as the sea is calm, as well as to perform ***The ship's roles*** (*„man overboard", „fire on board", „waterhole on board, flooding", „abbandon ship", „save and secure the others in the wreckage case", etc.)*

Therefore the practical training of the navigators is needed (to train on and on, all the time), in order to form and maintain the physical capabilities and a real capacity to perform the specific psycho-motional acts, needed inorder to navigate, no matter the conditions, in any situation.

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APPROXIMATION BY PROJECTION OF SOME OPERATORS

Approximation by projection of some operators, Eleonora Răpeanu

"Maritime" University Constanța

ABSTRACT

It is studied the approximation of nonlinear-local operators through the linear ones and it is proposed the resolving scheme of some operational equations.

1. INEGALITIES USED TO EXTEND THE OPERATORS

1.1 Let $X = C^1[0,1]$ with $u(0) = 0$.

Of inequality $u(x) = \int_0^x \frac{du}{dt}\,dt$ result

$$|u(x)| \le \int_0^x \frac{du}{dt}\,dt \le \int_0^1 \left|\frac{du}{dt}\right| dt \le \sqrt{\int_0^1 \left(\frac{du}{dt}\right)^2 dt}$$

$$|u(x)|^p \le \sqrt{\int_0^1 \left(\frac{du}{dt}\right)^2 dt}^{\,p}.$$

Integrate on [0,1]

$$\int_0^1 |u(x)|^p \le \int_0^1 \left(\sqrt{\int_0^1 \left(\frac{du}{dt}\right)^2 dt}\right)^p = \sqrt{\int_0^1 \left(\frac{du}{dt}\right)^2 dt}^{\,p}.$$

Completely extract the order *p*

$$\sqrt[p]{\int_0^1 |u(x)|^p} \le \sqrt{\int_0^1 \left(\frac{du}{dx}\right)^2 dx}.$$

Result $\|u\|_{L_p} \le \|u\|_{H^1}$ with $u(0) = 0$.

Closure of X in the norm L_p is L_p, closure of X in the norm H^1 with $u\ u(0) = 0$ is H^1 with $u(0) = 0$, result H^1-convergence with $u(0) = 0$ implies convergence in any L_p. Convergence in H^1 implies convergence in L_∞ and as functions in H^1 are continuous result uniform convergence.

In addition $\int_0^1 |u(x)|^p \le \left(\int_0^1 \left(\frac{du}{dx}\right)^2 dx\right)^{\frac{p}{2}}$.

1.2 Other inequalities

Let $u, v \in H(0,1)$ with $u(0) = 0$

$$\int_0^1 |u(x)|^p\,|v(x)|^q\,dx \le \sqrt{\int_0^1 u(x)^{2p}\,dx}\sqrt{\int_0^1 v(x)^{2q}\,dx} \le$$

$$\le \left(\int_0^1 u'(x)^2\right)^p \left(\int v'(x)^2\right)^q \le$$

$$\le \frac{1}{2}\left[\left(\int_0^1 u'(x)^2\right)^{2p} + \left(\int_0^1 v'(x)^2\right)^{2q}\right]$$

These inequalities can be used for extensions of such operators $y' + y^n$ from C' to $H_0^1(0,1)$.

2. NONLINEAR EQUATIONS WHICH LEAD US TO PROJECTIVE SCHEMES

Consider equation

$$-y'' + y^3 = f, \quad y(0) = y(1) = 0$$

$$P_y = -y'' + y^3$$

$P : C^2(0,1) \cap C[0,1]$ with $y(0) = y(1) = 0$.

2.1 If equation has classical solution then it is unique solution

Let $y_1, y_2 \in Dom(P)$, $P(y_1) = P(y_2)$ result

$-(y_1 - y_2)'' + y_1^3 - y_2^3 = 0$

multiplying the equation with $(y_1 - y_2)$ obtain

$$-\int_0^1 \left[(y_1(x) - y_2(x))''(y_1(x) - y_2(x)) + \right.$$

$$\left. + (y_1(x)^3 - y_2(x)^3)(y_1(x) - y_2(x))\right] dx = 0$$

$$\int_0^1 (y_1(x) - y_2(x))^2\,dx \le \int_0^1 (y_1(x) - y_2(x))'^2\,dx +$$

$$\int_0^1 (y_1(x) - y_2(x))^2 \left(y_1(x)^2 + y_1(x)y_2(x) + y_2(x)^2\right) dx = 0$$

result $y_1 = y_2$.

2.1 If the equation hasn't classical solution

$$-\int_0^1 y(x)'v(x)dx + \int_0^1 y(x)^3 v(x)dx = \int_0^1 f(x)v(x)dx$$

$$f \in L_2(0,1)$$

$$\int_0^1 y(x)'v(x)'dx + \int_0^1 y(x)^3 v(x)dx = \int_0^1 f(x)v(x)dx$$

$v \in Dom(P)$, $H_0^1(0,1)$ with product

$$(u,v) = \int_0^1 u(x)'v(x)'dx + \int_0^1 u(x)v(x)$$

$$a(u,v) = \int_0^1 u(x)'v(x)'dx$$

give equivalent norms, where $H_0^1(0,1)$ is completed $Dom\ (P)$ of in one of the two norms equivalent.

$$b(u,v)=\int_0^1 u(x)'v(x)'dx+\int_0^1 u(x)^3v(x)dx$$

makes sense on $H_0^1(0,1)\times H_0^1(0,1)$.

If $(y_n,v_n)\to(y_0,v_0)$ in $H_0^1(0,1)\times H_0^1(0,1)$ result $b(y_n,v_n)\to b(y_0,v_0)$.

$$b(y_n,v_n)-b(y_0,v_0)=$$
$$=b(y_n,v_n-v_0)+b(y_n-y_0,v_0)=$$
$$=\int_0^1 y_n'(v_n-v_0)'dx+$$
$$+\int_0^1 y_n{}^3(v_n-v_0)dx+\int_0^1 (y_n{}^3-y_0^3)v_0dx$$

$$|b(y_n,v_n)-b(y_0,v_0)|\le\left|\int_0^1 y_n'(v_n-v_0)'dx\right|+$$
$$+\left|\int_0^1 y_n{}^3(v_n-v_0)dx\right|+\left|\int_0^1 (y_n{}^3-y_0^3)v_0dx\right|$$

Taking part each term we have:

$$\left|\int_0^1 y_n'(v_n-v_0)'dx\right|=|a(y_n,v_n-v_0)|\le$$
$$\le\|y_n\|_a\cdot\|v_n-v_0\|_a\to 0$$

because $\|y_n\|_a$ is bounded and $\|v_n-v_0\|_a\to 0$.

$$\left|\int_0^1 y_n{}^3(v_n-v_0)dx\right|\le\sqrt{\int_0^1 y_n{}^6dx}\cdot\sqrt{\int_0^1(v_n-v_0)^2dx}\to 0$$

Because convergence in $H_0^1(0,1)$ implies convergence in any L_p results $\sqrt{\int_0^1 y_n{}^6dx}$ bounded and $\sqrt{\int_0^1(v_n-v_0)^2dx}\to 0$.

$$\left|\int_0^1(y_n{}^3-y_0^3)v_0dx\right|\le\sqrt{\int_0^1(y_n-y_0)^2\left(y_n{}^2+y_ny_0+y_0{}^2\right)dx}\cdot\sqrt{\int_0^1 v_0{}^2dx}\le$$
$$\le\sqrt[4]{\int_0^1(y_n-y_0)^4dx}\cdot\sqrt[4]{\int_0^1\left(y_n{}^2+y_ny_0+y_0{}^2\right)dx}\cdot$$
$$\cdot\sqrt[4]{\int_0^1 v_0{}^2dx}\to 0$$

because $\sqrt[4]{\int_0^1(y_n-y_0)^4dx}\to 0$ in any L_p and $\sqrt[4]{\int_0^1\left(y_n{}^2+y_ny_0+y_0{}^2\right)^4dx}$ is bounded sequence. Then $b(y_n,v_n)-b(y_0,v_0)\to 0$ result continuity $b(y,v)$.

If $b(u_1,v)=b(u_2,v_0)\quad\forall V\in H_0^1(0,1)$ result $u_1=u_2$. The equation has the unique generalized solution. It enough to take $v=u_1-u_2$ and then

$$0=b(u_1,u_1-u_2)-b(u_2,u_1-u_2)=\int_0^1(u_1-u_2)'^2dx+\int_0^1(u_1{}^3-u_2{}^3)(u_1-u_2)dx\ge$$
$$\ge\int_0^1(u_1-u_2)'^2$$

result $u_1=u_2$, u is the unique solution.

Existence of solution:

Separable Hilbert space $H_0^1(0,1)$ has a base Schauder and let $v_1,\cdots,v_{n_0},v_{n_0+1}$ where for any $i>n_0$ orthogonal to v_j any $i\ne j,\ j\ge 1$. $Dom\ (P)$ consider the operators

$$Q_{u_0}(u)=P(u_0+u)-P(u_0)=-u''+(u_0+u)^3-u_0{}^3$$
$$b_{Q_{u_0}}(u,v)=\int_0^1 u'v'dx+\int_0^1\left[(u_0+u)^3-u_0{}^3\right]v\,dx$$

are extending by continuity of $Dom(P)\times Dom(P)$ to $H_0^1(0,1)\times H_0^1(0,1)$.

$Dom\ (P)$ consider the operators $-y''$, y linear space generated by them $\alpha(-y'')+\beta y$. Linear and symmetrical forms attach:

$$C_{\alpha\beta}(u,v)=\alpha\int_0^1 u'v'dx+\beta\int_0^1 u\,v\,dx\cdot$$

These forms can be extended by continuity from $Dom(P)\times Dom(P)$ to $H_0^1(0,1)\times H_0^1(0,1)$.

Similar

$$\alpha_0(P(u_0+u)-P(u_0))+\alpha_1(P(u_1+u)-P(u_1))+\cdots$$
$$\cdots+\alpha_k(P(u_k+u)-P(u_k))+\beta(-u'')+\gamma_u$$

Bilinear attached forms may be extended by continuity from $H_0^1(0,1)\times H_0^1(0,1)$.

For an operator of the form

$$Q=\alpha(P(u+u_0)+P(u_0))+\beta(-y'')+\gamma\,y$$

with $b_Q(u,v):H_0^1(0,1)\times H_0^1(0,1)\to\Re$ are linear in v, and continued in u, v. For two such operators relative to base $v_1,\cdots,v_{n_0},v_{n_0+1},v_n$ enter the symmetric form

$$\langle Q_1,Q_2\rangle=\int_{[-1,1]^{n_0}\times[-1,1]^{n_0}} b_{Q_1}\left(\sum_{i=1}^{n_0}\alpha_iv_i,\sum_{j=1}^{n_0}\beta_jv_j\right)\cdot$$
$$\cdot b_{Q_2}\left(\sum_{i=1}^{n_0}\alpha_iv_i,\sum_{j=1}^{n_0}\beta_jv_j\right)d\alpha_1\ldots d\alpha_{n_0}d\beta_1\ldots d\beta_{n_0}+$$
$$+\sum_{n\ge n_0}\frac{1}{2^n a_n}\int_{[-1,1]^n\times[-1,1]^n} b_{Q_1}\left(\sum_{i=1}^{n}\alpha_iv_i,\sum_{j=1}^{n}\beta_jv_j\right)\cdot$$
$$\cdot b_{Q_2}\sum_{i=1}^{n}\alpha_iv_i,\sum_{j=1}^{n}\beta_jv_j)\,d\alpha_1\ldots d\alpha_n\,d\beta_1\ldots d\beta_n\ .$$

The relation

$$b_Q(u,v)=\langle Qu,v\rangle_{L_2}$$

on $Dom\, Q$ and the construction of b resulting symmetry and linearity of each argument and semipozitivity bilinear form.

$a_n \uparrow \infty$. We need a finite number of operators and if you find a_n (good all over). So that noting

$$Q_1(u) = P(u+u_0) - P(u_0)$$
$$Q_2(u) = -u''$$
$$Q_3(u) = u$$

$\langle Q_1, Q_1 \rangle$ convergent, $\langle Q_2, Q_2 \rangle$ convergent, $\langle Q_3, Q_3 \rangle$ convergent.

Scalar product of construction is apparent that

$$\int_{[-1,1]^n \times [-1,1]^n} b_{Q_1}(\sum_{i=1}^n \alpha_i v_i, \sum_{j=1}^n \beta_j v_j) \cdot b_{Q_2} \cdot$$
$$\cdot (\sum_{i=1}^n \alpha_i v_i, \sum_{j=1}^n \beta_j v_j)\, d\alpha_1 ... d\alpha_n\, d\beta_1 ... d\beta_n =$$
$$= \frac{2}{3} \int_{[-1,1]^n} b_{Q_1}(\sum_{i=1}^n \alpha_i v_i, v_j)\, b_{Q_2}$$
$$\cdot (\sum_{i=1}^n \alpha_i v_i, v_j)\, d\alpha_1 ... d\alpha_n \cdot \int_{[-1,1]^n} b_Q^2(\sum_{i=1}^n \alpha_i v_i, v_j) d\alpha = 0$$

involve

$$b_Q(\sum_{i=1}^n \alpha_i v_i, v_j) = 0 \quad \forall j$$

result

$$\left\langle Q(\sum_{i=1}^n \alpha_i, v_i), v_j \right\rangle = 0 \quad \forall j$$

and

$$Q(\sum_{i=1}^n \alpha_i, v_i) = 0 \cdot$$

For $x \in H_0^1(0,1)$, x write unique form

$$x = \sum_{i=1}^{\infty} \alpha_i v_i$$

of $x_n = \sum_{i=1}^n \alpha_i v_i \to x$ and $Q(\sum_{i=1}^n \alpha_i, v_i) = 0$ result $Q = 0$.

Bilinear form is introduced a scalar product.

If our equation for $u_0 \in H_0^1(0,1)$ project

$$Q(u) = P(u+u_0) - P(u_0)$$

on linear variety $Q_\lambda = -u'' + \lambda u$ with $\lambda \in \Re$.

Result

$$\langle Q - Q_\lambda, I \rangle = 0 \cdot$$

Noting $Q_2 = (u+u_0)^3 - u_0^3$

$$\langle Q_2 - \lambda I, I \rangle = 0$$

result

$$\lambda = \frac{\langle Q_2, I \rangle}{\langle I, I \rangle}, \quad \lambda > 0$$

projection is $-u'' + \lambda u$ with λ above.

Noting λ_n the projection of $(u+u_n)^3 - u_n^3$ we make iterative sequence

$$u_0 \in H_0^1(0,1)$$
$$u_1 = u_0 + v_0$$

where v_0 is the solution equation: $-u'' + \lambda_0 u = f - P(u_0)$ with $u_2 = u_1 + v_1$ and v_1 is the solution equation: $-u'' + \lambda_1 u = f - P(u_1) \cdot$

As $\lambda_n > 0$

$$L_{\lambda_n} = -u'' + \lambda_n u$$

are symmetric positive definite and invertible operators

$$u_{n+1} = u_n + L_{n+1}^{-1}(f - P(u_n)) \cdot$$

Such schemes in which each local projection operator improve the general schemes and the convergence of Newton-type method-type fractional steps; we use both to demonstrate the solution and to approximate the solution.

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