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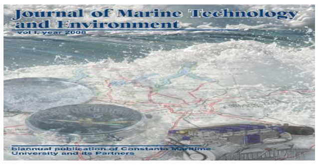

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CONTENTS

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APPLICATIONS IN MATLAB USING FINITE ELEMENT METHOD

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Abstract : Finite Element Method (FEM) is based on the concept of building complex objects using simple elements or division in small parts of complex objects easily manipulable. This paper presents the modeling equations of fluid and thermal analysis, namely equations type: hyperbolic, elliptical parabolic. It will be noted that it is important to know every step of the method as the main stage is the development model for calculating the structure. Other important steps are the domain meshing and interpolation process of meshing with the effect sharing model structure in a certain number of pieces called finite elements. Here, we will present three types of equations modeling using Matlab. Finally, we notice that there are several programs that are based on MEF instead with a user-friendly interface. Even here it is necessary to understand the method steps in order to properly model the model chosen.

Key words: finite element method, parabolic, elliptical, hyperbolic, wave.

1. INTRODUCTION

In this paper we discuss solving problems using the finite element method further noted MEF. This method is a general method for solving partial differential equations approximate that describe physical phenomena.

MEF consists of portions of the study areas and recomposing field of study respecting certain mathematical requirements.

MEF is based on the concept of building complex objects using simple elements or division in small parts of complex objects easily manipulable. The applications of this simple concept can be found easily in real life, especially in engineering, it can be extended in any field, such as:

- **Structural analysis** (determining the state of tension or deformation of a structure requested);
- **Thermal analysis** (determination of temperature field and the flow of heat from a thermal requested structure);
- **Fluid analysis** (determination of current or potential function of speed);
- **Analysis of electric / magnetic** (electric or magnetic flux determination).

Basis of this method was first formulated in 1943 by German mathematician Richard Courant of (1888-1972), which, combining with numerical analysis method Ritz issues variational calculation and minimization achieved satisfactory solution for vibration analysis systems.

Since the 70s, the finite element method was used to solve the most complex problems in the field of elastic structures continue from civil, industrial or construction of dams to ships, these cosmic.

In this paper we chose to model the equations of fluid and thermal analysis, with three types of equations: hyperbolic, elliptical parabolic.

In the first part we'll start with some basics about the finite element method analysis. It is important to know every step of the method as the main stage is the development model for calculating the structure. Other important steps are the domain meshing and interpolation process of meshing with the effect sharing model structure in a certain number of pieces called finite elements.

The following three types of equations will be modeling with MATLAB.

Finally, you will notice that there are several programs that are based on MEF instead with a user-friendly interface.

Even here it is necessary to understand the method steps in order to properly model the model chosen.

2. FINITE ELEMENT METHOD (FEM) OVERVIEW

In general, physical phenomena are described in terms of differential equations mathematically, by whose integration, boundary conditions data give an exact solution of the problem. This has the disadvantage that it is analytically applicable only to relatively simple problems. The problems arising in practice are often complex in composition to the physical and geometric parts, loading conditions, boundary conditions, etc., so the integration of differential equations is difficult or even impossible.

The finite element method is used as a starting point, a full model of the studied phenomenon. It applies a series of separate small parts of a continuous structure obtained by the mesh, known as the finite element connected to each other at points called knots.

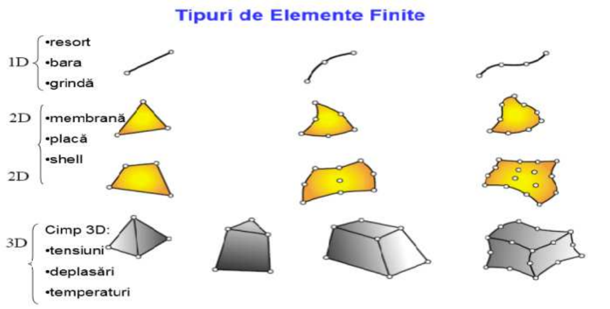


Figure 1 Types of finite elements

2.1. Steps To Solving A Problem Using The Finite Element Method

STEP 1. *Dividing range finite element analysis.*

In this step choose the type or types of finite elements suitable for the task, then divide finite element structure. This is called meshing and can be done by computer.

STEP 2. *Establishment of finite element equations (basic equations).*

Material behavior or the environment in the contents of a finite element is described by equations finite element equations called elementary. These form a system of equations of the item.

STEP 3. *Assembling basic equations in structure system equations*

The behavior of the entire structure is molded by assembling the system of equations of the finite elements in the system of equations of the structure, which in terms of physical means that the balance of the structure is conditioned by the finite element equilibrium. The assembly is necessary in the common node elements, function or unknown functions have the same value.

STEP 4. *Implementation of boundary conditions and solving the system of equations of the structure.*

The system of equations obtained from implementing appropriate boundary conditions concrete problem is solved by one of the processes obşinuite, for instance by eliminating or by digesting Gauss Choleski yield function values in knots. These are called and unknown primary or first order.

STEP 5. *Perform additional calculations to determine the unknown side.*

In some problems, after finding the primary unknowns, the analysis concludes. This is usually the case when heat conduction problems, the primary unknowns are the nodal temperatures. On other matters, however, only the unknown primary knowledge is not sufficient, the analysis must proceed with determination unknowns secondary or second order. These are higher order derivatives of the primary unknowns. Thus, for example, mechanical problems of elasticity, the primary unknowns are the nodal displacements. With their help at this stage, determine secondary unknowns that are specific strains and tensions. And if problems continue with thermal analysis can determine which side unknowns are the intensities of heat flows (thermal gradients).

3. NUMERICAL METHODS

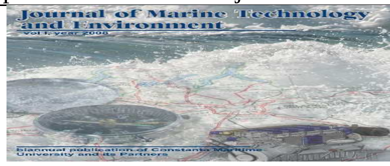
Of efficient numerical methods in finite element analysis method specified in the following Ritz and Galerkin method, exemplified by programs made in MATLAB.

3.1. Ritz Method

In 1908, W.Ritz proposed a simple and effective method for solving boundary value problems with a variational formulation. We know that solving a differential equation in a certain field and satisfying certain boundary conditions is equivalent to finding the minimum of a certain corresponding function expressed by a one-dimensional or an integral multiple full.

For example, the minimization of the functional

$$\int_a^b F\left(x, y, \frac{d}{dx}y\right) dx \qquad (1)$$



It is to determine an approximate solution to the problem variational form

$$y_n(x) = \sum_{k=1}^{n} c_k \varphi_k(x), \qquad (2)$$

functions satisfying the boundary conditions imposed occur.

Specific to the finite elements method is that minimizing the sub domain is studied, called finite elements, linked in points called nodes. As a result the minimization of the functional all the finite elements and the assembly was divided by the area over the range of the effects obtained by the finite element results in a system of algebraic equation whose solution is determined by the function values at the nodes studied. In order to minimize the finite elements domain functionalities analyzed unknown function or functions, continue throughout the area are approximated by a set of functions conventional finite element content only continue.

In the case of homogeneous conditions y (0) = 0, y (1) = 0, $\varphi_k(x)$ coordinate positions (x) may be, for example, as

$$\varphi_k(x) = (1-x)x^k$$

Or

$$\varphi_k(x) = \sin(k\pi x)$$

3.2. Galerkin method

Galerkin method is based on the weighted formula residue. For the presentation method we use this time, synthetic notations

$$Au = f, \qquad \hat{\imath}n\ \Omega$$

$$Bu\ l_{\partial\Omega} = 0 \qquad (3)$$

where A is a linear differential operator, and B is the border operator.

To determine the approximate solution of the equation, the unknown u is approximated by a combination of functions test

$$U(x) = \sum_{j=1}^{n} a_j \Phi_j(x) \qquad (4)$$

whose coefficients aj deducted from system

$$\int_{\Omega} v_i^T (Au - f) d\Omega + \int_{\partial\Omega} \bar{v}_i^T Bu\, d\,\sigma = 0. \qquad (5)$$

Here v_i and $\bar{v}_i$ are appropriately chosen test functions such as $v_i = \bar{v}_i = \Phi_i$.

Such solutions were considered approximate B.G.Galerkin mathematician (1878-1945).

An effective realization of the finite element method is obtained from the above scheme.

Choosing Φ_i functions and subspace V of V's

$$V = \{U \epsilon H^1(0,1) \setminus u(0) = 0\}$$

segmental linear functions built in.

Whether division

$$0 = x_0 < x_1 < \cdots < x_n = 1,$$

Ω that divides the items $e_j = (x_{j-1}, x_j)$ lengths and either $h = \max h_j$, where h is the norm division. It requires that the U's V be continuous on [0,1], each element e_j linear and

U(0) = 0.

$U \epsilon V$ functions can be described by their values u_j nodes. We

$$U(x) = a_1\Phi_1(x) + \cdots a_n\Phi_n(x), \qquad (6)$$

Where

$$\Phi_j(x) = \begin{cases} 1, & x = x_j \\ 0, & x = x_k \neq x_j \\ \frac{x - x_{j-1}}{h_j}, & x \epsilon (x_{j-1}, x_j). \\ \frac{x_{j+1} - x}{h_{j+1}}, & x \epsilon (x_j, x_{j+1}) \\ 0, & x \epsilon e_k, k \neq j, j+1 \end{cases} \qquad (7)$$

So the basic functions Φ_j have a value of 1 corresponding node x_j, with 0 on the other nodes and are segmental linear on each interval e_k. Obviously,

$U(x_j)=a_j$ for each one $j=1, ..., n$.

Basically, the classical Galerkin finite element type can be formulated as follows:

Find UϵV so

$$\int_0^1 (U' - f) v_h dx = 0, \forall\, v_h \in V. \qquad (8)$$

As U(x) has the form (6), choosing $v_h = \Phi_i$ for i = 1, ..., n, to obtain system

$$\sum_{j=1}^{n} \int_0^1 \Phi'_j(x) \Phi_i(x) a_j dx = \int_0^1 f(x) \Phi_i(x) dx,\ i = 1, \dots, n \qquad (9)$$

or writing matrix

$$[K][A]=[F] \qquad (10)$$

K_{ij} elements of the matrix [K] can be easily calculated (in the general case it is calculated by assembling the values of each element).

Obtained coefficients

$$K_{ii} = (\Phi'_i, \Phi_i) = \int_{x_{i-1}}^{x_i} \frac{1}{h_i} \cdot \frac{x - x_{i-1}}{h_i} dx + \int_{x_i}^{x_{i+1}} \frac{-1}{h_{i+1}} \cdot \frac{x_{i+1} - x}{h_{i+1}} dx = 0,$$

$$K_{nn} = (\Phi'_n, \Phi_n) = \int_{x_{n-1}}^{x_n} \frac{1}{h_n} \cdot \frac{x - x_{n-1}}{h_n} dx = \frac{1}{2}.$$

In addition, for i = 1, ..., n-1 have

$$K_{i-1,i} = (\Phi'_{i-1}, \Phi_i) = \int_{x_{i-1}}^{x_i} \frac{-1}{h_i} \cdot \frac{x - x_{i-1}}{h_i} dx = \frac{-1}{2},$$

$$K_{i+1,i} = (\Phi'_{i+1}, \Phi_i) = \int_{x_i}^{x_{i+1}} \frac{1}{h_{i+1}} \cdot \frac{x_{i+1} - x}{h_{i+1}} dx = \frac{1}{2}.$$

Matrix [K] has finally form

$$[K] = \frac{1}{2} \begin{pmatrix} 0 & 1 & 0 & 0 & \dots & 0 & \\ -1 & 0 & 1 & 0 & \dots & 0 & \\ 0 & -1 & 0 & 1 & \dots & 0 & \\ \vdots & \vdots & \ddots & \ddots & \ddots & \ddots & \dots \\ 0 & 0 & \dots & \dots & -1 & 0 & 1 \\ 0 & 0 & \dots & \dots & 0 & -1 & 1 \end{pmatrix}.$$

Regarding calculating [F], using quadrature simple formulas (eg trapezoid formula) is obtained for i = 1, ..., n-1

$$F_i = (f, \Phi_n) = \int_{x_{i-1}}^{x_i} f(x) \frac{x - x_{i-1}}{h_i} dx + \int_{x_i}^{x_{i+1}} f(x) \frac{x_{i+1} - x}{h_{i+1}} dx \cong \frac{f_i h_i}{2} + \frac{f_i h_{i+1}}{2}$$

$$F_n = (f, \Phi_n) = \int_{x_{n-1}}^{x_n} f(x) \frac{x - x_{n+1}}{h_n} dx \cong \frac{f_n h_n}{2}$$

where, if we choose a uniform grid $h_i = h = \frac{1}{n}$, [F] ie the system (10) become

$$[F] = h \begin{pmatrix} f_1 \\ f_2 \\ f_3 \\ \vdots \\ f_{n-1} \\ f_n/2 \end{pmatrix};$$

$$\frac{1}{2} \begin{pmatrix} 0 & 1 & 0 & 0 & \dots & 0 \\ -1 & 0 & 1 & 0 & \dots & 0 \\ 0 & -1 & 0 & 1 & \dots & 0 \\ \vdots & \vdots & \ddots & \ddots & \ddots & \vdots \\ 0 & 0 & \dots & -1 & 0 & 1 \\ 0 & 0 & \dots & 0 & -1 & 1 \end{pmatrix} \begin{pmatrix} a_1 \\ a_2 \\ a_3 \\ \vdots \\ \vdots \\ a_n \end{pmatrix} = h \begin{pmatrix} f_1 \\ f_2 \\ f_3 \\ \vdots \\ f_{n-1} \\ f_n/2 \end{pmatrix}.$$

Galerkin's method is general. It can be successfully applied to equations of different types: elliptical, hyperbolic, parabolic, even if they are not related to variational problems, which is an advantage over the method of Ritz. However, for applications related to variational problems, it is a close interdependence with Ritz's method, and in many cases is equivalent to the latter, meaning that both lead to the same approximate solution.

4. MATHEMATICAL MODELING IN MATLAB BY FINITE ELEMENT ANALYSIS

It made an application that allows the user to choose the modeling results in Matlab using finite element method for each of the three types of equations.

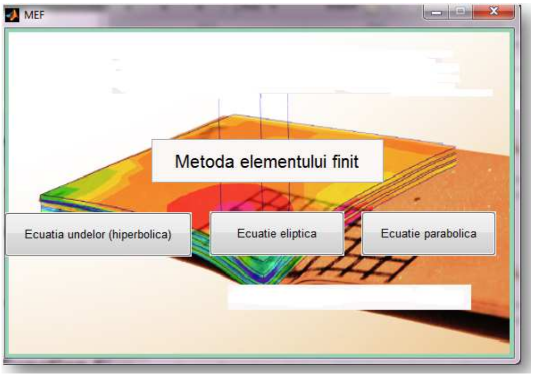


Figure 2 Interface for three types of equations in Matlab

4.1. Hyperbolic Equation

The first model chosen is the hyperbolic equation modeling especially where waves. The application allows the achievement of a movie showing the movement of the waves.

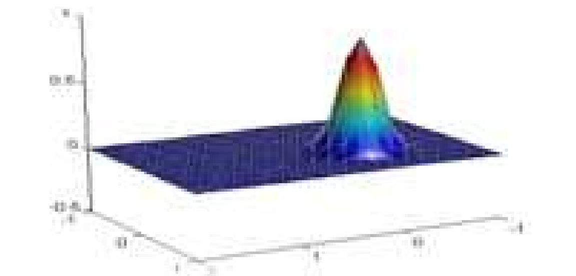


Figure 3 a) Wave equation

In these images is seen as wave height and spreads begin to decline further.

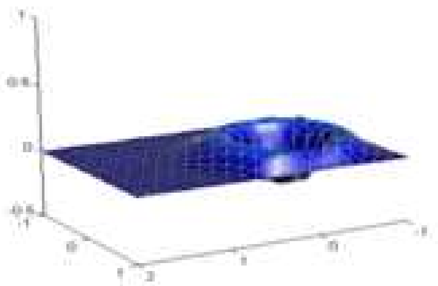


Figure 3 b) Wave equation

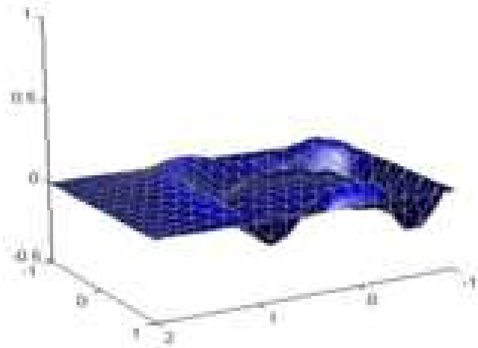


Figure 3 c) Wave equation

4.2. Elliptical Equation

For this equation to make an application to the MEF in 2D.

The equation is selected elliptical shape

$$-\Delta u = 32\left(x - x^2 + y - y^2\right):\ \text{pe}\ \Omega\ (\partial\Omega) = 0$$

with Dirichlet boundary conditions.

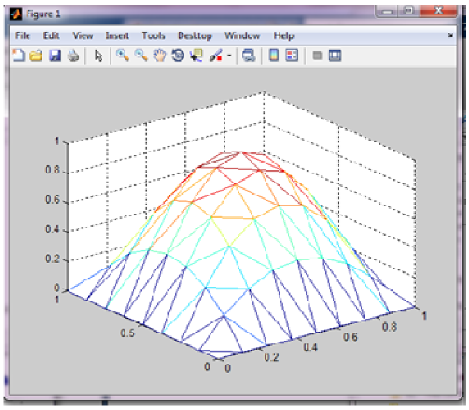
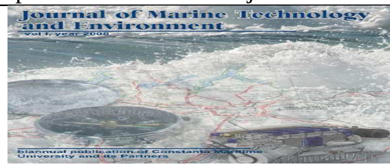


Figure 4 Elliptic equation

In the Figure 4, as a result of modeling, it is noted that the finite elements were chosen triangle type and the surface is uniform.



4.3. Parabolic Equation

For parabolic equation we chose a design that enables the modeling of the heat transfer body through the isotropic temperature-dependent heat transfer.

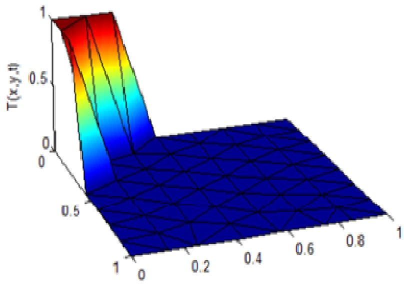


Figure 4 a) Heat transfer equation

The finite elements were all type triangle and in the following images is observed as the heat transfer from the body varies, the highest temperature being in the red and the blue color area below (Fig. 4a and Fig. 4b).

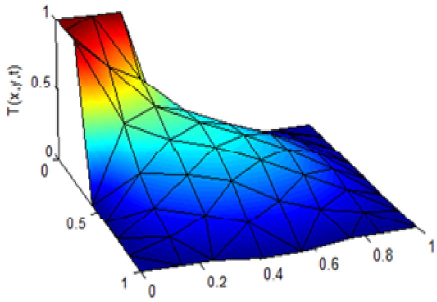


Figure 4 b) Heat transfer equation

Here, the user is able to see a movie to better understand how temperature varies and beginning to increase (as shown in Fig. 4c) as the body is subjected to certain tests.

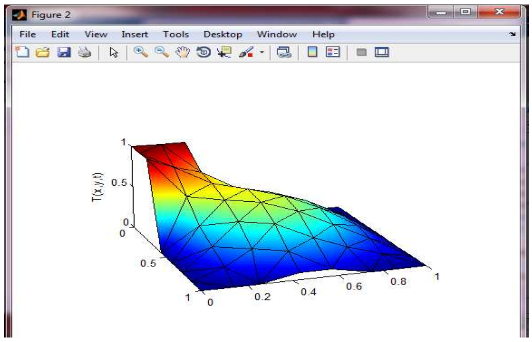
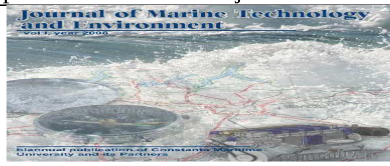


Figure 4 c) Heat transfer equation

5. CALCULATED BY COMPUTER-AIDED FINITE ELEMENT

Using a computer and appropriate software are indispensable for the application MEF as simple a structure. Even the principle of the method results in a large amount of numerical calculations that can not be achieved only on new computers with specialized software. Accordingly, FEM analysis of Analytical acquires a fence automation, which can be a trap by loss of control over the operations they carry out FEM program. For the analysis of complicated spatial structures can become difficult due to automation preprocessing model, check its accuracy, and correct errors in them and render amendments to the initial model.

At present there are numerous programs in general specialized types of problems. Some of these include: ANSYS, MIKE, FLUENT, COMSOL, NASTRAN, MOSAIC, GffTS, etc. They allow through all the stages referred to in Chapter 1 and others such as geometric model construction, introduction of information related to material, mesh geometric model, the application loads, and limit conditions, solving itself and post-processing calculations. Strong development of graphical user interfaces of computers today allows a particularly effective treatment, suggestive and rapid calculation results in the form of graphical representations of bodies compared deformed body - the body unaltered, travel by model, representing the portion of the pattern, etc.



Journal of Marine technology and Environment Year 2015, Vol. 2

5.1. Prerequisites A User M.E.F.

A user is forced to solving a particular problem. The program applied calculation method does not solve the problem but a model of it, which generally conceives user. The results can be confirmed or not, depending on how the model was chosen calculation.

Modeling is a task of simplifying the structure by including various portions of the structure in the category: bars, plates, massive bodies, by considering and bearing loads.

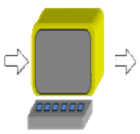
Correct modeling is a matter of experience, inspiration and not least the knowledge of the theoretical basis of the method.

Once established computing model needs to be prepared to solve the problem input. Each finite element program has certain peculiarities that must be learned, but there is a basic method that, once mastered, allows any program finite element approach.

THE STAGES OF ANALYSIS BY FEM

Large corporate programs are three important stages of solving a problem using MEF.

Table 1 – FEM solving phases

Input data (Preprocessing)	**Processing**	**Output** (Postprocessing)
Nodal coordinates; Types of bearing; Jams (boundary conditions); Loading (mechanical, thermal, etc.); Material properties; The shape, type and size of F.E.		Tensions; Movements; Temperatures; Current function; Electric / magnetic flux

Preprocessing step is preparation of input data needed to resolve a problem and save them in a data file.

Processing is effective in solving the problem numerically model. Data already prepared (in preprocessor) are taken from the data file and run the type of problem.

Postprocessing is the "viewing" stage of the results in tabular or graphical form. This phase allows evaluating and commenting on the results.

Factors that influence mesh

A number of elements which are meshing condition:

- Type Finite Element. They are chosen depending on the type and scope of analysis, required accuracy, of unknown size variation etc.

- Parabolic elements are preferable to linear, because the same number of nodes, element discretization parabolic solution is more accurate than the linear elements.

- If there are several types of finite elements, on the border between them should be mainstreamed.

- The size and number of finite elements influencing convergence solution. Note that a larger number of elements approaching the solution exact result, but an excessive increase may lead to a "collapse" due to its error by car to a large volume of calculations.

- Positioning nodes, which generally is uniform in structure. Discontinuity in geometry or in loading require the choice of intermediate nodes. Moving to an area with fine mesh one with coarse mesh should be done gradually, not suddenly.

- The degree of uniformity of the mesh. Avoid using items with elongated (very sharp triangles, rectangles with aspect ratio higher than 3). Preferably it would be like meshing with triangles contain only equilateral triangles, rectangles contain only mesh with square and type the space with elements still BRICK, especially elements still contain cubic.

6. CONCLUSIONS

This paper deals with the method MEF from mathematical point of view can be treated as a process for obtaining a numerical solutions approximate for solving a system of difference equations defined partly on a finite domain (D) with boundary conditions (boundary) data.

It was noted that the work (D) is decomposed in a finite number of simple subdomains (Finite Element), connected to each other on the borders of separation in a finite number of points called nodes. In general geometry of the domain (D) is approximated by simple subdomains meeting.

Unknown function (temperature, displacement, etc.) is approximated by locally every finite element interpolation functions defined in relation to their values in hubs located along finite elements. These functions have been termed as the basic functions.

Meeting interpolation functions for the entire domain (D) is a set of function approximation and their nodal values are generalized coordinates. Test functions are introduced into the system of differential equations and nodal values are determined by methods employed in calculating the variational (Ritz method, Galerkin).

All steps were taken to resolve the three types of equations: elliptic, parabolic and hyperbolic where he finally obtained a 2D / 3D modeling of this equation.

It was noted that there are a multitude of programs that work with finite element method, but not requiring full calculation of each user; they have a more friendly graphical interface that allow only the introduction of basic data such as the type of equation, the number of finite elements to be meshed area etc.

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PROBABILISTIC METHODS OF DECISION MAKING IN SHIPPING ACTIVITIES

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Abstract: When studying a large number of phenomena and processes, researchers strive to create simple patterns. From the wide variety of factors separate the main and the rest are considered secondary and ignored. Very often, in practice, in making management decisions in the presence of many options is the task to recalculate the probability of each hypothesis, once it has been observed event. Such circumstances can be decided by the theorem to verify the hypotheses (Bayesian formula) obtained as a consequence of the theorem for multiplication formula for the total probability. Bayesian formula can calculate conditional probabilities of each hypothesis, then most likely of them is taken as the basis for future action. To obtain the practical utility of the theorem to check the hypothesis, we examined two cases of decision arising in shipping activity.

Key words: decision making, Bayesian formula, probability event, the conditional probability of hypotheses, diagnostic indicators, technical diagnostic, analysis of the situation.

1. INTRODUCTION

When studying a large number of phenomena and processes, researchers strive to create simple patterns. From the wide variety of factors separate the main and the rest are considered secondary and ignored. The result, however, can not be freed from the influence of neglected factors, which manifests itself in the presence of errors, interference, noise or simply deviations from previously alleged condition, called random. The more accurately be predicted score, the more factors must be considered. Nevertheless, taking into account all factors is practically impossible, which means that it is impossible to obtain absolutely deterministic results.

Sometimes there are several options to fruition a complex event, look for the impact of each option. For example, complex event C (collision of two vessels) may be fulfilled in the event jointly amendment O (dangerous meeting of ships) and event $\bar{M}$ (default maneuver divergence). We want to determine the influence of each of the two events on the security of navigation.

The probability of the event C (collision of two ships) is:

$$P(C) = P(O.\bar{M}) = P(O).\ P(\bar{M}) \qquad (1)$$

The probability of the opposite event to C (no conflict $\bar{C}$) is:

$$\begin{aligned} P(\bar{C}) &= 1 - P(C) = 1 - P(O).\ P(\bar{M}) = \\ &= 1 - [1 - P(\bar{O})].[1 - P(M)] = \\ &= P(\bar{O}) + P(M) - P(\bar{O}).\ P(M) \end{aligned} \qquad (2)$$

It is evident that security management is enhanced by the appropriate choice of route ($\bar{O}$- avoid dangerous encounters) and improving maneuverability at the complex "navigator - ship".

Sometimes it is necessary to determine the probability of occurrence of some event A, which can be realized with one of the events $H_1, H_2, \ldots, H_n$, forming a complete group of incompatible events. $H_1, H_2, \ldots, H_n$ are called hypotheses, and the probability of A is given by the formula for the total probability:

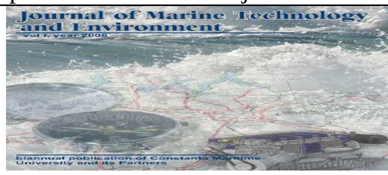
$$\begin{aligned} P(A) &= P(A\ H_1) + P(A\ H_2) + \ldots + P(A\ H_n) = \\ &= \sum_{i=1}^{n} P(H_i) + \sum_{i=1}^{n} P(A/H_i) \end{aligned} \qquad (3)$$

Very often, in practice, in making management decisions in the presence of many options ($H_1, H_2, \ldots, H_n$) there is the task to recalculate the probability of each hypothesis H_i, once it has been observed event A. Such circumstances can be resolved by theorem of verifying the hypotheses (Bayes formula) obtained as a result of the theorem of multiplication, and the formula for the total probability as follows: [2];

$$P(AH_i) = P(A).\ P(H_i/A) = P(H_i).\ (A/H_i) \qquad (4)$$

Rejecting the left side of this equation we get the equation:

$$P(H_i/A) = \frac{P(H_i).P(A/H_i)}{P(A)} = \frac{P(H_i).\ P(A/H_i)}{\sum_{i=1}^{n} P(H_i).\ P(A/H_i)} \qquad (5)$$



Here, $P(H_i)$, $i=1$-n are the probabilities of the hypotheses to the experiment and $P(H_i/A)$ is the probability of the ith hypothesis after the experiment.

Bayesian formula can calculate conditional probabilities of each hypothesis, then the most likely of them is taken as the basis for future actions.

2. PROBABILISTIC METHODS OF DECISION MAKING

To obtain the practical utility of the theorem for checking the hypotheses will consider two cases for adopting decisions, arising in shipping activity.

In the first case it comes to solving a problem in technical diagnostics of the main ship internal combustion engine. Reference is an indirect assessment of the crankshaft bearings condition through the analysis of the measurement results of two available diagnostic signs (Fig 1, Fig 2a, Fig 2b). [3, 4]

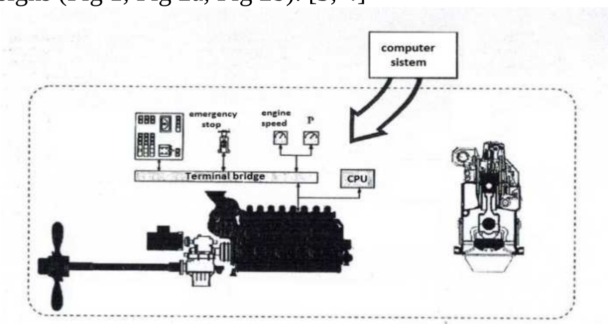


Figure 1 Control and diagnosis of internal combustion engine

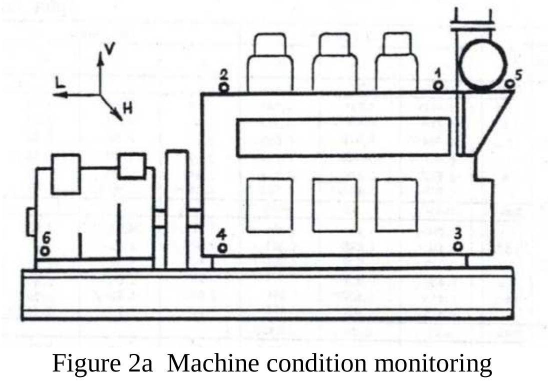


Figure 2a Machine condition monitoring

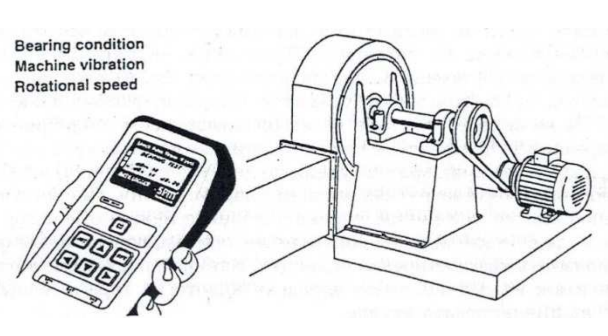


Figure 2b Machine condition monitoring

There are two cases (hypothesis):

H_1 - The current state of the assessment is good;

H_2 - The condition is not good and can be considered as a rejection.

The bearing condition is assessed indirectly by two diagnostic method measuring two diagnostic indicators:

S_1 - Noise level in the vicinity of the bearings;

S_2 - Quantity of metal impurities in samples of crankcase oil.

From preliminary data it is known that at the time of assessment the probability the subject to be in good condition (H_1) is $P(H_1) = 0.6$, and not in good (H_2) is $P(H_2) = 0.4$.

Two diagnostic ways are based on indirect measurements and with no absolute assurance. From preliminary experiments it was found that the credibility of the first method is $P_1 = 0.6$ $(q_1 = 0.4)$ and the second $P_2 = 0.7$ $(q_2 = 0.3)$.

Adopting the best solution in various combinations of diagnostic conclusions in both methods is required.

The following cases are possible:

First case: Prepared message (event A): diagnostic conclusions of the two methods are that the state of the object is good. Conditional probabilities of hypotheses $P(H_1)$ and $P(H_2)$ after the occurrence of the event A are recalculated by using formula (5).

As a result:

$P(H_1) = 0.6;\ P(A/H_1) = P(A/H_1) \,.\, P_2 = 0.6.\ 0.7 = 0.42,$

i.e. both sensors give correct conclusions in hypothesis H_1 **.**

Then:

$$P(H_1/A) = \frac{P(H_1).P(A/H_1)}{P(H_1).P(A/H_1) + P(H_2).P(A/H_2)} = 0.84 \qquad (6)$$

and

$P(H_2) = 0.4;\ P(A/H_2) = P(H_2).q_2 = 0.12$**,**

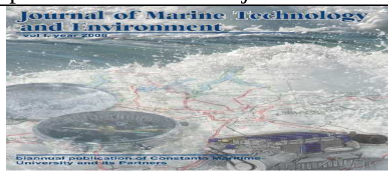
in case H_2 both sensors give false conclusions.

Exactly this value is substituted as a general product in the second member of the denominator of the expression (6). As for the $P(A/H_2)$, according to the above, below expression is calculated:

$$P(H_2/A) = \frac{P(H_2).\ P(A/H_2)}{P(H_1).\ P(A/H_1) + P(H_2).\ P(A/H_2)} = 0{,}16;$$

$$i.\ e.\ P(H_1/A) > P(H_2/A) \qquad (7)$$

Then, upon receipt of the message, marked as an event A, the hypothesis of the good condition of the bearings is assumed to conditional probability, greater than the output, i. e. 0.84 > 0.6.



Second case: Obtained message (an event A) that the diagnostic findings and the two methods indicate poor condition of the object, i. e. a failure occurred. According to initial conditions: $P(H_1)$ = 0.6; $P(A/H_1) = (P\ (H_2)\ .q_2)$ = 0.4 . 0.3 = 0.12 - this means that the correct hypothesis and both sensors give wrong conclusions.

Then:

$$P\ (\ H_1/\ A) = \frac{P(H_1).P(\ A/H_1)}{P(H_1).P(A/H_1)+P(H_2).P(A/H_2)} = 0{,}3 \qquad (8)$$

since:

$P(H_2)$=*0.4,* a $P(A/\ H_2 P(H_1).P_2$ = *0.6 . 0.7 = 0.42,*

i.e. the object is damaged and sensors provide very accurate readings.

Then:

$$P(H_2/A)= \frac{P(H_2).P(A/H_2)}{P(H_1).P(A/H_1)+P(H_2).P(A/H_2)} = 0.7 \qquad (9)$$

In this case, upon receipt of a message A, with conditional probability, greater than output, i. e. 0.7 > 0.4, the hypothesis of a failure in the bearings is accepted.

Third case: a received message A has the following nature: the method based on acoustic measurements carries information to good condition, and the study of metal impurities in the oil shows poor condition. According to the accepted initial conditions will occur:

$$P(H_1 = 0{,}6; P(A/H_1)=P(H_1).\ q_2=0.6\ .\ 0.3=0.18,$$

which means that the first method gives true, and the second - false conclusion.

Then:

$$P(H_1/A) = \frac{P(H_1).P(A/H_1)}{P(H_1).P(A/H_1)+P(H_2).P(A/H_2)} = 0.49 \qquad (10)$$

since:

$P(H_2)$ = *0.4,* a $P(A/H_2) = P(H_2).\ P_2$ = *0.4 . 0.7 = 0.28,*

i. e. the object is damaged, the first method shows false and the second shows true.

And

$$P(H_2/A)=\frac{P(H_2).P\left(\frac{A}{H_2}\right)}{P(H_1).P\left(\frac{A}{H_1}\right)+P(H_2).P\left(\frac{A}{H_2}\right)} = \frac{0.112}{0.22} \approx 0.51 \qquad (11)$$

There is a reason to accept the hypothesis of rejection. To make more definite conclusion it is necessary to conduct several measurements. If as a result $P\,(H_2/A)$ increases, the hypothesis of a rejection is confirmed.

Fourth case: Obtained message whereby acoustic method brings about rejection, while the analysis of the oil shows good condition. The known procedure is carried out again:

$P(H_1)$ = *0.6;* $P(A/H_1) = P(H_2).P_2$ = *0.4 . 0.7 = 0.28,*

i. e. in correct hypothesis H_1, the first method is wrong, and the second gives the correct result.

In this situation:

(8)

$$P\ (H_1/A\ ) =\frac{P(H_1).P\ (A/H_1)}{P(H_1).P(A/H_1)+P(H_2).P(A/H_2)}=0.7 \qquad (12)$$

since:

$P(H_2)$ = *0.4, a* $P(A/H_2) = P(H_1).\ q_2$ = *0.6 . 0.3 = 0.18,*

i.e. the object is damaged, the first method has true, and the second - false indication.

$P\ (H_2/A)$ is checked by using:

$$P(H_2/A) = \frac{P(H_2).P(A/H_2)}{P(H_1).P(A/H_1)+P(H_2).P(A/H_2)} = 0.3 \qquad (13)$$

There is a reason to accept the H_1 hypothesis of a good condition. But here again to express more definite opinion, several consecutive measurements have to be performed.

To avoid hasty or inaccurate conclusions, conditional probabilities of the hypothesis in other inputs are calculated. The credibility of the two diagnostic ways are preserved P_1 = *0.6;* q_1 = *0.4;* P_2 = *0.7;* q_2 = *0.3,* and is assumed that the probability of the hypothesis for good condition is bigger $P\ (H_1)$ = *0.9,* and $P\ (H_2)$ = *0.1.* Again four cases are considered. In order not to clutter the exhibition, the final results are pointed straight, as it was clearly shown how to perform all the calculations - given entries from (5) and (6).

First case: Both methods give information to good condition.

(10)

$$P(H_1/A) = 0.969 > 0.9;\ P(H_2/A) = 0.031 < 0.1 \qquad (14)$$

It is accepted the hypothesis of good condition which is conditional probability $P(H_1/A)$. Moreover, it is greater than the other 0.969 > 0.031, and has increased even further after the experiment, designated as the event A, i.e. 0.969 > 0.9.

Second case: The two methods indicate failure of the bearings.

$$P(H_1/A) = 0.72 < 0.9;\ P\ (H_2/A) = 0.28 > 0.1 \qquad (15)$$

Although the both diagnostic methods indicate a state of bearings disrepair, there is still no reason to accept this hypothesis, since the probability of the hypothesis of the absence of fault is bigger $P(H_1/A) = 0.72 > P(H_2/A) = 0.28$. However, the fact that the probability of the first hypothesis fell after measurement (0.72 < 0.9) causes to be careful and to make a final decision after conducting several consecutive measurements. The reason for the decision is due to the assumption that the refusal of new or recently refurbished products are unlikely.

Third case: The method is a basis for acoustic measurement and brings information about good, but analysis of oil - for poor condition.

$$P(H_1/A) = 0.852 < 0.9; P(H_2/A) = 0.148 > 0.1 \quad (16)$$

There is a reason to accept the hypothesis of rejection absence, as it is more possible - $P(H_1/A)$ = 0.852 > $P(H_2/A)$ = 0.148. However, the fact that probability fells after the experiment, i.e. $P(H_1/A) = 0.852 < P(H_1) = 0.9$, causes to be careful and to conduct several measurements before taking the final decision.

Fourth case: The method is based on acoustic measurements and provides information for refusal, and oil analysis for the absence of rejection.

$$P(H_1/A) = 0.93 > 0.9; P(H_2/A) = 0.07 < 0.1. \quad (17)$$

The hypothesis of the absence of rejection is accepted, as it is more possible, but the fact that $P(H_1/A) = 0.93 > P(H_1) = 0.9$ allows to be more confident that decision is correct.

In all four cases decisions are received, which relate the observations to the conclusion of a lack of rejection. This example is described to point out that the same diagnostic procedure carried out in different periods of time for work lead to different diagnostic conclusions. As mentioned above, this is due to the fact that the rejections of new (or recently renovated) products are more unlikely.

Further it can be stated that the determination of the whole complex of reliability indicators only by using the mathematical apparatus of random events is impossible. In determining the very first reliable indicator (average reliable operation) averaging operation of data with different probabilities is used:

$$\hat{t}_{\text{cp}} = \sum_{i=1}^{k} \frac{t_i n_i}{N_0} = \sum_{i=1}^{k} P_i t_i \quad (18)$$

This fact shows that the problem goes beyond the field of random events and is headed to the aparatus of random variables.

The adoption of hypotheses in one stage of solving the problem of ships maneuvering is considered as a second example. More specifically, here it is considered only one task of the general algorithm for preventing collisions, namely determined of head-on situation.

The process of management of the ship in case of maneuvering is normal navigation operation, which occurs as a result of accidental event - the collision of two or more ships. This operation should be performed safely and rationally, in accordance with the existing navigational-, hydro-, legal- and other restrictions. The entire process of control is divided into several steps, each of which is characterized by the use of specific methods and technical aids. Determining factor for successful implementation of the next stage is the timely attained high-quality results of the previous stage. From a formal point of view, the operation is divided into the following stages: choosing the route of sailing u_0, detection of another ship O_1, determine the elements of approach E_2, analysis of the situation A_3, the formation of the next trajectory F_4, performing the maneuver M_5, control deviations of the program trajectory K_6, and completion of the operation Q_7.

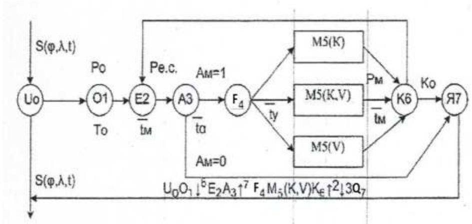


Figure 3 Logic and formal record of the stages of the operation "ship maneuvering"

The choice of the navigation route u_0 is the initial stage in which, among other tasks must assess the probability of collisions in suspected areas of sailing, look for and process additional information, etc.

The first stage during the sailing is detection of the another vessel O_1. If in conditions of good visibility and well organized watch keeping the probability of detection could be considered equal to one, then in conditions of

poor visibility, the distance of detection depends on the hydro-meteorological conditions, radar`s operating technical data, the types of counterclaims ships, the proficiency of the observer and others.

At the next stage E_2 the elements of approach and the parameters needed to analyze the situation are defined. They include: the closest point of approach (CPA), time of CPA and ships velocity vectors. In conditions of poor visibility, the navigator spends some time to obtain and to process the information, and the results can have significant errors, creating uncertainty of the situation.

Stage A_3 provides probabilistic-logical analysis of the situation, taking into account existing international and local rules of sailing, navigation and other restrictions. The various external conditions, insufficient clarity of IRPCS recommendations, in which primarily qualitative evaluations (seamanship) are used, the existence of non- deterministic constraints and signs require usage of statistical estimations of the dangerous situation.

When establishing the safety for further movement continues achieving the main purpose of the trip ($F_4 \rightarrow M_5$). In the presence of a potential danger a decision is adopted for the time and type of the collision avoiding maneuver [M_5 (K, V); M_5 (V)].

At stage K_6 further programmatic trajectory is formed considering the navigational restrictions, hydraulic characteristics and sizes of the hull, and the ability of the management system of the ship to create the necessary accelerations. The more complex the situation is and less time for analysis, the greater is the probability of wrong decisions acceptance, adopted on the basis of primarily a priori experience.

At the fifth stage A_5 the solution adopted for maneuvering is implemented with the help of the course and speed controls of the ship. The evaluation of the successful implementation of this step is formed by the basis of the optimal control theory. The deviation of the actual trajectory of the program is controlled in K_6 and either an adjustment of managing impacts is performed E_2 if necessary, or the operation is considered to be successfully implemented Q_7.

At various stages of the operation "maneuvering of the ship" various technical means are involved, some of which are united in a common complex, and a part – outside it.

Identification of the approaching ship is important in terms of the decision making speed in accordance with the international regulations for preventing collisions at sea. It is assumed that the observer’s ship sails in the area in which meetings with vessels managing business,

control or other activities i.e. vessels sailing in coastal areas are possible, where the probability of sudden meeting is real. Sailing is performed at night in a relatively poor visibility. In preliminary investigations it was found that in this region of sailing probability of moving fast boats (hypothesis H_1) is $P(H_1) = 0.3$, and the other type of vessels (e.g. fishing vessels to 200 DVT) is $P(H_2) = 0.7$.

Monitoring is carried out in two ways: - S_1 - Type detection using the signal from the radar with possible error of 2% when the distance to the object is about 4-8 nautical miles;

- S_2 - masthead lights or side lights of possible errors in these distances is about 8%* (* This data is only for illustration [1])

An event A is observed, which consists of the following message: "radar information indicates that the approaching subject is a cutter, and the visual control and analysis indicates that the object is a fishing vessel with a displacement of less than 200 DVT".

Which of these two hypotheses to accept?

The hypothesis which after the appearance of the event A is the more possible should be accepted.

- Hypothesis H_1: the approaching object is a cutter $P(H_1) = 0.3$

- Hypothesis H_2: the object is a fishing vessel $P(H_2) = 0.7$

Credibility of control methods is:

S_1: $P_1 = 0{,}98$; $q_1 = 0{,}02$: $P(A/H_1) =$
$= P_1.q_2 = 0.98 \,.\, 0.08 = 0.0784$

S_2: $P_2 = 0{,}92$; $q_2 = 0{,}08$: $P(A/H_2) =$
$= q_1.P_2 = 0.02 \,.\, 0.92 = 0.0184$.

The posterior probability of the first hypothesis after the event A is:

$$P(H_1/A) = \frac{P(H_1).P(A/H_1)}{P(H_1).P(A/H_1) + P(H_2).P(A/H_2)} = 0.645 \quad (19)$$

$P(H_2/A) = 0.345.$

The first hypothesis H_1 is accepted: the approaching object is a cutter.

To avoid hasty and misleading conclusions the part of the initial conditions will be changed. It is assume that the sailing is carried out in an area where the probabilities of hypotheses before the experience are changing:

$$P(H_1) = 0.1;\ P(H_2) = 0.9 \quad (20)$$

Posterior probability of the hypothesis after the event A, which is the same message as in the previous case:

$P(H_1/A) = 0.322$
$P(H_2/A) = 0.678$

The second hypothesis H_2 is accepted: the approaching object is a fishing vessel.

This example shows the decisive influence of the real situation in the area of navigation.

3. CONCLUSION

These algorithms, whose performance is proved, may be included in the mathematical and software systems for diagnostics and navigation complexes providing information to the ship systems of stochastic optimal control of shipping activities described in details in reference [3].

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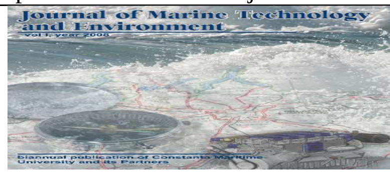

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STATISTICAL MODEL OF A LNG TERMINAL – WAYS OF IMPROVING THE LNG TERMINAL EFFICIENCY

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Abstract: The best way of improving the efficiency is to create a basic statistical model which can be used in the future for optimizing the work of a new terminal in the near future. The proposed model represents LNG terminal as queuing system. The model created is basic one but can be used as good foundation for creating a more sophisticated model once the main characteristics of the a new LNG terminal are known.

Key words: LNG terminal, statistical model, LNG supply chain, Queuing Theory, efficiency indexes.

1. INTRODUCTION

The The sea trade is essential for the development of the world economy due to the simple fact that some countries for example have oil but don't have grain and the other way around. This imbalance makes the two countries to trade. The best and cheapest way to trade large quantities of cargo is with ships, because no other transportation means can reach the productivity level of the ships. Not only from economical but also from an environmental point of view the ships are one of the cleanest ways to transport cargo having in mind the economies of scale.

Baird (2007) explains some of the advantages of the sea, and therefore maritime transport, when compared with land-based modes. "The sea is free, or virtually free, it already exists, and does not require ongoing maintenance (though this does not mean that the sea is a natural highway!). Seas tend to comprise very large and spacious areas, which are for the most part unaffected by traffic congestion, unlike roadways and railways. Sea transport capacity may be increased, substantially and speedily, through the addition of more ships, or larger ships, or faster ships, whereas to expand roadway or railway capacity requires very expensive adjustments to infrastructure, new legislation, etc. These virtues should, all things being equal, give sea transport at least some degree of economic advantage (over land-based modes), but it also means that sea transport is a fundamentally different mode conceptually from land-based modes" [1].

In this respect there is a growing necessity to evaluate the efficiency of a shipping terminal in different conditions of work. It is known that it depends on different random factors like time of arrival of the ships, transit time of the ships, availability of pilots and tugs (if necessary) etc. That is why it is hard to evaluate the efficiency.

The following research proposes a statistical model for evaluating some of the parameters like mean waiting time in the system, the expected probability of the ships to be served during different intensity of arriving and servicing time. The model will be able to simulate the arriving and the servicing of the ships with different initial data which will enable the model to be as close as possible to the real work process.

The goal of the proposed model is to reflect the work of newly build LNG terminal.

This will be achieved by solving the following problems:

- Analyzing the distribution of the arriving ships;
- Analyzing the time in the system and the structural organization of the work in the LNG terminal;
- Developing a model algorithm representing the work of the LNG terminal;

Queuing Theory will be used to present the LNG terminal as a Queuing System from a certain type. That is why we will refer to the ships as customers and the combination of berth and lines and tanks capacity as servers.

2. ARRIVAL OF SHIPS

Following Hillier (2008) example we will assume that the form of the probability distribution of interarrival times is an exponential distribution [3]:

$$D(x) = 1 - e^{-\lambda x}.$$

"The characteristics of the exponential distribution are a high likelihood of small interarrival times, well under the mean and also a small chance of a very large interarrival time, much larger than the mean. All this is characteristics of interarrival times observed in practice. Several ships might arrive quickly. Then there may be a long pause until the next arrival.

This variability in interarrival time makes it impossible to predict just when in the future arrivals will occur. When the variability is as large as for the exponential distribution, this is referred to as having random arrivals. Having random arrivals means that arrival times are completely unpredictable in the sense that the chance of an arrival in the next minute always is just the same (no more or less) as for any other minute. It does not matter how long it has been since the last arrival occurred. The only distribution that fits having random arrivals is the exponential distribution.

"The fact that the probability of an arrival in the next minute is completely uninfluenced by when the last arrival occurred is called lack-of-memory property (or the Markovian property). It implies that the probability distribution of the remaining time from now until the next arrival occurs always is the same, regardless of whether the last arrival occurred just now or a long time ago" (Hillier, 2008).

"Having made this analysis we can conclude that λ - the mean arrival rate and the $1/\lambda$ – the expected interarrival time are sufficient parameters for describing the arrival of the customers (ships) [3]".

For example:
λ = (1000 ships)/(1 year) ≈ 3 ships per day;

$1/\lambda$ ≈ 8 hours between ships on the average.

In the LNG terminals the order of arriving ships is generally known, but assuming that the ships arrive randomly we assume the worst case scenario.

3. TIME IN THE SYSTEM

According to Hillier (2008) in the queuing systems the times in the system is a sum of the times spend in the queue and the time for service. "In the queuing systems the most popular choice for the probability distribution of service times is also the exponential distribution" (Hillier, 2008).

"The symbol used for the mean of the service distribution is:

$1/\mu$ = Expected service time

The interpretation of μ itself is:
μ = expected number of service completions per unit time for a single continuously busy server [2]".

For example the expected time for a cargo operation is

$1/\mu$ = 8 hours per ship,

μ = 3 ships per day.

"From a queuing theory point of view the LNG terminal can be regarded as a Queuing System (QS) with multiple servers ($n > 1$) – multiple-server system, because there is more than one pilot and tug. The channels are using multiple pilots, multiple tugs with different speed which means that the channel is not always available when a ship arrives in other words the channel is not-fully-accessible system. In most QS when a customer (ship) arrives and there is an available server (pilot with line) it is accepted immediately for service. If all servers are busy at the moment then the ship stays in the system as waiting customer for unknown time – Wq - waiting time in the queue. Depending on the on the value of the Wq the QS are separated in three main groups differing significantly regarding the organization of the service, the mathematical formulation and the efficiency of the service" [3].

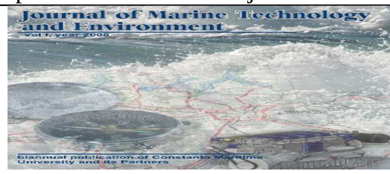
"In the QS with unlimited Wq ($Wq = \infty$) the customer arrived when all the servers are busy stays on the queue waiting until a server is available and to service it. Such systems are called systems with infinite queue.

The QS with $Wq = 0$ when a customer leaves after seeing that all the servers are busy and the service process does not matter are called systems with finite queue [2]".

4. LIMITED QUEUING SYSTEMS

"The QS that are somewhere between these two systems are mixed type of system or so called "Limited systems". There are two types of limited systems, limited by the Wq – waiting time in the queue and limited by the W – waiting time in the system.

- In the first type of limited systems the customer stays in the queue for Wq ($0 < Wq < \infty$). If in this period of time no server becomes available the customer leaves the system unattended. With this constrain only the waiting time in the queue is limited. A started service is finished even if the total time in the system exceeds the time allowed in the queue $W > Wq$.



• The second type of limited systems is when the customer is limited by the time spend in the system and leaves the system after certain time W regardless if the service is finished or not [3]".

The waiting time in the queue Wq can be defined as the time between the Estimated Time of Arrival (ETA) until the boarding of the First Pilot and the service time Ws can be defined as the time between the boarding of the First Pilot until the disembarkation of the Last Pilot. The ideal situation is when it is known the exact time at which the berth will be available so that the ship can adjust (increase/decrease) its speed. That way the waiting time in the queue will be brought to zero and the ship will be served as soon as it arrives.

In the group of Limited Systems are also included the QS that restrict the length of the queue. In these systems the customer stays in the queue only in case that the number of customers does not exceed particular number (sometimes random). In the channel case this might happen when the channel is closed or over congested and the allowed time in the system W will be exceeded.

Looking at the QS from a customer service point of view the following cases are possible:

• The available servers are taken by the order of their availability. The most recently available server is not put to work if there is another server was available earlier. Such order of work assignment is used to achieve an equal work loading of the servers, when no pilot stays without working.

• A classification of the servers is made on the basis of the customers and when the customer arrives the right server is assigned to him. This is the case when different size ships arrive with a different maneuverability and speed characteristics. Slower ships with bad maneuvering characteristics need more time and tugs than smaller ones. The server in the channel is a combination of pilot and tug availability. Depending on the terminal characteristics there might be available berth but no free tank capacity. Or there might be available tank capacity but not enough berths for the ship to moor then all the free space will be utilized to work on the currently moored ships – first case.

• The available servers are assigned to the customers in a random way. This will be the case when there is only one ship for cargo operations and the time that will be needed to be served will not affect the next ship (next ships arrives on the next day) then the place and the number of lines connected will be the optimum number required for the efficient cargo handling.

5. THE QUEUE DISCIPLINE

"When in the system there is a queue the customers are assigned to the servers in the order of their availability. That is why it is necessary to examine how the customers are chosen. This can be achieved by determining "the queue discipline" which means the rule with which customers are assigned to the recently available customer. Most common are the following versions:

• Most common is the rule of "First Comes – First Served". This might be the case when the terminal is operated from the shipper or the receiver of the cargo and the company treats all ships are with the same priority in order to minimize demurrage costs.

• The rule "Last Comes – First Served" might happen when the last ship is in a hurry and cannot wait i.e. vessel hire or demurrage is a lot more higher than the ships in the queue and they are willing to wait more (Hillier, 2008)".

• "Third rule is when the customer is chosen randomly. In this case the order by which the customers arrive is not taken into consideration and the first available customer is chosen [3]". Such order can be observed when the ship is not ready to be served, for example the relieving crew has not arrived, the cargo plan is being processed or there is a breakdown in the ship. Then the first available ship is served sooner.

• "Fourth rule is when the customers are served depending on their priority [3]". There are many reasons why a ship might be given different priorities. The terminal does not have enough storage space. The vessel is operated by the terminal Owner and they want to have the vessel, which has arrived late, to be served first in order to be ready for next business i.e. not to miss the laycan. In another case the Owner/Operator might speed up the vessel deliberately if the demurrage of the vessel is higher than the daily hire, this does not mean that the vessel will be served first.

6. QUEUING SYSTEMS WITH PRIORITY

"The QS with priority can be divided into two types:

• In the first type when a customer with a high priority arrives he waits until the customer with low priority is being served and it is assigned to the first available server. Such systems are called systems without interruption of the service or systems with relative priority.

• In the second type of systems when a customer arrives, then the server stops serving the customer with a low priority and begins serving the customer with high priority. The unattended customer either leaves the system or waits on the queue. In the second case the service begins from the point it was interrupted. Such systems are called systems with absolute priority [3]".

In shipping such system for example might be the one where ships without regasification system are with high priority in order not to lose cargo. Then, when such ship arrives the cargo operation of a vessel with re-liquefaction system has to be stopped and resumed when the vessel leaves. Although, the option for LNG carrier of leaving the port halfway served is not impossible it is highly undesirable because it might lead to losing customers.

In the LNG terminal the priority definition is based on different considerations. The priority scale for the LNG terminal can be created from considerations outside of the system like the size of the ship, the price of the cargo (more expensive cargo higher priority), the amount of money the terminal is prepared to pay for service.

The other case is when the priorities are based on the indexes related to the terminal. For example highest priority might be the minimum time spend in the system (W = min), minimum service time (W – Wq = min).

The current model will be with one priority based on speed – the fast cargo handling of the vessel.

7. CHARACTERISTICS OF THE LNG TERMINAL SHOWN AS A QUEUING SYSTEM

From the analysis above are determined the following characteristics for the LNG terminal shown as a Queuing System (QS).

1. The servers are more than one, due to the fact that a terminal has more than one berth and more than one cargo line.
2. The servers are not fully accessible, the size of the ships is limited from the draft and sometimes all the cargo lines and berths are busy.
3. Service cannot be denied to ships that arrive in the terminal, likewise they cannot wait forever to be serviced.
4. The total time in the system W should include the time needed for the ship to be serviced plus the time in the queue Wq.
5. The time spend in the queue can be approximately determined by the number of customers waiting in the queue and the time require for servicing them.

Schedule of a queuing system of a LNG terminal based on the assumptions made above is shown on Fig. 1:

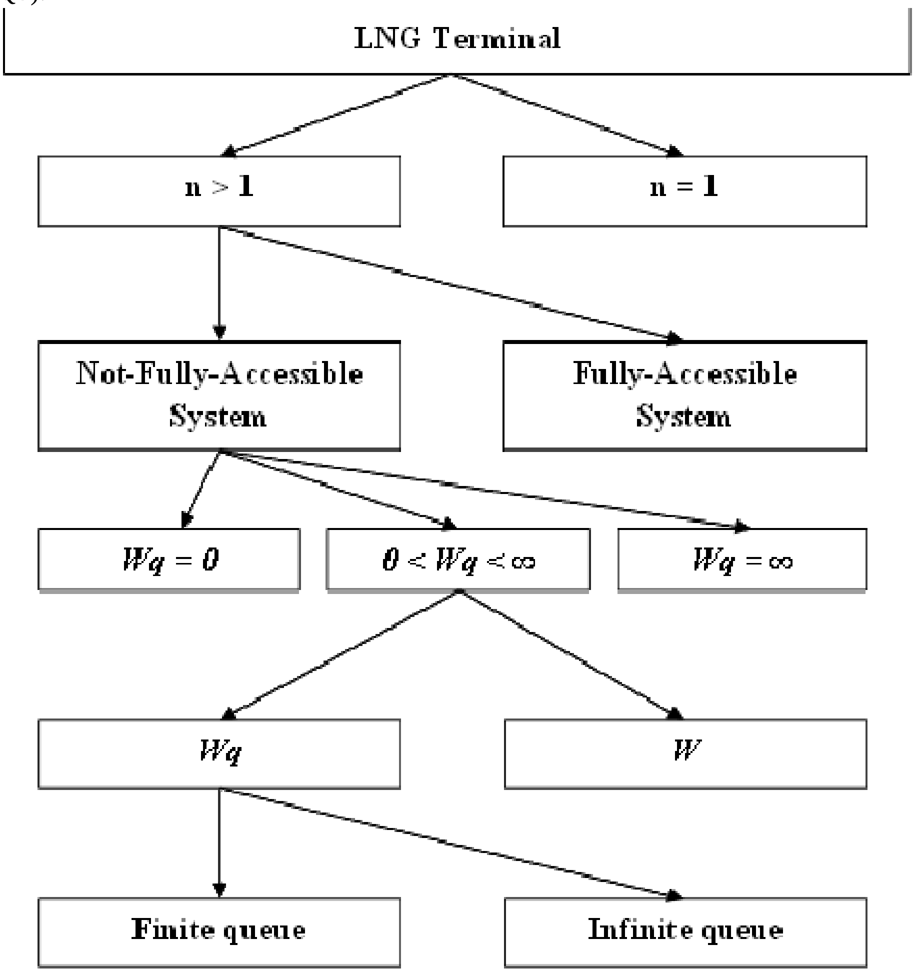


Figure 1 Schedule of a queuing system of a LNG terminal

8. EFFICIENCY INDEXES

The chosen indexes for the efficiency of the work of the proposed model are:

The probability for a delay of a customer (ship):

$P = m/n$

The average waiting time of the customers (ships)

m – the number of delayed customers;

n – the number of all arrived customers.

The indexes are restricted to only two due to the fact that in practice it is enough to know what percentage of all ships will be delayed and how long will the delay will be.

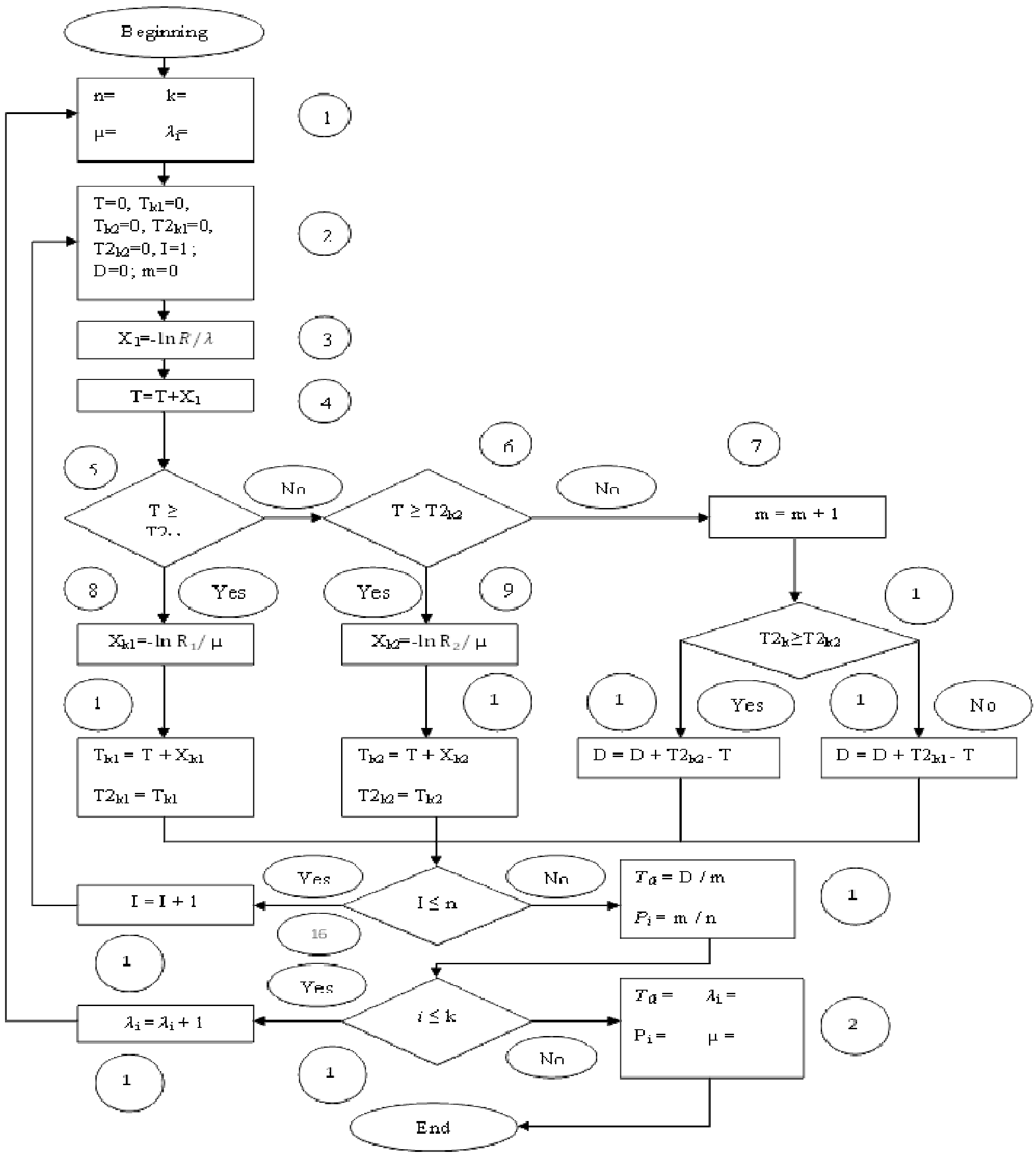


Figure 2 The model algorithm

9. THE MODEL ALGORITHM

The realization of the statistical model and the calculation of the work efficiency indexes of a LNG terminal with two servers are done by the algorithm shown in Fig. 2.

The algorithm works as follows:

In Bloc 1 is put the indicial data:

n – amount of ships;

μ - the expected time for a cargo operation;

λi - the mean arrival rate

k – the number of serviced ship from λi

In Bloc 2 are determined the initial values of the following variables:

T – arriving time of the ships;

Tk1 and Tk2 – time for service;

I – number of the current cycle;

T2k1 and T2k2 – duration of the service;

m – number of the delayed ships;

D – time of the delayed ships.

In Bloc 3 is determined the interval in which the ships arrive. This is achieved by generating a random number the realization of which is achieved with the shown formula.

In Bloc 4 determines the moments of the ships arriving.

Operator 5 checks if the first server is available.

If yes the next step is Bloc 8 in which the service time is determined with the given intensity μ.

If not the following step is in Operator 6, where a check is performed if the second server is available.

If yes next step is Bloc 9 analogical to Bloc 8.

If not next step is Bloc 7, where the number of the delayed ships "m" is determined.

Operator 10 checks which of the two servers is available.

If yes the next bloc is Bloc 13.

If not the next bloc is Bloc 14.

The working principal of blocs 13 and 14 is analogical to blocs 11 and 12.

Operator 16 checks if all ships are served.

If yes the cycle continues through Bloc 15 until its completion.

If not in Bloc 17 are calculated the average delay time of the ships – T0i, and the probability of a delayed ship – Pi.

Operator 19 checks if k has reached the number of server ships from λi.

If yes in Bloc 18 the next value of λi is adopted until every value is served.

If not next step is Bloc 20 in which the values of T_{oi} and Pi are shown.

10. CONCLUSIONS

The proposed model can help in a research and analysis of the work of future LNG terminal. The results from the research and the analysis will enable managers to create parameters and recommendations which will help optimize the work of the new terminal.

The model will be used as foundation for more complex and precise model once the main features like: draught, quayside length, number of storage tanks; are known and can be implemented in it. Then it will be possible to test the model and even create a visualized simulation of the terminal. Additional work will be done when the operator of the terminal is known. Then his requirement over the different priorities will be known and the model can be adjusted, either by adding additional ones or by changing the current one. The other part of the model which will be developed in the future is the servers. Knowing the exact number of storage tanks and berth length it will be possible to create an optimum solution for the berth storage tank allocation problem.

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OIL LEAKAGE SIMULATION AND SPILL PREDICTION NEAR ODESSA HARBOR

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Abstract: The paper presents a computer simulation of an emergency situation generated from an oil spill, inside Odessa harbor, using the software POTENTIAL INCIDENT SIMULATOR EVALUATION AND CONTROL SYSTEM (Pisces II), who it is especially designed for assessing the consequences of oil pollution on sea water.

Key words: Odessa, oil, pollution, spill.

1. INTRODUCTION

To simulate the emergency situation generated from a possible oil spill we have used the POTENTIAL INCIDENT SIMULATOR CONTROL AND

EVALUATION SYSTEM (Pisces II), which is installed at Constanta Maritime University in the Environmental Engineering Department [2].

PISCES is an incident response simulator designed for preparing and conducting command centre exercises and area drills. The application is developed to support exercises focusing on oil spill response.

The mathematical model used by the simulator is the dispersion oil-water model, taking account all external conditions [2].

The model takes into account the main physicochemical processes occurring in the oil slick, which include evaporation, dispersion, emulsification and viscosity variation.

Simulation is carried out with regard to the following environment factors: coastline, field of currents, weather, sea state, ice conditions and environmentally sensitive areas. In addition, models of response resource application including booming and recovery have been developed [1], [3], [4].

The simulator is designed to handle real situations such as oil pollution of the sea and permits to obtain the best realistic result comparing with other simulation software.

2. DATA ENTRY

A ship who is at anchor, at a distance of 7 km from shoreline, has a fuel leak. Until shipboard personnel order to rectify the malfunction, of its tanks are leaking about 475 tons (548 m^3) of heavy fuel.

This oil spill generate an emergency situation and its severity depends on the time to remedy the fault and thus the amount of oil spilled

Since we can´t know the hydrometeorological conditions we approximate their values as follows:

- weather:
  - water temperature: 8 °C
  - air temperature: 0 °C
  - sea state: 1 m
  - water density: 1 026 kg/m^3
  - cloudiness: 5
- current surface:
  - speed: 1 m/s
  - direction: 283 °
- wind:
  - speed: 15 m/s
  - direction: 225. °

Wind speed is intentionally inserted more than likely, similarly speed surface marine currents is considerably higher than the maximum existing in the Black Sea. In this way a high hazard phenomenon print more than likely, resulting in a scenario with the greatest impact.

The physical characteristics of spilled oil:

- name: BENT HORN;
- group: II;
- density: 819 kg/m^{3};
- surface tension: 53.5 dyn/cm;
- viscosity: 29.3 cSt;
- maximum water content: 70 %;
- emulsifying constant: 0 %;
- pour point: -18 °C;
- flash point: -9 °C.

3. RESULTS

The model takes into account the main physicochemical processes occurring in the oil slick, which include evaporation, dispersion, emulsification and viscosity variation.

Simulation is carried out with regard to the following environment factors:

- coastline;
- field of currents;
- weather;
- sea state;
- ice conditions;
- environmentally sensitive areas.

The simulation results are presented below:

a) At one hour after the start of pollution:

- amount spilled: 548 m^3;
- amount floating: 505 m^3;
- amount evaporated: 7.9 m^3;
- amount dispersed: 36 m^3;
- amount stranded: 0 m^3;
- amount sunk: 0 m^3;
- amount floating mixture: 1 258 m^3;
- maximum oil film thickness: 19.7 mm;
- slick area: 193 874 m^2;
- viscosity: 263 cP. (Figure 1).

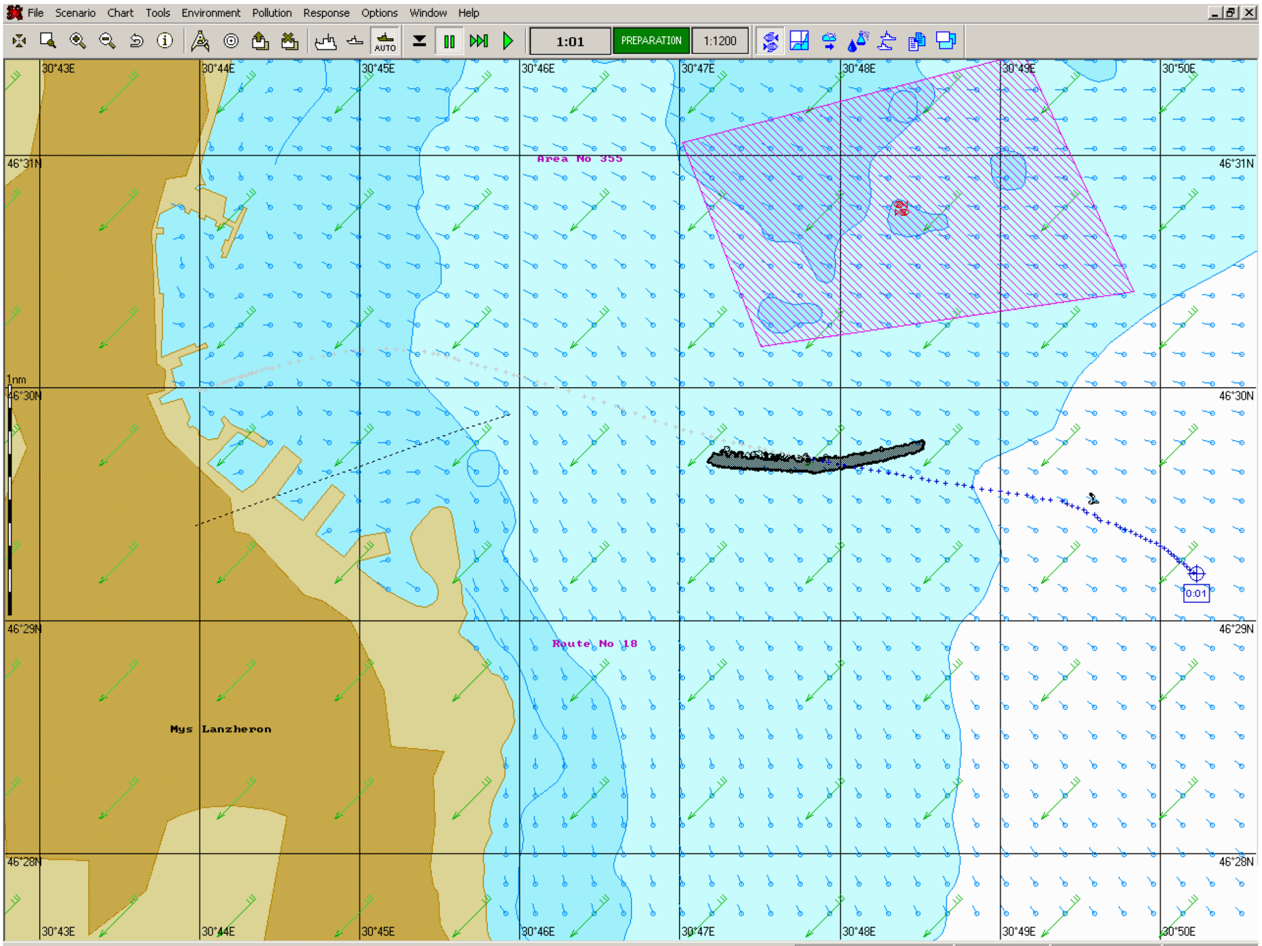

Figure 1 Evolution of oil spill (after 1st hour)

b) At six hours after the start of pollution:
- amount spilled: 548 m^3;
- amount floating: 485 m^3;
- amount evaporated: 19.2 m^3;
- amount dispersed: 42.9 m^3;
- amount stranded: 2.4 m^3;
- amount sunk: 0 m^3;
- amount floating mixture: 1 574 m^3;
- maximum oil film thickness: 205 mm;
- slick area: 258 997 m^2;
- viscosity: 649 cP. (Figure 2).

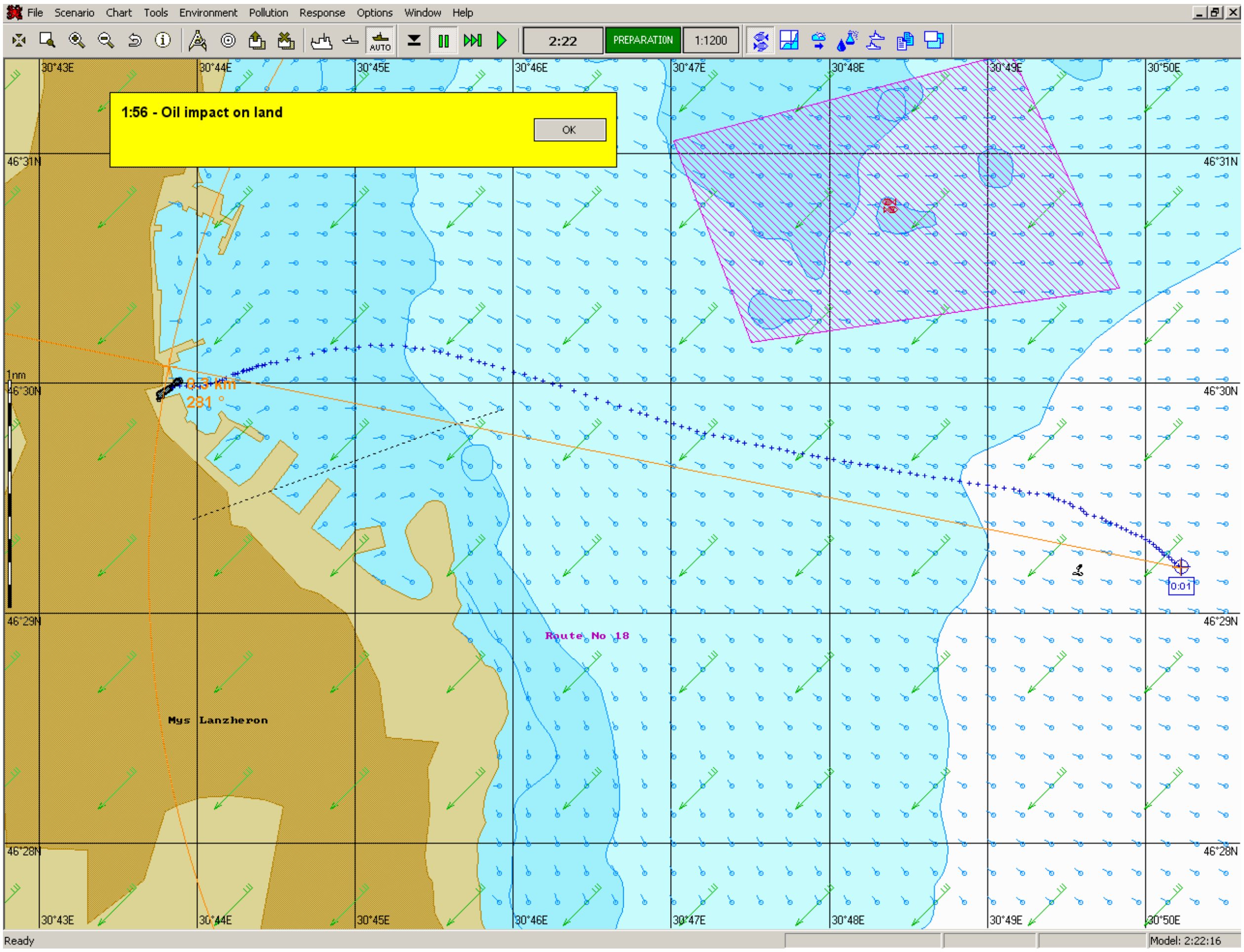

Figure 2 Evolution of oil spill (after 2nd hour)

4. CONCLUSIONS

Simulation results confirm that the shoreline pollution is imminent, but it can not reach the shore earlier than one and a half hours after the oil is spilled in the Black Sea water, so that, the entity, who is responsible in Ukraina, for environment protection and oil waist, is alarmed for this event and it is forced to use any methods to prevent pollution with spilled petroleum products, of the Black Sea shoreline.

In this case the entity, who is responsible in the matter, have a short time for prepare and move in the direction of oil spill location to isolate the spill area and instal the booms and the skimers for collecting the oil products in the sea water, so the impact of the spill on the shoreline to be as small, and in the same time to avoid an ecological disaster inside Odessa harbor.

Unless timely intervention is not organized, the harbor it will be polluted with 485 m^3 of floating spilled oil, the maximum oil film thickness will be about 205 mm and the spilled area will be about 258 997 m^2. The costs of an intervention for cleaning the shoreline in this situation will be considerably higher, and the effort will be commensurate.

Major impact produced on the environment from accidental spillage of petroleum products on the surface of water has led to the need for better monitoring of pollution and reducing the time to intervention for the organization and conduct remediation operations. Therefore, modeling of the pollution is becoming a very important and useful operation required for all institutions involved in remediation operations. [6]

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THE EVOLUTION OF AN ACCIDENTAL RELEASE OF OIL, NEAR BURGAS

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Abstract: In this paper it is presented a computer simulation for a possible prediction of an oil slick near Burgas harbor. The simulation it is carried out using POTENTIAL INCIDENT SIMULATOR EVALUATION AND CONTROL SYSTEM (Pisces II) which is a software, especially designed for assessing the consequences of oil pollution on sea water. PISCES is an incident response simulator designed for preparing and conducting command centre exercises and area drills. The application is developed to support exercises focusing on oil spill response. The model takes into account the main physicochemical processes occurring in the oil slick, which include evaporation, dispersion, emulsification and viscosity variation. Simulation is carried out with regard to the following environment factors: coastline, field of currents, weather, sea state, ice conditions and environmentally sensitive areas. In addition, models of response resource application including booming and recovery have been developed [1], [3], [4].

Key words: oil spill, pollution, simulation.

1. INTRODUCTION

The simulation is performed with POTENTIAL INCIDENT SIMULATOR CONTROL AND EVALUATION SYSTEM (Pisces II), which is a computational model used by specialists to assess the consequences of water pollution with oil [5].

The mathematical model used by the simulator is the dispersion oil-water model, taking account all external conditions [2].

2. DATA ENTRY

It is assumed that at some point a point source of 500 tones of petroleum product (573 m^3) is spilled suddenly on the Black Sea water at an approximate distance of 17 km from shore.

Since we can´t know the hydrometeorogical conditions we approximate their values as follows:

- weather:
  - water temperature: 8 C;
  - air temperature: 0 C;
  - sea state: 0.2 m;
  - water density: 1026 kg/m^3;
  - cloudiness: 5.
- current surface:
  - speed: 0.5 m/s;
  - direction: 225,
- wind:
  - speed: 10 m/s,
  - direction: 225 .

Wind speed is intentionally inserted more than likely, similarly speed surface marine currents is considerably higher than the maximum existing in the Black Sea. In this way a high hazard phenomenon print more than likely, resulting in a scenario with the greatest impact.

The physical characteristics of spilled oil:

- name: KUWEIT;
- group: III;
- density: 873 kg/m^3;
- surface tension: 13.4 dyn/cm;
- viscosity: 25.2 cSt;
- maximum water content: 90%;
- emulsifying constant: 0 %;
- pour point: -20 C;
- flash point: 25 C.

3. RESULTS

The pollution development scenario obtained from the PISCIS Simulator, is presented below:

a) An hour after the start of pollution:
- amount spilled: 573 m^3;
- amount floating: 563 m^3;
- amount evaporated: 4.2 m^3;
- amount dispersed: 5.4 m^3;
- amount floating mixture: 1 255 m^3;
- maximum oil film thickness: 24.8 mm;
- slick area: 95 753 m^2;
- viscosity: 166 cP. (Figure 1).

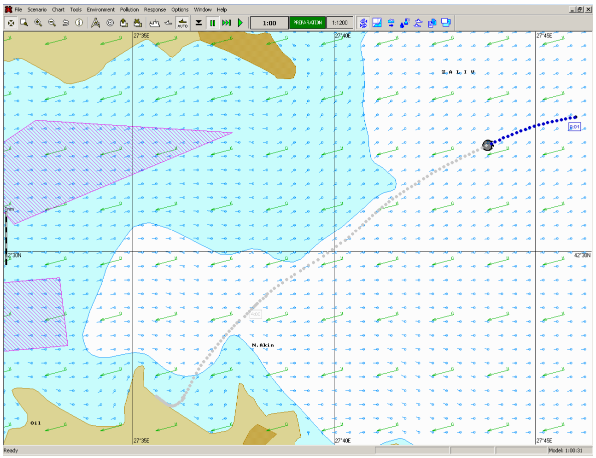

Figure 1 Evolution of oil spill one hour after pollution

b) At two hours after the start of pollution:
- amount spilled: 573 m^3;
- amount floating: 558 m^3;
- amount evaporated: 9.2 m^3;
- amount dispersed: 6 m^3;
- amount floating mixture: 2 398 m^3;
- maximum oil film thickness: 42.1 mm;
- slick area: 127 105 m^2;
- viscosity: 972 cP. (Figure 2).

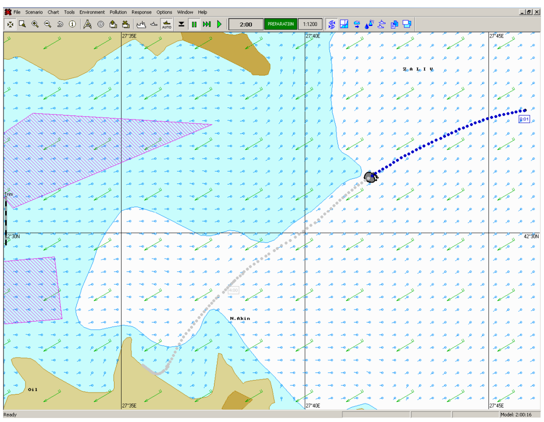

Figure 2 Evolution of oil spill two hours after pollution

c) At three hours after the start of pollution:
- amount spilled: 573 m^3;
- amount floating: 552 m^3;
- amount evaporated: 14.4 m^3;
- amount dispersed: 6.2 m^3;
- amount floating mixture: 3 673 m^3;
- maximum oil film thickness: 50.1 mm;
- slick area: 178 278 m^2;
- viscosity: 2 658 cP. (Figure 3).

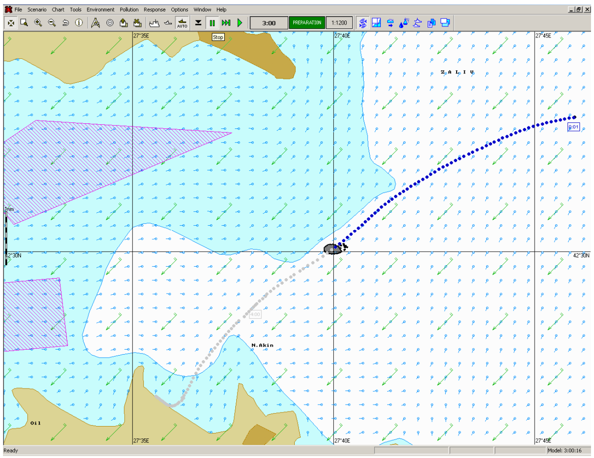

Figure 3 Evolution of oil spill three hours after pollution

d) At four hours after the start of pollution:
- amount spilled: 573 m^3;
- amount floating: 547 m^3;
- amount evaporated: 19.6 m^3;
- amount dispersed: 6.2 m^3;
- amount floating mixture: 4 591 m^3;
- maximum oil film thickness: 124 mm;
- slick area: 115 099 m^2;
- viscosity: 4 379 cP. (Figure 4).

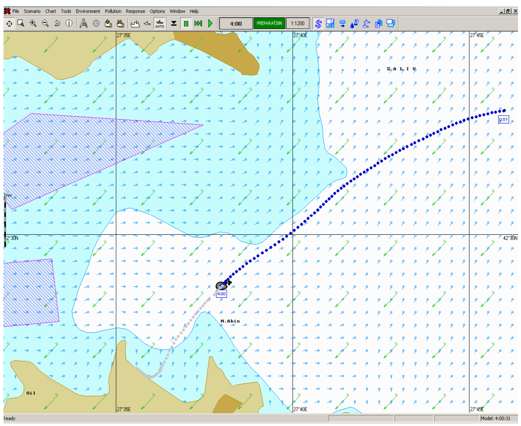

Figure 4 Evolution of oil spill four hours after pollution

e) At five hours after the start of pollution:

- amount spilled: 573 m^3;
- amount floating: 542 m^3;
- amount evaporated: 24.1 m^3;
- amount dispersed: 6.3 m^3;
- amount floating mixture: 5 057 m^3;
- maximum oil film thickness: 244 mm;
- slick area: 235 177 m^2;
- viscosity: 5 583 cP (Figure 5).

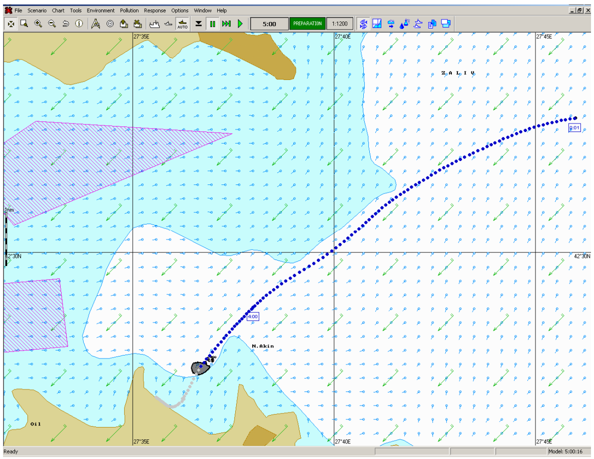

Figure 5 Evolution of oil spill five hours after pollution

f) At six hours after the start of pollution:

- amount spilled: 573 m^3;
- amount floating: 537 m^3;
- amount evaporated: 28 m^3;
- amount dispersed: 6.3 m^3;
- amount floating mixture: 5 228 m^3;
- maximum oil film thickness: 693 mm;
- slick area: 22 724 m^2;
- viscosity: 6 377 cP. (Figure 5).

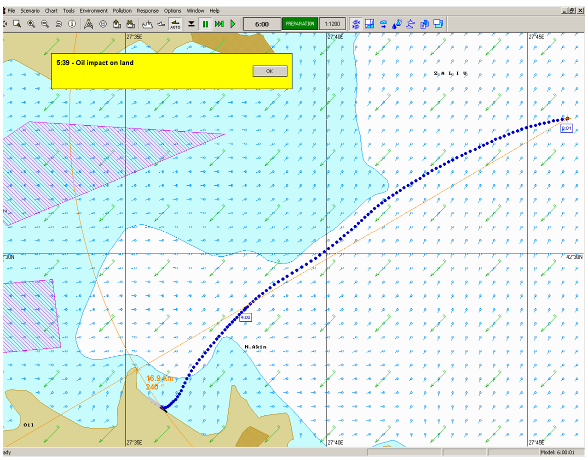

Figure 6 Evolution of oil spill six hours after pollution

4. CONCLUSIONS

Simulation results confirm that the shoreline pollution is imminent, but it can not reach the shore earlier than five hours after the oil is spilled in the Black Sea water, so that, the entity, who is responsible in Bulgaria, for environment protection and oil waist, is alarmed for this event and it is forced to use any methods to prevent pollution with spilled petroleum products, of the Black Sea shoreline.

In this case the entity, who is responsible in the matter, has enough time for prepare and move in the direction of oil spill location to isolate the spill area and instal the booms and the skimers for collecting the oil products in the sea water, so the impact of the spill on the shoreline to be as small, and in the same time to avoid an ecological disaster inside Burgas harbor.

Unless timely intervention is not organized, the harbor it will be polluted with 537 m^3 of floating spilled oil, the maximum oil film thickness will be about 639 mm and the spilled area will be about 22 724 m^2. The costs of an intervention for cleaning the shoreline in this situation will be considerably higher, and the effort will be commensurate.

Major impact produced on the environment from accidental spillage of petroleum products on the surface of water has led to the need for better monitoring of pollution and reducing the time to intervention for the organization and conduct remediation operations. Therefore, modeling of the pollution is becoming a very important and useful operation required for all institutions involved in remediation operations. [6]

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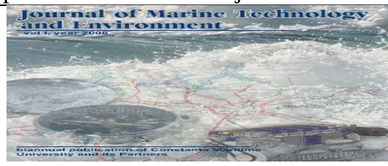

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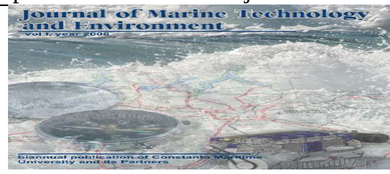

ANALYSIS OF THE OPERATING SOFTWARE USED FOR WEATHER ASSESSMENT ON BOARD OF THE SHIP

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Abstract: Nowadays, many computer agencies offers to the companies operating in the maritime field as ship owners, ship operators and charterers, various services related to the processing of meteorological information. However the use of competent meteorological advisory company did not relieves the master and navigating officers from responsibility concerning the safety of the ship, lives of crew members and condition of the cargo. This paper discusses the companies, software and internet sites, which presents a great amount of meteorological information to the ship business. The obtained meteorological information can be used on board of the ship for: voyage planning by masters; planning the duration of the voyage and calculation of the fuel coast by ship owners; raising a claim by charterers concerning the insufficient speed of the vessel as agreed in charter party, or for any other calculation and predictions relating shipping. Some of these services are free of charge while the others required regular payment. On board of the modern vessel, using new satellite technologies, it is a matter of minutes to obtain the required meteorological information.

Key words: meteorological information, ship routing, weather forecast.

1. INTRODUCTION

Communications between the ship and routing agency concerning ship's performance in current weather condition are very important for obtaining the best route and the possibility of the ship to proceed in the developing weather situation. Ship condition, type of the cargo and maximum available speed are the characteristics about which the routing company should be fully aware at all times.

2. METEOROLOGICAL SERVICES PROVIDED BY SHIP ROUTING COMPANIES

There are two main types of operational meteorological services provided by the routing companies:

- Optimum Ship Routing (Weather Routing) and
- Vessel Performance Analysis (Performance Monitoring)

"Weather Routing" of the ship represents the "best route" for a vessel, based on existing weather forecasts, the technical characteristics of the ship, ocean currents and the special requirements of the loaded cargo. For most routes, this means a minimum passage duration and avoiding a serious risk to the ship, crew and cargo. Other important aspects about the route may include passenger comfort, fuel economy and compliance with a precise timetable. The main goal is not to avoid all the adverse weather conditions, but to find the best balance and minimize passage time and fuel consumption, without the risk of damage to the ship's hull or injuries to crew members during the voyage due to weather conditions.

Initial notice of the ship's route must be submitted to the master before leaving the port with details on the projected movements of the storms, initial proposal of the intended route and the reasons for the recommendation as well as the expected weather conditions on this route or any alternative routes. This allows the master to plan the route better and it offers the opportunity to coordinate with the routing company some particular concerns that the master might have in relation to the nature and condition of the cargo on board. The ship's movement is monitored closely after sailing and meteorological information updates are sent to the master as well as routing advices if necessary.

Weather Routing of merchant ships began in 1950. Modern ideas about the routing of the ships dates from the Second World War, when the US Navy have established "Marine Meteorological and Oceanographic Centre" at the military base in Norfolk in 1958. "Optimum Track Ship Routing"(OTSR) started the personalized services for safety and savings for all vessels used by the military for long overseas trips.

"Optimum Ship Routing" saves the ship operators money by reducing the time for passage and therefore reduces fuel consumption [2]. This service minimizes the risk of damage to the cargo or to the ship, and the risk of injury to crew or passengers, by avoiding the worst weather conditions. Ships which are regularly using this service receive a deduction of insurance contributions based on the improved reports for used routes.

"Vessel Performance Analysis" allows the ship operator, owner or charterer to receive daily analysis of the performance of the ship in connection with her speed and fuel consumption, based on the specifications of the charter-party time agreed and the actual time used considering the currents encountered during the voyage. Although the service "Ship Routing" is not provided, signaling messages can be generated by the ship owner, operator or charterer, when there are discrepancies with the initially announced data in the contract and the actual data reported during the voyage, so charterer or operator and/or owner can deal with problems affecting performance of the ship before arrival to the port of destination. At the end of the trip, the routing company prepares a more detailed analysis of the actual performance of the ship. This report includes several factors like: charter-party terms, actual vessel speed and fuel consumption considering vessel is in ballast or in laden condition and the actual wind, sea, swell and currents during the entire voyage. In addition, the performance of the ship in "good weather" as specified in the contract is usually considered separately. This report can be used by the charterers to terminate the contract, or can provide the ship's owner/operator with evidence for the settlement of any disputes in an unjustified claim by the charterer for the vessel's slow speed [1].

3. ANALYSIS OF THE POSIBILITIES FOR OBTAINING OF WEATHER INFORMATION ON BOARD

3.1. Programs used by ship owners or charterers, which requires payment on single voyage, monthly or yearly basis.

"Ship Routing" helps the masters to choose the most favorable and economical route considering the weather conditions. The American company "Applied Weather Technologies" (AWT), founded in 1996, is one of the leading providers of this service. AWT has developed the program "Bon voyage", which allows the user to receive meteorological information for selected geographic area on board of the ship by e-mail. This information contains following data: wind, sea, temperature, atmospheric pressure, tropical storms, currents, ice information and other important meteorological parameters.

The weather forecasts are received for a four day period, but it should be borne in mind that the accuracy of the forecasts after the third day significantly decreases. "Bon voyage" allows to simulate the voyage by comparing different routes and to optimize the voyage considering the restrictions caused by weather conditions. For optimal use of these services it is essential that before the vessels departure the masters of the ships and shipping companies have made all necessary arrangements that the ship to be equipped with charts covering navigation area and any deviations in relation to weather conditions. During the voyage, master receives messages by e-mail with recommendations, whether change of the intended route is required (Fig. 1). The service "Ship Routing" can be ordered additionally upon request [3].

The program "Bon voyage"of AWT is installed on board of more than 45 merchant ships of the company "Hapag-Lloyd". The two companies work together for improvement of the program "Bon Voyage" in order to meet all requirements of the ships' crews and to provide a full range of directional services to the marine industry worldwide. The improvement feedback from masters is used additionally with highly qualified staff of meteorologists, computer scientists, marine researchers and former ship captains for defining optimal shipping routes. Nowadays this program is used annually for more than 50,000 ship voyages. "Bon voyage" program also allows receiving recommendations for a route in graphical format.

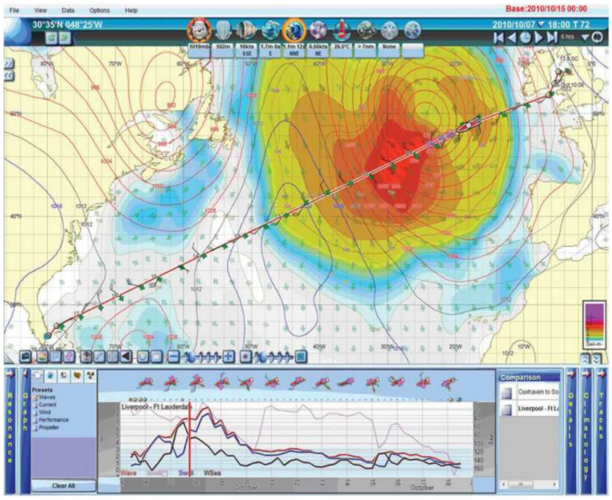

Figure 1 Program "Bon voyage"

In October 1, 2014 AWT signed an agreement with electronic navigation company NAVTOR. The two companies integrate the services, they offered, which lead to the best route planning. They created the software called "NavStation" (Fig. 2). Optimization Routing Service of AWT is available as a module in the "NavStation" program and this module gives route information and analysis of meteorological information for optimal planning. AWT transmits updated information in highly compressed formats minimizing communication costs. This gives to navigators the possibility continuously to update the sailing routes, increasing accuracy of the planned voyage and at the same time minimizing quantity of the fuel used and harmful emissions.

Along the agreement between AWT and NAVTOR, the computerized system “Navmaster ECDIS” is able to combine with MeteoGroup's SPOS weather routing service for optimization of the process for voyage planning (Fig. 3), [4]. The navigation company Raytheon Anschütz based in Kiel, Germany also offers integration of weather and electronic charts in Synapsis ECDIS [6]. On Globe Wireless communication system is also allowed to send the request from the ship to obtain three days forecasts.

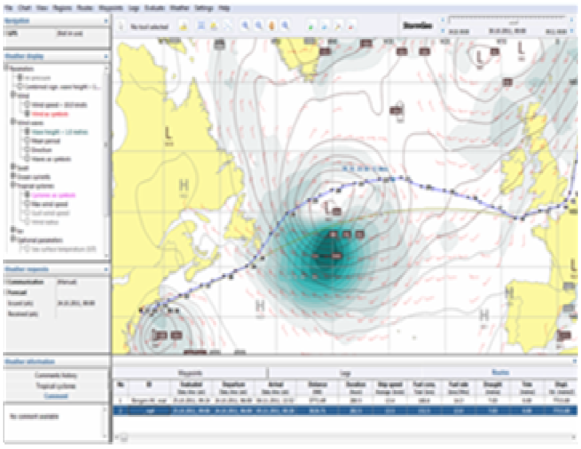

Figure 2 Program „NavStation“

Figure 3 Program „Navmaster“

From 1998 the ChartCo Company also provides meteorological data by E-mail, internet and radio, and the service is called „ChartCo MetManager“ (Fig. 4), [5].

According to the recommendations of SOLAS the forecast data is in graphical format. The data have been updated every six hours and includes:

- atmospheric pressure;
- direction and speed of the wind;
- wave height and swell;
- latest information about tropical cyclones (in text and graphical format).
- information about the ocean currents.
- ice information (in text and graphical format).
- analysis of sea surface temperature.

By ordering the service "Ship’s routing" the vessel will receive instructions which could be displayed on board using specialized software to get visual presentation of the proposed route.

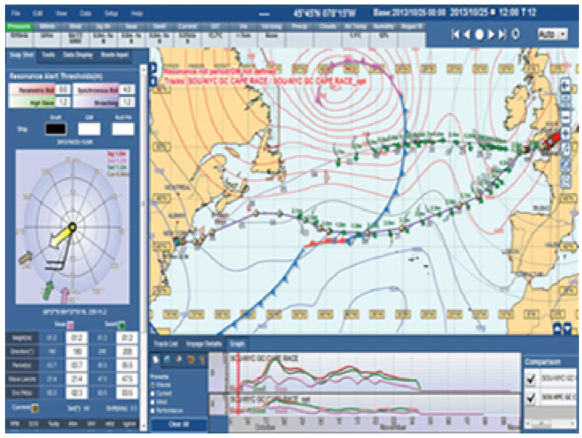

Figure 4 Program „ChartCo MetManager“

The advantage of program is automation of process for obtaining detailed and complete picture of weather situation, as well as 5 days and 16 days forecast for all geographical regions, without need of additional action by the ship's crew. After receiving a new forecast, the user can update a computer-based routing advice by performing a comparison of various routes and after analyzing the information to choose the most favorable route. Planning on board includes:

- determination of courses, wind and sea limits as well as prohibited areas for sailing.
- computer calculation of recommended courses.
- routes comparison.
- recording of meteorological data for the route.
- storm and ice information every six hours.
- simulation of the voyage.
- optimization (Earliest arrival time).
- optimization of fuel (Fixed time of arrival).
- forecast for the port and precipitation data.

The program “BRIDGE” (Fig. 5) can be used to choose a route when sailing in deteriorating weather

conditions. It is a part of the program “Optimum Ship Routing service” of the company Weather news, which is based in Japan and has 38 offices worldwide. The “BRIDGE” program is used by more than 3,500 ships worldwide. It displays weather conditions for the intended route and provides accurate representation of the expected weather conditions during the voyage. For a short voyages and if good weather conditions are expected the vessel may only receive weather forecasts without service “Weather routing”. The user must have a link via Inmarsat in order to receive the relevant meteorological information 24 hours a day. The program gives information about wind, sea, currents, temperature, atmospheric pressure and other parameters for the selected geographical region. The forecasts are made for a 10 days period. Another feature of the program is possibility for calculation of effect of the weather on the ship’s speed [7].

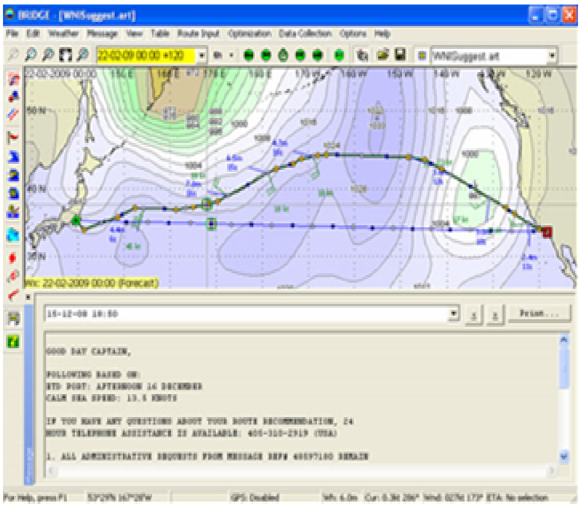

Figure 5 Program „BRIDGE“

Weather Routing Inc. (WRI) is a private meteorological consulting company, which offers marine weather forecasts and the “Weather routing” services worldwide and locally for areas like Caribbean, Mediterranean and many others. The company has great experience in providing its services for large ships and small yachts, combining the latest technologies with historical data of marine forecasts. WRI can offer to customers accurate and detailed forecasts. The company continuously monitors and analyzes the weather and ocean currents to choose the optimum route in terms of speed and safety of the vessels. The detailed forecast and the “Weather routing” services provided by the company WRI includes:

- preliminary report which is used by the ship’s masters for preparation for the voyage;
- detailed 5 days forecast for pressure, wind, sea.
- current state and forecast for ocean currents;
- optimal route taking into account distance, speed, time and currents;
- continuous monitoring for the occurrence of tropical cyclones. Tropical areas are under constant surveillance. Low tropical pressures are registered 2-3 days earlier, which gives enough time to make changes in preliminary selected route.
- continuous monitoring for deterioration of the weather;
- access to the website “Dolphin” with a set of detailed analysis and weather charts for wind, sea, visibility, ocean currents etc. Website “Dolphin” and Dolphin voyage planner (DVP) allows access to a wide variety of forecasting tools. Dolphin voyage planner service uses data with high resolution to maintain the ship at any time on the optimal route for the entire voyage.

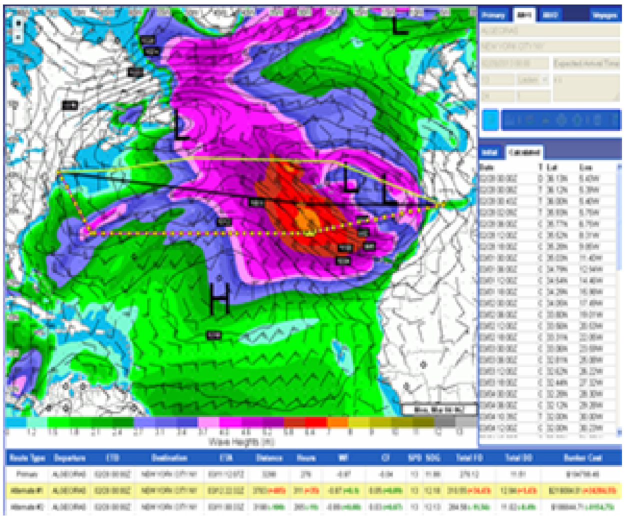

Figure 6 Report from Weather Routing Inc.

- warnings for occurrence of tsunami waves, earthquakes are immediately transmitted to the vessels for undertaking immediate actions if necessary. Alert messages for the possibility of development of tsunami waves can be sent to the vessels operators on request.

The company Aerospace and Marine International was founded in 1991 at San Jose, California, USA. She offers the service „Voyage Reconstruction” (Fig. 7). It is used in case of actions related to damage of the cargo or if the ship owners are to raising a claim or to verify the validity of the claim which has already been raised. The „Voyage Reconstruction” can restore the ship route and thus making an objective and reliable analysis of her passage and this data can be used for preparing “End of Voyage Report”. The report includes a detailed analysis of the vessel’s performance taking in consideration currents and weather conditions during the entire voyage to determine the speed, loss of time and fuel consumption. The report includes additional analysis for:

- daily fuel consumption (rates of consumption and actual consumption) by daily reports at 0000 and at 1200 UTC;
- wind, sea and swell;
- ship speed during the different parts of the voyage;
- average voyage speed, distance between ports and the time for voyage completion;
-detailed chart of the track for every single ship;
- further information upon request.

"End of Voyage Reports" can also be prepared according to the personal requirements of customers.

In order to increase the safety of shipping and saving of fuel (even in good weather) US company GAC Solutions and the Swedish Meteorological and Hydrographic Institute (SMHI) have jointly developed software for meteorological assessment. This program is used by owners/operators of all types of vessels including tankers, bulk carriers, Ro/Ro, refrigeration, car carrier, container ships and other specialized ships. Key advantages of the program include:

• fuel economy (the program allows to save up to 10% of fuel);
• time saving (a significant improvement in the accuracy of predicted arrival time);
• reducing the damage caused by the weather;
• 24 hour assistance to shipping operators by phone or e-mail;
• qualified meteorological assistance to the masters in choosing the best route;
• thorough evaluation of the performance of the entire fleet of vessels, regardless of the different navigational equipment on board, without requiring new investments for unification.
• updated worldwide data for maritime accidents through the program Fleetweb.

Web-based application Fleetweb helps to monitor and control the entire fleet and taking business decisions in a timely manner, based on reliable information and analysis in "Ongoing Voyage Analysis". Application Fleetweb (Fig. 8) provides real-time information for every ship in the fleet and weather information. The system also allows monitoring and forecasting. The data obtained from the on-board observations leads to increase of the accuracy of the forecast.

SMHI Onboard Routing (SOR) is software service for onboard planning which requires computer and e-mail. It allows the masters to receive high quality weather forecast and to optimize vessel route, as well as to carry out an analysis of the current or next voyage. In combination with routing advice from qualified marine meteorologists from SMHI it helps the master to make the right decision at the right time. There is a possibility on a single system on board in combination with existing ECDIS to carry out the planning of the trip not only in terms of weather, but also considering navigational restrictions in the sailing area.

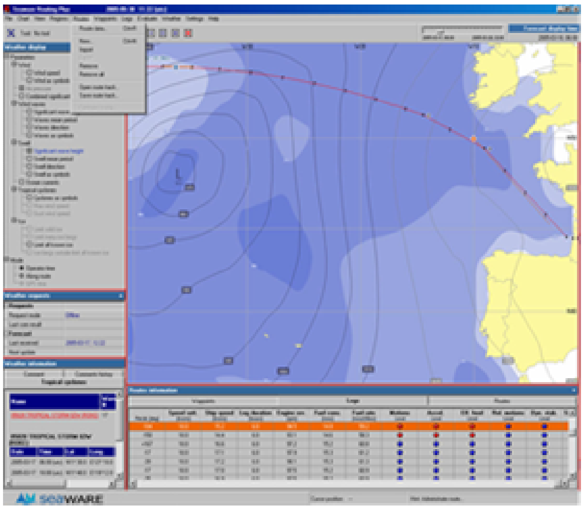

Figure 7 "Voyage reconstruction" of Aerospace and Marine International

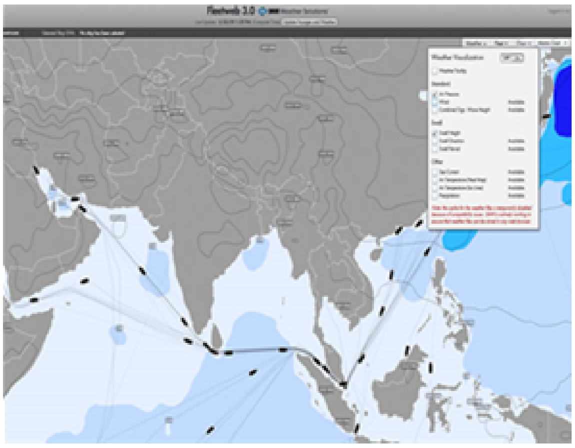

Figure 8 Web-based application Fleetweb

Application VisPer (Visualize Performance data) is used for optimization of the performance of the vessel by ship owners and/or operators. It allows combining the data measured on board of the ship and meteorological and oceanographic data with GAC-SMHI Weather Solutions and to create precise and easier analyzing graphics. VisPer allows users to view and filter the vast amount of data obtained from the analysis of the vessel's efficiency. It also helps detecting relations between different factors which affects the ship performance. The application allows to create custom reports and sending own data in Excel or PDF format.

Post Voyage Analysis (PVA) combines the recorded data with the reported information from the master to provide a reliable estimation of the performance of the vessel for every single trip [10].

3.2 Internet sites and GRIB files that provides weather information

Site "PassageWeather.com" allows seven days forecasts for wind, sea and atmospheric pressure. Weather charts for the selected region with three hour steps can be seen online or to be downloaded to a personal computer in Zip format [11].

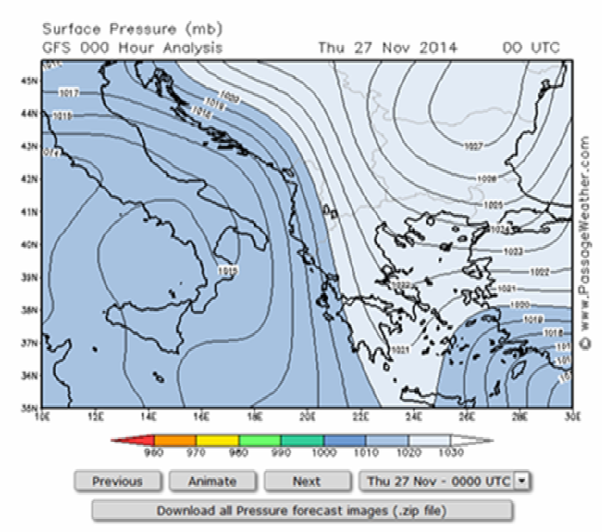

Figure 9 Weather information from the site „PassageWeather.com“

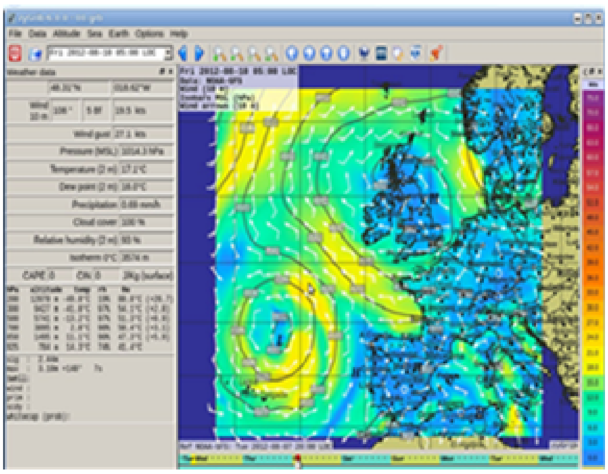

Figure 10 Weather information from GRIB-files

GRIB-files are computer generated files for weather forecasts from NCEP / NOAA, which are sent without a detailed examination. They can be received by e-mail or downloaded from sites like ZyGRIB, Predict Wind Offshore app. and others. The operator must select the boundaries of the desired geographical area, duration of the forecast and what kind of meteorological information is needed when sending the request. The size of the received file depends on the size of the chosen area. The files are usually received in one of the following formats: gzip * .gz; bzip2 * .bz2.

GRIB files (Fig. 10) are displayed for the required area as weather charts or diagrams. The charts have displayed information about the weather elements such as:

- atmospheric pressure at mean sea level;
- wind at 10 m above sea level;
- wind gusts;
- air temperature at a height of 2 meters above sea level
- minimum and maximum temperature at 2 meters above sea level;
- relative humidity at 2 m above sea level;
- precipitation;
- clouds;
- dew point at 2 meters above sea level;
- 0°C isotherm altitude;
- snow(probability of snowfall and snow cover height);
- CAPE - convective available potential energy and CIN
- convective inhibition;
- sea state.

Table 1. Agencies that offer data from GRIB files

	NOAA	**Meteoblue**	**FNMOC**
Updates	every 6 hours	every 12 hours;	every 6, 12 и 24 hours depend on the selected region.
Forecast	up to 8 days by 3 hours steps	up to 3 days by 1 hour steps;	Worldwide coverage: up to 7 days by 6 hours steps; Local coverage: up to 3 days by 6 hours steps;
Coverage	Worldwide	Switzerland and surroundings: 44N 003E 50N 003E 50N 014E 44N 003E	Worldwide

The operator can open these files with various programs like GRIB Viewer, or programs for electronic charts like Open CPN, MaxSea, Deckman, Evolution, Nobletec, MapTech, PC Plotter, Expedition and others. There is no guarantee that the data is accessible, accurate or correct. Users must be fully aware about that when working with these files. Agencies that offers data from GRIB files and their actual coverage are shown on Table 1.

The website PredictWind Offshore app allows downloading GRIB files on the computer machine and opening these files with above said programs (Fig. 11) [12].

The software for electronic charts „OpenCPN“ offers integrated weather programs like:

- Climatology plugin - can be used for preliminary voyage planning;

- Weather routing plugin (Fig. 12) - for viewing already downloaded GRIB files. Climate program used on passenger ships (most valuable for use in areas with prevailing winds). Both programs can be used together as complementary;

- Weather Fax plugin – for opening of image files directly or decode audio faxes in image. With a simple calibration, the resulting image is presented on ECDIS.

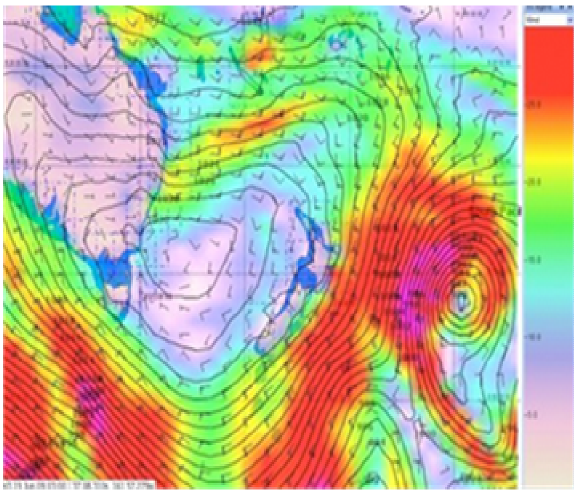

Figure 11 Weather information from the site „PredictWind Offshore app“

This program can convert images in different projections (mercator, polar, conical). Any image can be transformed into a raster map. It can receive information via SSB and Internet [13].

The operator can receive weather forecasts with MaxSea after purchasing the software „Max sea TimeZero“ (Fig. 13).

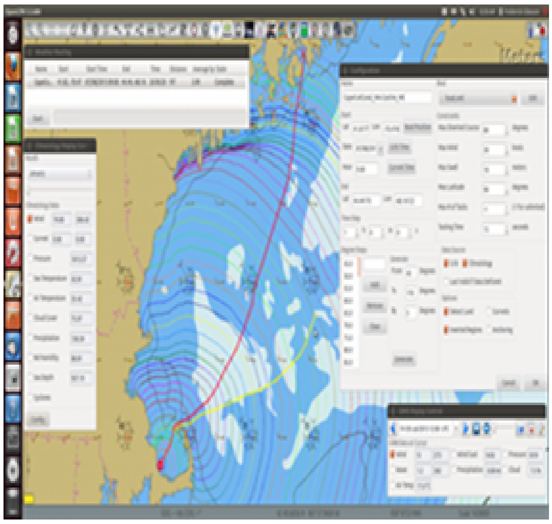

Figure 12 Weather routing plugin of the Program „OpenCPN“

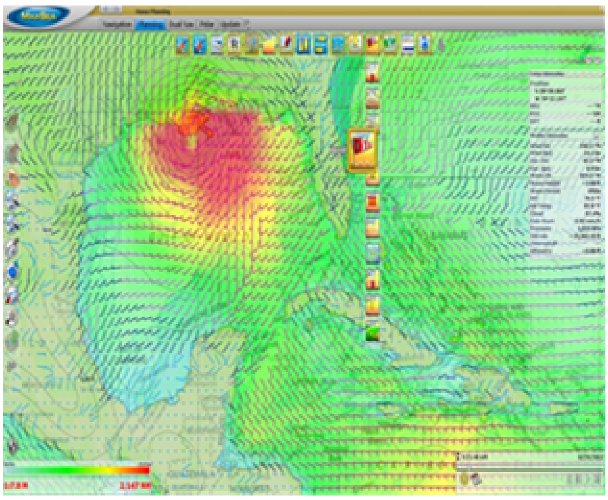

Figure 13 Program „Max sea TimeZero“

Saildocs is an email-based system for downloading and browsing documents. Saildocs can deliver weather reports on request, or provide subscription for automatic delivery. In addition Saildocs offers GRIB files from NOAA / NCEP and other sources upon request.

4. CONCLUSIONS

While assuming limits set by ship's speed performance curve the routing company and the master of the vessel may determine whether the diversion from the steering course is necessary or vessel can proceed on current course. It is vital for the master of the ship to do everything in his power to organize and collect sufficient amount of meteorological information on board for route planning.

Forecasts for ten days and more can be used for monitoring the development and movement of the storms, spread of ice, changes in the currents and tides and the impact to the weather of the different meteorological phenomena like El Nino and La Nina. It is very important to know that the accuracy of the forecast after seventh day highly decreases while forecasts up to three days can be used as reliable source for weather prediction.

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MONITORING SYSTEM FOR CONTROL, REGISTRATION AND MANAGEMENT OF ENERGY QUALITY INDICATORS IN SHIP POWER SYSTEMS

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Abstract: The paper presents the structure and operation of a developed mobile monitoring system for analysis, control, registration and management of the energy quality indicators in the ship electrical power systems. The system was successfully tested in the Ship's Electric Drives Laboratory of the Technical University of Varna.

Keywords: asset management operating* system*, planned maintenance system, data acquisition device, ship electrical power system,* theory of *Akagi, p-q theory, total harmonic distortion.

1. INTRODUCTION

The task associated with analysis of energy consumption pattern, nature of loading, and quality indicators of electrical power in Ship Power Systems (SPS) requires constant improvement both in equipment and theoretical models and software applications used. The technical system developed is versatile and open to further development based on multifunctional DAQ devices of National Instruments and software platform of Lab View. Where measurement, calculation and database generation are required for both electrical and non-electrical quantities (e.g. temperature, number of turn-ons, cycles, revolutions, etc.), almost all of the specialized systems for analysis of electricity consumption turn to be insufficiently suitable. The system suggested below completely solves this problem by making the real time analysis of three-phase consumers more complete and easier. In the version shown in this paper, it is used to analyse the consumption of high-scale three-phase power consumers, without the need of decommissioning. This makes it particularly suitable in examinations, periodic inspection, post-repair check-ups, etc. of Ship Power Systems. Planned Maintenance Systems (PMS) in SPS as regulated in International Safety Management Code (ISM), chapter 5, section 10 require the use of mobile systems for analysis of some quality indicators. A number of shipowning companies have introduced PMS systems, one of the most popular being the AMOS. In connection with the operation planning AMOS systems require periodic inspection by mobile network analysers of some quality indicators of electric power in typical units of SPS using analysers by approved manufacturers applying traditional methods of analysis (voltage deviation, frequency deviation, harmonic composition of currents and voltages, load mode – active, inductive, etc.). The system developed uses both traditional methods of analysis and Instantaneous Power Theory of Akagi, the latter being basic mathematical tool in control of active filters, compensators, etc. The system shown here makes it possible to evaluate the energy consumption patterns as well as make direct comparative analysis of technical and economic efficiency of introducing active filters, passive filters or compensating systems in SPS.

2. APPLICATION OF AKAGI'S METHOD TO DETERMINE THE INSTANTANEOUS POWERS IN SPS

There are several power theories based on use of instantaneous power [1,3]. In most cases, under the method of instantaneous power we understand the theory of Akagi-Naboe. Advantage of the theory is the simplicity of calculations based only on arithmetic operations. The theory makes it possible to define the modes in each electric power system achieving determination of the quantities within 1/6 to 1 cycle of the fundamental frequency. The essence of the p-q theory is the transformation of a stationary system with a-b-c coordinates into α-β-0 coordinate system. It corresponds to the algebraic transformation, known as the Clarke transformation wherein the α-β coordinates are orthogonal to each other, and the coordinate 0 corresponds to the components of zero sequence. The components of the zero sequence differ from the components of the zero sequence calculated by the method of symmetrical components (transformation of Fortescue) by a factor equal to √3. In its application in ship power systems, due to the missing neutral conductor the zero sequence value will be zero. Respective components could be excluded from the theory. In order to achieve better layout and comparability to other measuring systems intended for industrial sites, mathematical tool should not be changed as this is not a qualitative improvement of the theory and in using it the respective components of zero sequence will have zero values, which does not change the essence of the studies. Voltages and currents presented in α-β-0 coordinate system are defined by expressions [1,2]:

$$\begin{bmatrix} u_0 \\ u_\alpha \\ u_\beta \end{bmatrix} = T \cdot \begin{bmatrix} u_a \\ u_b \\ u_c \end{bmatrix} \qquad \begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} = T \cdot \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix}, \tag{1}$$

$$T = \sqrt{\frac{2}{3}} \cdot \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \tag{2}$$

In p-q theory, power components are calculated from voltages and currents in α-β-0 coordinates each component being devided in mean and alternating values.

- **Zero-sequence instantaneous power (p_0)**

$$p_0 = u_0 \cdot i_0 = \overline{p}_0 + \tilde{p}_0; \tag{3}$$

where in:

$\overline{p}_0$ - mean value of zero-sequence instantaneous power. It corresponds to the energy per time unity that is transferred from the power source to the load caused by the zero-sequence of voltage and current.

$\tilde{p}_0$ - alternating value of the instantaneous zero-sequence power. It corresponds to the energy per time unity that is exchanged between the power source and the load caused by the zero-sequence of voltage and current.

- **Instantaneous real power (p)**

$$p = u_\alpha \cdot i_\alpha + u_\beta \cdot i_\beta = \overline{p} + \tilde{p}; \tag{4}$$

wherein:

$\overline{p}$ - mean value of the instantaneous real power. It corresponds to the energy per time unity that is transferred from the power source to the load, in a balanced system of a-b-c coordinates. it is, indeed, the only useful (desired) power component.

$\tilde{p}$ - alternating value of the instantaneous power. It is the energy per time unity that is exchanged between the power source and the load in the a-b-c co-ordinates. Since this power does not involve any energy transfer from the power source to load, it must be compensated for.

- **Instantaneous Imaginary Power (q)**

$$q = u_\beta \cdot i_\alpha - u_\alpha \cdot i_\beta = \overline{q} + \tilde{q}; \tag{5}$$

$\overline{q}$ - mean value of instantaneous imaginary power;

$\tilde{q}$ - alternating value of instantaneous imaginary power.

3. SYSTEM STRUCTURE

System is built as portable, including PC with integrated multifunction DAQ card, clamp (A to mV) converters and specialized input section consisting of NI6210 USB converter and additionally developed input module. The system setup is shown in Figure 1.

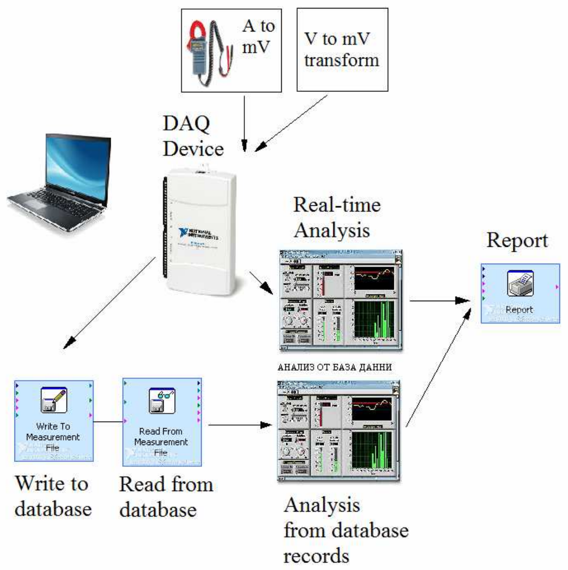

Figure 1 Block scheme of the system for analysis of the power consumption regimes

The input module allows direct measurement of voltage signals or measurement by galvanic isolation. Circuit of the additionally developed input module is illustrated in Figure 2. A view of the input module is shown in Figure 3.

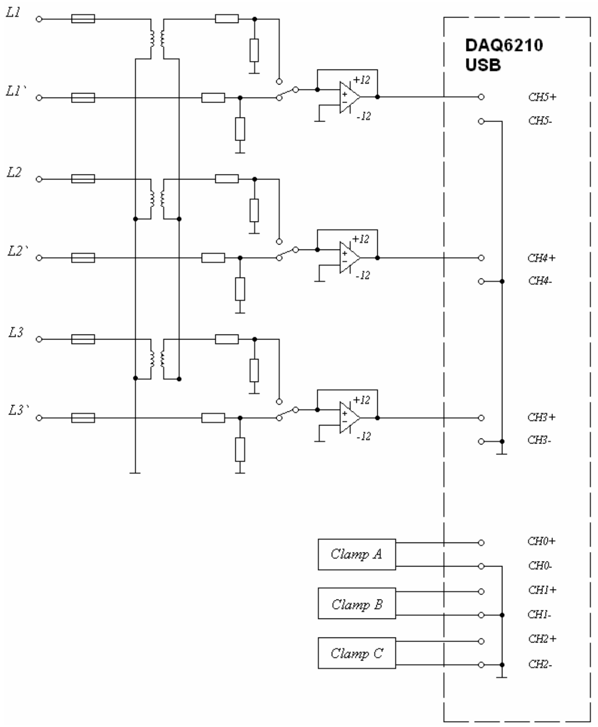

Figure 2 Extension module for direct connection (L1 ', L2', L3 ') or coupling with galvanic separation (L1, L2, L3) of DAQ to a low voltage network

The illustrated version is built on the basis of standard computer configuration, USB DAQ Device and LabView Software. Thus achieving a high functionality at relatively low cost. Of course, such a system can be built with a laptop and PCMCIA or USB DAQ Device. The configuration allows both simultaneous real-time analysis and generation of a database for further analysis. In this case, instantaneous values of the three phase voltages and currents are used as input quantities.

Depending on the selected components it is possible to simultaneously monitor more than 16 input analogue quantities. Thus monitoring of electrical and non-electrical parameters is achieved (e.g., monitoring of temperature, revolutions, pressure, etc.). The fact that Clamp type converters are used to read the values of the currents allows coupling the system without the need for stopping the researched object. By using different range converters it is possible to investigate a wide range of users' facilities with load from 0 to 1500 A. These converters are standardized and certified and produced by a number of leading companies (Voltcraft, Velleman, Fluke, etc.). In this case the model used is by Velleman, range 0 ÷ 300 A and accuracy class of 1.5. The DAQ card itself is also able to calibrate to reference devices. The versatility of this system allows a number of options for processing the results. The versatility of this system allows a number of options for processing the results.

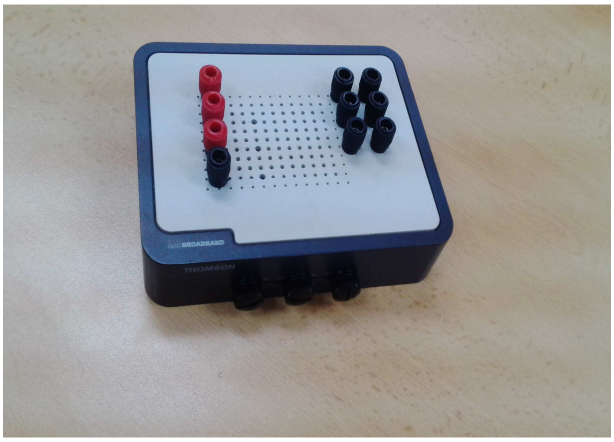

Figure 3 View of the input module for connection of clamp transducers to a network (L1, L2, L3).

A view of the developed mobile system at work in the laboratory is shown in Figure 4.

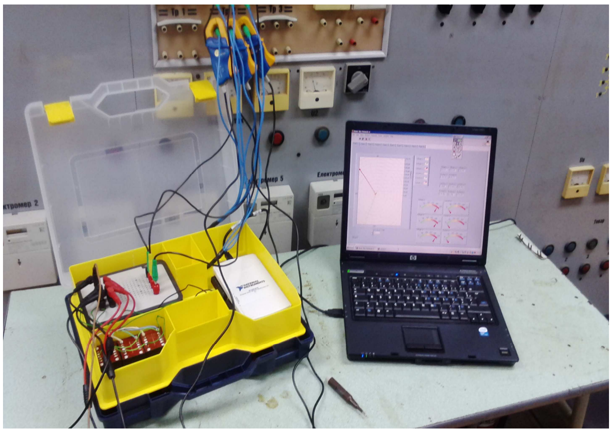

Figure 4 View of the developed mobile system at work in the laboratory.

The resulting database can be processed using a number of software products (compatible with Excel, Mathcad, etc.), but LabView offers the ability to measure, calculate and generate reports in real time. For this purpose a flowchart is made, allowing the creation of specified algorithms and use of virtual tools. In this case a methodology of calculations has been put together carrying out the calculation procedures stage by stage as shown in Figure 5.

- Stage 1 – calculating the THD for currents and voltages using fast Fourier analysis;

- Stage 2 – calculating the effective values of currents and voltages determining the initial phases, and phase shift angles.

- Stage 3 –calculating the apparent (S), active (P), reactive (Q) power and power factor (PF) for each phase as effective values.

- Stage 4 - calculating the p-q theory of instantaneous power.

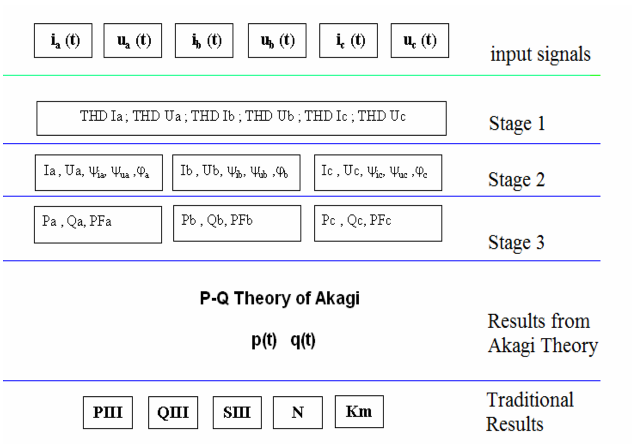

Figure 5 Structure of the stages of the calculations

The front panel of software application displays vector diagrams of currents and voltages, which is easy to use from maintenance engineers in real time (Figure 6).

The front panel displays all relevant parameters in the operating mode for a three-phase consumer. For each phase voltages and currents are plotted in graphic form as analog quantities (conventional view known from multichannel oscilloscopes), but also as effective values (conventional layout known from pointer instruments, convenient for practical use of the system). The front panel allows the use of correction factors (e.g. introduction of transformation factors of current and voltage measuring transformers when attaching the system to those allowing reporting of the actual readings; introduction of nominal voltage to read the voltage deviation, etc.). The effective values of calculated quantities are also displayed - frequency, phase angles, dephasing angles, THD, active, full, reactive power for each phase, three-phase power (active, full, reactive), power factor (by phase and as three-phase quantity), complex view of vectors of positive and reverse sequence of currents and voltages, etc.

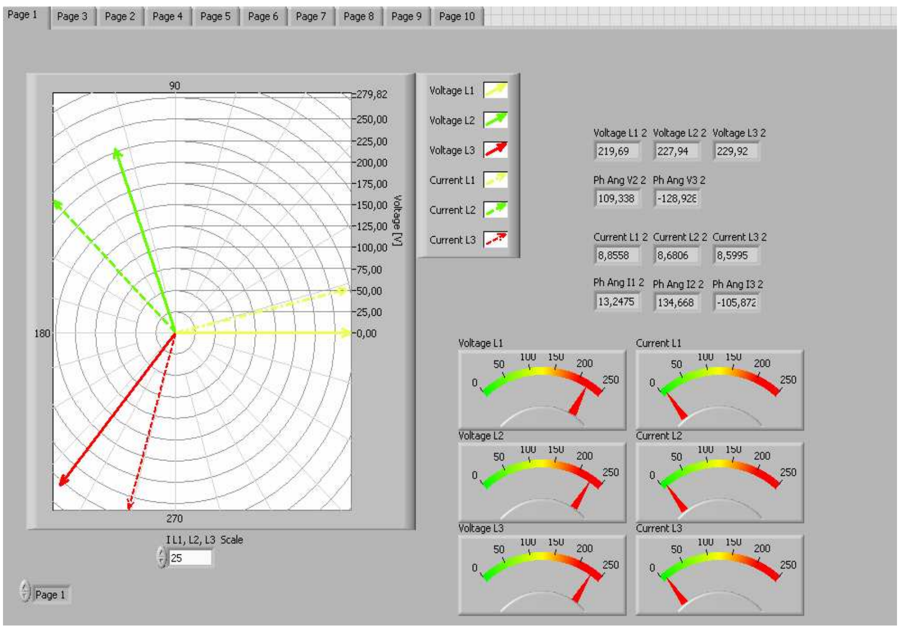

Figure 6 Screen (front panel) of the developed software application for vector visualization

The visualization of phase voltages and currents as instantaneous values is shown in Figure 7. The instantaneous values of Iα, Iβ, I 0 , Uα, Iβ, U0 from Clarke Transform and their deviation are represented with Lissajous Graphs (Figure 8).Some typical results from application of developed system are shown in Figure 9 and Figure 10.

To perform the various calculations are used sub-modules developed by the software platform LabView. Sub-module for determining the voltage selection and calculating the transformation of Clarke is shown in Figure 11.

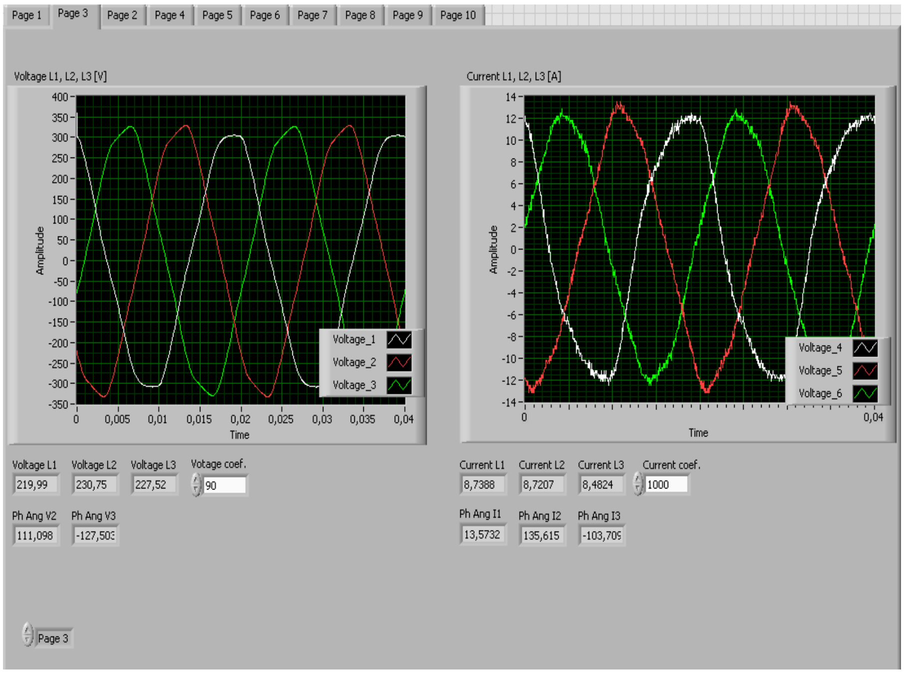

Figure 7 Screen (front panel) of the developed software application for visualization of the instantaneous values of the currents and voltages

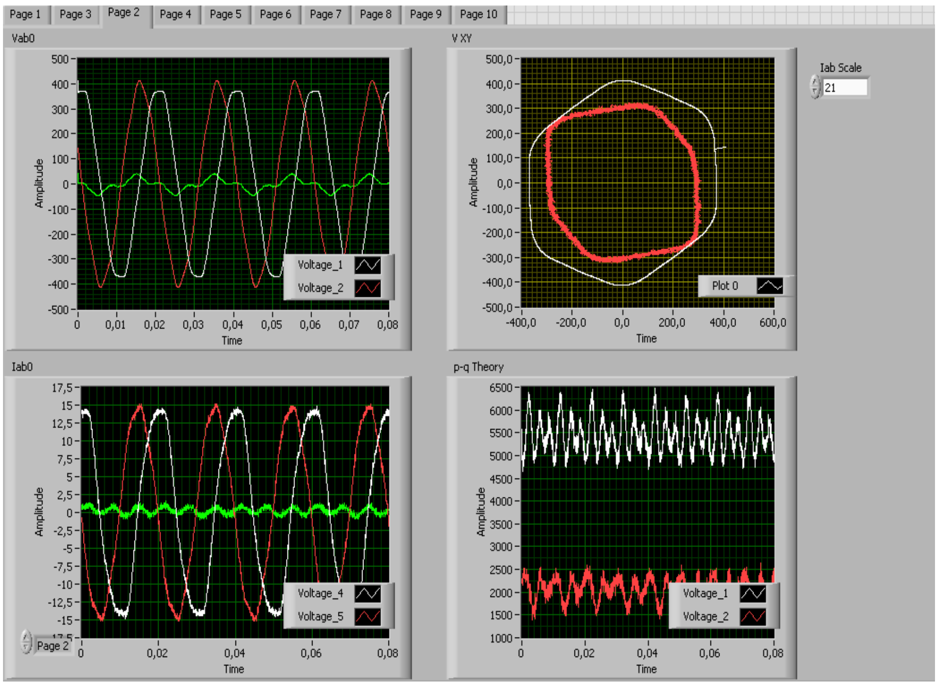

Figure 8 Screen (front panel) of the developed software application for visualization of the p-q theory in the presence of asymmetry and non-sinusoidality

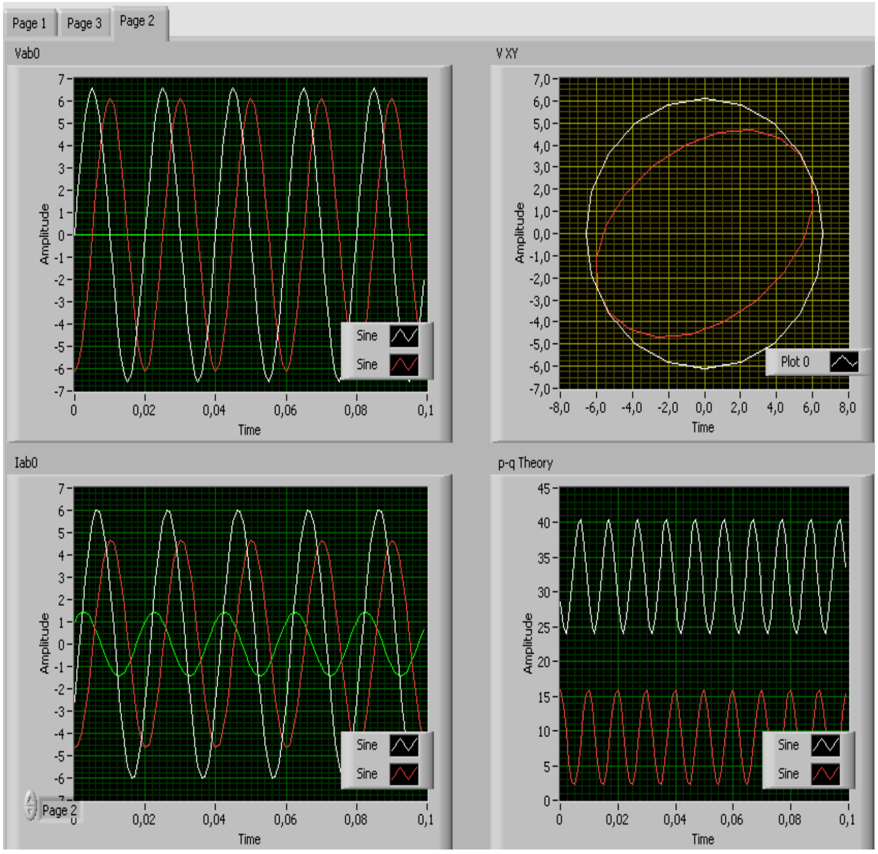

Figure 9 Screen (front panel) of the developed software application for visualization of the p-q theory in the absence of higher harmonics and presence of symmetry of the currents and voltage unbalance

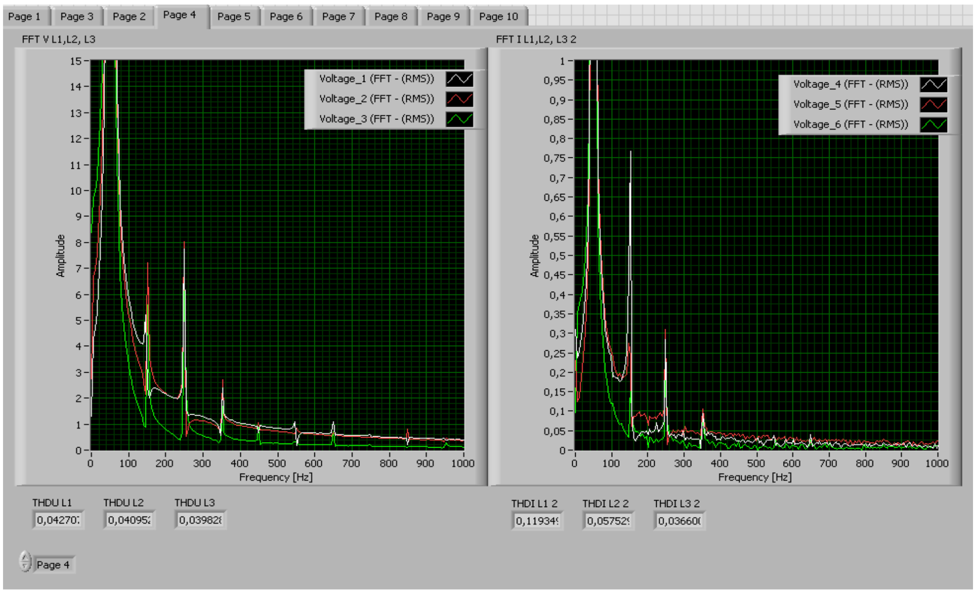

Figure 10 Screen (front panel) of the developed software application for visualization of the harmonics composition of the voltages (left) and currents (right)

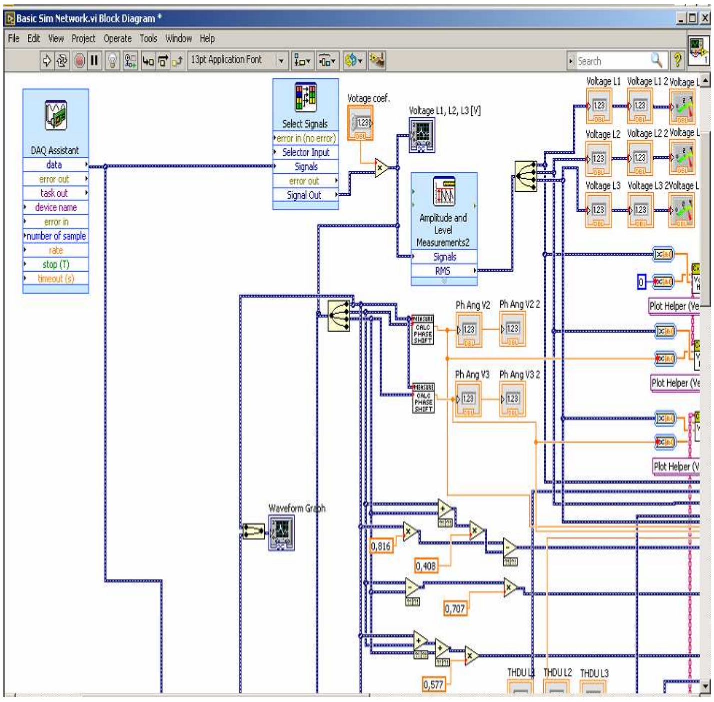

Figure 11 Sub-module for determining the voltage selection and calculating the transformation of Clarke

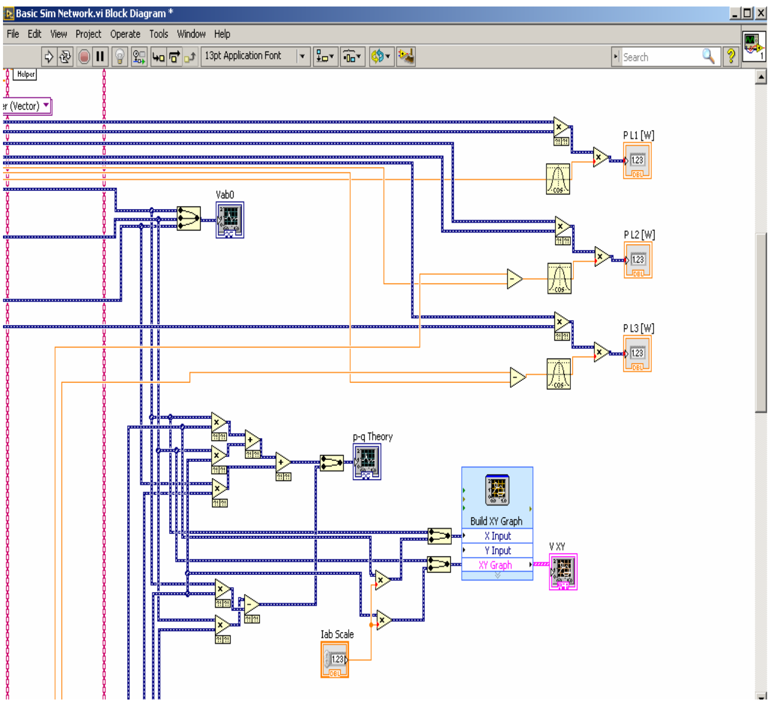

Figure 12 Sub-module for calculating the p-q theory of Akagi

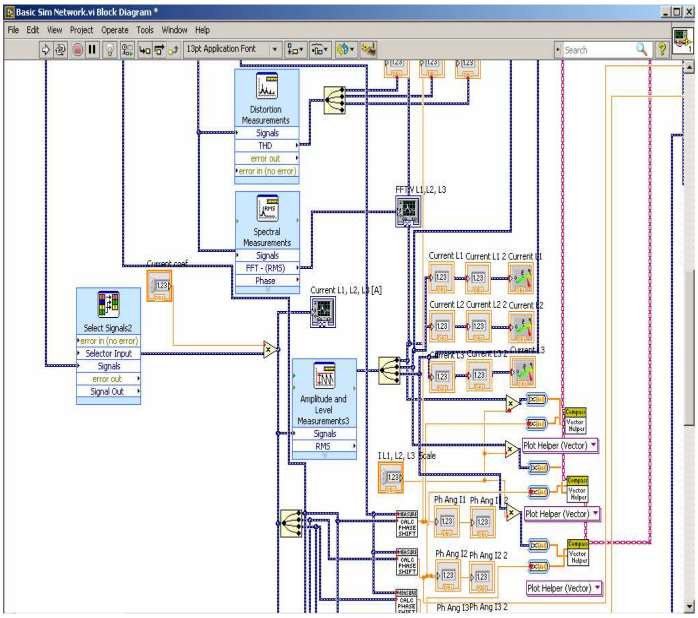

Figure 12 Sub-module for calculating harmonics composition and graphic vector display

4. CONCLUSIONS

The mobile system developed for testing modes of operation and power quality indicators in ship power systems and individual consumers has application to research works and engineering practice. Combining advantages of various measuring instruments (portable network analyzers, multi-channel oscilloscopes, voltmeters, ammeters, instruments measuring power, spectral composition, phase shift, etc.) used simultaneously, the system makes possible the measuring, processing, calculations, recording and reporting of various energy indicators and electric power quality indicators. The capabilities of the proposed system to be further developed, to change parameters examined according to the specificity of the test items, etc., makes it particularly suitable for research, periodic inspection, post-repair inspection and solving specific problems in ship power systems. In this form it is suitable for use as an alternative of the network analysers with its user-defined criteria for expert analysis. In particular, it can be used in a planned operation in the presence of AMOS systems and also in need of preliminary assessment of effectiveness of the implementation of improvements in the electric power quality operating through control algorithms based on the p-q theory. Most of today's active filters for ship power systems developed by leading manufacturers work with Akagi's theory. This type of system can provide preliminary assessment with high confidence level of the need and returns from investing in improvements of the electric power quality as active filters, passive filters and compensating systems.

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ELABORATION OF THE AUTOMATIC VOLTAGE REGULATORS OF THE SHIP SYNCHRONOUS GENERATORS

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Abstract: In order to raise the effectiveness of the energy system an electronic voltage regulator with a high speed operation can be installed. An original AVR scheme which uses, which uses proportional-integral-differential control and pulse-width modulation scheme to control the output voltage of the compound system, is presented. The scheme of the electronic regulator is enclosed.

Key words: ship's synchronous generator, automatic voltage regulator, compound excitation system, proportional-integral-differential regulator, width impulse modulation.

1. INTRODUCTION

There are high requirements towards excitation systems of the ship synchronous generators compared to the industrial ones. The reason is in the limited power of the ship synchronous generators which are commensurable with their load. They need to have increased exploitation reliability, hose-proof characteristic, high accuracy and fast operation. Moreover, the generators with automatic systems of excitation have to produce electricity in the needed quantity and relevant quality. It requires voltage and frequency maintenance in the given parameters.

According to the requirements of the ship registers the power system has to have the following characteristics. In steady state the Automatic voltage regulators (AVR) must be able to keep the voltage within ±2,5% of the rated voltage under all steady load conditions.

The limit can be increased to ±3,5% for emergency generator sets. When specifying the requirements for voltage regulation in load changes, a definition of sudden load is used. The sudden load is defined to be more than 60% of the full load current at power factor of 0,4 lagging or less.

When switching on the sudden load the instantaneous voltage drop must not exceed 15% of the rated voltage. When the load is switched off the voltage rise must not exceed 20%. In both cases the voltage regulation must restore the voltage within ±3% of the rated voltage within 1,5 s. For emergency generator sets not in parallel operation, the limits can be increased to ±4% and 5 s.

2. MARINE COMPOUND SYSTEM

For voltage regulation of generator control AVR employing conventional, fixed parameter compensators is able to provide good steady state voltage regulation and fast dynamic response to disturbances.

Marine compound system is a typical example of a compound type of automatic voltage regulator of ship synchronous generator.

Synchronous generator: type: SSG 5/2 IP22, rated parameters: 5 kVA; f = 50 Hz; U = 390/235 V;
I = 7,4/4,5 A; n = 3000 rpm; Uf = 90 V; If = 3,8 A;
Ra = 1,5 ; Rf = 18,2 ; Xa = 8,5 mH; Xf = 518 mH;
xd' = 0,17 p.u.; xd" = 0,12 p.u.

It consists of:
- summing transformer with magnetic by-pass;
- operation block of voltage regulator;
- initial excitation generator

Journal of Marine Technology and Environment Year 2015, Vol.2

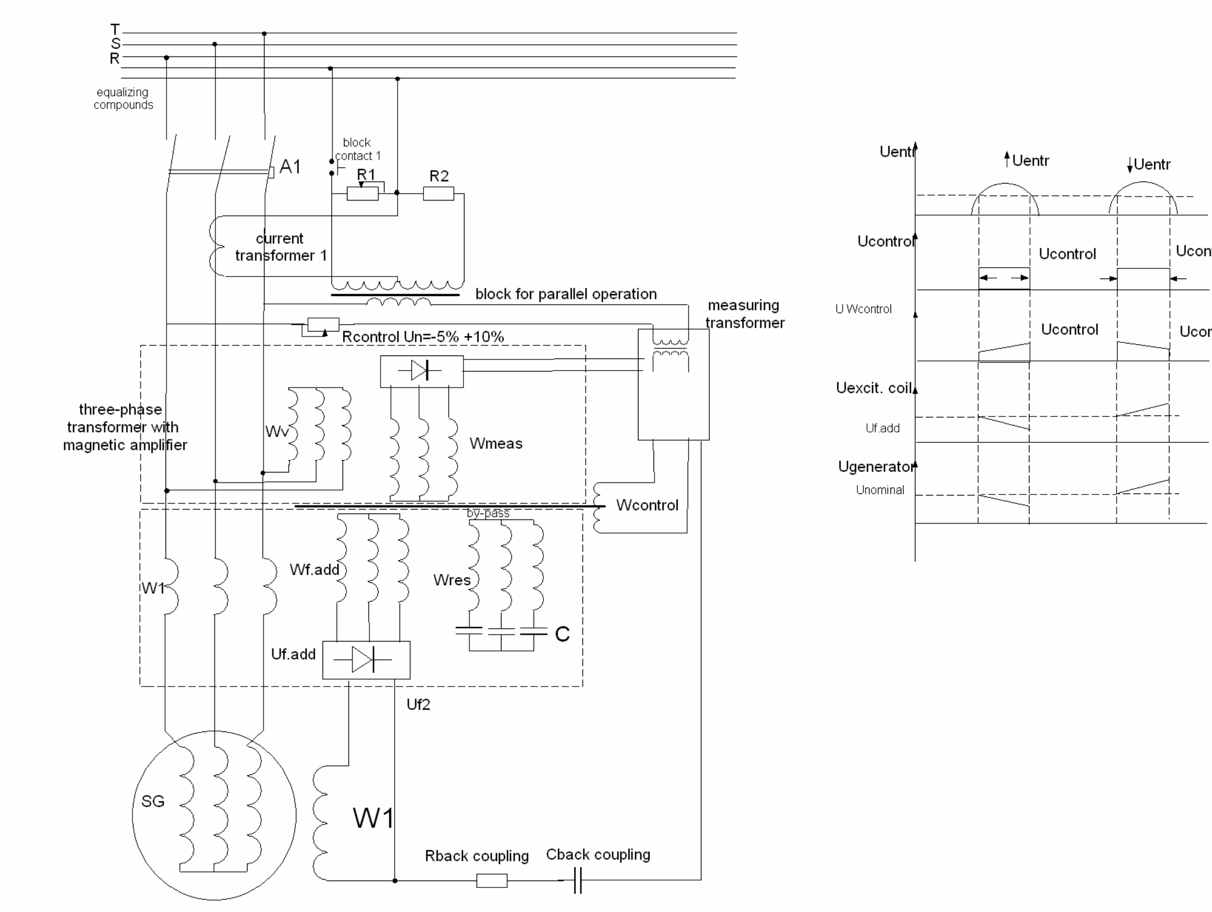

Figure 1 Marine compound system

The summing transformer has three basic and three additional coils. The basic coils are the two primary coils - voltage ù1 and current ù c, and secondary coil ù2. The voltage coil is separated by the current one and the secondary one by a magnetic by-pass. The air interspace between the by-pass and the main bodies of the transformer is regulated by non-magnetic pads in such a way that the needed coefficient of mutual induction is achieved. The secondary coil ù2 supplies the excitation coil of the generator through rectifier bridge.

The additional coils of the transformer have a supplementary function. They are the supplying coil, the resonant coil and the control coil. The first coil supplies the voltage regulator. A condenser type battery is switched in to the resonant coil in order to ease the generator's excitation. The excitation of the generators with smaller dimensions the excitation is ensured by a generator for initial excitation instead of resonant circuit.

The control coil is switched in at the exit of the voltage regulator. It magnetizes the magnetic system of the summing transformer to an extent depending on the exit signal of the regulator.The effective magnetic induction makes voltage in the secondary coil. The induction is a result of the geometric summing of the voltages of the primary voltage and the current coil.

When there is no electricity in the control coil the applied voltage to the excitation coil of the generator becomes bigger than needed. Reaching the normal excitation voltage is achieved by applying control current from the voltage regulator.

The voltage regulator has two main parts: a measurement unit and an amplifier. The measurement unit measures the generator's voltage and compares it with the set level. The difference between the two voltages is amplified and is applied to the control coil of the summing transformer.

The voltage applied to the control coil of the summing transformer by the regulator has impulse form. The pulse height is constant but its width changes due to the generator's voltage. When the generator's voltage goes up the pulse width becomes bigger the current of the control coil increases. The induced voltage of the secondary coil of the transformer decreases. The result is the refund of the generator's voltage. When the generator's voltage goes down, the reverse process takes place.

Journal of Marine Technology and Environment Year 2015, Vol.2

The disadvantage of this type operation of the generator's voltage is that the control coil is affected first, it distributes the magnetic field and finally the excitation coil is affected. The result is a slow control of the generator's voltage.

In order to improve this process an additional automatic regulator is introduced which affects the excitation coil directly.

Automatic voltage regulator measures the voltage of the generator and the change of the reactive current and regulates the voltage of excitation in a such a way that the generator's voltage is maintained in a state which is at least

± 2% accurate as it ensures the static character at the reactive loading within the above-mentioned 2%.

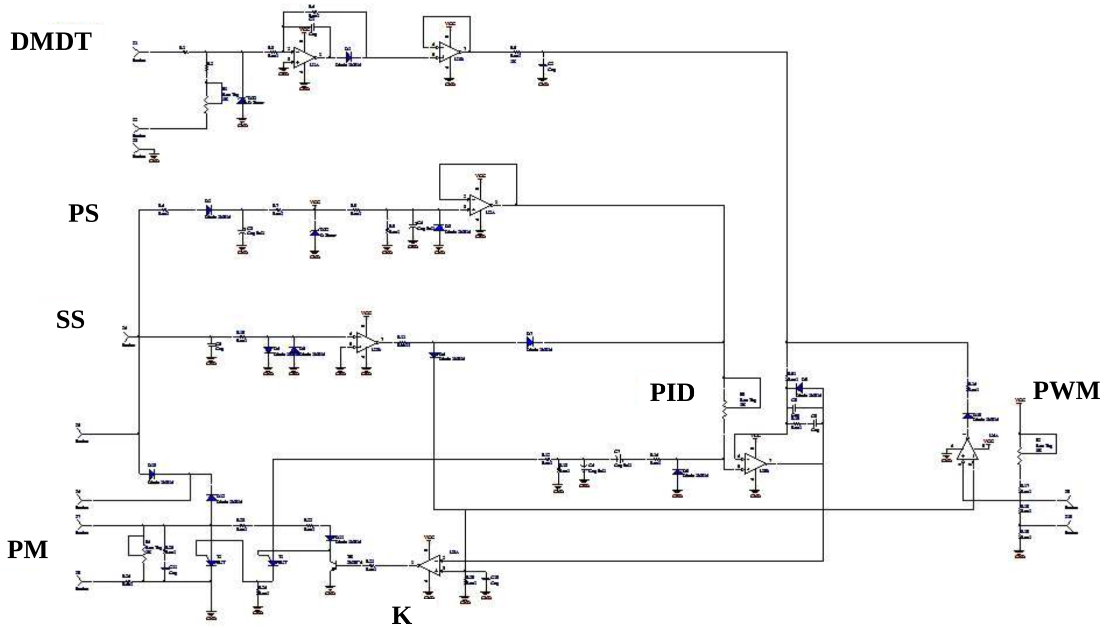

Figure 2 Electronic scheme of automatic voltage regulator

The voltage regulator influences the voltage as it lowers the generator's current through the resistors connected to it. The regulator works on the base of the width-impulse principle as it regulates the width of the impulses towards the excitation coil and thus regulates the amount of the rotor current. The amount of the basic stabilized voltage, which is compared to the generator's voltage, is changed by the means of the potentiometer of the supplying plate.

On this scheme the following indications are shown:

DMDT - Device for measurement and droop tune;
PID – proportional-integral-differential controller;
PS – power supply;
SS – synchronization scheme;
PM – power module;
PWM – pulse-width modulation scheme;
K – comparator.

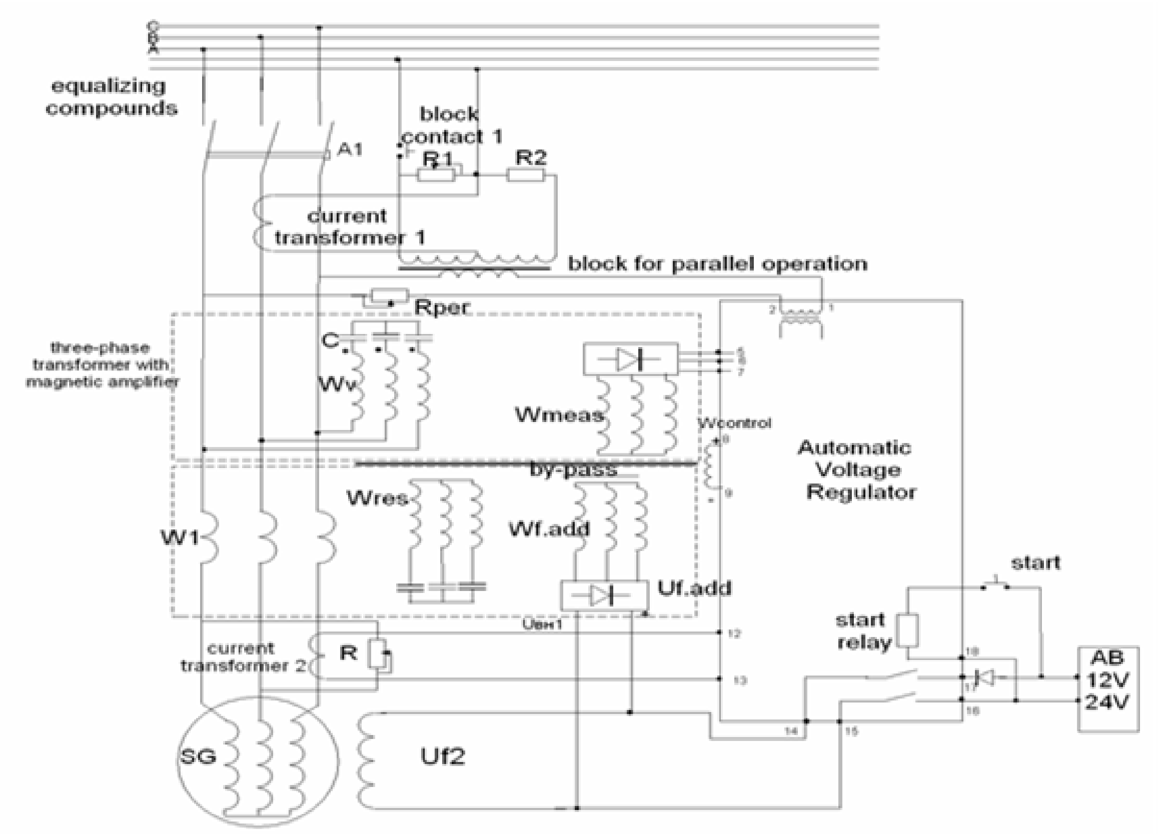

Figure 3 Modernized marine compound system

Device for measurement and droop tune (DMDT). The generator's voltage Ug enters the automatic regulator, and at the other end, a voltage which is proportional to the pilot voltage Uref is applied.

The difference between the generator's voltage Ug and the pilot voltage Uref is sent to the PID controller.

Power supply. The power supply ensures the supply of all modules of the automatic voltage regulator. The three-phase voltage of the generator is transformed by a transformer and is stabilized.

Synchronization scheme. Synchronization scheme (SS) is a functional generator which sends impulses by the means of the comparator which operates the pulse-width modulation scheme.

PID controller. This module forms the law of PID controlling according to which the voltage regulator functions and is presented by the formula:

$$U = k_p \cdot U_{mes} + \frac{1}{T_i} \cdot \int U_{mes}\, dt + T_d \cdot \frac{dU_{mes}}{dt} \qquad (1)$$

PID controller is supported by the pulse-width modulation scheme.

The electrical protection module U/f transfers impulses which lock the power module at lower frequency of rotation of the generator up to 30 Hz, which results in the lower voltage supply to the excitation coil.

Comparator. It is an electronic scheme with analogue input and impulse output, i.e. the PID controller sends impulses with certain length and amplitude based on the input voltage to it. The output impulse indicates whether the input voltage Ug is bigger than the pilot voltage Uref or not. This impulse operates the thyristors of the power module.

Power module. It supplies the excitation coil with rectified voltage.

The modernized scheme of the marine compound system is presented in fig. 3. It shows that the old voltage regulator affects the amplitude of the rectified voltage and the new voltage regulator changes the control current to the excitation coil using pulse-width modulation. It will raise the accuracy of the regulated voltage to 1% .

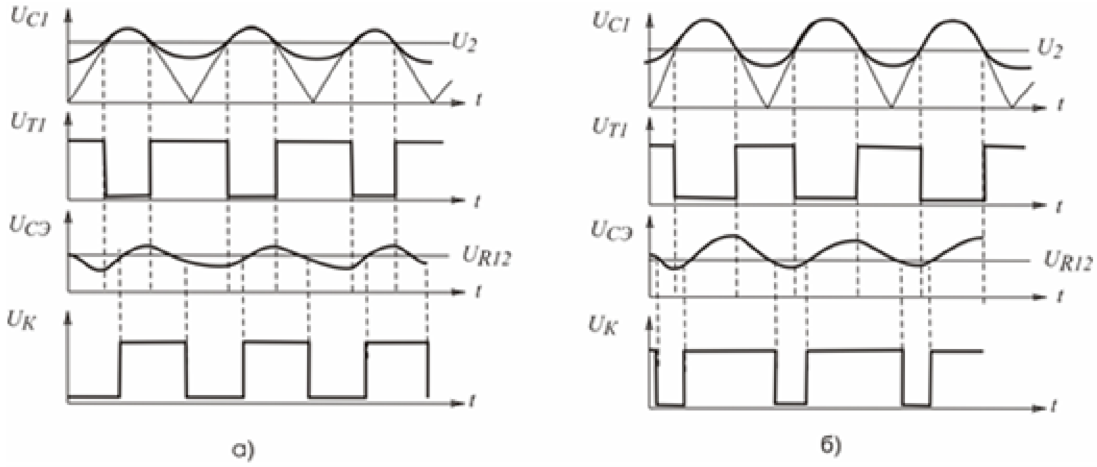

Figure 4 Graphics of marine compound system

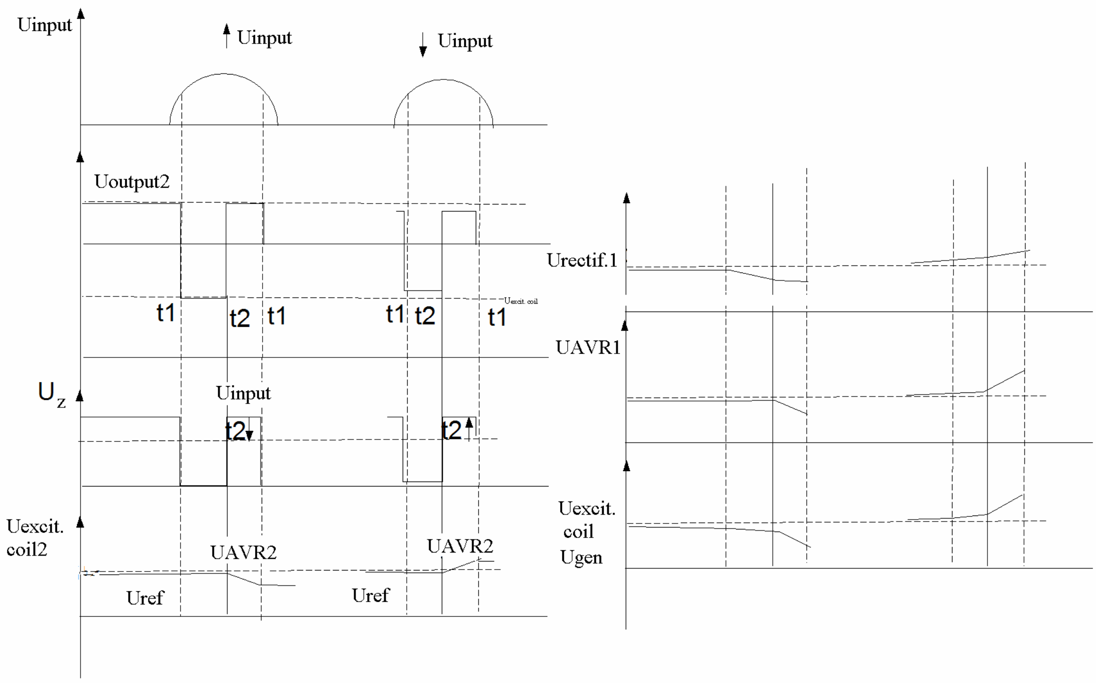

Figure 5 Graphics presenting the principle of the marine compound system

3. CONCLUSIONS

The introduced amplitude-width modulation effect with the new voltage regulator increases the accuracy of regulation 3-5 times. Thus the requirements of the ship registers will be fulfilled.

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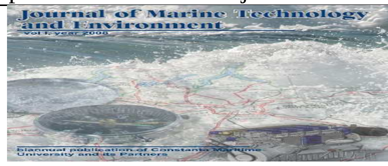

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Journal of Marine technology and Environment Year 2015, Vol.2

METHOD OF CHOOSING A BETTER ROUTE IN SHIPPING

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Abstract: This paper presents a different view on the evidence theory and Dijkstra's algorithm. In this paper, the algorithm will be used in the further analysis to additional paths between nodes can be found in the maritime sector. In many cases, the best solution for a single criterion is not sufficient. It would be search for more effective solutions of the starting point to use for subsequent analysis or decision of the captain of the vessel. With innovative thinking mechanisms it is possible to create a decision support system based on known Dijkstra's algorithm. Reasoning mechanism is based on the theory of evidence. The intervals were used, where interval means a set of real numbers with the property that any number that lies between two numbers in the set is also included in the set.

Key words: Dempster-Shafer theory, Dijkstra Algorithm, ship route planning, intervals.

1. INTRODUCTION

Best Path Selection Algorithm is a one of most difficult algorithms in transport systems. The traditional way is to base the estimate of estimated time of arrival on ships. However, the new technology of satellite position reporting combined with electronic map allows users to land to check weather or update the master’s estimated time of arrival at regular intervals, not interfering with the crew of the ship at all hours.

The paper presents an efficient algorithm for determining the estimated time of arrival in port the ship is at sea. The algorithm is implemented in a decision support system in planning the operation of ships, one of which is installed and used by several owners. By calculating the distance of the route between the ship and the port of destination, estimated time of arrival can be estimated by dividing the distance by the speed sailing. Calculating the distance between the ship and the port of destination may be considered to determine the shortest path between two points in the presence of polygonal obstacles, where one point corresponds to the vessel and the other end to the port of destination. Sections defining polygons are obstacles coast. Estimated time of arrival accuracy can be improved by defining special network structures in areas with limited speed, or are waiting for the pilots.

Paper is a continuation of research on the selection of a good transit route in the marine environment. More about this approach was published in [1].

2. THE OPTIMISATION PROBLEM OF OBSERVATORY STATIONS DISTRIBUTION

Optimisation is determining the finest solution, therefore finding the extremum of given function in terms of specified criterion (e.g., cost, time, distance, efficiency).

The optimisation of observatory stations distribution is achieved by such location of stations that makes the tracking surface of the monitored area nearest to the overall surface of study area. Obtaining equality in two aforementioned surfaces marks an ideal state of no occurrence of shaded area. The usage of a given sort of observatory stations affects the type and size of shaded areas resulting from environmental impact. In case of conventional radar stations tracking surface depends on:

- blind spots caused by port infrastructure, topography of the area;
- range and bearing discrimination.

Arrangement of shore stations seeks to maximize the tracking surface while minimising the number of newly built radar stations. Object-caused bind spots may be eliminated by installing higher number of observatory stations in various locations in a manner enabling their range to cover the entire tracking surface. This goal may be achieved by using a number of additional observatory stations. However, one of the regarded optimisation criteria are economic conditions, additionally: the characteristics of the terrain where stations are to be built, technical possibilities of connecting stations to the network. The presented approach has been implemented in the computer application allowing for analysing maritime areas, proposing a distribution of observatory stations, as well as for comparative assessment of existing area monitoring schemes [2].

3. FACILITY LOCATION AND LOCATION SCIENCE

Facility location problems investigate where to physically locate a set of facilities (resources, stations, etc.) so as to minimize the cost of satisfying some set of demands (customers) subject to some set of constraints. Location decisions are integral to a particular system's ability to satisfy its demands in an efficient manner. In addition, because these decisions can have lasting impacts, facility location decisions will also affect the system's flexibility to meet these demands as they evolve over time.

Facility location models are used in a wide variety of applications. These include, but are not limited to, locating warehouses within a supply chain to minimize the average time to market, locating hazardous material sites to minimize exposure to the public, locating railroad stations to minimize the variability of delivery schedules, locating automatic teller machines to best serve the bank's customers, locating a coastal search and rescue station to minimize the maximum response time to maritime accidents, and locating a observatory stations to cover monitored area. These six problems fall under the realm of facility location research, yet they all have different objective functions. Indeed, facility location models can differ in their objective function, the distance metric applied, the number and size of the facilities to locate, and several other decision indices. Depending on the specific application, inclusion and consideration of these various indices in the problem formulation will lead to very different location models [2].

There exists two predominant objective functions in location science: minisum and minimax. These are also known as the median and centre problems, respectively. The diametrics of these objective functions also exist (maxisum and maximin), although they are somewhat less studied. Other objective functions are also studied within the location science community, especially recently. The most notable of these are the set covering and maximal covering objective functions. The former of these two objectives attempts to locate the minimum number of new facilities such that a prescribed distance constraint to existing facilities is not violated. In contrast, the latter strives to locate a given number of facilities to best meet the (weighted) demands of the existing facilities subject to a maximum distance between new and existing facility. It should be noted that for the set covering formulation, because all of the demands must be met (covered) regardless, the relative weight of the demands generated by the existing facilities are inconsequential, whereas in the maximal covering objective some existing facility demands may be left unmet (uncovered) [3].

Location problems are generally solved on one of three basic spaces: continuous spaces (spatial), discrete spaces, and network spaces. The first of these three deals with location problems on a continuous space (in one, two, or three dimensions) where any location within the realm is a feasible location for a new facility. The second looks at problems where locations must be chosen from a pre-defined set while the third looks at location problems that are confined to the arcs and nodes of an underlying network [2].

4. THE DEMPSTER-SHAFER BELIEF THEORY

Dempster-Shafer theory of evidence differs from the Bayesian probability theory as it allows assigning beliefs not only to atomic elements but to sets of elements as well. The base of the Dempster's belief distribution is the frame of discernment (Ω) - an exhaustive set of mutually exclusive alternatives. A belief distribution function (also called mass function or belief potential) m(A) represents the influence of a piece of evidence on subsets of **Ω** and has the following constraints:

$$m(\phi)=0\,; \tag{1}$$

$$\sum_{A\subseteq\Omega} m(A)=1\,, \tag{2}$$

m(A) defines the amount of belief assigned to the subset A. When m(A) > 0, A is referred to as a focal element. If each focal element A contains only a single element, the mass function is reduced to be a probability distribution. Mass also can be assigned to the whole set of **Ω**. This represents the uncertainty of the piece of evidence about which of the elements in **Ω** is true. In our case each mass function is defined on a set of variables D = {x1, ..., xn} called the domain of m [4].

Each variable is Boolean and represents an assertion in the knowledge base. For a single variable we can get degree of support Sup(x) = m({true}) and degree of plausibility Pl(x) = m({true}) + m({true; false}). Plausibility specifies how likely it is that the statement is false. Based on plausibility it is possible to select from a set of statements the one to be removed.

Given two mass functions m1 and m2, Dempster-Shafer theory also provides a combination rule for combining them, which is defined as follows:

$$m(C)=\frac{\sum_{A\cap B=C} m_1(A)m_2(B)}{1-\sum_{A\cap B=\phi} m_1(A)m_2(B)}\,. \tag{3}$$

Combination rules specify how two mass functions, say m1 and m2, are fused into one combined belief measure m12 = m1 x m2 (we here let the binary operator x denote any rule for mass function combination). Many combination rules have been suggested (several are presented in [16]), and below we briefly discuss the ones we use in our study.

To combine multiple mass functions, the combination rule is applied repeatedly. Most combination rules are associative, i.e., (m1 x m2) x m3 = m1 x (m2 x m3), meaning that the order in which mass functions are combined does not affect the final outcome. For non-associative rules, however, that do not have this algebraic property, the order matters. Hence, unless a specific order of the classifier outputs can be justified, the result of using this type of rules is ambiguous.

5. THE INTERVAL NUMBER SYSTEM

Recall that the closed interval denoted by [a, b] is the set of real numbers given by

$$[a,b]=\{x\in R : a\le x\le b\}. \tag{4}$$

Although various other types of intervals (open, half-open) appear throughout mathematics, our work will center primarily on closed intervals. The term interval will mean closed interval. [5]

We will adopt the convention of denoting intervals and their endpoints by capital letters. The left and right endpoints of an interval X will be denoted by X and X, respectively. Thus, $X=\left[\underline{X},\overline{X}\right]$.

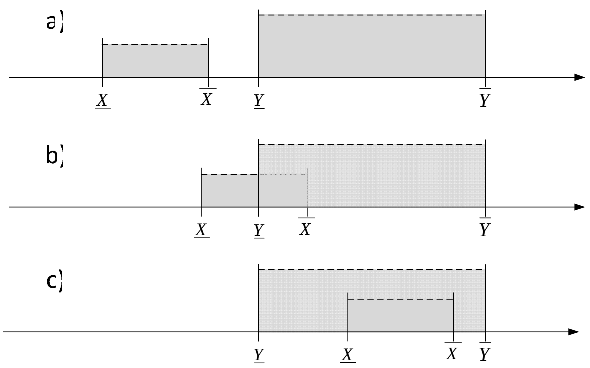

Figure 1 An example of the relationship between intervals

The intervals can be entered to the rule Dempster, see eq. (3). After the calculations main factors are as follows:

$$\underline{m(A)}^{*}=\frac{\underline{m(A)}}{1-max\left[\underline{m(\varnothing)},1-\sum_{\substack{B\neq A\\ B\neq\varnothing}}\overline{m(B)}-\underline{m(A)}\right]},\tag{5}$$

$$\overline{m(A)}^{*}=\frac{\overline{m(A)}}{1-min\left[\overline{m(\varnothing)},1-\sum_{\substack{B\neq A\\ B\neq\varnothing}}\underline{m(B)}-\overline{m(A)}\right]}.\tag{6}$$

In the previous paragraphs the theoretical basis used in the development of a method to determine the location of the offshore observation stations. In the next section, Demsper - Shafer will be presented in a practical example. Schematically in Figure 2 shows a sea area bounded by the three zones of the mainland. At each observation station placed a sea area between them. Presented a problem with the detection capabilities of the marine facility at P.

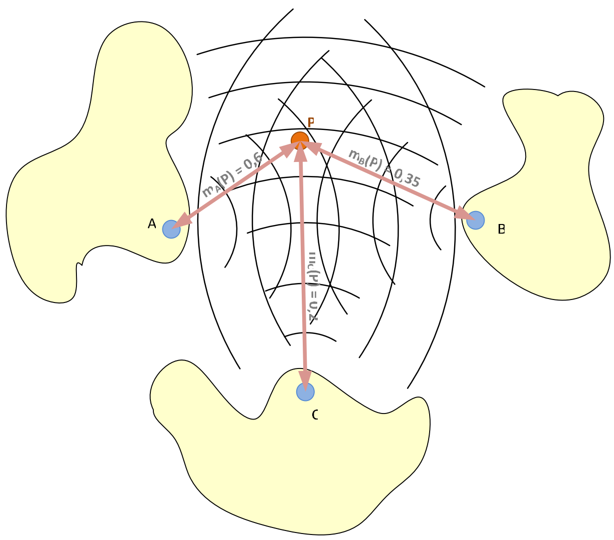

Figure 2 The detection of the object point P by three observation stations

6. STATIONS SYSTEM IN SEA AREA

For each characteristic point coverage area is checked by each of the monitoring stations analyzed included in the maritime area. If the value of the probability of detection of the marine object at a given point is 0, the current drive calculations are performed for the first time. It is here assumed that the sensed object is able to detect the probability of detection of the object. The probability of non-detection of the object is the object of a set of probability of detection of the object. In the next iteration cycle, if a characteristic point will be under the control of another observation station, the probability of non-detection of the object is obtained by multiplying the probability of non-detection of the previous value and the value corresponding to the ability to detect the new station. The detailed algorithm is presented in Figure 3.

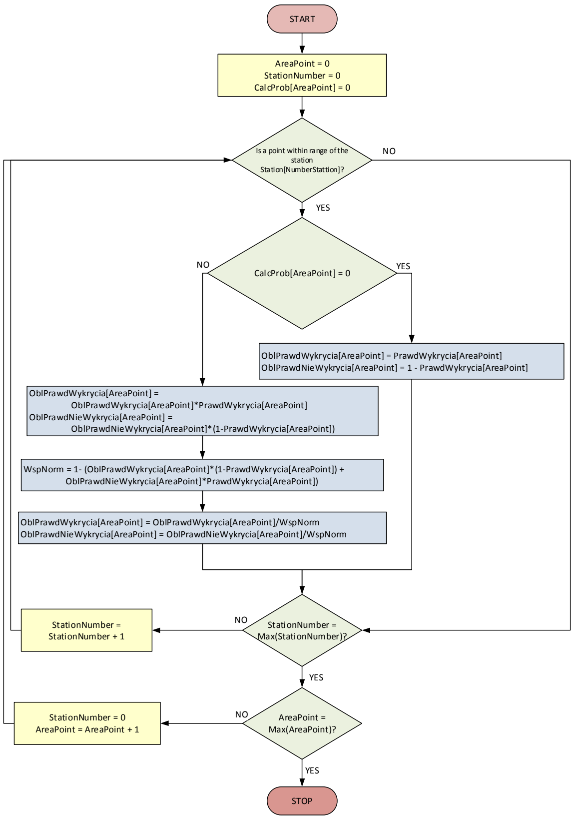

Figure 3 Calculation of probability of detection algorithm in Section Area

Dempster theory can be used to designate the ability to detect marine units in selected areas. In Figure 4 presented an example of seashore radar system. The main task is to detect vessels in the sea area [6].

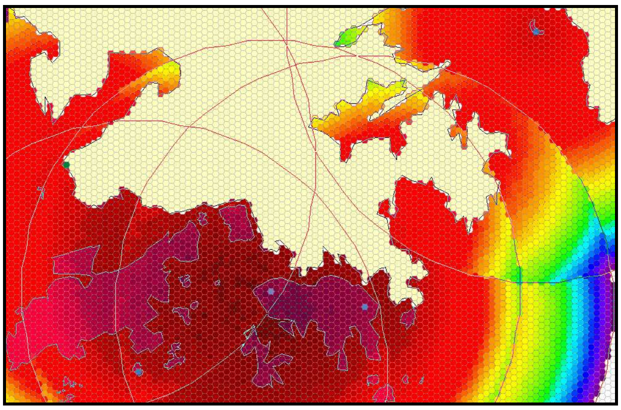

Figure 4 Example of seashore radar system

When the rapid and accurate calculation of the estimated time of arrival at the port of destination of the ship at sea, is of great importance in many areas of the ocean shipping industry. For example, the route and schedule of ships on a day to day, it is important to know when the ship reached the port of destination and to be available for new loads. Estimated time of arrival can also be important in the planning of port operations. Give a reliable estimated time of arrival for ships entering the port, planning port operations, such as work assignments, loading/unloading equipment and harbours for ships can be more efficiently done [7].

For a given source vertex (node) in the graph, the algorithm finds the path with lowest cost (ie the shortest path) between that vertex and every other vertex. It can also be used for finding the shortest cost path from one vertex to a destination vertex by stopping the algorithm is determined by the shortest path to the destination node. For example, if the vertices of the graph represent the city and are the costs of running paths edge distances between pairs of cities connected directly to the road, Dijkstra□s algorithm can be used to find the shortest route between one city and all other cities. As a result, the shortest path algorithm is widely used routing protocols in a network, in particular the IS - IS and Open Shortest Path First [8].

The proposed scheme is shown in figure 5. Provides an overview of the optimal path, the removal of all further edges.

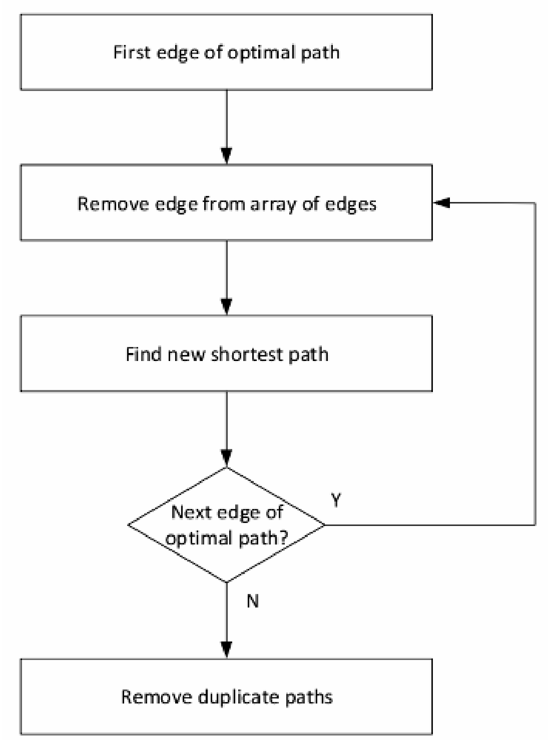

Figure5 Diagram of searching new paths

Because the input parameters are not precisely defined intervals are proposed (see chapter 5). Inputs to the model record ship characteristics, movement report data and numerical weather prediction data: the model will integrate consumption curves, speed reduction curves, ship class, ship wind and weather sea borders, movement report speed, maximum allowed speed, movement report trace data to include waypoints, latitude and longitude. In addition to data related to the movement of the vessel it is necessary to the description of the environment. Especially important is the description of the possible routes between the points start and end.

7. CONCLUSIONS

The Dempster-Shafer and Dijkstra algorithms are well known. The Dijjksta algorithm was first published almost a half a century ago. To this day, finding connections between vertices is used. But not always the shortest path is the best. It is to consider various criteria. This paper is an introduction to further research.

In this study was developed a model of the ship routing network that solves problems optimal path using a modified version of Dijkstras shortest path algorithm and the basic function of the reaction vessel. Was established fidelity models by testing. As you can see, the model avoids the adverse weather conditions and solves the path of least time to your destination. It calculates the useful time, distance, fuel consumption and metrics to quantify routing decisions. All calculations was made by intervals.

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COMPUTATIONAL FLUID DYNAMIC ANALYSIS OF MARITIME CONTAINER TERMINALS

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***Abstract:** The existing movement for the reduction of environmental impact and improvement of efficiency of processes, lead to a need for optimizing the transport and logistic chains. Here it is presented a possible approach for using Constructal Theory in order to develop an alternative for shape optimization and access to the storage area in a container terminal for reaching sustainability. The approach consist on the utilization of the Constructal Theory for generating optimized geometrical shapes of the container storage area. The analysis shall be made based on the analogy between transport systems and fluid dynamics, which can be transferred for advanced analysis in a FEM application. The results will show the possibility presented by this kind of application for the overall optimization of transport systems and reduction of transport times, thus decreasing the impact on the terminal and reducing GHG emissions.*

***Key words** container terminal, Constructal Theory, Finite Element Method, fluid dynamics, optimization, transport.*

1. INTRODUCTION

Transport systems are an essential part of any economy. The existing global situation finds a highly distributed production process, as emerging eastern Asian countries attracted a large amount of contracts for products and services. In this case, the transport systems needed to cope with the increased demand.

One of the most important branches of the transport, is the intermodal transport which is based on the transport of container units. The invention of the container had a great impact on transport systems, as the direct manipulation of cargo in transfer hubs was decreased or eliminated altogether. Also the customs procedures were simplified for intermediate transport hubs, as the containers needed to be checked at the beginning and the end of the transport route.

At this point, container terminals became an essential part of the transport system, as they needed on one side to handle the ever increasing number of transport units (containers) and on the other side, to provide improved value added services for customers.

The increased traffic figures for containers led to a need to optimize the existing container terminals or to develop new terminals based on more efficient designs. However, the designs were based mostly on urban planning experience, with low mathematical support. Such a design is the grid shape, which has proven its efficiency. For the optimization of movement within a given domain, there were introduced algorithms which could calculate time, routes, consumption and other specific parameters. Most of the algorithms for optimizing transport systems were developed for IT applications, which came with advantages and disadvantages.

The continuous need for improvement of container terminals gave rise to numerous attempts to conceive new approaches for geometric, process or economic optimization of activities.

The current paper aims the analysis of a new concept for developing the geometrical shape of a container terminal, in order to obtain the optimal distribution of container flows within the terminal, with minimal transport times and minimal energy use. The approach is based on the findings of the Constructal Theory (CT) in the field of transport systems.

2. CONTAINER TRANSPORT IN EUROPE AND THE BLACK SEA

Intermodal transport is defined as “the movement of goods in one and the same loading unit or road vehicle, using successively two or more modes of transport without handling the goods themselves in changing modes” (ECMT/UN Definition)

Intermodal transport had a high impact on the transport figures and prices, as companies realized that it was cheaper to produce goods in the eastern Asian countries and to ship them via containers to assembling

factories, in order to achieve lower costs and a competitive position on the global market.

A 20 years statistic developed by the United Nations Conference on Trade and Development – UNCTAD, shows a mean yearly growth of container traffic of 8.2%. Even considering the 2009 drop in container transport due to the economic crisis, the figures for 2011 were showing a 12.9% increase compared with 2009. [10]

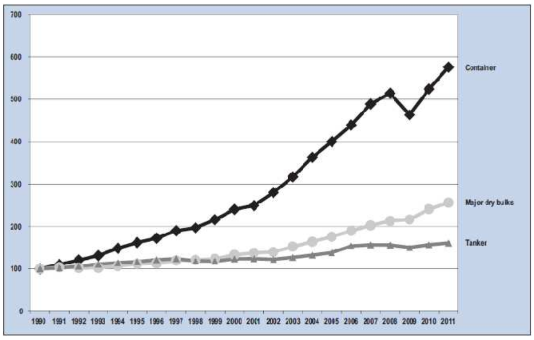


Figure 1 Global traffic for containers, bulk and oil products [9]

For the European region, the trend was similar. However, the share of the container transport figures is unbalanced between western and eastern Europe.

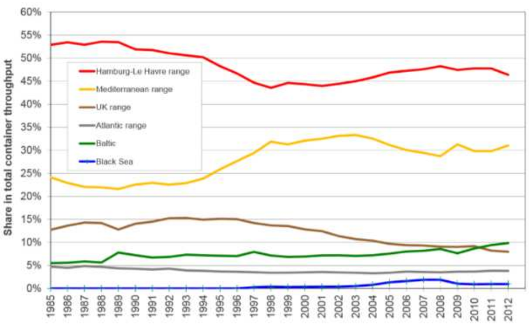


Figure 2: European container traffic [6]

As it can be seen from Figure 2, the majority of the container traffic is split between the northern western ports and Mediterranean ports. Black Sea container traffic still has the lowest transport figures, even considering that Constanta Port was declared by the European Union as the eastern gate for import and export of goods.

The unique geographical position of Constanta port and the existing connectivity with all transport modes, makes it a suitable candidate for analysis.

For the intermodal transport, Constanta port has four container terminals: Constanta South Container Terminal (CSCT), APM Terminal, SOCEP and UMEX. Of the existing terminals, CSCT is the most important, with a 97.44% share of container traffic in 2013. [7]

For this reason, the geometrical optimization of CSCT was chosen for further analysis.

3. CONSTRUCTAL THEORY IN TRANSPORT

From the existing approaches on the subject matter, the Constructal Theory (CT) was identified as being a suitable candidate in the development of optimal transport systems, as it is able to develop the basic shape and structure of the system.

The Constructal Law was first enounced by Prof. Bejan in 1997 and it states that: "For a finite-size system to persist in time (to live), it must evolve in such a way that it provides easier access to the imposed currents that flow through it". [1]

According to the law, the need of a system to self-optimize in the presence of local and global constraints will generate the shape and structure of the system, by optimal distribution of its imperfections, the system remaining imperfect. The Constructal Theory admits that imperfections are a part of nature and is not disregarding them, but is integrating them in the developing system.

Although the Constructal Theory began as a method of determining optimal configurations for thermal flows, later research proved that the theory can be applied in an increasing range on engineering fields, including the transport systems [4].

In the case of transport, the approach is to consider a surface that is assembled as a sum of elementary surfaces that are being dictated by the area of existing objects (buildings other constructions, parking lots for different types of cars and in our case, transport units). The theory considers a first construct that comprises of a longitudinal channel that splits a surface in two symmetrical shapes. The area (Figure 1) is fixed (A_1=H_1L_1), but the ratio between length and width (H_1/L_1) varies and is subject to optimization. This is helpful in the case of container terminals, where the surface that needs to be optimized, is fixed and to expand would imply greater costs.

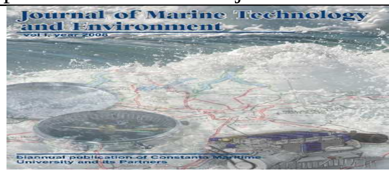
For the smallest element, it is not important to calculate travel time for all the points inside the area, but to consider a point P that is the most disadvantaged and its travel time to a point M, the entry/exit to/from the surface.

The travel time shall be:

$$t_1 = \frac{L_1}{V_1} + \frac{f_1 H_1}{2V_0}, \tag{1}$$

where

$$f_1 = \frac{1}{\cos\alpha_1} - \frac{V_0}{V_1}\tan\alpha_1, \tag{2}$$



and α_1 is the angle between V_0 and the perpendicular to V_1.

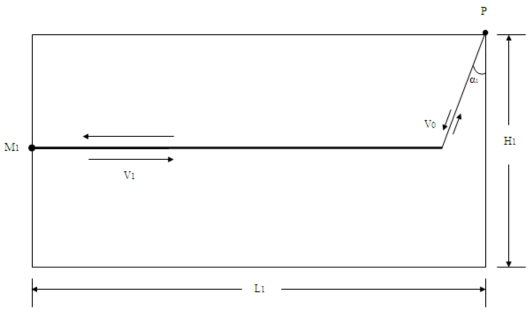


Figure 3 – The basic surface

Equation (1) is valid when is valid when $\tan\alpha_1 < 2L_1/H_1$.

The next step is to eliminate L_1 from the equation (1) and we shall get the equations for the optimal shape and minimum travel time:

$$H_{1,opt} = \left(\frac{2V_0 A_1}{f_1 V_1}\right)^{1/2}, \tag{3}$$

$$\left(\frac{H_1}{L_1}\right)_{opt} = \frac{2V_0}{f_1 V_1}, \tag{4}$$

$$t_{1,\min} = \left(\frac{2 f_1 A_1}{V_0 V_1}\right)^{1/2}. \tag{5}$$

The minimal time can be optimized by varying the angle α_1, obtaining:

$$\alpha_{1,opt} = \sin^{-1}\left(\frac{V_0}{V_1}\right), \quad f_{1,\min} = \cos\alpha_{1,opt}. \tag{6}$$

Having the A_1 area optimized, there can be developed the next order, as it is shown in Figure 4.

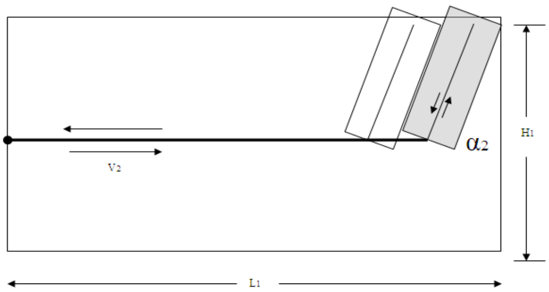


Figure 4 Second level construct

The next area A_2 shall be developed with the help of an "n" numbers of A_1. In this case, $A_2 \cong n_2 A_1$. The approximation is a consequence of the angle α that was introduced for minimum travel time and it can be noticed in Figure 4 as the space left unoccupied by A_1 elements. This is an important aspect of the Constructal Theory, as the imperfections of the system are considered as part of any natural developed system.

As other theories and practices are aiming to eliminate the existing imperfections or disregard them from the calculations, the Constructal Theory handles the imperfections by integrating them along the system at the smallest scale.

The A_2 shape shall be determined by the following formulas:

$$H_{2,opt} = \left(\frac{A_2 V_1}{f_2 V_2}\right)^{1/2}, \tag{7}$$

$$\left(\frac{H_2}{L_2}\right)_{opt} = \frac{V_1}{f_2 V_2}, \tag{8}$$

$$t_{2,\min} = 2\left(\frac{f_2 A_2}{V_1 V_2}\right)^{1/2}, \tag{9}$$

$$f_2 = \frac{1}{\cos\alpha_2} - \frac{V_1}{2V_2}\tan\alpha 2. \tag{10}$$

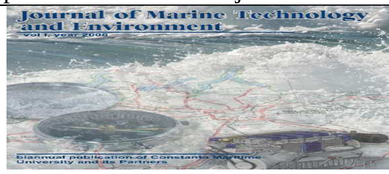
The angle factor is minim when $\alpha_{2,opt} = \sin^{-1}(V_1/2V_2)$, provided that $\tan\alpha_2 < 2L_2/H_2$.

The number of A_1 elements that are necessary to cover the entire A_2 surface shall be calculated with the following formula:

$$n_2 \cong 2 f_1 f_2 \frac{V_2}{V_0}\left(1 - \frac{V_1^2}{4V_2^2}\right). \tag{11}$$

For A_i, $i \geq 2$, the formulas are determining a pattern for higher order constructs:

$$\left(\frac{H_i}{L_i}\right)_{opt} = \frac{V_{i-1}}{f_i V_i}, \tag{12}$$



$$\alpha_{i,opt} = \sin^{-1}\frac{V_{i-1}}{2V_i}, \tag{13}$$

$$t_{i,\min} = 2\left(\frac{f_i A_i}{V_{i-1}V_i}\right)^{1/2}. \tag{14}$$

By applying the formulas above, the shape that is emerging will not be a fractal, as the shape of every construct shall be determined by the difference in travel speeds. As the speed factor increases for higher constructs, the secondary streets are approaching more and more the perpendicular on the main streets.

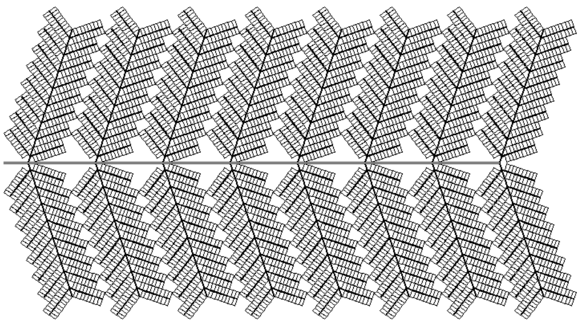


Figure 5 Leaf shaped system (higher level constructs)

4. HYDRAULIC ANALOGY

It has to be mentioned from the beginning that in the present paper, there is no attempt to create a strict similitude between the transport and hydraulic systems. The main problem is the way flows are developed: fluid flows are composed of large numbers of atoms or molecules whereas transport flows are based on relatively small macro units.

In order to be able to analyze the transport systems based on fluid mechanics, there were developed similarities at a basic level. This kind of analysis comes in handy when made with CFD software, as the results are given also in a visual manner, which can offer a better view and understanding of eventual bottlenecks in the transport systems, possibilities to optimize them or identify unused space.

The analogy can be easily developed by considering the similarities between the two kinds of systems. In this way, the following properties can be considered as analogues (transport-fluid):

- Start point – source
- Destination – sink
- Transport route – pipeline
- Parking lot – storage tank
- TEU/time – flow
- Drag – viscosity

For the purpose of the current CFD analysis, the parameters which shall be taken into consideration are the source, sink and pipe.

5. DESIGN DEVELOPMENT

Within a container terminal, the most important aspect is related to the size and geometrical shape of the container storage area. The shape defines the terminal and the flows through the terminal.

Based on the finding of the constructal theory in the field of transport systems, there will be developed a theoretical shape for the container terminal. In parallel, the storage area of CSCT will be transposed in CFD and analyzed. The two systems will be superimposed and there will be identified possibilities for optimization.

5.1 Development of the theoretical design

According to the constructal theory, the development of the geometrical shape needs to take into consideration the local and global constraints of the system. Taking into account the aspects identified within CSCT, the constraints are the ISO standard dimensions of containers, the terminal equipment need and limitations, access routes dimensions, auxiliary access route under RTG crane (Rubber Tyred Gantry).

Considering these aspects, the elementary area was developed by taking into consideration the standard dimension of a FEU (Forty-foot equivalent unit) of 12.2 x 2.44 m, arranged symmetrically on two rows of six containers. In order to allow the RTG cranes to grab the containers, there was introduced a gap of 0.5 m along the width of containers and 0.6 m on the length. Additionally there was the need to add the rolling path of the RTG crane, as it can be seen in Figure 6. [14] [13]

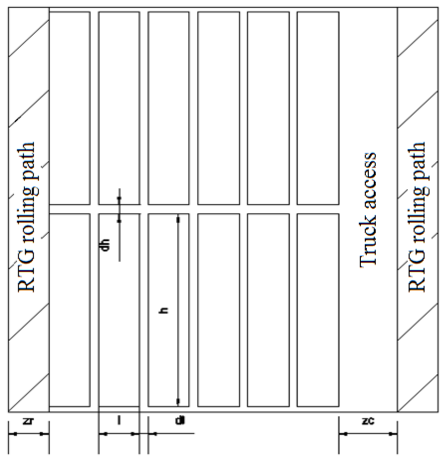


Figure 6 Basic area A_1

For the basic surface, it is considered:

$$l_1 = l \cdot 6 + dl \cdot 5 + zr \cdot 2 + zc \quad (15)$$

where:

- l –FEU width
- dl – distance between FEU on width
- zr – width of RTG rolling path
- zc – width of truck access path

From (5.1), results:

$$l_1 = 17{,}14 + 2{,}4 + 3{,}5 + 2{,}4 = 25{,}44\ m. \quad (16)$$

For A_1 width:

$$h_1 = h \cdot 2 + dh + \frac{dh}{2} \cdot 2 = \\ = 12{,}2 \cdot 2 + 1{,}2 = 25{,}6\ m \quad (17)$$

Thus:

$$A_1 = l_1 \cdot h_1 = 651{,}264\ m^2 \quad (18)$$

For higher designs there were considered the traveling speeds on the symmetry axes: v_0 = 0,278 m/s (1 km/h), v_1 = 0,35 m/s (1.26 km/h), v_2 = 1,39 m/s (5 km/h) □i v_3 = 5,55 m/s (20 km/h).

For A_2 it is considered

$$\alpha_2 = sin^{-1}\left(\frac{v_1}{2v_2}\right) = 7{,}23° \quad (19)$$

and

$$f_2 = \frac{1}{\cos\alpha_2} - \frac{v_1}{2v_2}\tan\alpha_2 = 0{,}9922 \quad (20)$$

Area A_2 will be constituted of n areas A_1:

$$n_2 \cong 2 \cdot f_1 \cdot f_2 \frac{v_2}{v_0}\left(1 - \frac{v_1^2}{4v_2^2}\right) \cong \\ \cong 2 \cdot 1 \cdot 0{,}9922 \cdot 5 \cdot 0{,}98415 \cong 9{,}76 \quad (21)$$

In order to obtain a symmetric surface, the value of n_2 is rounded to 10. Moreover there was introduced a distance of 0.5 m between A_1 areas, needed for the movement of RTGs and the access road which is considered to have 3.5m wide with four lanes (two ways).

For A_2:

$$l_2 = 5 \cdot h_1 = 25{,}6 \cdot 5 + 7 = 135\ m \quad (22)$$

$$h_2 = 2 \cdot l_1 + 3{,}5 + 0{,}5 \cdot 2 = 55{,}38\ m \quad (23)$$

$$A_2 = l_2 \cdot h_2 = 135 \cdot 55{,}38 = 7476{,}3\ m^2 \quad (24)$$

or:

$$A_2 \cong n_2 A_1 + 3{,}5 \cdot 135 + (0{,}5 + 0{,}5) \cdot 135 \\ + 2 \cdot 25 \cdot 7 \cong \\ \cong 10 \cdot 651{,}264 + 3{,}5 \cdot 135 + \\ +135 \cong 7476{,}3\ m^2 \quad (25)$$

For the access time to the surface:

$$t_{2,min} = \left(\frac{2f_2A_2}{v_1v_2}\right)^{1/2} = \\ \left(\frac{14835{,}96972}{0.4865}\right)^{1/2} = 174{,}63\ s \quad (26)$$

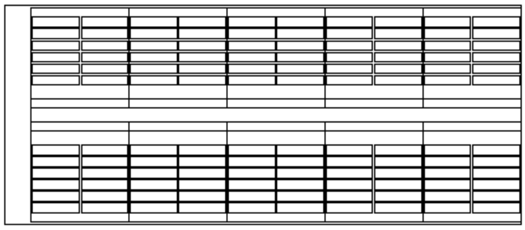


Figure 7: A_2 surface without the optimization angle α

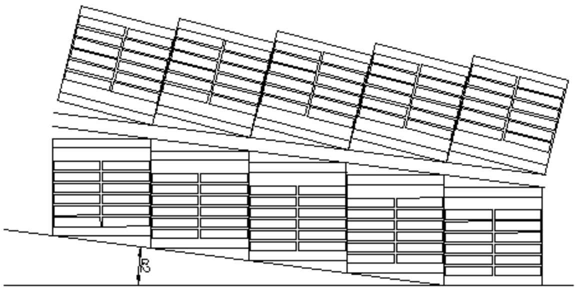


Figure 8: A_2 surface with the optimization angle α

For the next construct (A_3):

$$\alpha_3 = sin^{-1}\left(\frac{v_2}{2v_3}\right) = 7{,}19° \quad (27)$$

$$f_3 = \frac{1}{\cos\alpha_3} - \frac{v_2}{2v_3}\tan\alpha_3 = 0{,}9921 \quad (28)$$

$$n_3 \cong 2 \cdot f_2 \cdot f_3 \frac{v_3}{v_1}\left(1 - \frac{v_2^2}{4v_3^2}\right) \cong \\ 2 \cdot 0{,}9922 \cdot 0{,}9921 \cdot 15{,}8571\left(1 - \frac{1{,}39^2}{4 \cdot 5{,}55^2}\right) \\ \cong 30{,}22 \quad (29)$$

The dimension of the storage area shall be:

$$l_3 = 15 \cdot h_2 = 830{,}7\ m \quad (30)$$

$$h_3 = 2 \cdot l_2 = 270\ m \quad (31)$$

$$A_3 = l_3 \cdot h_3 = 830{,}7 \cdot 270 = 224289\ m^2 \quad (32)$$

Minimum time for surface access shall be:

(33)

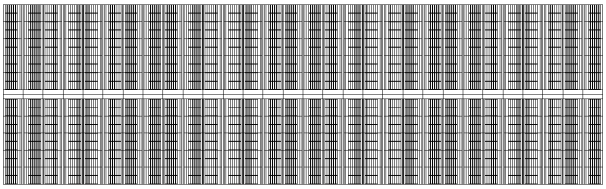


Figure 9 A_3 surface without the optimization angle α

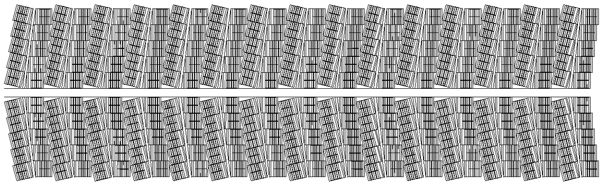


Figure 10 A_3 surface with the optimization angle α

5.2 Modeling of the CSCT storage area

The configuration of the terminal is the grid pattern. It has 14 identical subsections (191x17m) and 4 longer subsections (338x17m). [13]

Figure 11 CSCT storage area

Figure 12 CAD representation of the storage area

Traffic flow is regulated through the terminal as it can be seen from Figure 13.

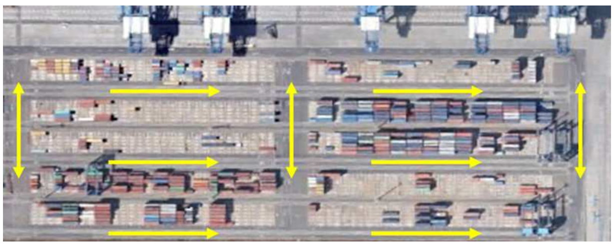


Figure 13 Traffic regulations within the storage area

The configuration is different from the one way, one flow per sense constructal approach, in the sense that the flows from the terminal are sometimes intersecting.

In order to be analyzed as a hydraulic system, the storage area was transferred into a CAD design:

Figure 14 CAD representation of a subsection

6. CFD ANALYSIS OF MODELS

As it was stated in the beginning of the paper, the objective is to analyze the real and theoretical models separately and to superimpose them in order to check optimization possibilities.

The analysis shall be made with the help of Ansys Fluent, one of the most popular and professional applications for CFD. [12]

6.1 Analysis of theoretical design

From the designs developed in chapter 5.1, there were extracted the access routes and transferred in the form of a pipe network into Ansys.

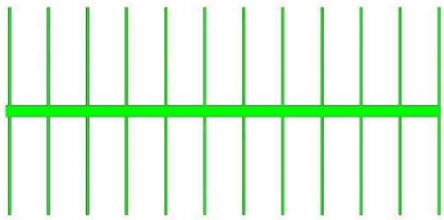


Figure 15 Mesh of the CT grid

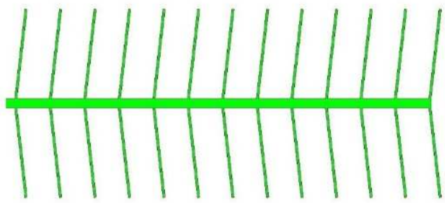


Figure 16 Mesh of the CT arborescent shape

Figure 15 and Figure 16 are showing the optimal geometry for a terminal, given the parameters set in the beginning. However, one constraint that resulted from the real terminal is the development area. In order to make the comparison, the theoretical model was cropped to only 3 secondary branches in order to fit in the given area and to be similar to the real storage area.

Another constraints that arises from the real terminal is the necessity for a grid shape. The equipment of the terminal is designed to work in a linear manner. The introduction of the optimization angle α is increasing the traveling speed within the terminal for transport vehicles on the main routes, but it increases the maneuvering time for other types of transport (e.g. RTGs). In this case, the analysis shall be conducted only on the grid pattern.

The working fluid for all cases was set to water as real fluid (not ideal) and the speed of the fluid was set to 5.55 m/s (20 km/h). The analysis was done for two flow possibilities: M to P and P to M (see Figure 3).

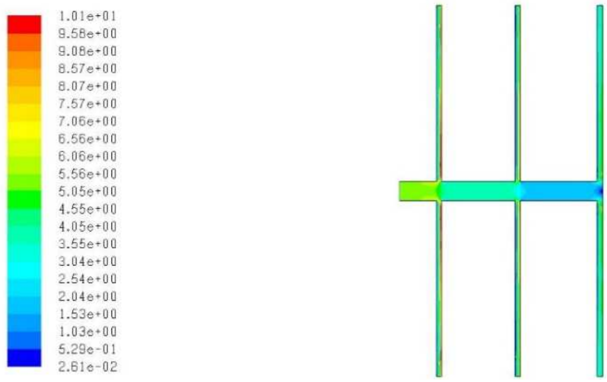


Figure 16 M→P velocity vectors (m/s)

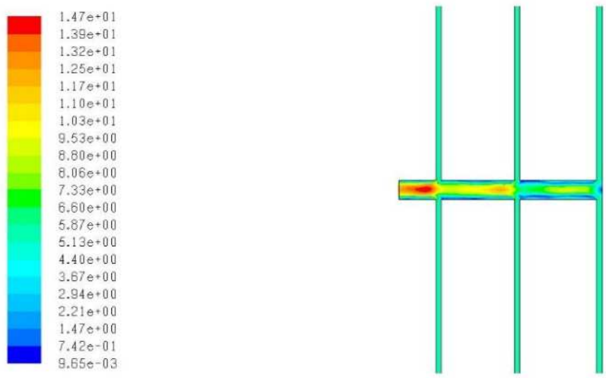


Figure 17: P→M velocity vectors (m/s)

For an initial speed of 5.55 m/s, the attained speed for M→P is 10.1 m/s. For the second case, the speed of 14.7 m/s is higher, but this is partly due to the convergence of fluid from the six small pipes into the main pipe. The analysis model was set to laminar flow, but the results showed a deviation from laminar, especially for the P→M analysis. The disturbance is created when the flows are intersecting.

6.2 Analysis of CSCT model

In the case of the real container terminal, the analysis was developed in a similar way, with water as working fluid, with an inlet speed of 5.55 m/s (20 km/h). The symmetrical shape of the analyzed section gives the possibility to conduct only one analysis on the geometry.

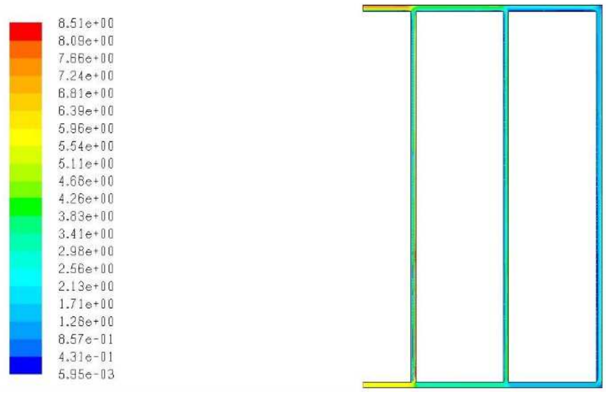


Figure 18 Velocity vectors for CSCT model (m/s)

For the CSCT case, the maximum speed of the flow within the analyzed system is of 8.51 m/s. An increase from 5.55 m/s of the inlet flow, but not as much as the theoretical design. The same as the theoretical models, the analysis type was set to laminar. In this case, it was observed the same deviation from the laminar model.

7. CONCLUSIONS

The constructal theory offers a new and interesting view on the way transport systems are developing based on the reduction of energy consumed. Movement patterns were developed by early civilizations based on the individual needs. As communities became larger, urban systems were starting to be based on the need of groups of people. This developing pattern was the basic principle behind the development of transport related research by Prof. Bejan. [2], [3]

The theory is based on the reduction of energy consumption and optimization of access for thermodynamic systems. By considering the natural optimization of systems, Prof. Bejan was able to put into mathematical formulas what nature is doing at any given moment: it is optimizing flows in order to improve overall efficiency of systems.

In the case of transport systems, the constructal theory's solution comes close to the grid pattern which was developed based on human experience and observations. In the case of a domain which needs access only to and from one point (point M), the optimization angle α creates a leaf shaped pattern which in many cases is better than the grid shape. In the case of existing urban systems, the optimization angle can be an impediment, by diminishing the access within the same area.

In the case of container terminals, if we consider only the case where containers are transported between the ship and the storage area, α angle is optimizing the transport speed and time. But, as it was shown before, yard equipment is developed for grid shaped storage area.

The case of CSCT was chosen due to its geographical location and connection to major transport routes. Since the inauguration of the terminal in 2006, the capacity of the terminal increased to 1.2 million TEU/year. Future investments were aiming to increase the capacity to 5 million TEU/year, but the economic crisis put a stop on the large expansion. [5]

For the existing situation of the terminal, large investment in infrastructure are not possible. One of the objectives of the current paper was to find optimization possibilities for the container terminal. [8]

The comparison between the theoretical and real geometries revealed two main optimization possibilities: one for the shape and one for the flows.

In the case of changing the geometry, the optimal shape of a sub-branch should be 135 meters, based on the theoretical model. In order to modify the existing system, there would be necessary large investments in the terminal. The storage sections for containers are specially designed to stack 5 containers. The access routes are designed for yard traffic. The modifications would require for the access routes to be shifted and new storage places to be constructed.

The second possibility comes from analysis made in Fluent. As it was shown in Figure 13, the movement within the terminal follows the regulations of right - hand traffic. This means that when a vehicle is exiting a sub-section, it needs to give way to left and right traffic.

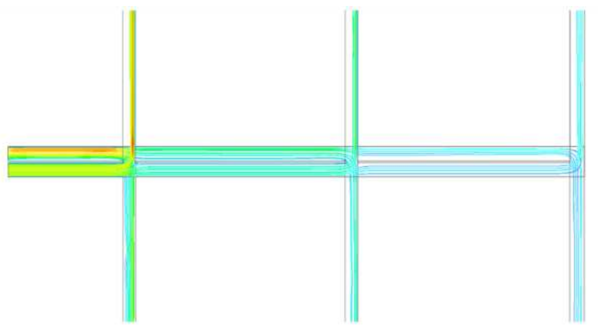


Figure 19 Overlapping of flows at intersections

In this case, there are two possibilities: to shift the movement of vehicles to left-hand traffic or to change the one way current direction of travel on the sub-sections.

The shift to left-hand traffic is possible, but not recommended. The right-hand driving is native to Romania and the drivers could become confused inside the terminal. Plus any mistake of a visiting driver could lead to incidents or accidents.

A less intrusive and cheaper approach can be the change in the one-way direction of travel in the sub-sections. The change will enable a better traffic flow, as the vehicles will only give way to only one traffic, from the left side. Combined with the existing wide access routes, the drivers can decide in good time even if they need to stop to give way.

CSCT has in normal operations 55 ITVs (Internal Transport Vehicle) and ECHs (Empty Container Handlers) within the terminal. [11] The yearly capacity of the terminal is measured by the number of handled containers. In this context, the improvement of transport figures by only one percent will result in an increase of transport figures with 12000 TEU/year, just by implementing a simple traffic scheme.

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BLUE ENERGY IN THE SEAS AND OCEANS

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Abstract: The seas and oceans have the potential to become important sources of clean energy. Marine renewable energy, which includes both offshore wind and ocean energy, presents an opportunity to generate economic growth and jobs, enhance the security of the energy supply and boost competitiveness through technological innovation, contributing to the decarbonisation goals.

In the context of a decrease of the primary resources, the blue energy generated by the oceans and seas captured the interests of many countries. We see today many studies, researches, projects that crossed the borders of the countries, developed by collaborative mixed teams. The results are promising, the success is guaranteed.

The present paper is a desk research on the ocean energy in Europe and not only in this region, showing the best practices in this area of activity and their implementation.

The conclusions are very clear and sustained by the figures; the blue energy gained its own place in the mix energy of many countries. This inexhaustible resource seems to gain more and more interests year by year.

Key words: blue energy, currents energy, ocean energy, renewable resource, tidal energy, wave energy.

1. INTRODUCTION

Energy Strategy is "a complex activity that involves the initiation, conduct and correlation of the political, economic, technical and environmental actions in order to ensure the national energy security, diversification of internal and external supply sources, to improve and diversify forms of energy production, the increase production efficiency and energy consumption, improving pollutant impact of energy production and consumption "[2].

Integrated Energy Strategy consists of a "set of interrelated measures that directs the energy sector to the most efficient, equitable and environmentally compatible use of resources."[1].

Globally, it is estimated that total energy demand in 2030 will be about 50% higher than in 2003, and oil demand will be about 46% higher. The secure known oil reserves can sustain the current levels of consumption only until 2040, and those of gas until 2070, while the world reserves of coal provides for more than 200 years even to an increase in the level of operation. Projections indicate an economic growth, which would imply a higher consumption of energy resources.

In terms of the structure of primary energy consumption worldwide, evolution and prognosis of the reference made by the International Energy Agency (IEA) highlights for the period 2010-2020 a quicker increase in the share of the renewable sources and natural gas.

It is estimated that about a quarter of the primary energy resources needs at the global level, will still be covered by coal. Along with increasing energy consumption and coal consumption will increase. Data from the World Energy Council (WEC) show an increase of nearly 50% of global coal mining in 2005 compared to 1980.

The increase of the prices for the fossil energy and dependence on imports makes it extremely necessary to the production and exploitation of renewable energy for heat, electricity and fuel.

Developing the renewable energy is a central objective of the European Commission's energy policy in Europe and of the most important countries in the world. There are several reasons for this. Renewable energy has an important role to play in reducing carbon dioxide emissions (CO_2) - a major objective. The increase of the share of renewable energy in the energy balance brings durability. It also helps to improve energy security by reducing dependence on growth of imported energy sources. Renewable energy sources are expected to be competitive economically with conventional energy sources in the medium and long term.

Among renewable energy, the ocean energy occupies a low place, but the potential of this source is very high. According to a recent study, the marine energy has a double potential compared to that of the entire nuclear energy produced in the present moment all over the world, and it is more reliable than wind and solar energies. It is estimated that it will take at least 5-10 years for the technology to get out of the demonstration phase and decrease costs so that marine energy can compete economically with that from other energy sources.

European Association for Ocean Energy (EU-OEA) has released another study, according to which, by 2050, marine energy could provide 15% of Europe's energy needs. [3]

2. OCEAN ENERGY

As oceans cover over 70% of Earth's surface, ocean energy (including wave power, tidal current power and ocean thermal energy conversion) represents a vast source of energy, estimated at between 2,000 and 4,000 TWh per year, enough energy to continuously light between 2 and 4 billion 11W low-energy light bulbs.

Ocean energy can be harvested in many forms. Wave energy depends on wave height, speed, length, and the density of the water. Tidal stream energy is generated from the flow of water in narrow channels whereas tidal range technologies (or 'tidal barrages') exploit the difference in surface height in a dammed estuary or bay. Ocean energy can also be generated from temperature differences between surface and sub-surface water while salinity gradient power relies on the difference in salinity between salt and fresh water [3].

The ocean energy has some particular aspects, as follows:

- The ocean energy resource available globally exceeds the present and projected future energy needs. In the EU, the highest potential for the development of ocean energy is on the Atlantic seaboard, but is also present in the Mediterranean and the Baltic basins and in the Outermost Regions. For the North America, and particularly for U.S., the tidal power occurs only in Maine and Alaska; ocean thermal energy conversion is limited to tropical regions, such as Hawaii, and to a portion of the Atlantic coast; the wave energy has a more general application, with potential along the California coast. The western coastline has the highest wave potential in the U.S.; in California, the greatest potential is along the northern coast. Exploiting this indigenous resource would help to mitigate EU dependence on fossil fuels for electricity generation and enhance energy security. This may be particularly important for island nations and regions,
- where ocean energy can contribute to energy self-sufficiency and replace expensive diesel-generated electricity.
- The ocean energy sector can become an important part of the blue economy, fuelling economic growth in coastal regions, as well as inland.
- Ocean energy has the potential to create new, high-quality jobs in project development, component manufacturing and operations.
- Scaling up the deployment of ocean energy could contribute to the decarbonisation goals. Developing all sources of low-carbon energy in a cost-effective manner is very important in order to reduce the greenhouse gas emission.
- Ocean energy electricity output is different to that derived from other renewable energy sources. This means that ocean energy could help to balance out the output of other renewable energy sources such as wind energy and solar energy to ensure a steady aggregate supply of renewable energy to the grid.
- Ocean energy devices tend to be entirely or partially submerged and therefore have a low visual impact. As the scope for expansion of land-based renewable energy generation becomes constrained, the marine space offers a potential solution to public acceptance issues related to visual impact, which may hinder renewable energy developments on land.

2.1 Tidal energy

Tidal energy has been used since about the 11th Century, when small dams were built along ocean estuaries and small streams. The tidal water behind these dams was used to turn water wheels to mill grains.
Tidal current energy takes the kinetic energy available in currents and converts it into electricity.

Tides occur regularly in certain coastal areas in the world, with amplitudes that can sometimes reach 14 -18 m, causing slow oscillations of level of marine waters. For an efficient utilization of energy from tides, certain natural conditions are required. First, the amplitude of the tide to be at least 8 m, and, secondly, that there is a natural pond (typically an estuary) to communicate with the ocean by an extremely narrow opening. These natural conditions only occur in 20 areas of the world (for example: the Atlantic coasts of France, Great Britain, USA, Canada, in northern Australia, eastern China).

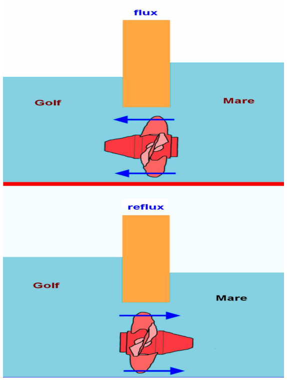

Figure 1 Operation of a power plant using tide power [5]

Some of the plants in the world that use the tidal energy are:

- Central Lake Sihwa, South Korea; the largest in the world, completed in 2011; 254 MW

Figure 2 Central Lake Sihwa, South Korea [6]

- Rance Tidal Power Station in the estuary Rance – installed power of 240 MW power; tidal amplitudes reaching over 13 m;

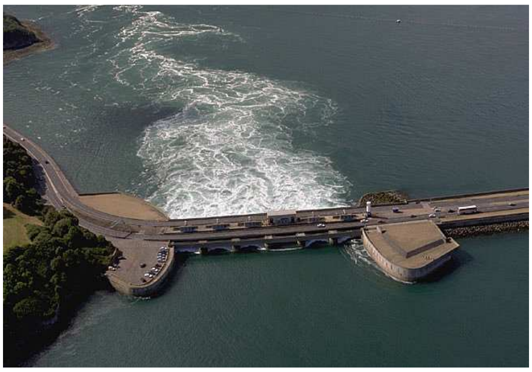

Figure 3 Rance Tidal Power Station [7]

- North America – “Annapolis Royal Generating Station”, put into operation in 1984, in the Bay of Fundy; installed power: 20 MW.

2.2 Marine currents

Marine currents are carriers of particularly high kinetic energy. Thus, it was calculated that an ocean current with a width of about 100 m, 10 m depth and speed of 1m / s, for one year could provide a kinetic energy of about 2000 kwh. [8]

2.3 Waves

The waves are a form of energy storage transmitted by wind energy calculable and worthy of consideration. Calculations have shown that waves with height of 1 m, length 40 m and period of 5 s, have a power of around 5 KW on a1 m wide front.

Wave energy research worldwide has experienced great magnitude in the last years. Today, capture and convert wave energy is widely applied in many buoys and signaling installations. But realization of energy power plants based on waves requires longer efforts currently being carried out a sustained activity in many countries.

Numerous research institutes in hydraulic and energy in the US, France, Britain and Japan have in their activities program, production of the installations in order to the wave energy.

And some projects are under study aiming sea energy recovery by using the temperature difference between the different layers of the World Ocean water. Frequently, in the warm sea waters there are large temperature differences between the surface layers and the depth, differences that would allow the operation of power plants based on the use of two different temperature heat sources.

Currently, there are hundreds of signaling buoys using wave energy, manufactured by China and Japan, and strives to achieve high power plants. These plants are based on different principles. Analyzing the operation of these plants, it can be seen that all have a common feature, namely training through turbine generators. It should be noted that the axial air turbines may have higher returns because of their intubation.

Types capture wave energy installations currently investigated can be grouped as follows:

- Plants capture wave energy for the shore (shoreline) and near the shore (nearshore)

• Installations with oscillating column - OWC (oscillating water column). Consisting essentially of an enclosure in which waves that penetrate form an oscillating column. This column acts a volume of air passing through an air turbine valve;

• Installations TAPCHAN. They consist of a pool where the waves coming through a specially designed channel cause the water to accumulate at a higher sea level. The obtained difference level allows powering the turbines;

• Plants swinging hinged panel. In a specially designed space, a panel varies due to waves propagate horizontally and operates a hydraulic pump. The pump feeds a hydraulic turbine.
- Plants capture wave energy for large areas (offshore)
• Danish plant with pump and float. It is an installation where a float operates a pump that it is anchored to the seabed, acting hydraulic turbines;
• Swedish plant HOSEPUMP. It is based on a cylinder made of elastomers, driven by a float, allowing the expulsion of water from the interior, feeding of a hydraulic pump and the drive power of a turbine;
• McCABE PUMP WAVE installation. It is consisting of some pontoons that move toward a central pontoon, acting hydraulic pump which supplies more hydraulic turbines;
• PELAMIS installation. It consists of several large size tubes, connected to one another by hinges which, because of the angular inclinations caused by waves, acts some liquid pump. In turn, the pumps operate the turbines connected with the electric generators (power plant from Portugal) [9].

In Europe, according to the EU report, the ocean energy resource available globally exceeds the present and projected future energy needs. In the EU, the highest potential for the development of ocean energy is on the Atlantic seaboard, but is also present in the Mediterranean and the Baltic basins and in the Outermost Regions. Exploiting this indigenous resource would help to mitigate EU dependence on fossil fuels for electricity generation and enhance energy security. This may be particularly important for island nations and regions, where ocean energy can contribute to energy self-sufficiency and replace expensive diesel-generated electricity.

With technological improvements and additional public support for early stage development, the ocean energy sector may be able to develop to a similar scale as offshore wind over time. Ocean energy currently is an infant industry, within which wave and tidal stream technologies are relatively more developed than other technologies. There are currently 10MW of installed wave and tidal stream capacity in the EU, which is almost a three-fold increase from 3.5MW four years ago. Located in the UK, Spain, Sweden and Denmark, these projects are mostly pre-commercial, demonstrating the reliability and survivability of tested devices. Huge growth is already predicted, however, with some 2GW of projects in the pipeline (predominantly in the UK, France and Ireland). If all of these projects are implemented, they could supply electricity to more than 1.5 million households. [4]

As a practical example, in Europe, Scotland runs the largest wave energy project in the world.

Scotland began in January 2015 construction of the largest tidal energy project in the world; the investment will be developed off the coast of Scotland. MeyGen project could power nearly 175,000 homes through a network of 269 turbines on the seabed off the Ness Quoys Caithness, north-east Scotland. Scotland has access to one of the richest marine energy resources in the world. According to the report, it is expected that by 2020 can be installed capacity of 1,300 MW in Scottish waters, adding 100 MW each year.
The first deliveries to the national electricity grid could take place in 2016. [10]

In Portugal there is a new type of power plant that uses wave, ranked as the largest wave power plant functional, Agucadoura Waves Farm, near Póvoa de Varzim, 5 km from shore. It cost about $ 13 million (the majority to achieve electrical cables underwater), and has an output of 2.25 MW of energy.
Although it may seem expensive at first glance, this solution competes in efficiency / cost, both solar panels and wind turbines. And being the first implementation, the wave energy will increasingly be better exploited. An advantage of this power plant is that the waves provide energy continually.

Generators that turn wave power into electricity were produced by Pelamis Wave Power Limited Scottish Company, and have an individual capacity of 750 kW. Each has a diameter of 3.5 meters, and a length of 140 meters.

Portuguese planning a second phase of the project, when they will increase the number of generating 3 to 28. And then it will produce 21 megawatts of power, enough for about 15,000 homes. [11], [12]

Figure 4 Agucadoura Waves Farm [12]

Among the projects that are using wave energy, there is also the largest hydropower turbine in the world, SeaGen turbine in Strangford Lough, Ireland.

Related wind turbines, but powered by the movement of water and no wind, hydro turbines transform the currents from the depths of the oceans into electricity. SeaGen of 1.2 megawatts, which consists of a pair of turbines, each with 20 meters in diameter, is currently the only commercial-scale hydropower turbine in the world. Propeller blades have the ability to rotate 180 degrees depending on the direction of movement of currents and may be removed from the water for maintenance, the common nature of their work being underwater.

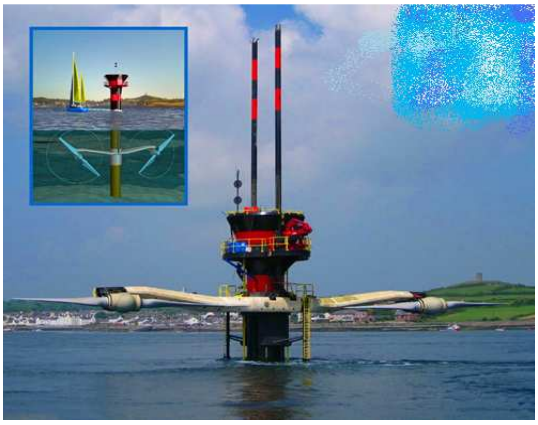

Figure 5 The largest hydropower turbine in the world, SeaGen turbine in Strangford Lough, Ireland [12]

A succesful non-European project that has been already implemented is CETO 5 in Australia.

An Australian company has developed a system that produces electricity using ocean movements, specifically the power of the waves.

CETO 5 system was already connected to the mains of Australia. CETO 5 is composed of three large buoys completely immersed into water and water pumps. When ocean waves hitting the buoys, the pumps are activated that push water under pressure into electric turbines. At the same time, is fed to a desalination system. Australian authorities are already planning system implementation CETO 6, which will provide four times more energy than CETO 5.

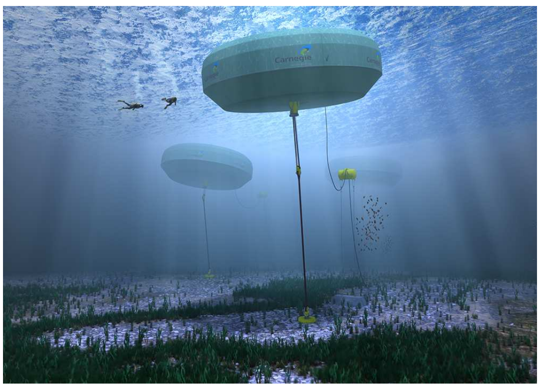

Figure 6 CETO 5 [13]

3. ACTION PLAN FOR OCEAN ENERGY IN EUROPE

In Europe, the commission to the European Parliament established an Action plan for Ocean Energy. [4]

For pre-commercial ocean energy technologies, however, a stable and low risk framework of support is crucial as it ensures the bankability of projects and thus allows for the growth of installed capacity. The European Commission issued guidance on best practice for renewable energy support schemes. The guidance therefore allows for projects of first commercial scale deployment and thereby recognises the need for a targeted support framework for technologies such as ocean energy.

There were sets out a two-step action plan that will assist this promising industrial sector in developing its potential.

First phase of action (2014 – 2016)

Ocean Energy Forum

An Ocean Energy Forum will be set up, bringing together stakeholders in a series of workshops in order to develop a shared understanding of the problems at hand and to collectively devise workable solutions. It will be instrumental in building capacity and critical mass as well as fostering cooperation through the involvement of a wide range of stakeholders. The forum will also explore the synergies with other marine industries, particularly offshore wind, in matters relating to supply chains, grid connection, operations and maintenance, logistics and spatial planning.

Ocean Energy Strategic Roadmap

Based on the outcomes of the Ocean Energy Forum, a Strategic Roadmap will be developed setting out clear targets for the industrial development of the sector as well as a timeframe for their achievement. This roadmap will be elaborated jointly by industry, Member States, interested regional authorities, NGOs and other relevant stakeholders through a structured and participative process, as outlined above. The roadmap will bring together findings from all areas relevant to the development of the industry and provide an agreed blueprint for action in order to help the ocean energy sector move towards industrialisation.

Second phase of action (2017-2020)

European Industrial Initiative

An European Industrial Initiative could be developed based on the outcomes of the Ocean Energy Forum. In order to establish a viable European Industrial Initiative, however, the industrial stakeholders must first have a clear strategy for the development of the sector and they must be well organised in order to be able to deliver on its objectives.

Sector-specific guidelines for the implementation of relevant legislation

Based on the experience gathered in the administrative issues and finance workstream and the environment workstream, guidelines could be developed to streamline and facilitate the implementation of the Habitats and Birds Directives and Article 13 of the Renewable Energy Directive as well as to assist with maritime spatial planning processes. The aim of these guidelines will be to reduce uncertainty through the provision of clearer and more specific guidance for the licensing of relevant projects and thus ease the burden faced by public authorities and project developers.

4. CONCLUSIONS

All the forecasts estimate that the energy demand will increase in the next years. The primary resources prove their limitations in time: until 2040 for the secure known oil reserves, gas until 2070, the world reserves of coal for more than 200 years, at the current levels of consumption. But the projections show an economic growth that naturally will be done with a higher consumption of energy resources.

In the last decades, it was noticed the concerns of the specialists to find new energy resources in order to sustain the increasing energy demand. Thus, the mix energy of the countries showed changes in the last years, the renewable energy resources gaining more and more shares.

Thus, it is time to explore all possible options in a sustained and collective effort to mitigate the effects of climate change and to diversify the portfolio of renewable energy sources. Supporting innovation in low-carbon energy technologies can help to tackle these challenges.

The growth of the wind and solar energy sectors in recent years clearly demonstrates that concerted efforts to put in place appropriate policy and funding frameworks can provide the incentives required by industry to deliver results. It is noticed the trend of encouraging the investments in renewable energy technologies through revenue support schemes, capital grants and research funding, but only a few have dedicated support in place for ocean energy.

Although ocean energy deployment figures are modest compared to the offshore wind sector, Constanta Maritime University, Constanta Maritime University, Constanta Maritime University, Canstanta Marritime University, Constanta maritime University, Constanta Maritime University commercial interest in the sector is increasing, as evidenced by the growing involvement of large manufacturers and utilities. If we translate this information in figures, we will see that in the EU power mix, in 2014, the Ocean Energy is about 0.03% compared to 0% in 2000, a modest share, indeed, but an important presence from the point of view of this sector potential.

For Europe, there are estimations that by 2050, the marine energy could provide 15% of Europe's energy needs.

As oceans cover over 70% of Earth's surface, ocean energy (including wave power, tidal current power and ocean thermal energy conversion) represents a vast source of energy, estimated at between 2,000 and 4,000 TWh per year, enough energy to continuously light between 2 and 4 billion 11W low-energy light bulbs.

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ANALYSIS ON THE OFFSHORE WIND IN THE EUROPEAN MIX ENERGY

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Abstract: The energy sector of a country is stronger when multiple ways of producing energy exist, so when there are multiple systems of energy and is less resistant when there is only one way of applied producing energy.

The solution for the future stability of everyday life is from the energetic point of view, the existence of several energy systems in parallel.

In this system, the renewable energy sources (RES) play an increasingly important place, contributing to a sustainable and efficient development, compatible with a cleaner environment. Among these energy sources, the marine RES, which include both offshore wind and ocean energy, become from one year to another, important resources generating economic growth and jobs enhance the security of its energy supply and boost competitiveness through technological innovation.

Between the both marine RES sectors, it is distinguished the importance of the offshore energy that increases year by year. The figures that will be presented in the paper are relevant in this sense.

The paper contains a desk analysis of the offshore energy area, showing figures, images, dates and conclusions on these new technologies and their effects on short and long terms. Also, a SWOT analysis is included, representing a necessary assessment of the strong and weak points, trying to adjust the strengths to the opportunities and reduction at a minimum level of the threats, eliminated the weak points.

The projects based on this type of energy source, its positive results outline a promising perspective for the investors and authorities. The benefits are conclusive in this area: this inexhaustible and free resource generates energy with zero emissions, provides permanent and temporary jobs, services and economic growth, a balanced proportion between supply and demand of energy.

Key words: marine RES, ocean energy, offshore energy, offshore wind farm, wind turbine.

1. INTRODUCTION

The concept of sustainable development means all forms and methods of socio-economic development that focuses primarily on ensuring a balance between social, economic and ecological elements of natural capital. [10] The best known definition of this concept is certainly one given by the World Commission on Environment and Development (WCED) report "Our Common Future", also known as the Brundtland Report: "Sustainable development is development that aims to satisfy the needs of the present without compromising the ability of future generations to meet their own needs."

Unanimously, it is recognized that economic development cannot be stopped, but that strategies need to be changed so as to match the ecological limits offered by the environment and the planet's resources.

Closely related to the notion of sustainable development is that one of the energy strategy. Energy Strategy is "a complex activity that involves the initiation, conduct and correlation of the political, economic, technical and environmental actions in order to ensure the national energy security, diversification of internal and external supply sources, to improve and diversify forms of energy production, the increase production efficiency and energy consumption, improving pollutant impact of energy production and consumption "[1].

The energy sector of a country is stronger when multiple ways of producing energy exist, so when there are multiple systems of energy and is less resistant when there is only one way of applied producing energy. The solution for the future stability of everyday life is from the energetic point of view, the existence of several energy systems in parallel.

In the latest period, it is noticed that the countries that are net importers of energy direct their efforts to the renewable energy and improving energy efficiency. However, in many countries, it is reconsidered the nuclear option, following the events at Fukushima - Japan in 2011. [3]

At the European level, Member States have very different energy mixes. The mix varies considerably from country to country and evolve with time due to the geographical conditions of the respective countries, such as the availability of and access to the natural resources, national policy options, such as the decision of whether or not nuclear energy, change of the financial incentives, progress in terms of technology, the requirements for decarbonisation and developing internal market. It was agreed, commonly, three main objectives to be achieved by 2020 (often referred to as "20 20 20 2020"): reducing CO2 emissions by 20% compared to 1990, increasing to 20% the proportion of the renewable resources in total EU energy mix and increase the energy efficiency by 20%. These objectives are also basic elements of the Europe 2020 strategy for smart, sustainable and favourable inclusion.

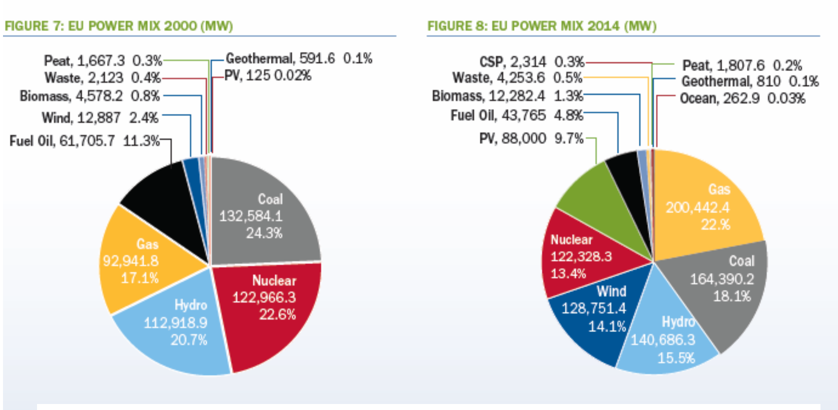


Figure 1 EU power mix [5]

2. OFFSHORE WIND POWER

The seas and oceans have the potential to become important sources of clean energy. Marine renewable energy, which includes both offshore wind and ocean energy, presents the EU with an opportunity to generate economic growth and jobs, enhance the security of its energy supply and boost competitiveness through technological innovation.

While land-based wind energy will remain dominant in the immediate future, installations at sea will become increasingly important. Compared to onshore wind, offshore wind is more complex and costly to install and maintain but also has a number of key advantages. Winds are typically stronger and more stable at sea than on land, resulting in significantly higher production per unit installed. At sea, wind turbines can be bigger than on land because of the logistical difficulties of transporting very large turbine components from the place of manufacturing by road to installation sites on land. Wind farms at sea also have less potential to cause concern among neighbouring citizens and other stakeholders unless they interfere with competing maritime activities or impact negatively on important marine environmental interests. In fact, wind farms at sea may be advantageous to protect marine ecosystems and may generate synergies with other emerging uses of the sea such as offshore aquaculture, which can benefit from the substructures of wind farms.

In Europe and not only in this region, the works are very advanced in this direction of the offshore wind farms.

The reports launched in 2015 by EWEA (European Wind Energy Association) offers a comprehensive image of the offshore wind market in 2014 and overall in Europe.

Below, there are figures and data taken out from the aforementioned reports.

Onshore and offshore annual markets [5]

Offshore wind installations in 2014 were 5.3% less than in 2013, with 1,483.3 MW of new capacity grid connected. Offshore wind power installations represent 12.6% of the annual EU wind energy market, down from 14% in 2013.

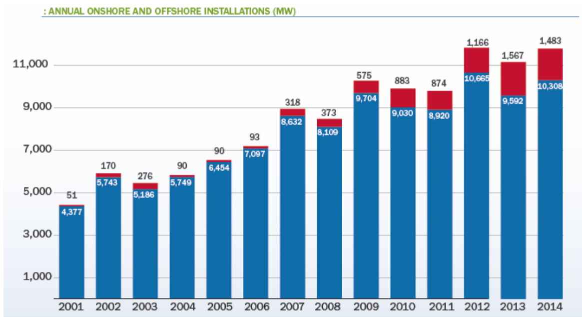


Figure 2 Annual onshore and offshore installations (MW) [5]

Year 2014 in figures

- 408 new offshore wind turbines in nine wind farms and one demonstration project were fully grid connected between 1 January and 31 December 2014. The new capacity totals 1,483.3 MW - 5.34% less than in 2013;
- 536 turbines were erected during 2014, an average of 5.9 MW per day. 373 of these turbines are awaiting grid connection;
- Work is on-going on 12 projects.
- 2,488 turbines are now installed and grid connected, making a cumulative total of 8,045.3 MW in 74 wind farms in 11 European countries;

Once completed, the 12 offshore projects currently under construction will increase installed capacity by a further 2.9 GW, bringing the cumulative capacity in Europe to 10.9 GW.

During 2014, work was carried out on 17 offshore wind farms in Europe, thus:

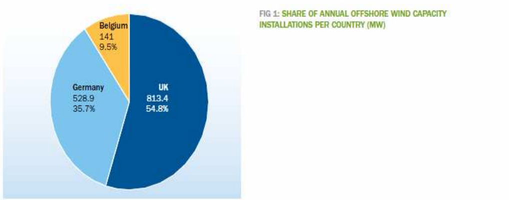


TABLE 2: NUMBER OF TURBINES AND MW FULLY CONNECTED TO THE GRID DURING 2014 PER COUNTRY (MW)

Country	Belgium	Germany	UK
No. of farms	1	5	4
No. of turbines connected	47	142	219
MW connected to the grid	141	528.9	813.4

Figure 3 Share of annual offshore wind capacity installations per country (MW) [4]

Of the total 1,483.3 MW connected in European waters, 50.7% were in the Atlantic Ocean, and 49.3% were located in the North Sea.

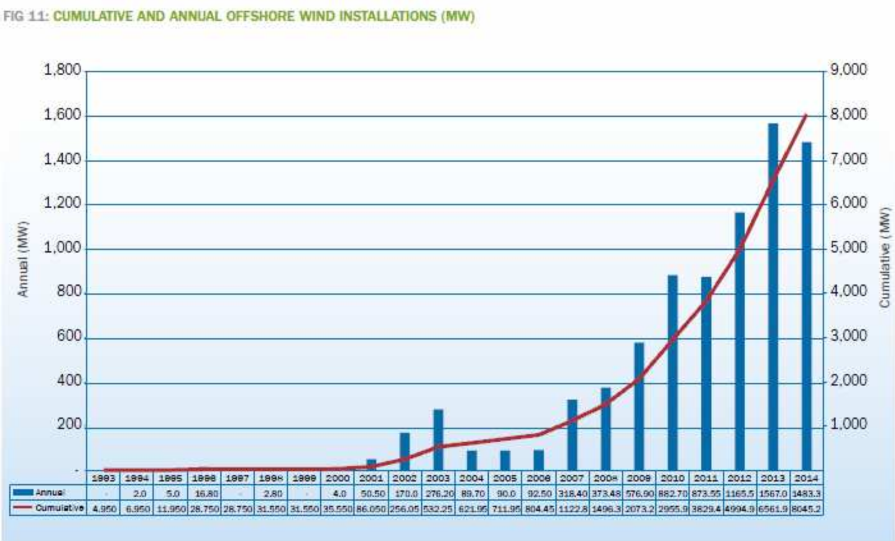
Siemens continues to be the top offshore wind turbine supplier in terms of annual installations. With 1,278 MW of new capacity connected Siemens accounts for 86.2% of the market. Vestas (141 MW, 9.5%), Areva (45 MW, 3%) and Senvion (12.3 MW, 0.8%) are the other turbine manufacturers who had turbines grid connected in full-scale wind farms during 2014. Samsung connected its demonstration turbine to the grid in Fife, UK (7 MW, 0.5%).

Similarly, in terms of units connected, Siemens remains at the top with 340 3.6 MW turbines and nine 6 MW offshore wind turbines (85.5% of connected wind turbines) connected in European waters during 2014. Siemens is followed by Vestas which connected 47 3 MW turbines (11.5%), Areva (nine turbines of 5 MW, 2.2%) and Senvion (two turbines of 6.15 MW, 0.5%). Samsung, connected one demonstration turbine of 7 MW.

The average capacity rating of the 408 offshore wind turbines connected to the grid in 2014 was 3.7 MW, smaller than in 2013. The popularity of Siemens' 3.6 MW turbine (340 wind turbines connected in 2014) keeps the average turbine size near the 4 MW mark, despite the emergence and installation of larger rated turbines.

Cumulative market figures

A total of 2,488 wind turbines are now installed and connected to the electricity grid in 74 offshore wind farms in eleven countries across Europe. Total installed capacity at the end of 2014 reached 8,045.3 MW, producing 29.6 TWh in a normal wind year, enough to cover 1% of the EU's total electricity consumption.



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Annual	-	2.0	5.0	16.80	-	2.80	-	4.0	50.50	170.0	276.20	89.70	90.0	92.50	318.40	373.48	576.90	882.70	873.55	1165.5	1567.0	1483.3
Cumulative	4.950	6.950	11.950	28.750	28.750	31.550	31.550	35.550	86.050	256.05	532.25	621.95	711.95	804.45	1122.8	1496.3	2073.2	2955.9	3829.4	4994.9	6561.9	8045.2

Figure 4 Cumulative and annual offshore wind installations (MW) [4]

The UK has the largest amount of installed offshore wind capacity in Europe (4,494.4 MW) - 55.9% of all installations. Denmark follows with 1,271 MW (15.8%). With 1,048.9 MW (13% of total European installations), Germany is third, followed by Belgium (712 MW: 8.8%), the Netherlands (247 MW: 3.1%), Sweden (212 MW: 2.6%), Finland (26 MW: 0.3%), Ireland (25 MW), Spain (5 MW), Norway (2 MW) and Portugal (2 MW).
The 8,045.3 MW of offshore wind capacity are mainly installed in the North Sea (5,094.2 MW: 63.3%). 1,808.6 MW or 22.5% are installed in the Atlantic Ocean and 1,142.5 MW (14.2%) in the Baltic Sea.

Predictions for 2015 and 2016[4]

The market outlook for 2015 remains stable in terms of capacity to be brought online. There are twelve projects under construction - representing 2.9 GW - in the pipeline for the next 12 to 18 months. Five of these projects had some wind turbines connected to the grid in 2014; once completed they will result in a further 1.18 GW of capacity taking the cumulative offshore wind capacity to a minimum of 9.2 GW in Europe. However, predictions of reaching 10 GW by 2015 are well within industry expectations.

2015 will see Germany overtake the UK in annual grid connected capacity. The largest wind farms to be fully completed will be RWE’s Gwynt y Mor (576 MW) followed by Global Tech 1 (400 MW), both expected in Q1.

2016 however will see a slump in the market, featuring a low level of wind turbines being connected. The UK is unlikely to fully commission any hundred-MW scale offshore wind farms, though the 50 MW Kentish Flats Extension may be started and commissioned. Outside of the UK, only Germany and the Netherlands are expected to bring capacity online in 2016 with DONG Energy’s Gode Wind 1 and 2 and ENECO´s Westermeerwind.

Further in the future, EWEA has identified 26.4 GW of consented offshore wind farms in Europe and future plans for offshore wind farms totalling more than 98 GW.

Wind farm size

In 2012, the average size of connected offshore wind projects was 286 MW while in 2013 it was 485 MW. In 2014, it was 368 MW. This is the result of the completion in 2013 of the record breaking London Array (630 MW).

Related to this project, London Array expansion, postponed in 2014 was relaunched in 2015, thus, the British will have the largest offshore wind farm in the world. It is to be built off the coast of Yorkshire, where they will be installed no less than 400 wind turbines.
When completed, the project Dogger Bank Creyke Beck will be two times higher than the current largest offshore wind farm in the UK, which includes two plots of 200 wind turbines located on an area of 500 square kilometers.

Wind turbines will power 1.8 million homes - about 2.5% of the total electricity demand in the UK. [6]

The use at a maximum level of the available energy in the UK creates jobs and businesses in the country, while providing the best deal for consumers and reducing dependence on foreign imports. [7]

Related to the off-shore wind power, a further promising concept is offshore floating wind power. The deepening offshore coastal areas on the Atlantic seabed make offshore turbines with fixed foundations too expensive. A floating platform that is anchored to the seabed could be a more cost-effective solution in those waters. There are currently two offshore wind floating demonstration projects in operation, in Portugal and Norway. [2]

The world's first floating wind turbine on a large scale, Hywind, supported at a depth of 220 meters was assembled in Åmøy Fjord near Stavanger, Norway, in 2009, before the implementation of the North Sea.

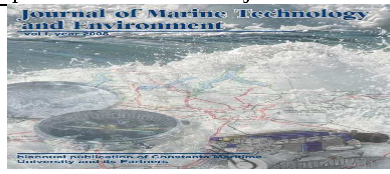
The "Hywind" was developed by the companies Siemens and StatoilHydro and it is tested in order to provide a detailed analzsis of this concept.

Hywind turbine was designed for placement at depths of 120-700 m, which could open up many opportunities in offshore wind turbine technology. The turbine has a length of 107 meters, is anchored with steel hoses and center of gravity is below the water surface. [8]

Figure 5 Hywind offshore floating turbine via Flickr CC

According to a new report by the European Wind Energy Association, the total electricity consumption in the European Union could have - in fact, it may be exceeded by more than four times – by the floating offshore wind farms in the deep waters of the Sea North. The report also calls on the EU to set new renewable energy targets for 2030.

The report argues that floating wind turbines - and / or other wind turbines specially adapted for deep waters of the North Sea - should be an important part of EU



energy infrastructure in the future. According to the European Wind Energy Association (EWEA), regardless of the development costs, the floating turbines - because of their very low use of steel - are competitive in terms of cost with the conventional turbines, which are installed in waters deeper than 50 meters.

The report states that if the appropriate policies are implemented now in order to impel the development and implementation of the next-generation floating turbines, the offshore wind EU total capacity could reach 150 GW by 2030.

The offshore wind sources are in a solid growth. But solid figures cannot counter that wind industry is experiencing instability policies and regulations, economic crisis and austerity. If European governments guarantee the stability of the policy and will solve the problem of connecting to the network, the offshore wind industry will have an important contribution to the energy needs. [9]

3. SWOT ANALYSIS

The SWOT analysis on the marine RES represents a necessary assessment of the strong and weak points, trying to adjust the strengths to the opportunities and reduction at a minimum level of the threats, eliminated the weak points.

The present SWOT analysis includes the four points, covering the marine RES: the offshore marine energy.

From the Strengths category, there can be listed:

- The RES sector expansion in recent years has favored the increase of the interest in exploiting the offshore wind energy.
- The offshore wind provides energy with zero emissions that not pollute in accordance with the objectives of reducing the pollution worldwide.
- The offshore wind energy is inexhaustible and free resources, the wind has unlimited potential compared with primary limited energy resources. The marine energy is a vast, indigenous, clean and renewable source.
- The energy generated by offshore wind could be transferred into mechanical and electrical energy.
- The energy produced by offshore wind could be used complementary with the solar energy.
- The offshore wind speed is higher than onshore wind speed, leading to a higher production of energy.
- The offshore projects are bigger than onshore projects.
- In the case of the onshore turbines, part of the marine RES, there was noticed that the blades, in their rotational motion associated with the noise can cause a state of stress in the residential areas. In offshore turbines, the long distance from the shore, including here from the populations, excludes this inconvenience. Thus, the wind farms at sea cause less concern among neighbouring citizens
- Larger experience in the wind energy sustains the expansion of the offshore wind energy.
- The development of the offshore wind energy in a specific region will provide significant contributions to the local economy and community. The positive impact will be resulted from the capital invested associated to the project implemented thus providing permanent and temporary jobs, services and economic growth.
- The use of offshore wind energy contributes to a more balanced proportion between supply and demand of energy and gives a greater level of independence from the limited primary resources. It contributes to the energy security of countries/regions and decreases the dependence on imports of energy from other regions.
- The continuous need to the efficiency increase of the technologies used in the offshore wind energy exploitation leads to the development of the research activity, distinguishing a permanent opening to the renewal and improvement.

In the Weaknesses area, there can be included:

- There is a low infrastructure that leads to higher cost for integration of the energy generated by the offshore wind into the existing energy network. The energy produced at sea is difficult to distribute on land. It is therefore necessary to extend the interconnection capacity.
- At the offshore wind turbines that are not connected to the National Energy System, it is necessary to store the energy in batteries, resulting higher costs to maintain the plants and installations.
- The offshore energy is not constant over time, depending directly on the wind speed; thus this marine source of energy is characterized by unpredictability of wind speed.
- There are higher expenses for construction and maintenance of the offshore wind plants, which in the absence of a solid and appropriate government support transform this type of energy source: marine RES, in an undesirable area for potential investors.

- Larger expenses are reflected in higher rates of these sources of energy compared to other energy resources.

In the Opportunities sector, the following are contained:

- Working-out of the land for the onshore wind turbines
- Working-out of the primary resources
- The existence of the government programs of financial support in developing this renewable energy source represents prerequisites for investors to reduce the risks of these investment projects.
- Complementary investment guided to the commercial space area
- The development of offshore wind turbines with larger blades and more effective
- New technologies which attempts to climb obstacles appeared after the current operation (floating offshore turbines).
- The existence of programs and ongoing concerns in Europe and worldwide on pollution and strategic objectives of reducing pollution and integration of RES (and implicitly marine RES) in the energy mix creates opportunities for RES development (implicitly marine RES)

In the Threats, there are included:

- Higher costs for the offshore wind turbines compared to onshore ones; hence the higher investments and high interest in the onshore area, a real obstacle for the development of the offshore wind turbines. The offshore turbines will not be preferred until the land for the onshore ones is not worked out.
- There are risks arising from the novelty of the procedure and lack of experience in some specific fields working with some new technologies that have not long.
- The international financial problems
- Changing consumption behavior of consumers
- Legislative instability and lack of adequate measures for financial support
- Involvement of politics at a high level in this area of activity and legislative changes arising from this trend
- Competition that it faces from the onshore wind energy sector (and other RES sectors) and the oil and gas industry for financing, equipment and expertise

4. CONCLUSIONS

Undoubtedly, the RES sector gained an important place in the energy mix of many countries in the last years. The trend is natural in a growing economy; in a society with limited primary resources where the intention is to limit the environmental pollution, the solution is to find and use the alternative energy sources. Within these renewable energy sources, the marine RES occupy a significant place, due to the characteristics of these resources. In this context, it is appropriate and relevant to mention the benefits faced by maritime wind energy; based on them, there are outlined directions for action to be taken in order to promote, develop this type of energy.

Among the benefits compared to the production of onshore wind energy, it can be mentioned:

- production units at sea are larger than on land;
- winds are stronger and more stable at sea than on land;
- wind farms at sea cause less concern among neighbouring citizens.

This type of wind farm can be beneficial for the protection of certain marine ecosystems and can also allow other new uses of the sea to be developed, especially offshore aquaculture, which can benefit from the substructures of wind farms.

This energy is also a vast, indigenous, clean and renewable source.

Other sources of energy production should also be developed on a large scale, such as tidal, wave, thermal or marine current energy.

The development of maritime wind energy is a relevant alternative because it contributes to the implementation of clean energies.

The figures are promising: in the European Union, the offshore wind power installations represent around 12% - 14% of the annual EU wind energy market in the last 2 years.

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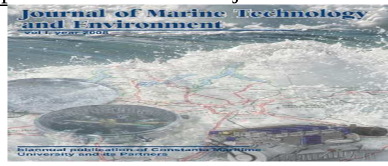

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PHOTOVOLTAIC CELLS - PROJECT OF USING THEM ON CARGO SHIPS

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Abstract: The main focus of this article is the development and use of clean renewable energy sources on ships. The main goal is the diversity of energy sources and the reduce of environmental pollution, hoping that this will ensure future energy security of supply. I propose to install the solar panels on a port-container. The reason of this article is to try to reduce ship pollution and the quantity of fuel used, that mince, to reduce the price of transportation and to save money. As a result of my research I discovered that is more convenient to use the Rawlemon photovoltaic sphere that normal solar panels. Photovoltaic sphere is generating energy by day and night, in all types of weather. It has a yield with 70% higher than normal photovoltaic panel attached to a fixed mount, it can generate upto 3.4 kWh/day.

Environmental impact of photovoltaic field is limited to space used and to the visual impact because there are nil polluting emissions, thermal or acoustic. Photovoltaic sphere is revolutionizing photovoltaics panels, it captures the Sun rays on the opposite side of the sphere acting as a lens which focuses them on a large area directly to the solar panel. Action on energy efficiency is one of the fastest and most effective ways to support improving the performance of companies with respect the protection of environment. Energy is one of the most controllable costs, because any energy savings are accounted directly into profits.

Key words: Conversion; Energy; Environment; Generator; Pollution; Ship; Solar.

1. INTRODUCTION

The environment can be defined as a combination of elements and natural and artificial fen omens from Earth, which provides the favourable conditions for the development of life and human activity.

The environment is the set of conditions and elements of the Earth: water, air, soil and subsoil, all layers of the atmosphere, all organic and inorganic materials, as well as living beings, natural systems interact, including items listed above, including material and spiritual values.

2. ENVIRONMENTAL POLLUTION

The most common forms of pollution are: water pollution, soil pollution, air pollution (atmospheric).

Pollution is changing the natural components through the presence of foreign components, called pollutants as a result of human activity, and causing by their nature, by the concentration which they are found and by the time they act, the harmful effects on health, which causes discomfort or prevent the use of environmental components essential to life.

By the definition content we can clearly see that the greatest responsibility for environmental pollution gate man, pollution is the mainly consequence of its social and economic activity.

Environmental pollution has emerged with the man, but it has developed and diversified with human society's evolution, reaching today one of the most important concerns of specialists from various fields of science and Governments, of the entire population of Earth.

Industry burn fossil fuels, releasing greenhouse gases into the atmosphere which warm the Earth.

Air pollution is caused by industry, transport, energy systems, agriculture, and every one of us.

Mankind continues to seek other energy sources to replace those present. Oil and fossil fuels will no longer be find in a few decades, and the people of Earth need energy that is cheap but not polluting: renewable energy

While depletion of fossil fuel reserves, combined with rising the higher price of oil and strong increase of environmental pollution, resulting from the use of fossil fuels, led to shift in energy policy. The main focus is the development and use of clean renewable energy sources. The main goal is the diversify of energy sources and the reduce of environmental pollution, hoping that this will ensure future energy security of supply, for the mankind.

3. RENEWABLE ENERGY

Renewable energy is energy that comes from natural resources such as sunlight, wind, rain, tides and geothermal heat.

Using renewable energy sources in the maritime industry would reduce environmental pollution and why not, at least, reduce of fossil fuel costs for carriers.

In this article I propose the use of green energy as an alternative source of energy for container ship vessels.

Solar energy can help us to slow down or stop global warming, which threatens the survival of human society and the survival of countless species.

Solar energy is the transmitted electromagnetic energy, generated by Sun thru Nuclear Fusion. It underpins all life on Earth and is about 420 trillion kWh. This amount of energy, generated by the Sun, is several thousand times greater than the total amount of energy used by all people.

Advantages and disadvantages of solar energy:

Advantages:

- It is an inexhaustible source of energy
- It is free as a primary energy form
- It is relatively evenly distributed throughout the globe
- It is a clean energy
- It is a safe energy source (sun rises and sets every day all over the world, knowing exactly at what time will be the sunrise every day of the year)

Provides Energy Security (can not put tax on Sun).

- Provides energy independence (after you have installed solar panels you have an independent source of electricity that is only yours).

Disadvantages:

- Diffuse character
- Low Density
- Discontinuous character: shows daily and seasonal cycles of variation

The needs of using batteries to store electricity produced by the solar panels to use it later.

4. THE SOLAR ENERGY POTENTIAL

- The greatest theoretical potential of renewable energy is solar energy - about 89,000 TW. Direct normal radiation is the most important component of solar energy in terms of energy conversion. This is affected by both climatic conditions and the distance travelled by sunlight through the atmosphere.
- Given that direct sunlight is less intense in the morning and evening and zero at night, a daily average of 250 $\frac{W}{m^2}$ is often used to estimate the intensity of solar power systems. This number depends on the location of the system.
- Regarding solar hours, this means that in a decent location, the photovoltaic system will get about 6 hours of sun per day (250 W for 24 hours or 6 hours of sun).

The image below represents the general map of potential solar radiation on the globe. One hour of sun equals 1 kWh per square meter per day.

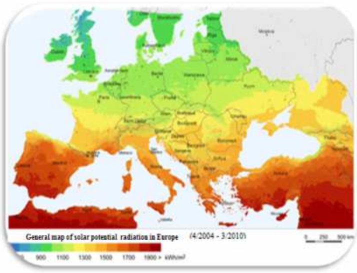


Figure 1 General map of solar potential radiation in Europe

Table 1. The generation potential of electrical solar energy using the thermodynamic conversion

Features	***The amount of energy TWh / year***
Global solar radiation on th surface of Earth	240 x 10^6
The area of desert occupies 7% of the total area of the Earth	17.0 x 10^6
Available direct radiation fraction (about 70 %)	11.2 x 10^6
The annual average efficiency of solar energy conversion into electricity (about 15 %)	11.2 x 10^6
Semiarid and arid of locations for solar plants in space habitat and access to facilities (1 % of the Desert)	16.8 x 10^3
Overall electricity production in 2000	15.0 x 10^3

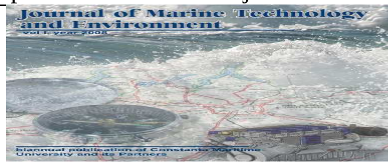
The areas most favourable in terms of solar energy conversion, are at the equator and the desert.

5. ENERGY CONVERSION

In order to use solar energy, we need its conversion in other forms of energy, such as:

5.1 Photothermic conversion

Photothermic conversion (thermo-conversion) involves transferring the energy from sunlight to water, steam, hot air, other media (liquid, solid or gaseous). The



heat thus obtained can be used directly or converted into electricity by power plants or thermionic effect. It can also be used by thermochemical transformations or may be stored in various solid or liquid medium. Photochemical conversion has a great importance in industrial applications, space heating, preparing of hot water consumption, drying materials, water distillation, etc.

Photovoltaic solar panels generate electricity 4h/day- 6h/day.

Solar panels generate electricity and simultaneously store energy, in batteries for use during night time without connection to the national electricity grid.

5.2 Photomechanical Conversion

Photo mechanics Energy Conversion is important in space energetics, where conversion based on light pressure gives energy for the engine type "solar sail", used in spacecraft flights. Photo mechanics conversion refers at equipping the spacecraft which are designated for long journeys, interplanetary, with so-called "sail Solar", which, due to the interaction between photons and large reflective surfaces, conducted after the ship reached the cosmic void, it occurs the spacecraft propulsion by the ceded momentum of photons at interaction.

5.3 Photochemical Conversion

Photochemical Conversion is divided into two categories: one involves the use of direct sun light to excite molecules of a body and the other indirect use by plants (photosynthesis) or processing the products of animal dejection. Photochemical conversion is used for obtaining fuel cells by the above processes.

5.4 Photoelectric conversion

Direct photoelectric conversion is performed using the properties of semiconductor materials used in manufacturing solar cells. Solar energy can be used in industrial, agricultural and household in the area.

Solar energy uses photovoltaic panels that capture energy from the sun to generate electricity. It is one of the sources with the fastest growing energy and solar panels are becoming more efficient, easier to transport and to install.

Photovoltaic panels convert light directly into electricity at the atomic level. Some materials have the property of absorbing light photons and to release electrons. This effect is called the photoelectric effect. When these electrons are trapped results an electric current which can be used as electricity.

They are now used to supply with electricity common household items, but also to generate power for a whole house, locating them on the roofs of houses.

It is based on the direct production of electricity through silicon cells. When the sun shines and when climatic conditions are favorable, the sun provides power of 1 kW/m². Photovoltaic panels allow direct conversion into electricity of 10-15 % of this power.

Energy production of such a panel varies with increase or decrease of the solar intensity: 100 kWh / sqm / year in Northern Europe and in the Mediterranean area is twice as bigger. A photovoltaic roof of 5x4 meter has a 3kW power and produce 2-6 MWh / year. If the 10,000 km^2 existing roof in France would be used as a solar generator, the output production would be 1,000 TWh per year, more than double of the final electricity consumption in France in early 2000 (450 TWh). The main barriers to widespread use of photovoltaic solar energy (and heat) represents, on one hand the available power output, which constrains the electricity storage for autonomous operations or the use of complementary energy solutions and secondly economic competitively.

6. SOLARCELL

The photovoltaic effect is based on three simultaneous physical phenomena:

- Absorption of light by materials;
- The transfer of energy from photons to electrical charges;
- Collection tasks.

Silicon solar cells are composed of non-crystalline (amorphous) or crystalline.

Solar cells from other materials such as GaAs or CuInSe2 are still in the development phase. Silicon atoms not ordered, which allows the production of thin silicon sheets. Amorphous silicon is used in modules with a power of 30 W. The disadvantage is the low yield of 5-7 %. Therefore, it is necessary doubling the surface of solar modules monocrystalline or polycrystalline.

7. MATERIALS AND SOLAR CELL TYPES

Many solar cells made of various materials have been developed in recent years. The material used to manufacture most solar cells, based on semiconductors is silicon. Cells are classified as crystalline or thin film.

Crystalline cells are "cut slices" from ingots or "casting" crystal silicon and thin-film cells contain very thin layers of cheap material (glass, stainless steel or plastic).

If at first were used for solar cell production waste from other processes based on semiconductors, today we rely on materials manufactured specifically for this purpose.

Silicon is almost ideal for producing semiconductor material. It's cheap, it can be produce from a single crystal at a high degree of purity and can be contaminate in semiconductor type "n" and "p". By simply oxidation can be created thin insulating layers.

However forbidden zone breadth of silicon are less suitable for direct use of the photoelectric effect. Solar cells based on crystalline silicon requires a layer of thickness of 100 µm or at more for absorbing the sunlight effectively.

In cells with thin film of direct semiconductor of a type such as GaAs or silicon with strong crystalline structure which is disturbed, are enough 10 µm.

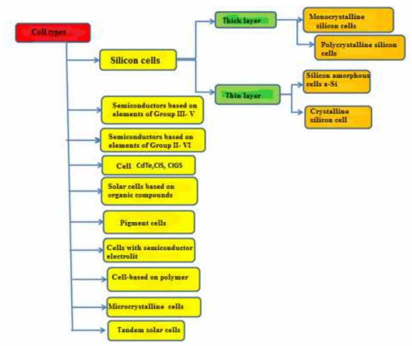


Figure 2 Types of cells

8. SOLAR AND LUNAR ENERGY GENERATOR (Photovoltaic sphere wich is tracking the Sun)

The German architect André Broessel, set in Barcelona, made a prototype of a solar concentrator functional and efficient.

Made of a glass, the sphere is filled with water. The device can capture and focus both solar energy which is direct but also the energy reflected by moon. The ensemble, which is currently in the phase of licensing is the third prototype done, its effectiveness compared to other systems is, according to the calculations of A. Broessel, increased by 35 %.

Broessel through his company Rawlemon proposes an alternative device at the classic mode of capturing solar energy . Who knows, maybe we will soon have an integrating sphere in each wall of the house.

Figure 3 Photovoltaic sphere [1]

The company Rawlemon came on the solar market with an innovative idea of collecting solar energy in the form of a sphere capable of capturing as much as possible of the solar radiation.

The most effective methods of harnessing the solar energy are those that involve focusing the sunlight into a point and the solution of the Spanish from Rawlemon is based precisely on this concept. They created a sphere that incorporates a small solar panel. The sun's rays are captured by the opposite side of the sphere, which acts as a lens which is focuses them on a large area directly to the solar panel. In addition, the scope is mounted on a base similar of holding an Earth globe which allows the panel constantly, its orientation to benefit as much from sunlight. Basically, in this way, the surface of the photovoltaic panel is only 1 % of that of a photovoltaic panel which is situated in a seated plan.

9. THE RAWLEMON CONCEPT

Figure 4 The Rawlemon concept or photovoltaic sphere

By the combination of spherical geometry with a double-axis tracking systems, spherical solar system of

Rawlemon can reach an excendent up to 70 % compared to a conventional photovoltaic panel, when both of them are arranged vertically. This enables solar capturing energy systems of Rawlemon to be integrated anywhere and anytime. At the same time it is reduced the surface of photovoltaic cells at only 1 %, which gives a revolutionary perspective of producing electricity at a low cost. Rawlemon is the first company that focuses on concentration diffused light. From the economic point of view, this is a unique opportunity to produce solar energy where conventional systems failed.

Rawlemon intends to put on market several models of spheres, named Beta. Ey, with different diameters. The smallest of them is Beta. Ey S with a diameter of only 10 cm and with the battery capacity of 27.5 Wh. It was designed to be used as a charger for smartphone via a USB 2.0 cable.

Another model, is Beta.Ray 1.0 which will generate up to 1.1 kWh per day, storing the energy in a battery with a capacity of 1.8 Wh.

The most powerful model, will be Beta. Ray 1.8 which will have a diameter of 180 cm and will be able to generate up to 3.4 kWh per day and which a storing energy capacity in a battery of 5.4 kWh. Unlike the miniature model Beta. Ray 1.0 and Beta. 1.8 Ray, the lens will be incorporated in the polymer filled with water. Of course, that means they can simultaneously generate also heat. The solution seems to be extremely clever, but the prices of the spheres are still far away from a home user. Beta. Ray 1.0 costs is $ 6,000, and Beta. Ray 1.8 costs is $ 12,000.

The company goals are to provide an alternative to the current technology marketing energy production from solar radiation and to launch a revolutionary system of architecture for buildings, to produce electricity independently.

The reason for creating the system of producing spherical solar electricity has gone from the idea that "we can squeeze more energy from the Sun " said Spanish from Rawlemon.

10. COMPARISONS BETWEEN DIFFERENT TYPES OF CAPTURE AND FOCUS SYSTEMS IN PV

- Fix on a fixed mount (fixed on roof or ground) gives: Energy produced per day / Summer 500 Wh / Day, Maximum power 125 W, voltage 12 V, 17.5 V voltage at the maximum power, maximum power current 7.14 A, 21.7 V voltage off, short circuit current 8 A, Number cell / panel 36 PCS, 156 x 156 mm cell size, weight 12.1 kg / 3.2 mm, 26 years warranty, Panel size 1500 x 680 x 35 mm;
- Fixed on a solar tracking system - with a single axis of rotation: East-West, gives: Energy produced per day / Summer 700 Wh / Day, Maximum power 125 W, voltage 12 V, maximum power voltage is 17,5 V, maximum power current is 7.14 A, 21.7 V voltage off, short circuit current 8 A, Number cell / panel 36 PCS, 156 x 156 mm cell size, weight 12.1 kg / 3.2 mm, Warranty 26 years, panel size 1500 x 680 x 35 mm, so a 40% higher yield;
- Fixate tracking system on a solar - two rotary axes: east-west and north-south, gives: Energy produced per day / Summer 750 Wh / Day, Maximum power 125 W, voltage 12 V, maximum power voltage 17.5 V, a maximum power current of 7.14 A, 21.7 V voltage off, short circuit current 8 A, Number cell / panel 36 PCS, 156 x 156 mm cell size, weight 12.1 kg / 3.2 mm Warranty 26 years, size 1500 x 680 panel x 35 mm, so a higher yield by 45%;

Generator of solar-energy and lunar sphere Rawlemon photovoltaic gives: Energy produced per day / all-weather 3400 Wh / day = 3.4 kWh / day, 1800 mm diameter sphere, so a 70% higher yield than photovoltaic panel attached to a fixed mount.

11. SOLAR ENERGY STORAGE

Solar energy from the Earth crust is a source of energy dependent of the rotation of the Earth and atmospheric conditions . The energy demand is variable over time and depends on the number of consumers connected at a certain moment of time. As a consequently, if we want some consumers to be supplied with energy derived from sunlight, is necessary to provide adequate storage elements (accumulation) for energy.

The features which must fulfill a solar energy storage unit:

- the storage unit must be able to receive energy with maximum speed without excessive thermodynamic forces (e.g. differences of temperature, pressure, potential, etc.);
- storage unit must deliver energy with maximum speed (depending on the purpose plant) without using excessive thermodynamic forces;
- storage unit must have low loss (a low self-discharge characteristic);
- energy storage unit must be capable of supporting a large number of charge-discharge cycles without substantial reduction in its capacity;

The drive should be relatively cheap.

The autonomous electrical energy storage systems is ensured by batteries, and the type used are lead-acid batteries.

They are of two types:

1. batteries with liquid electrolyte;
2. batteries containing stabilized.

12. SOLAR ENERGY - APPLICATIONS AND USES

12.1 Using solar energy on ships

Auriga Leader is a car carrier vessel (RO -RO) under Japanese operator NYK with a gross tonnage of 60,000 tons , which can carry up to 6,200 cars. It has been upgraded with solar cell modules hoping to reduce CO_2 emissions and fuel consumption.

During the tests it was shown that solar energy carried by the solar modules was enough to save 13 tons of fuel .According to tests carried out proved that any change of weather has a significant influence on the amount of energy generated by the solar modules.

Figure 5.1 RO-RO ship with solar energy systems as an alternative source [2]

The researchers decided to use batteries to store energy produced by solar panels and use it when is cloudy or night.

Auriga Leader is equipped with a hybrid power system. On board are brand batteries nickel hydrogen Gigacell massive, developed by Kawasaki Heavy Industries. The batteries are discharge /charge depending on the power needed by the ship and the electrical power generated by the solar cells.

If it turns out that it is a success, Kawasaki and NYK Line hopes to commercialize this type of vessel for reducing the emissions and fuel use in cargo ships that burn an average of 120 gallons of fuel per mile.

Auriga Leader ship's diesel generator running with a low sulfur content. The ship has a treatment system for ballast water to prevent introduction invasive species in the ports that they visit.

12.2 Planet Solar

Planet Solar is the largest catamaran in the world powered by 512 m^2 of solar panels.

Figure 5.2 Solar Boat [3]

To make it easier, but also resistant its structure is made of carbon. It is equipped with 6 blocks of lithium-ion battery that gives autonomy of navigation in dark about 72 hours.

Planet Solar is fitted with a 60 kW electric motor, its average consumption is only 20 kW. This boat is 100 % ecologic, with 0 emissions of CO_2.

With a draft of 1.5 m, a height of 6.3 m building, the length between perpendiculars fore / aft of 35 m and a maximum width of 23 m , weighing 89 tons, Planet Solar has a top speed of 14 Nd, the average being 5 Nd. In the craft can fit up to 60 people.

The boat was built in 14 months in Germany in Kiel , worth 12 million euro.

Photovoltaic spheres will be located on aft part of containerships Pelican on level 84.

At the stern of the ship we have available surface:

S=L x l = 32 x 30 = 960 m^2

A photovoltaic sphere covers an area of 1.8 m^2. Given that between spheres will be a space for connection and maintenance thereafter, we consider that the area required for the establishment of a sphere is 2.2 m^2. The maximum number of spheres that we can locate on the ship stern is:

N = total surface: surface of a sphere =960:2.2 = 436 m^2.

Ensemble of the spheres will generate a power of:

P= 436 x 3,4 Kwh per day = 1482 Kwh per day = 1482/24=62 kW

With this energy we can power part of secondary consumers like:

- The lights of the castle
- Consumers service (sockets)
- The lights in engine room
- The lights on the main deck
- Fire Detection System
- Fire extinguishing system with water and foam in engine room

- Smoke detection system in the cargo
- Emergency generator Console from engine room and the bridge console
- The control panel for charging / discharging batteries

Schematic, for connecting photovoltaic spheres at the cargo ship we must follow the following steps:

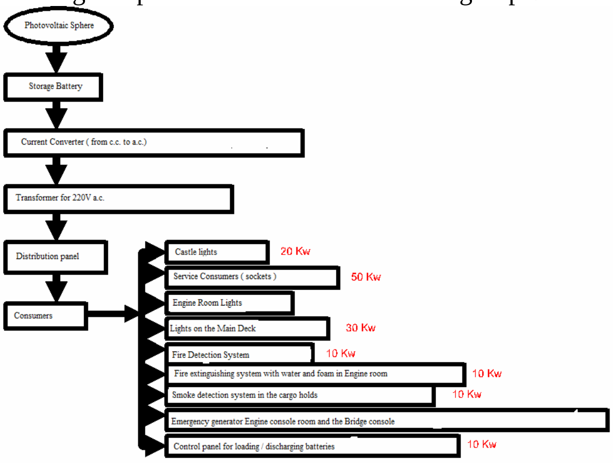


Figure 5.3 Scheme of connecting photovoltaic spheres on a Ship

13. CONCLUSIONS

➢ Environmental impact of photovoltaic field is limited to space used and to the visual impact because there are nil polluting emissions, thermal or acoustic. Of course, energy balance and environmental context must be taken into account, energy consumption and emissions resulting from production of PV modules. High energy values are obtained when the photovoltaic field is connected to the network and installed in areas with many sunny days per year.

➢ Is it relevant to the community to be informed about the performance of PV systems, information is vital in this area; any delay in promoting recent discoveries may slow down the implementation of solar energy on a global scale.

➢ The time for using the solar panels is expected to be 25 years, in which case their performance should not fall below 80% of baseline.

➢ Photovoltaic sphere is revolutionizing photovoltaics panels, she captures the Sun rays on the opposite side of the sphere acting as a lens which focuses them on a large area directly to the solar panel. The sphere is mounted on a base similar of holding an Earth globe which allows the panel to orientate constantly and to benefit as much from sunlight. Photovoltaic Sphere can generate heat and electricity simultaneously.

➢ Action on energy efficiency is one of the fastest and most effective ways to support improving the performance of companies with respect the protection of environment. Energy is one of the most controllable costs, because any energy savings are accounted directly into profits.

The uptake of renewables energies has been improved in the recent years, benefiting from direct support of the government. While it is risky to make predictions, I believe that renewable energy will come in foreground and will play an important role in the world of tomorrow, beginning with the decade that we are passing it.

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