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MATHEMATICAL MODEL OF ROLLING COMPRESSION OF BAKED LAYER OF INSIDE SURFACE OF CYLINDER BUSH OF MARINE ENGINE

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Abstract
Model description of process of restoration of inside surface of cylinder bush of marine engine, realized by method of spraying of surface layer with it subsequent compression by rolling arrangement is given. Dependence of quantity and time of compression, also force of strength to swinging of rolling velocity and force influence of rolling arrangement on compression layer are obtained.
Keywords: *bush, compression, glutinous plastic strength to swinging.*

Introduction

Restoration of inside surface of cylinder bush of marine engine is accompanied by numerous factors, directly influencing both on quality of carried out repair works and on further exploitation characteristics of this bush. Among these factors there are deformation parameters, as for example, intensity of compression process and created strength strained condition in compression layer [1].

Investigation of influence of these factors, creation of adequate mathematical model of the realizing technological process allows to manage the formation of geometrical parameters of surface layer of cylinder bush, when purposely and well rolling them with torus rolls.

Organization of a task

Arrangement for rolling of inside surface of bushes, offered in (1) is schematically given in Figure 1. It includes three torus rolls, disposed symmetrically along circle. We shall consider that the diameters of rolls are less than the diameters of inside surface of bush. In this case the motion of roll around circular orbit may be substituted by the motion along straight line boundary of layer.

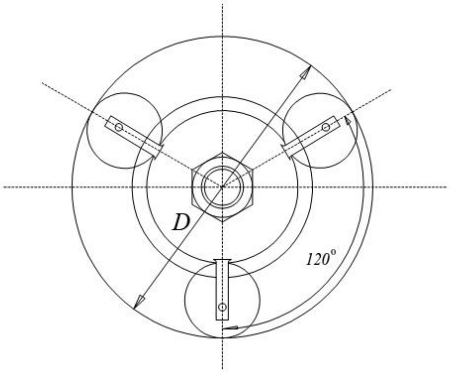

Figure 1. Arrangement for rolling of inside surface of bushes

As the hard properties of the material of bushes and rolls considerably excel the hard property of baked layer, we shall in the future neglect the deformation properties of material of bushes and rolls, considering them absolutely hard. Then the task about the compression of baked layer of inside surface bush at its rolling of three-system rolls may be presented as a task about the rolling of plane layer when swinging cylinder at given velocity of motion of its axis (Figure 2). We shall neglect the influence of contact of baked layer and bush in the first approach.

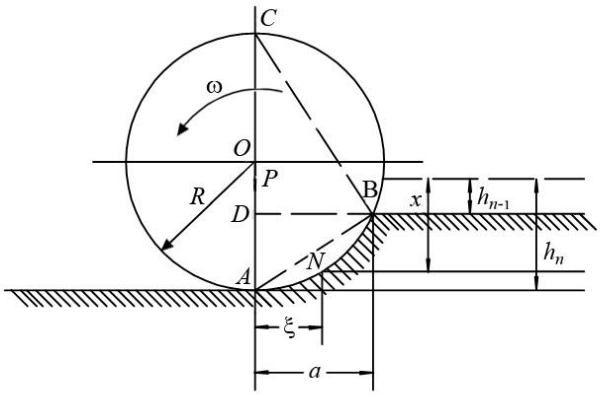

Figure 2. Calculation scheme of task

Availabity of three rolls is taken into consideration by the succession of repeated rolling of cylinder on surface of layer, the periodicity of which is: $T = \frac{2\pi}{3\omega}$ where ω is augular velocity of rotation of rolling arrangement. For the simplicity we shall consider the strained condition of layer uniaxial neglecting lateral thrust.

Compression of baked layer is connected with availabity of sufficient residual plastic deformation. That is why the contact pressure influenced on layer by the roll must be so that, arisen strain by it in the layer will excel the limit of the fluidity layer material and it will be considered to to be carried out.

The material of the baked is glutinous-plastic, which is described by model Shvedov-Bingom [3]:

$$\sigma = \sigma_m + \mu \frac{d\varepsilon}{dt}; \quad \sigma \geq \sigma_m \tag{1}$$

where σ in the strength, ε -is deformation, is coefficient of toughness.

So, let's consider the wheel of radius r, loaded by force P and moved to the right with constant axis velocity υ, determined through angular velocity of rotation of rolling arrangement, where R - is the distance from axis of roll to the centre of rolling arrangement $R = 0{,}5D - r$.

Deformation under the point with the longitudinal coordinate in one – dimension variant is determined as $\varepsilon = \frac{x}{H}$, where H is the elementary thickness of sprayed coating. Then, considering the stressed condition in transversal direction uniform, we shall obtain the [1] formula

$$\sigma = \sigma_m + \frac{\mu}{H}\frac{dx}{dt}; \quad \sigma > \sigma_m \tag{2}$$

Solution of task

Let's mark h_n sediment of coating its compression, after several rolling of this section of coating. As the material of coating is glutinous-plastic and is deprived the property of elastic restoration of any part before deformation form, then their contact at movement of coating roll stops: in the lowest point of roll. To expose the characteristics of compression process of coating we shall use the scheme, given in the work [2].

According to Figure 2 the length of projection a for horizontal plane will be determined

$$a^2 = DB^2 = DC - AD = (AC - AD)AD = (2R - (h_n - h_{n-1}))(h_n - h_{n-1})$$

Having limited to linear item relative to small quantity of joint sediment

$$\Delta h_n = h_n - h_{n-1} \tag{3}$$

we shall approximately get:

$$a^2 = 2R(h_n - h_{n-1}) \tag{4}$$

Let ξ be the distance from the considered contact point N of roll with coating till the vertical line which passes through axis of roll and the maximum contact point A. Then sediment of coating in the considered contact point M is presented by formula analogous to the formula (4), but with the substitution a to ξ and h_{n-1} to x:

$$\xi^2 = 2R(h_n - x)$$

we shall find

$$x = h_n - \frac{\xi^2}{2R} \tag{5}$$

Differentiating (5) by time t and taking into consideration that

$$\upsilon = \frac{d(R-\xi)}{dt} = -\frac{d\xi}{dt}$$

we shall obtain

$$\frac{dx}{dt} = \frac{\xi}{R}\upsilon \tag{6}$$

We shall put this expression into (2), and find:

$$\sigma = \sigma_m + \frac{\mu}{HR}\xi\upsilon \tag{7}$$

Necessary force P, pressing the roll to the coating is determined as a sum of contact reinforcement under the roll:

$$P = \int_0^a \sigma b d\xi\,. \tag{8}$$

Where b is the width of thin border of roll. Taking into consideration (7) in (8) for this force we shall find the expression:

$$P = ba\left(\sigma_m + \frac{\mu a}{2HR}\upsilon\right). \tag{9}$$

This formula at this compressed force of roll P, determines the length a of contact of roll with coating. Knowing this quantity, from (4), according to ratio:

$$h_n = h_{n-1} + \frac{a^2}{2R}\,. \tag{10}$$

Sediment on the next *n* on numbers of rolling is found. From formula (10) it results that the most quantity a of section length of contact corresponds to the most compression of coating. From (9) we have

$$a = \frac{\sigma_m HR}{\mu\upsilon}\left[\sqrt{1 + \frac{2\mu\upsilon P}{bHR\sigma_m^2}} - 1\right]. \tag{11}$$

According to this formula the least velocity υ corresponds to most quantity a. We shall get from (9) the limit value of maximum quantity $a_{\max}$, when $\upsilon = 0$

$$a_{\max} = \frac{P}{b\sigma_m}\,. \tag{12}$$

And then in accordance with the ratio (3) and (4) we shall get the joint of coating sediment for maximum quantity:

$$\Delta h_{\max} = \frac{a_{\max}^2}{2R} = \frac{P^2}{2Rb^2\sigma_m^2}\,. \tag{13}$$

At greater value of velocity υ, emitting the first item of the right of formula (9) we shall get

$$P = \frac{b\mu\upsilon}{2HR}a^2 = \frac{b\mu\upsilon}{H}\Delta h\,. \tag{14}$$

Whence we shall get

$$\Delta h = \frac{PH}{b\mu\upsilon}. \tag{15}$$

Hence it results that the increase of rolling velocity influences negatively on the process of coating compression.

In general case at mean velocity quantity *v* of the rolling with coating roll, the joint of sediment Δh is determined as $\Delta h = \frac{a^2}{2R}$ where quantity a is given by formula (11). Let's determine the strength of roll on coating. Knowledge of this quantity allows determining the necessary power expenditures for the process of restoration of inside surface of bush. The quantity of strength swinging on ground is characterized by moment M, which is determined by formula

$$M = b\int_0^a \xi\sigma d\xi$$

Taking into consideration the formula (7), we shall find

$$M = \frac{b\sigma_m}{2}\ a^2 + \frac{\mu b\upsilon}{3HR}a^2. \tag{16}$$

The force of friction swinging $F = \frac{M}{R}$ will be

$$F = \frac{b\sigma_m}{2R}a^2 + \frac{\mu b\upsilon}{3HR^2}a^2. \tag{17}$$

Putting the expression (11) into (16) and (17) we shall get the formula of moment dependences and force of friction swinging from velocity and rolling. Let's imagine these dependences in stretch quantities. We shall put these stretch quantities as follows;

$$\left\{\begin{array}{l} a = \frac{a}{R}; q = \frac{P}{bR\sigma_m}; m = \frac{M}{bR^2\sigma_m}; \\ u = \frac{\mu}{H\sigma_m}\upsilon \end{array}\right\} \tag{18}$$

then (16) and (17) will be:

$$\left\{\begin{array}{l} m = \frac{1}{2}a^2 + \frac{1}{3}ua^3; \\ a = \frac{1}{u}\left[\sqrt{1+2uq}-1\right] \end{array}\right\} \tag{19}$$

These formulas reflect the dependence of strength on swinging roll, on rolling surface of coating from rolling velocity.

At given quantity of angular velocity ω of rotation of roll rolling arrangement the number of passage ways with rolls of each section of raised dust coating in unity of time, is:

$$v = \frac{1}{T} = \frac{3\omega}{2\pi} = \frac{3v}{2\pi R}.$$

Then the general sediment or the compression of given coating section in time t after the beginning of rolling process will be

$$h_n = \sum_{k-1}^{n}\Delta h = \Delta h$$

taking into account that the joint of sediment Δh from the previous quantity of sediment does not depend where $n = \nu t$. Then $h_n = \nu t\Delta h$. Here taking into account that $\Delta h = \frac{a^2}{2R}$ and a is given by formula

(11), we shall get the following formula for time t_δ, necessary for achievement of given compression quantity $\Delta h_n = \delta$:

$$t_\delta = \frac{\delta}{v\Delta h} = \frac{4\pi\delta\mu^2\upsilon}{3\sigma^2{}_m H^2}\left(\sqrt{1+\frac{2\mu\upsilon P}{bHR\sigma^2{}_m}}-1\right)^2 \tag{20}$$

or in stretch quantities (18), also

$$\tau_\delta = \frac{\sigma_m}{\mu}t_\delta; \qquad \lambda = \frac{4\pi\delta}{3H} \tag{21}$$

we shall get:

$$\tau_\delta = \frac{\lambda u}{\left(\sqrt{1+2uq}-1\right)^2} \tag{22}$$

For small quantity of stretch velocity, we shall approximately get:

$$\tau_\delta \approx \frac{\lambda}{q-\frac{1}{2}q^2u} \approx \frac{\lambda}{q}\left(1+\frac{1}{2}qu\right) \tag{23}$$

Diagrams of dependence τ_δ from the rolling velocity and for quantities $q = 0{,}01$ and $q = 0{,}5$ at $\lambda = 0{,}1$ are shown in fig 3.

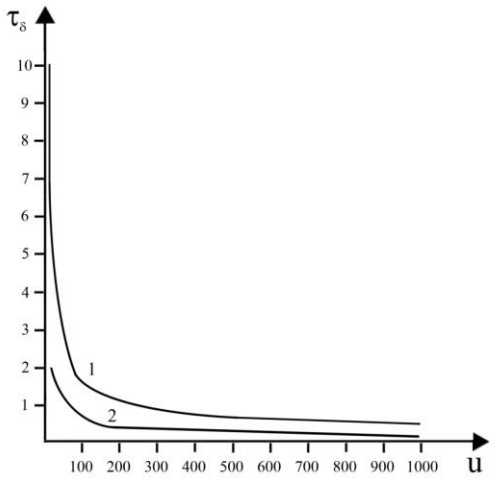

Figure 3. Diagrams of dependence τ_δ from rolling velocity and for quantities *q=0,01(curve 1) and q=0,5 (curve at λ =0,1)*

Conclusions

Task on determination of achievement time of given compression of inside raised dust surface layer of bush of marine engine when rolling it with rolling arrangement is solved. Closed analytical formulas for compression quantity, its corresponding time depending on rolling velocity and force compressed the roll are obtained.

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INVESTIGATION OF THE TECHNICAL CONDITION OF BEARING UNITS OF THE SHIP'S ELECTRICAL MACHINES BY MEANS OF THE METHODS OF VIBRO -ACOUSTIC AND SPECTRAL DISTRIBUTION ANALYSIS OF THE CONSUMED CURRENTS

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Abstract
The paper proposes a method of monitoring of the bearing units of electrical machines according to the results of unified analysis of data of vibro-diagnostics and amplitude spectral components of the consumed current. The typical frequencies generated by the details of bearings - rings, separators, balls - are defined. The described method is based on the analysis of the spectral components of the current consumed by the electrical motor. The proposed scheme can simultaneously measure, register and process mechanical vibrations and electrical parameters of the supply current and voltage.
Keywords: *bearing unit, defects of the bearings, vibro-acoustic analysis, spectral components of the current, harmonics of the magnetic induction, typical (informative) frequencies, induction in air gap.*

Introduction

The induction three-phase motors are widely used in industry, land and sea transport, building. The failure of an induction motor results in the stopping of a mechanism, its dead time, disturbances in the technological process. It leads to the increased economic expenses. About 30 -35% of the failures are in the bearing units of the induction motors [6]. Therefore the permanent control (monitoring) of the technical condition of the bearing units is effective and economically justified. It allows an opportune exposure of defects and transforming them from the category of sudden defects to those of gradual. The methods of bearing units vibro-control are widely known. Together with high effectiveness of these methods they also have some disadvantages. For example, impossibility of direct access to the bearing unit for the vibro-measurements, a high vibration background of the equipment operating at close distance. Another method of the control of the technical condition of the bearing units according to the spectral components of the consumed current and voltage is proposed [4, 9]. The measurements can be realised directly at the terminals of the motor as well as in the nearest enclosure. At that there is no requirement in stop of the motor and its disconnection from the supply [12]. The comparison of the results of vibro-acoustic methods and those of the consumed current spectral analysis is of high interest.

Statement of the task

The essence of the method is in the determination of typical (informative) frequencies in the spectral components of the supply current (voltage) of the induction motor. In the air gap of a real machine there is a large number of higher harmonics of magnetic field. The modern measurement and microprocessor equipment allows an accurate analysis of these harmonics having low amplitude (up to parts per cent). The higher harmonics are divided into time and space. The time harmonics are defined with the spectral components of voltage and non-linear changes of the torque on the shaft and frequency of its rotation. The space harmonics of the field in air gap exist because of non-linear parameters of the machine and its constructive features.

The mechanical defects in the running slots of the bearing rings, rotating bodies and separators result in slowing down of the rotor, micro changes of its angular velocity and acceleration, changing in the space position of rotor in the stator boring. It results in different electromagnetic interaction of rotor and stator, in the oscillations of rotating electro-magnetic torque. The harmonics (typical frequencies) the amplitude and frequency of which depend on the technical condition of the bearing unit appear in the spectrum of the consumed current. The frequency and amplitude of these harmonics are the diagnostic parameters.

The operating rolling bearing generates mechanical oscillations divisible by basic frequency of rotation of the three-phase electric motor. These frequencies are called typical.

$f = k_1 * f_n$, (1)

where: f – are the typical frequencies;

$k_1 = 1…5$ – coefficients;

f_n – the typical frequencies when there are defects in the bearings elements. In some cases coefficient k_1 can get a value within the range 04…-0,8 f_n .

The basic characteristics of the spectral analysis of vibro-acoustics as well as the spectral components of the consumed currents are the frequency and amplitude. 5 typical frequencies, the amplitudes of which are very different for the bearing unit with defect and for that being defect-free, can be calculated for the rolling bearing [1, 13].

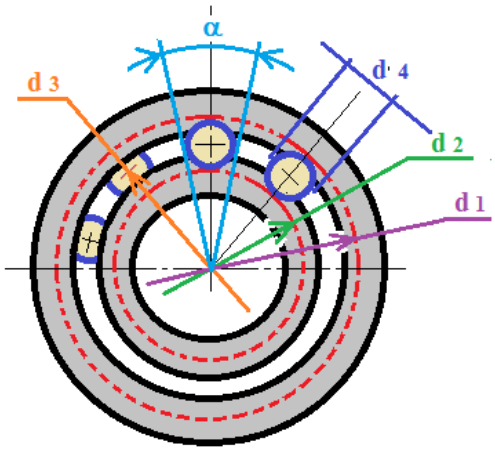

Figure 1. The basic parameters of the rolling bearings. 4 rolling bodies are conditionally given

f_1 - the rotation frequency of the rotor (of the inside ring of the bearing);
f_2 - the frequency of the rolling of the bearing bodies along the running slots of the outside rings (Formula 2).

$$f_2 = f_3 * Z = \frac{1}{2} f_1 (1 - \frac{d_4}{d_3} * \cos\alpha) * Z; \quad (2)$$

where: f_3 – is the frequency of the separator rotation;

d_4 - the diameter of the rolling bodies;

d_3 – the diameter of the separator (diameter of the circle going through the centres of the rotation bodies), and $d_3 = \frac{d_1 + d_2}{2}$;

d_1 - the diameter of the running slot of the outside ring;

d_2 – the diameter of the running slot of the inside ring;

α – the angle of the rolling bodies contact with the running slots;

Z- the number of rolling bodies.

Frequency f_2 is caused with the shaft „leaping" above each rolling body.
The frequency of rotation bodies rolling along the running slot of the inside ring (Formula 4).

$$f_4 = (f_1 - f_3) * Z = \frac{1}{2} f_1 (1 + \frac{d_4}{d3} \cos\alpha) * Z; \quad (3)$$

At this $f_2 + f_4 = f_1 * Z$. This frequency appears if the inside ring of the bearing (or of the shaft) is not of ideal round form.

f_3 – the frequency of the separator rotation (Formula 4).

$$f_3 = \frac{1}{2} f_1 (1 + \frac{d_4}{d_3} \cos\alpha) = \frac{1}{2} f_h; \quad (4)$$

This harmonic component appears in the case is one of the rolling bodies has a larger or smaller diameter. Then rotating the shaft is „leaping" or „falling in".

f_5 – the frequency of the rotation of the rolling bodies (Formula 5).

$$f_5 = \frac{1}{2} f_1 \frac{d_3}{d_4} * (1 - \frac{d_4^2}{d_3^2} * \cos^2 \alpha). \quad (5)$$

This frequency appears is the rolling bodies are of a facetted form. Usually this harmonic component evinces its even harmonics. The number of the even harmonics and their order depend on the number of sides of the rolling bodies. Let us consider the example of bearing of the average model 60305 with the rotation frequency f_1 =1420 min^{-1} and outside diameter of the outside ring 72 mm. The typical frequencies will be equal: f_2 = 4311 Hz; f_4 = 7049 Hz; f_5 = 2772 Hz; f_3 = 539 Hz.

Figure 2A demonstrates the spectrum of the frequencies of the forward bearing of the fan electric motor at the beginning of the examination, Figure 2B – the same in 500 hours of uninterruptable operation (3 weeks).

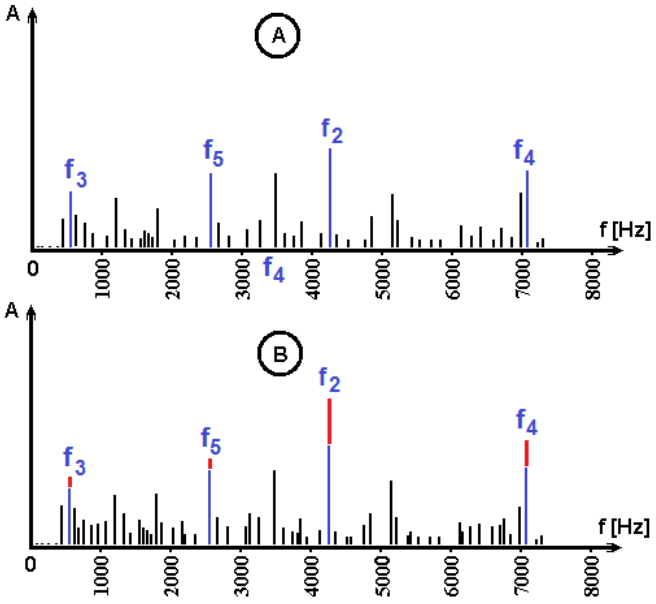

Figure 2. The spectral distribution of the bearing unit

The amplitude of the harmonics is given in relative units. For one the amplitude of 4311 Hz harmonic component is accepted on the frequency of rotation of the rolling bodies along the outside ring of the bearing of the defect-free motor (frequency № 2). The defect motor has the amplitude of all the

typical frequencies higher for about 12..18%, that first of all is signalling about the weakening of the lubrication regime of the bearing. The growth of the amplitude of frequency №2 is the most visible that is signalling about the appearance of a single defect ont he running slot of the outside bearing ring. Appearing 2 defects a harmonics with double frequency is possible 4311 x 2 = 8622 Hz. For example, if the load of the induction motor is a piston compressor then the basic operation frequency of it is in the range (with the angular velocity 1420 min^{-1}) 23…24 Hz. The signals with this frequency are filtered by the filter of lower frequencies.

To find the correlation between the harmonics of the frequencies of the mechanical oscillations and those of the magnetic induction in air gap the demonstrated in Figure 3 scheme is proposed.

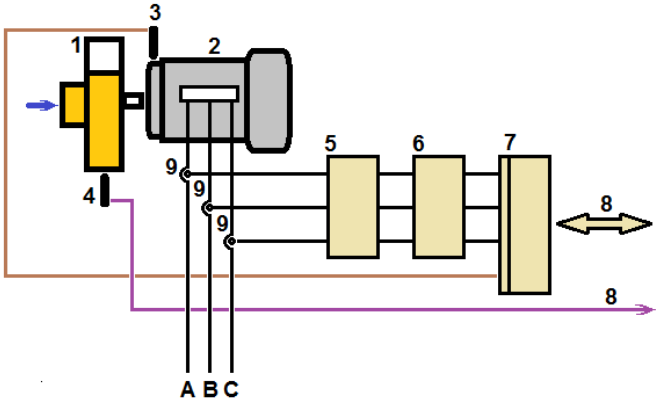

Figure 3. Block-scheme of the experimental installation

1 - fan; 2- electric motor; 3- piezo-accelerometer – the sensor of vibration; 4- the sensor of the angular velocity; 5 - band-pass filter; 6- filter of lower frequencies; 7 analogous-digital converter with the commutator at the input; 8- output to the computer; 9- sensors of current; A, B, C- supply voltage.

The vibrations of the front panel of the electric motor are measured with piezo-accelerometer 3 (Figure 3). The measured signal from it comes to analogue-digital converter 7. The angular velocity is measured by sensor 4. This sensor is installed inside the body of the fan and operates when the fan's blades pass by it. The number of the fan's blades and their step is known. Measuring the time interval of the blades passing by the sensor it is possible to measure the instant angular velocity and the instant acceleration of the motor shaft as well. In an ideal case the instant angular velocity per one turn of the rotor will be constant, and the acceleration will be zero. The defects of the bearing units cause the changing of the instant angular velocity and instant acceleration. The exceeding of these parameters over the preset bounds signals about an incipient defect of the bearing units. The signals from the sensors of current 9 firstly come to the band-pass filter 5. This filter is tuned for the frequencies range which should include also the informative (typical) frequency. Further the signals are supplied to the filter of lower frequencies 6 (it delays the electrical signals lower than a particular frequency) and then to analogue-digital converter 7. The information 8 from it does to the computer. The software includes a program of spectral analysis. The information is analysed determining the amplitude and frequency spectral range of the signals. The obtained results are saved and the compared with the further measurements. The spectral range of the consumed current is complicated in its nature including a large number of frequencies. But the changing of the typical frequencies is of the most interest. The appearance of new frequencies allows to judge the technical condition of the bearing unit. The sensor of angular velocity 4 has a digital output and is connected to the computer port passing by analogue-digital converter 7. Mechanical oscillations of the rotor cause periodic changes of the air gap size in the magnetic circuit of the electric machine. It results in the harmonics in the spectral component of magnetic induction. These changes in the amplitude-harmonic component of the induction cause the changes in that of the consumed current and voltage. Thus an unstable position of the rotor in the stator boring (mechanical harmonics) modulates the magnetic flux in the air gap. The frequency of new harmonics of magnetic flow can differ from the typical frequencies of the mechanical oscillations generated in bearings in 1-12 times [2]. The magnetic flux is modulated when the frequencies are added as well as subtracted.

In general case the spectral component of the consumed current and voltage can be represented as a sum of harmonics with different frequencies and phases:

$$u = U_0 + \sum_{i=1}^{n} U_{i\max} * \sin(i\,\omega t + \phi_i); \quad (6)$$

$$i = I_0 + \sum I_{i\max} * \sin(i\omega t + \phi_i - \varphi_i). \quad (7)$$

The basic task of the investigation of the processes in air gap is the determination of the currents in the machine windings at a changing operation mode (space oscillation of the rotor) that requires the solution of the system of equations of emf balance in the electrical circuits of the machine. The complexity and accuracy of the investigation and the mathematical model as well usually increase with the increasing of the number of factors taken into account and depend on the types of these factors and methods of the investigation. All the equations in the system are in the relative units or p.u. system with equal resistances of the mutual inductance and magnetization forces [7, 10].

The mathematical model of induction motor in *d, q, 0* - axes.

(10)

$$u_{cd} = r_c i_{cd} + \frac{d\Psi_{cd}}{dt} - \Psi_{cq}\omega;$$

$$u_{cq} = r_c i_{cq} + \frac{d\Psi_{cq}}{dt} - \Psi_{cd}\omega;$$

$$u_{pd} = r_p i_{pd} + \frac{d\Psi_{pd}}{dt} - \Psi_{pq}(\omega_k - \omega);$$

$$u_{pq} = r_p i_{pq} + \frac{d\Psi_{pq}}{dt} + \Psi_{pd}(\omega_k - \omega) \quad (11)$$

The flux linkages for all the loops of the machine in *d, q 0* - axes contain only the constant inductivities not depending on time:

$$\Psi_{cd} = x_c i_{cd} + x_{ad} i_{pd};$$
$$\Psi_{cq} = x_c i_{cq} + x_{ad} i_{pq};$$
$$\Psi_{pd} = x_{ad} i_{cd} + x_p i_{pd}; \quad (12)$$
$$\Psi_{pq} = x_{ad} i_{cq} + x_p i_{pq}.$$

The equation of motion is shown by Formula 13.

$$J\frac{d\omega}{dt} = M_{out} - M_c. \quad (13)$$

where: *J*- is the moment of inertia of the rotor and load mechanism;
M_{out} – rotating torque on the shaft;
M_c – resistive torque.

When the rotor is oscillating the kinetic energy is converted into the energy of electromagnetic field and vice versa. In this case along with the constant component $\boldsymbol{M_{out\ 0}}$ the rotating torque of the motor contains also the torques of the harmonic components $\boldsymbol{M_{out\ \nu}}$.

$$\mathrm{M}_{\mathrm{out}} = \mathrm{M}_{\mathrm{out}\ 0} + \sum_{\nu} \mathrm{M}_{\mathrm{out}\ \nu\mathrm{m}} \cos(\nu\omega t + \varphi_\nu). \quad (14)$$

The electromagnetic torque of the motor is related to the magnetic flux with the equation

$$M = C\Phi I_{2s} \cos\phi_{2s}; \quad (15)$$

where: *C*- is a constructive constant of electric motor;

Φ- magnetic flow in the air gap;
I_{2s} - current in the operating rotor;
cos φ_{2s} - power factor describing the delay of current I_{2s} produced by emf E_{2s} for angle φ_{2s}.

The equations under consideration demonstrate the relationship of the electromagnetic processes in electric motor with the parameters of magnetic induction in the air gap. The parameters of magnetic induction depend also on the geometry of the air gap, i.e. on the space position of the rotor in the stator boring. The position of the rotor is determined with the current technical condition of the bearing units.

Conclusions

1. The analysis of the spectral power parameters of the consumed current gives an opportunity to obtain additional information on the condition of the bearing units.
2. The extraction of the diagnostic information separately for the front and back bearing units of the induction motor is a topical task. The extending of this method allows the estimation of the technical condition and monitoring of not only induction motor but the driven assembly – gear, pump, etc. as well.
3. The current control – monitoring – of the bearing units allows the prognosis of their residual resource.

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MONITORING OF BEARING UNITS OF THE SHIPS ELECTRICAL AC MACHINES ON THE BASIS OF MAGNETIC INDUCTION IN AIR GAP

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Abstract
The methods of the investigations of the bearing units of AC machines are analysed in the article. The work proposes the method of monitoring of the bearing units according to the results of re-distribution of magnetic induction in air gap of an AC machine. The three-dimension magnetic field in electrical machine is described mathematically. All the calculations are made on the basis of three components of magnetic induction. The three-dimension magnetic field in induction machine is analysed for the symmetrical air gap and different level of shift of rotor axis (the defect of one of the bearings). The proposed method allows on-the-run monitor of the bearing units of electrical machines without their stopping, breaking of the technology process and without withdrawal. The data of the monitoring give a possibility of prognoses of the residual life of the bearing units, transmit a part of sudden failures into the category of gradual failures and determine the level of the necessary service.
Keywords: *electrical machine, monitoring, bearing units, magnetic field, three-dimensional magnetic induction*

Introduction

The AC machines (induction motors and synchronous generators) are widely applied in industry and maritime transport. They consume from 70 to 80% of all the consumed power. Approximately 20...25 % of the failures of the industrial installations is the share of induction motors. Most of the failures are caused with incorrect technical maintenance of the motors or its full absence. Up to 40% of all the possible failures in turn are in the bearing units of IM. The current monitoring of the bearing units technical condition of AC machines, especially induction motors, is economically justified and effective, and timely identifies arising failures and transform them to the category of gradual failures [2, 3, 4, 5].

The most important sources of AC on board the ships are the synchronous generators. Those can be a component of diesel-generators as well as can operate like shaft-generators. The number of diesel generators on the vessels is usually 2-4 units. According to their power the synchronous generators can have either both bearing units or only one back-side. In this case the bearing of the crankshaft of the diesel is that of front-side of the synchronous generator.

The traditional methods of the units vibro-control are widely known. Alongside with the high effectiveness of this method it also has a number of drawbacks. It is labour-intensive and requires a special equipment and high qualified personnel. The defect of the bearing units cause harmonics and re-distribution of magnetic induction in air gap of the induction motor resulting in the deformation of the spectral distribution of the consumed current. In the real machines except the basic harmonic there are a lot of higher harmonics of magnetic field in the air gap [1, 3, 7]. The higher harmonics are traditionally divided into temporal and space.

The temporal harmonics are defined with the voltage spectral distribution and non-linear changing of the rotation torque on the machine shaft and frequency of its rotation. The space harmonics of the field in the air gap are caused by the non-linear parameters of the machine and its constructive features. If the power of motor is comparable with that of generator like in autonomous networks (e.g. ship power installations) then non-sine field in the air gap will result in non-sine form of voltage across the terminals of the machine so that the currents of the high harmonics are closed across the load. [2, 3, 7]. The basic space harmonics are also tooth harmonics, MMF harmonics, those caused by the non-linear parameters of

the machine, combination and technological harmonics. The latter are caused by the technological parameters - axis misalignment of the rotor and stator, tapering and ellipse form of rotor, eccentricity of the stator bore, defects of the bearing units.

The mathematical description of the magnetic field in the air gap of electric machine

The investigation of the influence of the above mentioned defects of bearing units on the magnetic field of induction machine was based on the calculation of stationary magnetic field system of the electric machine.

$$\begin{cases} rot\vec{H} = \vec{\delta} \\ div\vec{B} = 0\ , \\ \vec{B} = \mu\vec{H} \end{cases} \tag{1}$$

where:

$\vec{H}$ - the intensity of magnetic field;

$\vec{\delta}$ - density of electrical current;

$\vec{B}$ - the induction of magnetic field;

μ - the magnetic permeability of steel

The Poisson equation mathematical description is considered for the calculation of three-dimension stationary magnetic field [8]:

$$\begin{cases} \frac{\partial}{\partial y}\left(\frac{\partial A_y}{\partial x}\right)+\frac{\partial}{\partial z}\left(\frac{\partial A_z}{\partial x}\right)-\frac{\partial}{\partial y}\left(\frac{\partial Ax}{\partial y}\right)-\frac{\partial}{\partial z}\left(\frac{\partial A_x}{\partial z}\right)=-\mu\delta_x \\ \frac{\partial}{\partial z}\left(\frac{\partial A_z}{\partial y}\right)+\frac{\partial}{\partial x}\left(\frac{\partial A_x}{\partial y}\right)-\frac{\partial}{\partial z}\left(\frac{\partial A_y}{\partial z}\right)-\frac{\partial}{\partial x}\left(\frac{\partial A_y}{\partial x}\right)=-\mu\delta_y, \\ \frac{\partial}{\partial x}\left(\frac{\partial A_x}{\partial z}\right)+\frac{\partial}{\partial y}\left(\frac{\partial A_y}{\partial z}\right)-\frac{\partial}{\partial x}\left(\frac{\partial A_z}{\partial x}\right)-\frac{\partial}{\partial y}\left(\frac{\partial A_z}{\partial y}\right)=-\mu\delta_z \end{cases} \tag{2}$$

where:

A_x, A_y, A_z, δ_x, δ_y, δ_z – the components of the vector magnetic potential and current density vector along axes x, y, z correspondingly.

On the basis of the system of pre-set currents and magnetic parameters of different space sectors it is necessary to calculate the space distribution of vector A, meeting the equations of the system (2) and boundary conditions of the space size.

The task of calculation of the magnetic field is solved minimizing the functional:

$$F=\int_V\left[\left(\frac{1}{\mu}\int_0^{B_x}B_x dB_x-A_x\delta_x\right)+\left(\frac{1}{\mu}\int_0^{B_y}B_y dB_y-A_y\delta_y\right)+\left(\frac{1}{\mu}\int_0^{B_z}B_z dB_z-A_z\delta_z\right)\right]dV. \tag{3}$$

For the minimization of functional (3) the investigated size is divided into the set of finite elements. The finite element is selected as a tetrahedron.

Minimum of functional (3) is found solving the equations system:

$$\frac{\partial F}{\partial \{A\}} = \frac{\partial}{\partial \{A\}} \sum_{m=1}^{m=r} F^m = \sum_{m=1}^{m=r} \frac{\partial F}{\partial \{A\}} = 0, \quad (4)$$

where the input of the element into the functional is in matrix form:

$$\frac{\partial F^m}{\partial \{A\}} = \frac{1}{36V_m} \left[N^m\right] \{A\} - \frac{V_m}{4} \{\delta\}, \quad (5)$$

where:

V_m – is the size of tetrahedron m;

$[N^m]$ – the matrix of tetrahedrons;

$\{\delta\}$ – the vector of the current density components in tetrahedron;

r - the number of tetrahedron of the calculations space.

On the basis of expression (4) we can get the system of non-linear algebraic equations the solution of which provides functional minimum (3) giving thus the solution of the equations system (2).

For the analysis of the magnetic field calculations the value of magnetic induction is applied represented with the following equation by means of vector magnetic potential [10]:

$$\vec{B} = \text{rot}\, \vec{A}. \quad (6)$$

The analysis of magnetic field is based on the components of magnetic induction represented as follows [8]:

$$B_x = \frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z}, \quad (7)$$

$$B_y = \frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x}, \quad (8)$$

$$B_z = \frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}. \quad (9)$$

The description of the realization of the method of finite elements (MFE) for the calculation of three-dimension magnetic field of electric machine and the program are represented in [9, 10].

Calculation results

The three-dimension magnetic field in electrical AC machine is analysed by means of induction machine model demonstrated in Figure 1. The calculations and analysis are made for the machine with symmetric air gap (without defects) and different levels of non-symmetry of it (with the defects in bearing units, e.g. misalignment of rotor, tapering and ellipse form of rotor, eccentricity of the stator bore).

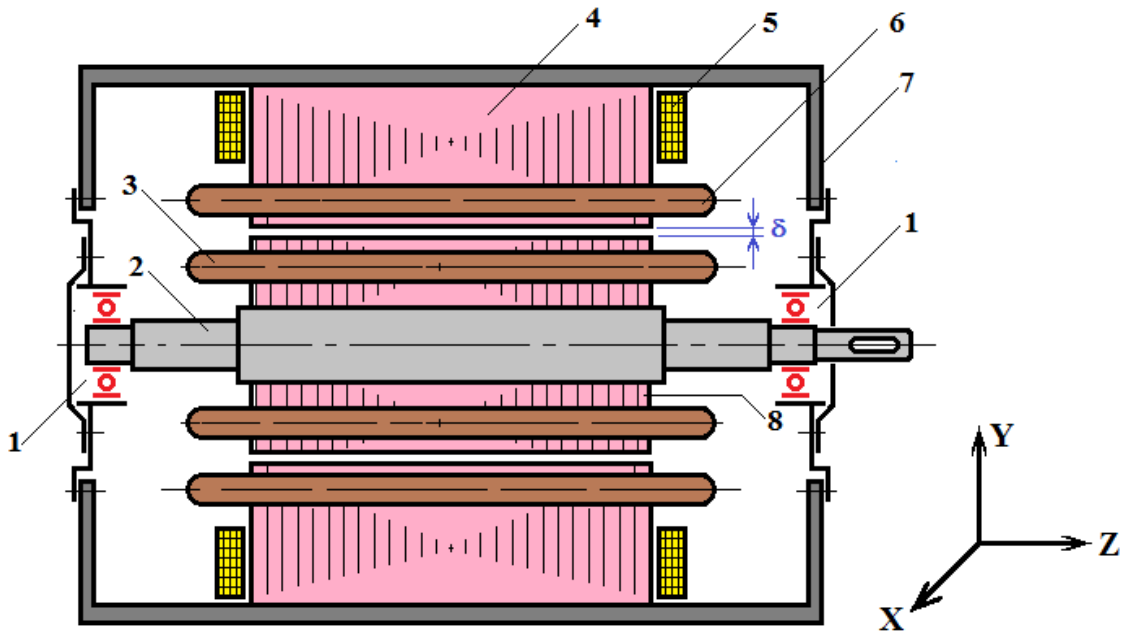

Figure1. The model of the induction machine under investigation.
1 - bearing unit; 2 - shaft; 3 - rotor winding; 4 –stator core; 5 – pressure rings of stator core; 6 - stator winding; 7 – enclosure; 8- rotor core.

The investigations resulted in the pictures of magnetic force lines of the packages edge zone (in X-Y coordinates) of the investigated model (Figure 1) with a defect (level of rotor shift according to the stator $\delta_{max}/\ \delta_{sim}= 1,75$) (Figure 2b) as well as without a defect (rotor symmetrical to stator δ_{sim}) (Figure 2a). The results of the magnetic field allow a qualitative extraction of the zone of significant weakening of magnetic induction in the area of maximum shift of the rotor axis according to that of stator.

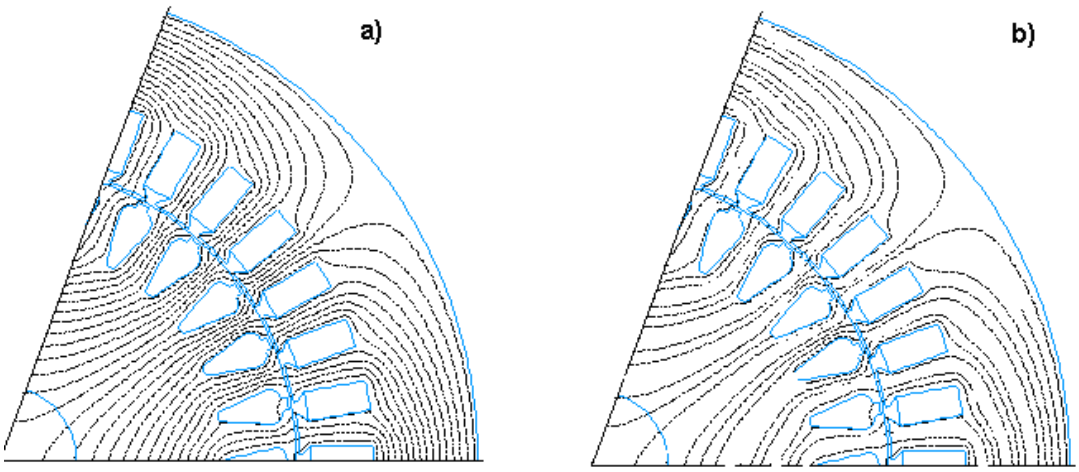

Figure 2. The calculation of magnetic field of induction machine (force lines of the magnetic field in the pole pitch) without defects - 2a and with defects (in the right bearing unit, rotor shift $\delta_{max}/\ \delta_{sim}= 1,75$) - 2b.

Figure 3 demonstrates the results of the calculations of magnetic induction in the air gap of induction AC machine in axial direction (along Z axis) without defects as well as with that in the right bearing unit (shift of the rotor $\delta_{max}/\ \delta_{sim}= 1,5$ и 1,75). Table 1 represents the results of percentage changing (reducing) of the amplitude of the air gap induction (ΔB) of basic and tooth harmonics with different levels of the rotor shift according to the symmetry axis of the stator.

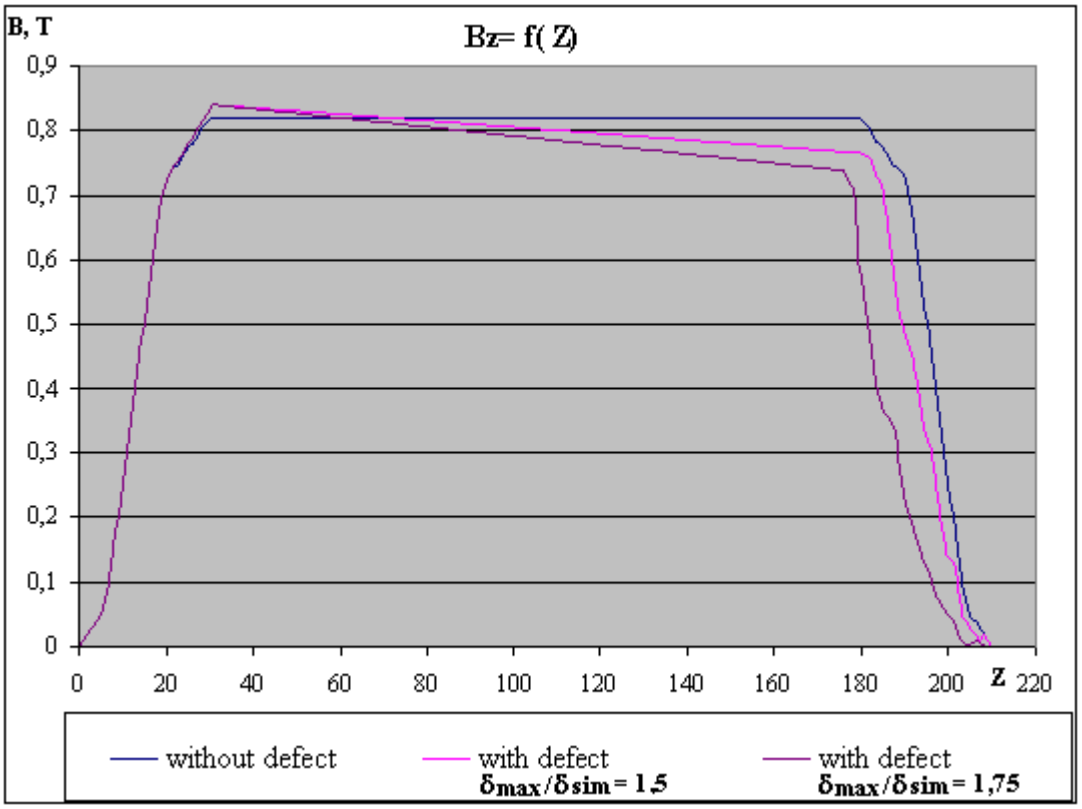

Figure 3. Distribution of magnetic induction in air gap in the axial direction of the machine

Table 1.

Level of the shift $\delta_{max}/\delta_{sim}$	**ΔB (%)** (basic harmonic)	**ΔB (%)** (tooth harmonic)
1.25	- 5	-12
1.5	-12	-23
1.75	-19	- 31

Conclusions

1. The proposed method give an opportunity for technical monitoring of the bearing units of the electrical machines with the shift of rotor according to the axis of stator along all 3 space axes (X-Y-Z).

2. With the shift of the rotor ($\delta_{max}/\delta_{sim}$= 1,75) (the defect of one of the bearings) the meanings of the basic harmonic of the induction in air gap reduce for up to 20%, but of the tooth one up to 30 %. These changes are the diagnostic parameters of the technical monitoring of the electrical machines.

3. The defects of the piston-cylinder group, gas-distributing mechanism and other aggregates of the diesel and driven mechanism (pump, fan, etc.) also influence the harmonic composition of the magnetic induction in air gap but their frequency is significantly lower that those produced of the bearings.

4. This method allows on-the-run monitor of the bearing units of electrical machines without their stopping, breaking of the technology process and without withdrawal.

5. The data of the monitoring give a possibility of prognoses of the residual life of the bearing units, transmit a part of sudden failures into the category of gradual failures and determine the level of the necessary service.

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DEVELOPMENT OF THE MARITIME SELF-CONCEPT OF SEAFARER'S PERSONALITY IN REGARD TO EUROPEAN HISTORY OF IDEOLOGY

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Abstract
Development of the maritime self-concept of seafarer's personality is described. The personality value is analyzed from the point of view of the contact with the sea. The research object is a development of the maritime self-concept. The object has been researched at scientific levels of ideological and psycho-educational prerequisites. The research goal is a discovery of the formation of maritime self-concept from the ideological and psycho-educational point of view. Tasks are as follows – characterization of the European maritime self-concept from the historical and ideological point of view, and revelation of psycho-educational factors of the maritime self-concept development. Methodology of the research consists of the STCW convention, paradigm of universal upbringing, idealism, humanism, existentialism, existential phenomenology and neotomism. Transcendental perspective of the maritime self-concept, classic European mentality, intuitive and creative mythologization of marine events, direct experience of the sea, marine education of the health, maritime studies and professional activity enrich the seafarer's personality.
Keywords: *maritime self-concept, seafarer's personality, European ideology, psycho-education.*

Introduction

Development of the maritime self-concept, at methodological levels of the personality value and IMO[1] positive campaign "Go to sea!" [1], is described in the scientific article. The personality value is analyzed from the point of view of the contact with the sea. What is personality value and what criterion defines it? The personality value can be perceived as high and very small but altogether it appears as a natural spiritual rudiment from the methodological point of view.

This is fundamental ontological and anthropological minimum of human nature. The scientific theory of the maritime self-concept reflects the value of personality. The personality is intended to live on the highest values and improve its value, harmony and spiritual maturity [21]. The aspiration of personal harmony and maturity needs a minimal level of the personality value at least.

The essence of the maritime self-concept of personality consists of free, individual, phenomenological and subjective perception of the sea and valuable self-consciousness from the axiological, methodological and practical point of view.

It is possible to register physic and partially psychic development of the personality. However it is most difficult to explore a spiritual dimension. The specifics and complexity of the spiritual dimension promote confidence in the ideal and phenomenological research [13]. The phenomenological analysis of the maritime self-concept helps get closer to the truth at the level of scientific prerequisites. This truth is not absolute but it is valid scientifically and significant for educational practice.

The scientific problem of the maritime self-concept of the personality is multidimensional. This problem includes many factors, conditions and positions. However education of the maritime self-concept demands ideological and psychologically suggestive basis primarily from the hodegetical point of view. Education of the maritime self-concept is based on a transcendental idea of the European culture tradition. This idea lets feel the value and dignity of the personality and its European identity. The most important condition of personal dignity is freedom to move away from the absolutely natural and deterministic self-consciousness [11, 12].

[1] IMO (International Maritime Organization)

The tradition of the European maritime culture is directly related to development of spiritual and mental horizons of the personality. The most prominent factors of the maritime development are as follows:

- Arabic origins of the maritime navigation and astrophysics;
- Greek mythology and philosophy raising sea symbols;
- Maritime missions, which have been encouraged from the Judeo-Christian mentality and manifested on new geographic and ethnographic discoveries;
- The decisive role of this mentality appeared in formation of European states and institutional culture, in development of literacy and rising of universities from monastic libraries (X–XI c.) and first Portuguese maritime schools (XV c.) [8, 18].

Expansion of the mental horizon of the personality in the Mediterranean civilization, from the point of view of Judeo-Christian qualitative leap, was necessary for the formation of the European maritime self-concept at three strategic levels:

- Marine-physic;
- Scientific-intellectual;
- Spiritual-transcendental.

A possibility to recognize oneself, gain recognition from others and freely decide in the presence of transcendence must be open to people from the point of views of anthropology and European culture development [22]. These conditions were significant for a personal acquirement to foster cognitive interest and perceive the human value. It is a possibility of the existential liberation and perfection of the personality from the ideological point of view.

The sea is a value in itself and not only for economic reason [9]. This ontological approach consists of a priori dignity of the personality and the need of them, especially when questions of the origin and destiny of life, existential and psychoanalytic problems of education are directly linked to water and its symbolism. It is actualized in the significance of the integral personality and complex value approach at levels of the European maritime policy and environment [26].

Political and educational decisions of sea-related activities need harmonious consensus. The personality, who preserves and enriches oneself and the environment, can create a culture of sustainability at applied scientific levels of the cultural relationship with the sea and conscious self-education. However it is difficult to appreciate, when it does not suffice for the sustainable social environment. Perhaps it is even more difficult to appreciate and protect the natural environment, when a person did not have opportunities to develop the adequate self-esteem or has lost it.

The grade of the exploration

Researches of national maritime mentality, maritime culture, respect for oneself and the sea, philosophical consciousness, self-management of the personality and his / her career, maritime policy and economics, social responsible politics of the maritime business, vocational training of seafarers and their physic and psychic health, self-educational needs of seafarers, psychological terror and education of students for maritime self-consciousness are close to the scientific problem of formation of the maritime self-concept in Lithuania [2, 5, 6, 7, 10, 16, 23, 25].

The major part of psycho-pedagogical data of internalization of the maritime self-concept is detected at levels of social image of the sea, personal sea-image formation, mental motives of attraction and avoidance of the sea, psychoanalysis and marine symbols, psychological analysis of sea perception, virtual space effect, change of epochs, moral way of Europeans' maritime life, protestant maritime business and sense of freedom, self-development needs of seafarers, measures of their psycho-prophylactics, seafarers competence of stress management and psycho-education of the personality on the sailing [4, 14, 15, 17, 19, 20].

Thus the scientific problem of the research is development of the maritime self-concept of seafarer's personality in regard to European history of ideology, and psycho-education. The system of scientific ideas, facts and research results is given in the scientific study. Parameters of development of the personality value are made scientifically meaningful from the point of view of the maritime self-concept.

Goal and tasks of the research

The research goal is a discovery of the formation of maritime self-concept from the ideological and psycho-educational point of view.

Tasks are as follows:

1. Characterization of the European maritime self-concept from the historical – ideological point of view.
2. Revelation of psycho-educational factors of the maritime self-concept development.

The research object is a development of the maritime self-concept. The object has been researched at scientific levels of ideological and psycho-educational prerequisites.

The research methodology

Methodology of the research consists of the STCW[2] convention, paradigm of universal upbringing, idealism, humanism, existentialism, existential phenomenology and neotomism.

Methodological attitudes are as follows:

- STCW convention is important for assessing of the vocational maritime self-concept of maritime students and internalization of their maritime self-concept especially from the point of view of the social responsibility requirement.
- The paradigm of universal upbringing indicates to development of the full power of personality. The context of biological, psychological and spiritual needs determines development of the maritime self-concept of an entire personality.
- Idealism accentuates the spiritual nature of the man. Enrichment of the personality is based on the transcendental ideal at axiological level of the maritime self-concept. The final meaning of the human life promotes a sense of the individual freedom.
- Humanism indicates the spirituality that is an inherent basis for education of the personal spiritual culture. The internalization of the maritime self-concept allows better understanding of existential human dignity from the humanistic point of view of personality freedom.
- Existentialism refers to the human fear in the land and at sea. Existential psychology is a cause for the hope. This psychology denied an attachment to life pleasures and promotes personality liberation and purification of his / her existence. Development of the maritime self-concept expands a horizon and helps people overcome the tragedy of the existence, improve the emotional state and find the unique comfort.
- Existential phenomenology indicates to self-education of valuable attitudes through the existential experience, artistic creativity, imagination, insight and reflection of values. The education through the experience is very important in relation to the marine phenomenon.
- Neotomism refers to personalism and raises the personality above the daily. Formation of the maritime self-concept is based on the transcendental ideal of the European culture tradition. This ideal led to feel the value and dignity of the personality.

Methodological type the research is theoretically descriptive, empirical diagnostic, qualitative phenomenological, semi-deep.

Methods of the research

There were used such research methods:

- Retrospective, comparative, extrapolative, heuristic analysis and meta-analysis of scientific literature;
- Convenient selection of respondents (the third-year students of the marine navigation), instructional interview, written survey (questionnaire procedure with open questions, self-reflection and free association), phenomenological content-analysis of internalization of the students' maritime self-concept, interpretation, reduction, classification and systemization;
- Hypothetical prognostic modeling of training of seafarers at the level of development of their maritime self-concept from the point of view of the personality value, and synthesis.

Steps of the phenomenological content-analysis after some modifications:

- Selection of manifest categories;
- Categories are divided into subcategories;
- Setting of the repetition frequency of (sub)categories;
- Interpretation of results [24].

The research basis is the Lithuanian maritime academy. The research was made in a homogeneous group in accordance with the science ethics.

50 potential respondents were invited to answer the questionnaire:

[2] STCW (Standards of Training, Certification and Watchkeeping for Seafarers)

- The were 25 who felt free to answer the large-scale questionnaire, which consists of 67 open questions;
- 9 respondents answered the questionnaire negligently;
- 16 tough future seafarers answered all questions of the questionnaire in about two academic hours.

Empirical results can be applied only to the respondent population.

European maritime self-concept from the historical – ideological point of view

There was made the analysis of the transcendental ideal of European maritime self-concept from the point of view of the qualitative leap. The transcendental ideal of the European maritime self-concept was characterized. The mental closure in the pagan perception of space educates the closed maritime self-concept. It promotes deification of waters. The sea is experienced as a mystery.

The ancient man is naturally shy and gullible but also strong. Personality has not conciliated with the fearsome sea-mythology and strained to the relationship with sea, began and developed a seamanship. The personal sense of existential freedom is not based on the transcendence at the ideological level in the pre-monotheistic epoch. The value of the personality is not treated exclusively inter other elements of the cosmic nature.

The monotheistic leap of self-consciousness in the Jewish civilization has opened a transcendental perspective of the maritime self-concept. God is above nature – the sea and land, and he is perceived as the Creator of the Universe from the monotheistic point of view. The God's name is *love* in Hebrew. This qualitative leap has liberated the self-consciousness of the personality from the pagan mental-closure and formed a new conception of the sea.

The water was created from love of the Creator. The water is not an office of gods but the work of the Creator. Therefore a monotheist can interact with water safely and responsibly, and the value of the personality is treated at the higher level. The man is created from love and he / she began to perceive the self-purpose for love, freedom and culture [3].

Christianity has extended the idea of water and man. God has created the water and the man with love. This new idea of Christianity formed the classic European mentality, which led to development of the maritime self-concept, the rise of universities from monastic libraries, development of the maritime geographic discoveries, science, global and universal education and the first maritime schools. The personality value takes a top in the self-concept because the loving God not only created a man but also became a man. The sustainable and socially responsible relationship with the sea is a direction of the maritime self-concept because man is free, dignified and loving. This condition of the personality is based on the experience of the new self-esteem.

The man sees the sea more pragmatically in the self-concept later at the level of decline of the transcendence. Global environmental problems were caused by the excessive exploitation of marine wealth and pollution. Integration of conventions of the sustainable development and upbringing of a conscious personality could and must solve ecological problems. The ideologically reduced value of the personality cannot guarantee a harmonious interaction with the sea in the post-protestant epoch. The use of the maritime self-concept as a mental tool of development of the personality enriches hodegetics and anthropologically and adequately promotes a harmonious expression of the human practice.

The analysis of conditions of the maritime self-concept formation in the Middle Ages and the New Times was made. The Medieval era is enough controversial and consistently changing. The menacing biblical image of the sea appears as a fear factor [17].

European education of monastic universities overshadows the menacing image of the sea in the late Middle Ages. The social situation of the maritime self-concept is more progressive ideologically in the late Middle Ages. The maritime sector is gradually recognized. Limits of perception of the value of the seafarer's personality are extended. Seafarers began to gain social guarantees. A system of the social welfare of seafarers was created in some nautical countries.

The new doctrine spread in the protestant era of the New Times. The man must understand oneself as an owner of the sea, which has been present by the loving Creator. Protestants did not limit themself at the level of Christian mythological tradition but aimed it to complement with a non-transcendental pre-Christian tradition, which is more positive and psychologically suggestive. It made influence to the content of valuable education of the personality. The socio-cultural content of valuable education was integral.

However, later the maritime self-concept was characterized by the formal pragmatism, only empirical science and too active marine functionalism on developing of commercial maritime fleets from

the ecological point of view. The superficial cultural and medical recreation appeared on the coast from the hodegetical point of view.

An action of the personality is raised not as a duty of the sustainable technologic interaction with the sea and universal improvement in the society but as an implementing of egoistic benefits and demands for well-being. The sea is recklessly and destructively exploited. It is other extreme compared with a fear of the sea in the Middle Ages. It caused serious environmental problems.

Psycho-educational factors of the maritime self-concept development

The analysis of psycho-educational factors of maritime self-concept development and the psychological mechanism of sea perception was made. Becoming of the maritime self-concept of personality is characterized by the pre-interactive expression of intuitive human nature. This expression is measured objectively and subjectively at the socio-axiological level, formed and transformed. Intuitive and creative mythologization of marine events stimulates development of the maritime self-concept. This mythologization promotes the personality to evaluate oneself existentially, give a sense to activities in the natural and individual ideological context [2].

A virtual level of the contact with the sea brings psychological influence on the maritime self-concept from the hodegetical point of view. This level is characterized by ambivalence – ecological values and ideal spirit of the marine documentary on the one hand, and psychological manipulations of only mercantile marine advertisements on the other hand. The direct experience of the sea gives natural, ontological, anthropological and psychological basis to improve the maritime self-concept of conscious and independent personality during his / her universal, deep, phenomenological and valuable interaction with the sea.

It is appropriate to improve the medical maritime self-concept and recognize and acknowledge a medical effect of the sea-algae especially from the point of view of achievements of the modern science. The health is a priority and the integral need of the human life. Marine education of the health enriches the personality and broadens opportunities of his / her development. This education helps give a sense to the personal life and feeling of the self-esteem.

The hypothetical model of education of the maritime self-concept was developed from the point of view of the psychological mechanism of the sea perception. The educational idea of the maritime self-concept is raised. The main valuable condition of the education consists from surviving of the personal constructive autonomy, expression of subjective self-esteem, responsible integration and self-realization in life. The science is based on the objective categorization of the research data and processes. However the subjective view is very important to praxis of the valuable education of the personality.

The analysis of the maritime self-concept was made at the vocational level. A condition of the internalization of the maritime self-concept of students was researched. Seafarer's personality is enriched, when he / she studies at the higher school, which works under instructions of EU conventions of the higher education. Thus the complex of one's socio-cultural and special competencies can be improved. The professional maritime higher education is more disintegrated in post-protestant West societies based on IMO conventions, when only technological training of maritime students is accentuated. It is not effective at the psycho-educational level of the creativity of seafarer's personality because technologies and situations at work are changing permanently.

The anthropological methodology helps maintain a correct conception of human nature and organize education of the personal and social culture from the point of view of unchangeable needs of seafarers at work. If the maritime self-concept is formed at the professional level in a context of the higher education, the priority must be given to improving of the vocation of seafarer. It helps recognize main personal ideals and develop the psychic, spiritual and partly physic health practically.

Most maritime students associate the mystery of the sea with their professionalism, self-esteem and personal responsibility at the transcendental level of the maritime self-concept. Students recognize their mental processes of self-development and professional commitment at existential level of the maritime self-concept. Students see the sea as a source of life and associate it mainly with their ecological activity.

The positive social interaction, valuable commitment, creativity, mythological meaningful aspirations, active cognitive processes and wide range of self-esteem indicators characterize the maritime self-concept of students from the point of view of general factors of education. The experience of the virtual sea enriches personality and improves his / her self-esteem. However the real sea influences on students' values and stimulates their positive emotions, cognitive aspirations and integral development of the self-esteem.

Students have made a phenomenological reconstruction of the sea perception mechanism. They described and characterized the phenomenological reconstruction by the practicality, maturity and didactic elements from the point of view of the maritime self-concept. Students expressed a perception of importance of maritime medicine. Their maritime self-concept expresses the well-being, cognitive aspirations, wellness activity and feeling of the self-esteem at the level of maritime medicine. Most students have accentuated natural development of their professional maritime self-concept.

Students have characterized their pre-studies level as recreation, inexpressive marine behavior and untrained self-esteem. Maritime studies expanded searches of the professional identity of students. They behave more mature and valuable at studies. The vocational choice is tested in a practice, which professional activity trains a personality of the student, stimulates positive emotions, cognitive aspirations of safety, adequate behavior and self-esteem mostly.

If seafarers are prepared in conditions of higher education system, it is important to comply with an integral process, which consists of three phases of the maritime self-concept – pre-studies, studies and practice. It is appropriate to train students universally and so improve their maritime self-concept as a basis of the personality value in the maritime state. The civil and professional maritime self-concept should be improved at strategic, tactic and operative levels of the constructive cooperation of the government, businesses and educational institutions from the point of integral view of the maritime society.

Conclusions

1. European maritime self-concept was characterized from the historical – ideological point of view. The personal sense of existential freedom is not based on the transcendence at the ideological level in the pre-monotheistic epoch. The monotheistic leap of self-consciousness in the Jewish civilization has opened a transcendental perspective of the maritime self-concept. Christianity formed the classic European mentality, which led to development of the maritime self-concept, the rise of universities from monastic libraries, development of the maritime geographic discoveries, science, global and universal education and the first maritime schools. Later the maritime self-concept was characterized by the formal pragmatism, only empirical science and too active marine functionalism on developing of commercial maritime fleets from the ecological point of view.

2. Psycho-educational factors of the maritime self-concept development were revealed. Intuitive and creative mythologization of marine events stimulates development of the maritime self-concept. A virtual level of the contact with the sea brings psychological influence on the maritime self-concept. The direct experience of the sea gives natural, ontological, anthropological and psychological basis to improve the maritime self-concept. Marine education of the health enriches the personality. The main valuable condition of the education consists from surviving of the personal constructive autonomy. Seafarer's personality is enriched, when he / she studies at the higher school. The vocational choice is tested in a practice, which professional activity trains a personality of the student, stimulates positive emotions, cognitive aspirations of safety, adequate behavior and self-esteem mostly. Empirical results can be applied only to the respondent population.

There are directions of the students' maritime self-concept development:

- Improvement of maritime studies programs of higher schools in regard to the human capital and importance of the adequate ideological and psychological culture of the personality in extreme conditions of seafarer's work.
- Development of inter-disciplinary integration at the level of the maritime self-concept culture in higher studies programs of seafarers, and textbooks, and improvement of methodological directions of educational work with maritime students.
- Determination of the hodegetical direction, content and structure of the maritime self-concept education, and creative modeling of development of the maritime self-concept of personality at formal – professional and informal levels from the point of view of the maritime science popularization as general socio-educational influence.

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PROPOSED ADVANCED TRAINING AND EDUCATIONAL METHODOLOGIES FOR TANKER AND GAS INDUSTRY

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Abstract
Oil and gas are considered to be among the world's most precious resources. Hence, no doubtfully, the oil and gas industry plays a significant role in the global economy. Petroleum itself is used for numerous products, in addition to serving as the world's primary fuel source. Furthermore, the processes and technologies concerned in producing and distributing oil and gas are highly complex, capital-intensive and necessitate state-of-the-art technology. Nonetheless, human resources operating these technologies in a safe efficient mode are more important. This fact is a reason for the main concern. What will be ideal global unified education and training methodologies provided by Maritime education & Training institutes in such critical rather indispensable industry to ensure "Safer Seas & Cleaner oceans" (IMO 1994)? This paper will illustrate ideal training & education methodologies to be delivered to crew in campus or rather on-board as well as highlights current conventions for promoting skills and inducing quality for such dedicated rather crucial industry.
Keywords: *advanced training, maritime education, tanker and gas industry.*

Introduction

Global standards for seafarer have been a major concern for the maritime industry which has shown the way to the birth of the STCW 78. It was expected that it would promote competence of seafarers. Consequently, it was widely welcomed by the industry as it was the first convention ever to be delivered by the IMO setting global minimum standards for seafarers. Later the maritime society realized by that the convention had not achieved its purpose. This was mainly because it lacked accuracy in its standards. In addition, implementation of the convention was left to the "satisfaction of the Maritime Administrations". This resulted in different interpretations by various administrations, thus there was an immanent need for revision.

After the implementation, all member states have adopted and amended their curriculum according to the new requirements during a transitional period of five years, yet no crucial evidence can be obtained with reference to major improvement to seafarer's competence due to many new tasks that remain unfinished to give full and complete effect to the convention globally. As the seven years period since 1997 has been both a success and failure, it appears now that with new technologies introduced onboard (i.e. ECDIS, AIS, Integrated Bridge Navigation Systems, and Automation with respect to minimum safe manning onboard) there is a need to revise STCW, to keep the convention dynamic as it is supposed to be.

Nowadays one of the key differences between the latest edition of STCW and its previous versions is the stress on competence rather than knowledge. STCW amendments stipulate in detail the required competences associated with different tasks, the knowledge and understanding required to perform them, methods for demonstrating competence and criteria for evaluating it.

The hydro carbon industry and transportation

The Figure 1 shows a noticeable decrease or non ascending tanker - gas carries causality rate. At present, the aim of maritime society is the application of modern technologies to board ship in order to achieve a zero causality rate. Nonetheless, an eminent problem of unification of Maritime education &

Training curriculum and pedagogical affairs in all MET institutes globally still exists. Hence the officers and engineers regardless of any nationality can still perform as equal. However, social and economical affairs might enable some to be trained perfectly, while others are deprived from proper training and education.

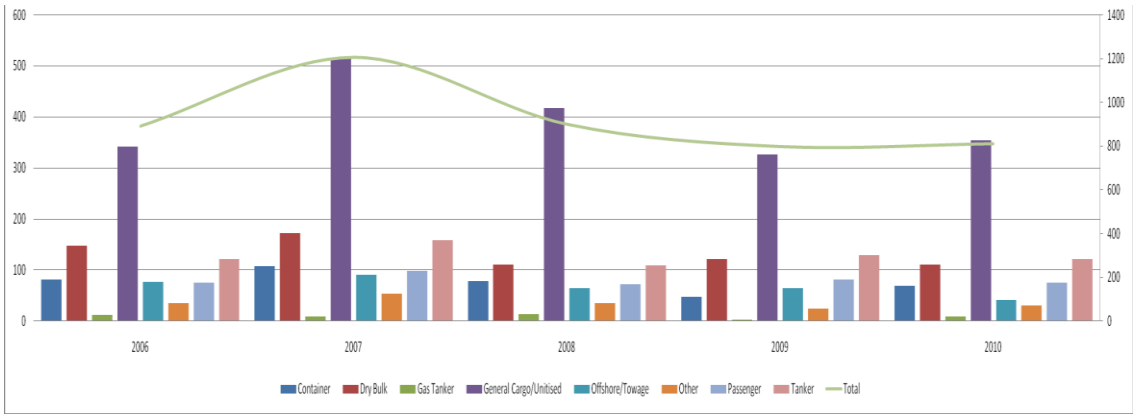

Figure 1. Serious casualties by vessel type within the period from 2006 to 2010
Source: Lloyd's List Intelligence 2012

Tankers are primarily the major haulers of oil. Tank vessels are constructed or adapted to carry oil or hazardous material in bulk as cargo or cargo residue. The earliest construction of tank vessels used single hulls. There are various types of tankers: oil tanker, parcel tanker (chemical vessels), combination carrier (designed to carry oil or solid cargoes in bulk), and barges. In addition, there are international bulk chemical codes governing the safe transport of chemical cargoes and providing various levels of protection against the uncontrolled release of substances that pose the greatest environmental risk.

Tank vessels are classified by the trade in which they normally operate over a period of time. The three most common categories are, firstly, crude oil carriers, secondly, product carriers, which can carry clean (e.g., gasoline, jet fuel) and dirty (e.g. black oils) carries, and thirdly, parcel carriers (chemicals). Tankers tend to remain in one trade but market conditions can dictate a change, even though the process to change a vessel's trade involves extensive work.

Crude carriers are classed as either VLCCs (Very Large Crude Carriers) or ULCCs (Ultra Large Crude Carriers) and are designed to transport huge quantities of crude oil over many long and heavily travelled sea routes. The appropriate economies of scale depend on the area from which the oil is being shipped. In addition, "lightering," offloading or transferring oil from large tankers to smaller ones, a process which can move 1,000 barrels per hour, are used so that the smaller vessels can enter smaller ports that the larger vessels cannot.

Historically, most of the nation's tanker fleets were built as single-hull vessels, i.e., a single layer of steel made up the hull. As ships and barges is a major link in the country's oil transportation network, both for transporting crude oil to U.S. refineries and for transporting refined oil products to market, the Oil Pollution Act (OPA) of 1990 made extensive changes designed to make these shipments environmentally safer. One change requires the phasing out of all shipment of oil cargoes in single-hull vessels in U.S. waters from 1995 to January 1, 2015, with the oldest and largest vessels phased out first. After January 1, 2015, only double hull vessels may be used. There are also European standards in this area with the Regulation of the European Parliament and of the European Council/Commission on Legislative Documents amending Regulation EC No. 417/2002 on the accelerated phasing-in of double-hull or equivalent design requirements for single-hull oil tankers.

One of the major concerns in the safe transport of bulk liquid cargos by tank vessel is the stress on the hull. Bending in the form of sagging (concentration of weight in the mid section of the vessel causing the deck to be subjected to compression forces while at the same time the keel is under tension), hogging (concentration of weight at both ends of the vessel causing the deck to experience tensile forces while the keel is under compression), and shear force, which occurs when two forces act in opposite directions parallel to each other, such as at a bulkhead between an empty ballast tank and a full cargo tank. The weight or gravitational and buoyant action experienced on either side of the bulkhead causes the shear force phenomenon.

The development of the super tanker came about due to an array of factors including Middle East hostilities that led to the closure of the Suez Canal, nationalization of oil fields in the Middle East, and

strong competition among international ship owners. VLCCs and ULCCs cover the most solitary trade routes, typically loading at offshore platforms or single-point moorings and discharging at designated lightering zones off the coast. As the demand for more crude oil is increasing and as more oil reserves are being discovered and developed in other areas such as the Caspian Basin, Latin America and the Middle East, the need for more tankers has grown.

The recommended change regarding training issues

STCW Manila Amendments

On June 25th, the International Maritime Organization (IMO) and other major stakeholders in the global shipping and manning industry formally ratified the so-called "Manila Amendments" to the current Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and its associated Code. The amendments aiming to bring the STCW up to date with developments since its conception and initial adoption in 1978, and the subsequent amendments in 1995. The Convention amendments will be adopted with a tacit acceptance procedure which has been agreed indicating that amendments will be accepted by 1st July 2011 UNLESS more than 50% of the parties to the STCW object such a development. As a result STCW Amendments are set to enter into force on January 1, 2012.

Enhancement of STCW Objectives

The following items outline the key improvements realised through the new Amendments:

certificates of competency & endorsements to be issued only by Administration - thereby reducing the possibility of fraudulent practices associated with issue of certificates of competency;

common medical standards for seafarers - seafarers from one country can serve on board ships of another country without undergoing another medical exam;

revalidation requirements rationalized for the benefit of the seafarer;

introduction of modern training methodology, i.e. distance learning and web based learning;

hours of rest harmonized with the requirements of ILO Maritime Labour Convention (2006) with a view to reducing fatigue;

requirements introduced to avoid alcohol and substance abuse;

new competencies required to be built and curriculum to be updated in life with modern developments and real life needs;

refresher training is properly addressed within the convention.

A brief outline of key curriculum upgrades is as follows.

Chapter I: General provision.

Regulation I/2: only Administrations to issue COC & maintain electronic database for verification of authenticity.

Regulation I/3: near coastal voyage requirements made more clear, including principals governing such voyages and entering "into an undertaking" with the Parties concerned (flag and coastal states).

Regulation I/4: PSC Assessment of seafarer watch keeping & security standards - "Compromise to security" in the list.

Regulation I/6: Guidance on e-learning.

Regulation I/9: Medical standards updated in line with ILO MLC Requirements.

Regulation I/11: revalidation requirements made more rational and includes revalidation requirements for tanker endorsements.

Regulation I/14: companies responsible for refresher training of seafarers on their ships.

Current programs

In order to provide the graduates of a maritime institute with a thorough and suitable education that includes the professional, competent knowledge and skills necessary to be a competent mariner, the MET institutes need to periodically revise the content of their curriculum as per new technologies installed onboard and industry needs. According to D. F. Sears [21], “Unfortunately, we are not masters of our own curriculum”, nevertheless, MET institutes should respond to the needs of the shipping companies, as the latter are the ones which employ their graduates, if the graduates require proficiency in a certain field. A good example would be the training on the use of Electronic Charts, as many shipping companies would necessitate that their Deck Officers have had the essential training ashore before joining on board as they have outfitted all of their vessels with ECDIS equipment.

It is indicated [21] that "On the other hand, it is very difficult to teach a topic that has little if any relevance, as both the students and the instructors recognize that the time spent mastering this subject is wasted." As an example, many nations continue to teach and test their deck license candidates on Radio Direction Finder fixes or how to obtain an OMEGA fix, an obsolete navigational aid and a skill that they will never use at sea in the pursuit of their profession.

Many major maritime nations such as the Netherlands represented by the "Willem Barentsz Maritime Institute" which the authors have had the privilege to visit have totally reduced the credit hours required to teach celestial navigation to a "by knowledge" situation, and not at the management level. As obtaining a proper celestial fix is subject to weather conditions and from the authors' personal experience, overcast skies persisted in some cases more than five days, while modern satellite navigation systems would operate properly in all weather conditions.

Some may argue that these skills must be always held in hand, in case of GPS or GMDSS systems failure. It is obvious to all persons in the maritime industry that for successful, proper, and economical vessel operations, the reliability of these systems is definitely required. This reliability is provided by the accuracy, punctuality and continuity regulated for GMDSS. Furthermore, most vessels now have more than one GPS receiver, as the cost is minimal also, portable GPS are also available.

At this stage, the authors would take an opportunity to recommend that other maritime curriculum's such as the subject of maritime signalling should be deleted entirely because it is slow, limited in effective range, and frankly, with the elimination of a radio officer on board and infrequent use of signalling by officers, there is no need for such a module.

Training subjects

Training onboard has its potential drawbacks. If training and assessment are to be done onboard, how would Maritime Administration supervise, monitor, and approve such exams while ship is at sea as it is required by the STCW? And, if assessment is to be carried out onboard then who will exactly supervise the procedures? B. K. Lima [16] states "if objective criterion is not applied, proficiency demonstration has the potential to become troublesome due to subjectivity of the demonstrations."

Furthermore, how do we expect heavily burdened officers to conduct training and assessment onboard while the issue of fatigue is continuously mentioned as the major cause of most maritime causalities? Accordingly the IMO and the ILO responded by setting standards for what is known to be the rest hours required for seafarers on board ships. Nevertheless, ship-owners criticized those rest hours, as J. R. Binnington [3] mentioned that rest hours adopted by STCW are considered as unreasonable, due to nature of work at sea. In addition, there is no guidance on the format in which hours of rest records may be kept due to the nature of some shipping lines.

In addition, there are still variations of institutions which should conduct the examinations, as in some nations examinations are conducted entirely by the national Maritime Administrations, while other nations MET institutes takes care of the examinations procedure.

Some parties issue documents with expiry date of five years. Hence, they require seafarers to retrain every five years, while others takes it for granted that there is no expiry date providing that an adequate training is done on board. Then how can we globalize and harmonize MET if different standards are still applied?

STCW encourages vocational MET education and discourages academic education for onboard jobs. The consequences of that, is the knowledge of seafarers would be of a very limited scope. Hence it will not be easily for mariners to find jobs ashore [20].

Also it is required by the STCW that there should be communication and submition of reports to the IMO every five years in order to make sure that the adopting and implementing of a quality system by the national maritime administrations is always monitored. Unfortunately, some MET institutes did the same.

Another topical issue regarding the tanker training and familiarization is very important due to the special nature of those ships and the major pollution accidents that nations suffer from. Nonetheless, such training requirements are not presented in the tabular form among other competencies. In addition, It is vitally important to mention that the STCW somehow neglected the training requirements for ratings, as the majority of the new provisions in the revised STCW convention concern competence standards for officers.

Training standards

It can be argued that the ISM code insists on familiarization periods for new members. Nevertheless, training for these systems is not always achievable for a mariner joining a vessel just prior to departure or a pilot boarding a vessel. Training for different designs of equipment ashore is difficult financially (equipping a training centre with different systems) as well. Seafarers always find themselves required to use at sea systems different from those they were trained to use. However, manufacturers can provide assistance and guide specific training by supplying such adequate tools as software and complete manuals.

In addition, the STCW did not provide any specifications for simulators required training, except for Radar/ARPA simulators. Also with the rapid development of technology and the wide use of GMDSS (Mandatory), ECDIS, AIS, and VDR onboard ships there is no criteria for training mentioned in STCW. There are many challenges encountered when we address and assess practical training needs for mariners in using technology based systems aboard, in order to be able to use technology based systems to make safe decisions.

It is not clear who should bear the costs of developing equipment specific training. However, Computer Based Training (CBT), Computer Aided Learning (CAL), and most importantly Distance Learning (DL) which is defined by the American institute for distance learning as "the bridge that covers the time and distance gap between learners and tutors" can provide the required modules for equipment use onboard or even ashore before joining the vessel. Accordingly, this can aid to improve the training and familiarization situation. It would be worthwhile to mention that technical manuals were reported to be insufficient training tools. Unfortunately, in many cases training on new technology is only focused on the use of the equipment and not on the use of the technology to assist the decision making process. The wide impact of this procedure will handicap the capabilities of seafarers.

No doubt, ECDIS and AIS are adding-value equipment that could improve the operations when it is used by well-trained officers who are good at managing and evaluating information. However, the same equipment can cause a disaster when it is used by an officer without skills in perceiving and prioritizing information. Nevertheless, there are numerous arguments about reliance upon them as it is said that their use has to be balanced with other appropriate means.

Recommended solutions

According to International Federation of Shipmasters' Associations (IFSMA, 2003) "Cascade training for onboard technology based systems (engineering, cargo, navigation, communication) may not be adequate to ensure safe operation", as there is no sufficient time to train. In addition, the officer providing the training may not fully understand the system themselves or may not be sufficiently capable of training or assessing.

Another new technology which is applied today on many modern ships is the Integrated Navigation system (INS) or, Integrated Bridge system (IBS), in an attempt by ship-owners to save the operating costs by appointing minimum crew onboard can result in "minimum manning" and not "safe manning". Though it has recognized advantages such as better use of ship technology, advanced team work, financial savings, it also has major recognized disadvantages. Namely, the watch office is heavily burdened and stressed, with the must of monitoring various monitors, gauges and variable alarm responses. Moreover, there is an absolute need to teach such officers to handle this equipment, yet we find no training standards available in the STCW.

Safe Cargo could be used for tankers safe training for liquid cargo operations. It is a flexible training simulator that provides real-time simulation of the thermodynamic and fluid properties of the liquids and gases involved, together with the process control systems used in the storage and handling of potentially hazardous bulk liquids. The system is primarily intended to be used for the training of personnel involved in handling of bulk liquids. In order to facilitate modern training for seafarers, many curriculum should be revised, as much valuable time is wasted on studying and training on obsolete topics with no reference to modern technologies applied on board today.

STCW compliance 2012

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) aims to achieve for the shipping industry what increased technology has so far failed to deliver, namely, a reduction of 80 % in accidents attributable to human error on board ship. Proper training and evaluation can make a real difference to these damning statistics.

Major revisions to the STCW Convention and its associated Code have been adopted at a Diplomatic Conference in Manila which the authors were privileged to attend in the Philippines, thereby ensuring that the necessary global standards will be in place to train and certify seafarers to operate technologically advanced ships for some time to come. The amendments, to be known as "The Manila amendments to the STCW Convention and Code" are set to enter into force on January 1, 2012 under the tacit acceptance procedure and are aimed at bringing the Convention and Code up to date with developments since they were initially adopted in 1978 and further revised in 1995; and to enable them to address issues that are anticipated to emerge in the foreseeable future.

Amongst the amendments adopted, there are a number of important changes in each chapter of the Convention and Code, including:

Improved measures to prevent fraudulent practices associated with certificates of competency and strengthen the evaluation process (monitoring of Parties' compliance with the Convention);

Revised requirements on hours of work and rest and new requirements for the prevention of drug and alcohol abuse, as well as updated standards relating to medical fitness standards for seafarers;

New certification requirements for able seafarers;

New requirements relating to training in modern technology such as electronic charts and information systems (ECDIS);

New requirements for marine environment awareness training and training in leadership and teamwork;

New training and certification requirements for electro-technical officers;

Updating of competence requirements for personnel serving on board all types of tankers, including new requirements for personnel serving on liquefied gas tankers;

New requirements for security training, as well as provisions to ensure that seafarers are properly trained to cope if their ship comes under attack by pirates;

Introduction of modern training methodology including distance learning and web-based learning;

New training guidance for personnel serving on board ships operating in polar waters; and

New training guidance for personnel operating Dynamic Positioning Systems.

The authors suggested that the successful closure of the Conference should be seen as marking the beginning of strenuous efforts at three levels. Firstly, it is necessary to commence, at the earliest possible opportunity, work to translate the revised STCW requirements into national regulations – with the aim of expediting their implementation. Secondly, with the aim of familiarizing STCW Parties with the revised requirements it is necessary to deliver, as appropriate, technical assistance through IMO's Integrated Technical Co-operation Programme and to provide useful technical advice on the STCW Convention and the STCW Code as a whole. Thirdly, it is important to initiate action, as may be necessary, to ensure the full and effective implementation and rigorous enforcement of the revised STCW Convention and Code when the amendments come into force on the agreed date of 1 January 2012.

Delivery of training on-board – challenging MET to change

The United States Distance Learning Association (USDLA), founded in 1987, defines distance learning (hereinafter - DL) as "the acquisition of knowledge and skills through mediated information and instruction, encompassing all technologies and other forms of learning at a distance." According to B. Willis [23] "the term distance learning refers to a teaching-learning arrangements in which the learner and teacher are separated by geography, time, and technology (i.e. voice, video, printed data, CBT, CAL, CAI), and Internet is used to bridge the instructional gap". Supporting the above opinion, Garrison (1989) concedes that the main characteristic of DL is the non-contiguity of the teacher and learner.

Most MET institutions use CBT as a part of their educational process. However, some people (Dinu, 2000) are of the opinion that DL is the answer to problems related to maritime institutes such as "non permanent attendance at courses, seminars and laboratories." [6] Lewarn (2001) states that, "if MET providers do not start developing their own future in a coherent, structured & systematic way, then others

will impose the change on them." [15] It means that MET providers have to think and react to these aspects of change.

It is now left for the education institutions to adapt to new techniques in teaching. DL is not a theory or a phenomenon that will fade away. On the contrary, the technology revolution is here to stay. Hence, traditional classroom teachers should also smoothly adapt to the new technologies other than resist them. This will ensure them a place in the coming world of DL. It is noted [19] that "in the 21st century, the maritime education and training community finds itself facing an explosion of new developments in communication tools, simulation, software training programs and expanding use of computers linked to the Internet and the Web." Currently education is becoming globalized, and it is treated as a commodity, where the customer is the student. Lewarn (2001) states that globalization of education will lead to a quick downfall of the traditional education and will induce a giant leap towards borderless education [15]. In addition, maritime educational institutions also face the challenge today of utilising new technology, communications and teaching methodologies in order to enhance the learning environment of tomorrow. Whether offering on-campus or off-campus courses, "computers and IT resources are rapidly becoming indispensable delivery tools." [19]

In order to meet the challenge MET institutions must adopt the new techniques and hopefully they will do that not on the account of quality. P. Muirhead believes that the "quality of academic standards & credibility is dependant upon many factors. In today's world, provision of up-to-minute computing and Internet services is crucial for education." [18] Traditionally, maritime educators have focused on the technical aspects of their systems, but with the current strong changes, providers of MET will need to take on these changes in order to maintain their role and to be able to reserve a seat among others in the educational world, otherwise, they will simply perish. One important aspect for DL, is that it can provide life-long learning. Hence changing that was known to be "just in case" to "just in time" which means life long learning only provided through DL [15; 24].

However, for DL to be fully adopted and implemented there is a need for legal guidelines set and recognition by the IMO. This would avoid conflict between providers and maritime administrations. A clear-cut definition of the contents of knowledge and skills constituting the DL subject should also be clarified by IMO.

Conclusions

Safety on board tankers requires more courses such as tanker safety, advanced fire fighting and tanker operation. Subsequently, a simulator for training tanker officers and engineers is required as well. Different interfaces result in increased training needs which are unpractical in many circumstances. Accordingly, if standardization of interfaces and symbols is not achieved, training for specific type is required to achieve safe operations.

STCW 2010, in educational terms, is a welcome change, as it should finally bring maritime education into line with accepted educational practice and needs of the industry. Nevertheless, the proper and up to date implementation lays in the hands of parties to the convention. Furthermore, requirements for training on the use of such electronic systems must be included and detailed in the STCW, in order to emphasize their use in assisting the decision making process rather than simply operating equipment itself.

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INTERNATIONAL WORDS IN MARITIME ENGLISH

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Abstract
The paper analyses the importance of international words in English. Latin has since the earliest period of the history of English been one of the principal donor languages in the expansion of the English vocabulary. Intercomprehension based on the understanding of words in several Romance languages contributes to effective maritime communications.
Keywords: *international words, borrowing, intercomprehension.*

Introduction

Everyone knows that language is variable. Part of the power and flexibility of language lies in the ability of speakers to multiply their vocabulary in any field in the interests of greater precision and clarity. As maritime technologies become more complex extensive technical vocabularies are developed, partly from borrowing and partly by adding new and specialised meanings to existing words.

There are not many more than five major world languages that have had an overwhelming impact as carriers of culture. They are classical Greek, Latin, Chinese, Sanskrit and Arabic. The general cultural influence of English has not so far been very important despite the fact that the English language itself is spreading because of the immense territories the English colonized over centuries. However, there is no evidence that it is anywhere entering into the lexical heart of other languages as French has influenced English or as Arabic the Persian and Turkish languages. This fact alone is significant of the power of nationalism, cultural as well as political, during the previous centuries.

European internationalisms originate primarily from Latin and Greek. Many non-European words have also become international, often by way of one or more European languages. International words are generated by new inventions, scientific and technological advances and are spread by speakers of one language living in geographical regions where other languages are spoken.

Navigation is the action of navigating; the action or practice of passing on water, esp. the sea, in ships or other vessels; sailing 1530s, from Latin *navigationem* (nom. *navigatio*), from *navigatus*, pp. of *navigare* "to sail, sail over, go by sea, steer a ship,"from *navis* "ship" and the root of *agere* "to drive" [1].

An admiral is a senior ranking officer in the US Navy, and the word signifies a commander of a fleet, or part of a fleet, in all maritime nations. It originates from the Arabic *amir* commander, (from *amara*, to command, order,) commonly Englished ameer, emir, occurs in many titles followed by *-al-* '(of) the,' as in *amir-al-umara* ruler of rulers, *amir-al-ma* commander of the water, *amir-al-bahr*, commander of the sea, the earliest of which is *amir-al-mumunin* commander of the faithful, assumed by the Caliph Omar, and Latinized in many forms by the early chroniclers [1].

Captain (ME. *capitain* late Old French (14^{th}) *capitaine, capitain*, late Latin *capitaneus* – chief, principal). Had Latin *capitaneus* been an old word, which lived on in French, its Old French form would have been *catain, chatain* being of somewhat later (10-11th c. origin); the actual OF. form was *cataigne, chataigne*; a still later (12th century) semipopular form, preserving the intertonic *i* of *capitaneus*, was *chevetaine* (whence Eng. chieftain). *Capitaine* was again a much later adaptation of the Latin form [1].

Engineer is one who contrives, designs, or invents; an author, designer. The word *engineer* is derived from the Latin root *ingenium*, meaning "cleverness" [1].

An academy (Gr) is an institution of higher learning, research, or honorary membership. The name traces back to Plato's school of philosophy [1], founded approximately 385 BC at *Akademia,* a sanctuary of Athens, the goddess of wisdom and skill.

A tsunami (Japanese lit. *harbour wave*) is a brief series of long, high undulations on the surface of the sea caused by an earthquake or similar underwater disturbance. These travel at great speed and often with sufficient force to inundate the land [1].

Nautic F. *nautique* (c1500) or L. *nautic-us*, ad. Gr. sailor, ship; relating to ships and sailing. [1]

Anchor is an appliance for holding a ship, etc., fixed in a particular place, by mooring it to the bottom of the sea or river; now consisting of a heavy iron, composed of a long shank, having a ring at one end to which the cable is fastened OE. *ancor*, a. L.*ancora* cogn. with Gr. Bend, crook, whence English *angle* [1].

These words constitute international scientific vocabulary i.e. a vocabulary of scientific and technical words, terms, formulae, and symbols that are almost universally understood by scientists and similarly used in at least two languages. International words fulfil a useful function in communication, facilitating a quick and adequate grasp of the message.

Conditions for Borrowing

The mere contact of two languages does not necessarily guarantee that one will borrow from the other. Speakers must have motives for the borrowing. People usually emulate those whom they admire, not only in speech patterns but also in all other respects [2]. In the course of history English has come in close contact with many languages, mainly Latin, French and Old Norse (or Scandinavian). The careful study of loan-words constitutes an interesting commentary on the history of culture.

It goes without saying that the content of language is intimately related to culture. The American Indians who had never seen or heard of a gun were compelled to invent or borrow a word for the weapon when they were confronted with it. In this sense the vocabulary of a language more or less truthfully reflects the culture of a nation. Therefore it is perfectly true to say that the history of language and the history of culture move along parallel lines.

Upper class Englishmen, in the days after the Norman Conquest learned the French language and used French expressions because French was the language of the new rulers of the country. The prestige factor leads to extensive borrowing from the dominant language into the lower language. Another motive for borrowing is the need filling motive. New experiences, new objects and practices bring new words into the language. Tea, coffee, tobacco, sugar, cocoa, chocolate have spread all over the world, along with the object these words refer to. Typhoons and tsunamis have not, but direct or indirect experience connected with them has.

The simplest kind of influence that one language may exert on another is the "borrowing" of words. When there is cultural borrowing there is always the likelihood that the associated words may be borrowed too [3]. When the early Germanic peoples of northern Europe first learned of paved streets from their commercial or warlike contact with the Romans, it was only natural that they should adopt the Latin words for the unfamiliar type of road *strata [via]*, English *street*, German *Strasse*.

Whatever the degree or nature of contact between neighboring peoples, it is generally sufficient to lead to some kind of linguistic interinfluencing. Frequently the influence runs heavily in one direction. The language of a people that is looked upon as a centre of culture is naturally far more likely to exert an appreciable influence on other languages spoken in its vicinity than to be influenced by them.

Once a borrowed word has come into widespread use, its subsequent history is like that of any other form in the language. During the period of importation, the shape of the word is subject to adaptation and variation because different borrowers imitate the word in slightly different ways.

The Effect of Borrowing on the English Language

If we base our conclusions on the study of the forms recorded in dictionaries, it is very easy to overestimate the effect of foreign words. The actual number of native words is extremely small compared with the number of foreign borrowings recorded. On the other hand, if we examine spoken English in familiar conversation, we find the proportion reversed. It has been estimated that less than fifty words, all of them native words, suffice for more than half our needs [4]. The proportion of native words to foreign words will naturally vary with the subject matter and any article on scientific knowledge would naturally contain a high percentage of borrowings. The careful study of such loan-words constitutes an interesting commentary on the history of culture.

Since the general opinion is that English has on the whole benefitted from the adoption of so many foreign words the obvious advantage is the wealth of synonyms which have been created by the adoption of a foreign word.

The English language incorporates many distinct strains. Besides the old "Anglo-Saxon," in other words North German, element which is conventionally represented as the basic strain, the English language comprises Norman French, Scandinavian, "Celtic," and pre-Celtic elements. English also embraces Scotch and Irish. The English language is historically most closely affiliated with Frisian, in second degree with the other West Germanic dialects (Low Saxon or "Plattdeutsch," Dutch, High German), only in third degree with Scandinavian, who overran England in the fifth and sixth centuries.

Word borrowing may, like other ways of augmenting the vocabulary, be motivated by the need for adequate denotation of new cognitive contents or concepts arising in the process of the material and spiritual development of society [5]. English borrowed an immense number of words from the French of the Norman invaders. And so the process has continued uninterruptedly down to the present day, each cultural wave bringing to the language a new deposit of loan-words.

When in two languages we find no trace of the exchange of loanwords one way or the other, we are safe to conclude that these two nations have had nothing to do with each other. But if they have been in contact, the number of loan words will inform us of their reciprocal relations, the influence they have had on each other and in what domains of human activity each has been superior to the other. The study of language proves the fact that when one nation produces something that its neighbours think worthy of imitation they will take over not only the thing, but also the name. Loan words are nearly always technical words belonging to one special branch of knowledge or industry, and may be grouped so as to show what each nation has learnt from the other [6].

The Influence of Latin on English

Much of the vocabulary of formal English is of Latin origin. In contrast, informal language is characterised by vocabulary of Anglo-Saxon origin e.g. *commence, continue, conclude {formal}; begin, keep up, end {less formal}*. Formality can be applied to aspects of the situation in which communication takes place and to the features of language which correlate with those aspects [7].

Latin has since the earliest period of the history of English been one of the principal donor languages in the expansion of the English vocabulary. A great many of the lexical items which can ultimately be traced back to Latin have entered the English language indirectly via French and various other Romance languages, which together with Latin probably contributed almost two thirds of the word stock of present day English.

A substantial part of Latin and Greek loans which have survived to the present day were first introduced as particular terms in science e.g. *theory (Gr), praxis (Gr), system (Gr), method (Gr), atmosphere (Gr),radius (L), formula (L), calculus (L), notion (L), concept(L), satellite(L), exist(L),* etc. [1] Sometimes quite a number of English words come from just one Latin root. For example, the Latin word *vocare, vocatus vocare* - to call; *vocatus* – called - has produced a whole range of words in English vocabulary e.g. *provoke, provocative, evoke, evocative, convoke, convocation, vocation, avocation, voice, vocal, revoke, revocation, revocable, irrevocable, convocator, advocate, advocate, advocation, provocation,* etc. [1]

Prefixes and Suffixes of Foreign Origin

The contact of English with various foreign languages has led to the adoption of countless foreign words. In the process, many derivative morphemes have also been introduced, suffixes as well as prefixes. As a consequence, there are many hybrid types of compounds in English. The majority of foreign suffixes owe their existence to the reinterpretation of loans. When a word of foreign extraction comes to be analysed as a compound, it may acquire derivative force. From landscape (which is Du landschap) resulted *scape* which is almost entirely used as the second element in compounds, as in *seascape, moonscape, skyscape, waterscape, etc*. [1]

Prefixes of foreign origin came into the English language ready made, due to syntagmatic loans from other languages: when a number of analysable foreign words of the same structure had been introduced into the language, the pattern could be extended to new formations [8].

There are many prefixes, chiefly used in learned words or in scientific terminology, which have come into the language through borrowing from Modern Latin, as *ante-*, *extra-*, *intra-*, *meta-*, *para-*, etc. A limited number of Latin prepositions can help build hundreds of new vocabulary words The Latin prefix *ab-* means *away from* [1]. It connotes motion from, and occurs in English words such as *absent, abstract, abstemious* and *abhorrent*. On the contrary, ad- means *to* or *toward* with.

A basic knowledge of suffixes can increase vocabulary for the student of English. An understanding of just one common ending can have a significant effect on student performance in reading and writing, e.g. Latin *–fy* to make or to become. The older English verbs in *–fy* are adoptions of French verbs in *–fier*, which are either adapted from Latin verbs or formed on the analogy of verbs [1]. To *magnify* is to make bigger. To *reify* is to make into a king. To *fortify* is to make stronger. To *pacify* is to make peace. To *edify* means to make or convert into something [1].

Greek *–logy* (*reason*, *word*, *speech*, and *thought).* In Greek, *logo* means word [1]. While it is the root of English words such *eulogy*, *logical*, and *prologue*, as a suffix *-logo* helps create hundreds, even thousands, of English derivatives, e.g. *logogracy, logogram, logograph, logometer, logonomy, logopedia, logotype, etc.*

The Role of Intercomprehension

The big problem of comprehension and intercomprehension involves recognizing language both grammatically and semantically. The process of *understanding* involves understanding the situation as well, and this relates the understanding of language to understanding the world. The vocabulary of the sciences and other specialized studies consists of words or other linguistic forms current in several Romance languages and differing from Latin in being adapted to the structure of the individual languages in which they appear.

The common Latin roots facilitate understanding cognate words in other Romance languages for students of all levels of ability and experience. The truth is, Latin roots are alive and strong not only in language teaching courses around the world, but also in our own daily intercourse. Latin words are used every day in most European languages. The following table (Table 1) shows a number of words of maritime vocabulary in English and several Romance languages where the common Latin roots contribute to understanding and intercomprehension.

Table 1. Words in maritime vocabulary in English and some Romance languages

English	*French*	*Italian*	*Spanish*	*Portuguese*
boat	le bateau	la barca	la barca	o barco
arrival	l'arrivée (f)	l'arrivo	la llegada	a chegada
anchor	l'ancre (f)	l'ancora	el ancla	a âncora
cabin	la cabine	la cabina	el camarote	a cabine
captain	le capitaine	il capitano	el capitan	o capitão
chain	la chaîne	la catena	la cadena	a corrente
compartment	le compartiment	lo scompartimento	el departamento	o compartimento
departure	le départ	la partenza	la partida	a partida
funnel	la cheminée	il fumaiolo	la chimenea	o funil
entrance	l'entrée (f)	l'entrata	la entrada	a entrada
engine	le moteur	il motore	el motor	o motor
keel	la quille	la chiglia	la quilla	a quilha
life boat	le canot de sauvetage	la lancia di salvataggio	el bote salvavides	o bote salvavidas
lever	le levier	la leva	la palanca	a alavanca
valve	la soupape	la valvola	la válvula	a válvula
mast	le mât	l'albero	el mástil	o mastro
oil	l'huile	il olio	el aceite	o óleo
passenger	le voyageur	il passegiere	el pasajero	o passageiro
passport	le passeport	il passaporto	el pasaporte	o passaporte
platform	le quai	la piattaforma	el andén	a plataforma
pump	la pompe	la pompa	la bomba	a bomba
radar	le radar	il radar	el radar	o radar
seaman	le marin	il marinaio	el marino	o marinheiro
seasickness	le mal de mer	il mal di mare	el mareo	o enjôo de mar

Conclusion

Language can control or influence actions and attitudes. Language is the most massive and inclusive art we know, a mountainous and anonymous work of unconscious generations. [3] The controlling aspect of communication is important in maritime communications to make meanings clear and unambiguous in order to promote vessel safety.

Because languages are rarely sufficient unto themselves, the necessities of intercourse bring the speakers of one language into direct or indirect contact with those of neighboring or culturally dominant languages. The intercourse may move on the plane of business and trade relations or it may consist of a borrowing or interchange of vocabulary dealing with art or science.

Intercomprehension based on the understanding of words in several Romance languages contributes to effective maritime communications. Relevant language structures in related languages express different kinds of social function in all manner of situations both ashore and afloat.

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SHOULD COMPETENT SEAFARER BE EDUCATED? LEGISLATIVE CORRESPONDENCE BETWEEN LEVELS OF COMPETENCE AND LEVELS OF EDUCATION

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Abstract
Regardless of unified international requirements for maritime education and training, national MET systems differ in academic level, content, duration of study programmes and consequence of school and sea time during these programmes. The requirements for competencies of seafarers are set by the international convention STCW 78 as amended in 2010, but the convention does not specify requirements for levels of adequate education. Therefore, question "Should competent seafarer be educated and what level of education is necessary?" rises again and again. Otherwise national MET systems of the EU countries should be in compliance with legislation of European educational area. In this relation European Qualifications Framework, adopted in 2008, could serve as a translation device between different qualifications systems and their levels. The analysis of STCW 78 and European Qualifications Framework reveals clear correspondence between levels of seafarers' competence and adequate levels of education.
Keywords: *MET, seafarer, level of competence, level of education*

Introduction

Regardless of unified international requirements for maritime education and training, great variety of national MET systems has formed historically and it still exists.

The requirement for competences of seafarers are set by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW 78) as amended in Manila in 2010 [12] and for EU countries additionally requirements are set by Directive 2008/106/EC on the minimum level of seafarers' training [3]. The above mentioned Convention and the Directive do not set any requirements for adequate levels of education for seafarers. Therefore, the question "Should competent seafarer be educated, what level of education is sufficient?" rises again and again [1, 2].

National MET systems are linked and supervised by both national maritime administrations and national educational authorities. Consequently, MET systems should be in compliance with the requirements for seafarer's professional competence and with the requirements for educational level as well. The link "Competence level – Level of education" could be a key equivalence for MET system harmonization with professional and educational requirements.

In 1999 the Bologna process was launched by 30 countries to create convergence between higher education systems. The countries participants of Bologna process transformed their national higher education systems to recognisable for common European area, the system of three sequential levels (cycles) of higher education qualifications: "Short cycle (pre or entry level)-Bachelor-Master-Doctor" [11].

The European labour market, as any other, cannot function effectively without common reference to the recognition of qualifications. The need for European qualifications framework became obvious after Lisbon treaty was signed [6]. The European Qualifications Framework was formally adopted in 2008 and aimed to contribute to modernising education and training systems for better interrelationship of education, training and employment [4].

The analysis of legislative requirements and recommendations for seafarers' levels of competence and adequate levels of education was performed; the conclusions and recommendations are presented in the article.

Variety of national MET systems

National MET systems differ in academic level, duration and consequence of MET programmes leading to unlimited certificate of competency [5, 9] and there is not common opinion about sufficient level of education for marine officers. It is still unclear what level of education is adequate for

responsibility level of senior officers or master of a ship – bachelor, Master of Science, or 2 year study programme in vocational school?

So called monovalent MET system, when separate programs leading to navigator or ship engineer certificate of competency are provided, exists today in a majority of countries. Bivalent (dual-purpose officers) MET system exists today in a minority of countries.

The sequence of school and sea time also differs in many countries:

- *Sandwich or step-by-step* MET system. A two-year or a three-year first step study programme, including seagoing training, leads to operational level certificate of competency. After seagoing experience a seafarer as a holder of operational level certificate of competency needs to come back to school for one or two years next step studies, leading to management level certificate of competency.
- *Front-ended* MET system. Study programme includes full theoretical training necessary for management level certificate of competency and practical training, necessary for operational level certificate of competency. After graduation no additional studies at school are needed to get management level certificate of competency, only seagoing experience and providing evidence of competence are required.
- Some countries follow *post-experienced* type MET system when practical training is going after studies.
- Other countries follow *pre-experienced* type MET system when programmes include a component of practical training before studies.

Levels and content of seafarers' competence in accordance with STCW 78 convention

STCW 78 convention gives some definitions and provide clarifications regarding competency [12]:

- Certificate of competency means a certificate issued and endorsed for masters, officers and GMDSS radio operators in accordance with the provisions of chapters II, III, IV or VII of this annex and entitling the lawful holder thereof to serve in the capacity and perform the functions involved at the level of responsibility specified therein.
- Function means a group of tasks, duties and responsibilities, as specified in the STCW Code, necessary for ship operation, safety of life at sea or protection of the marine environment (Figure 1).

Convention STCW 78 for both departments (Master and deck department and Engine department) sets three levels of responsibility:

- Support level (ratings);
- Operational level (officers);
- Management level (senior officers, master).

For each level of responsibility of each department convention STCW 78 describes relevant specification of minimum standard of competence, identifying corresponding functions onboard and specified competences (tasks, duties and responsibilities).

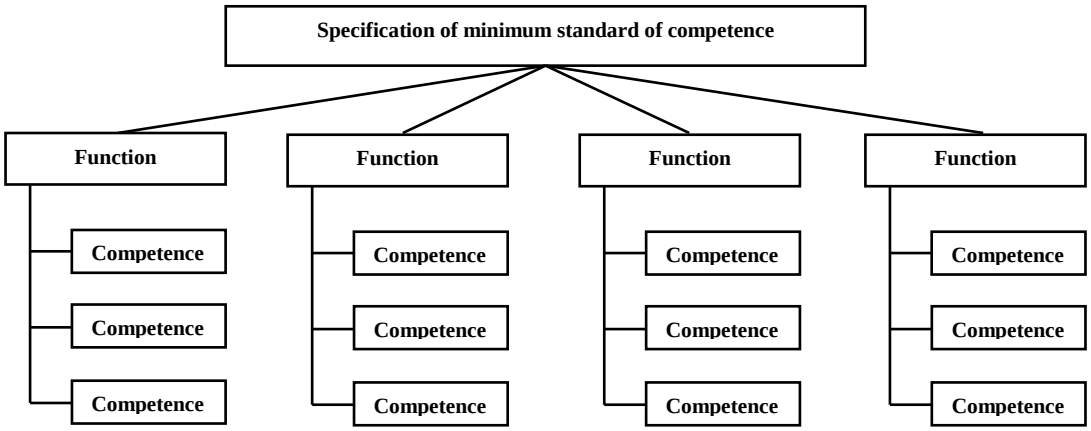

Figure 1. Structure of specification of minimum standard of seafarers' competence

Functions specified for master and deck department officers are:

- Navigation at the management level;

- Cargo handling and stowage at the management level;
- Controlling the operation of the ship and care for persons on board at the management level;
- Radio communication.

Functions specified for engine department officers are:

- Marine engineering at the management level;
- Electrical, electronic and control engineering at the management level;
- Controlling the operation of the ship and care for persons on board at the management level;
- Controlling the operation of the ship and care for persons on board at the management level age.

Functions specified for electro-technical officers are:

- Electrical, electronic and control engineering at the operational level;
- Maintenance and repair at the operational level;
- Controlling the operation of the ship and care for persons on board at operational level.

Every function in STCW 78 specifications of minimum standard of competence consists of specified competences (tasks, duties and responsibilities). Every specified competence should be proved by knowledge, understanding and proficiency (Figure 2).

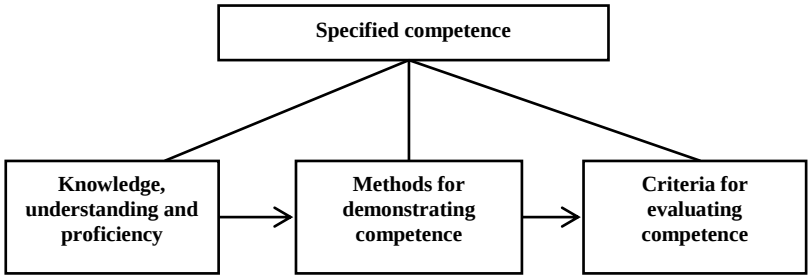

Figure 2. Seafarer specified competence acquisition and proving scheme in the context of STCW 78

Levels and content of qualification in accordance with Bologna process statements

In accordance with the Bologna process statements national higher education systems correspond to three sequential levels (cycles) of higher education (HE) and short cycle level [11]:

- Short cycle – pre or entry level;
- First cycle – Bachelor level;
- Second cycle – Master of level;
- Third cycle – Doctoral level.

Strictly speaking, short cycle level is not a qualification and therefore it is not a part of the framework for qualifications of the European Higher Education Area [11]. Moreover, there are diverse pathways into the various forms of higher education within some countries. Thus, programmes leading to a short cycle could be interpreted as a "start point" level for entry to higher education.

Traditionally higher education was relatively clear regarding the knowledge outcomes to be achieved, or at least the knowledge covered by the curriculum. During the development of the Bologna process the Dublin descriptor for the bachelor's, master's and doctoral qualifications was prepared [10], where the word competence is used in its broadest sense, allowing gradation of abilities or skills (Figure 3).

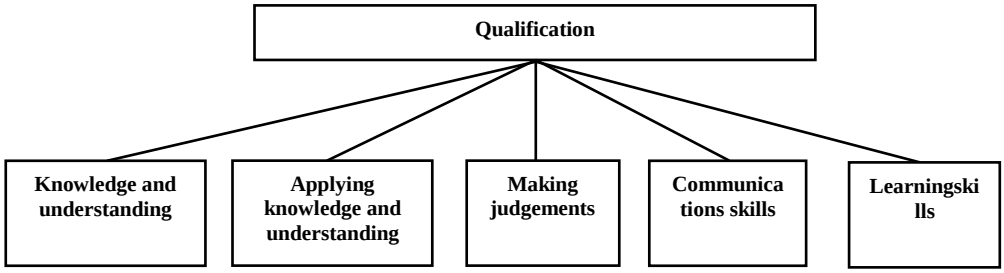

Figure 3. Qualification elements specified in Dublin descriptor

Levels of education are also used to refer to the provision of education, for example, in UNESCO's International Standard Classification of Education (ISCED), which is primarily a tool for statistical classification [6]. The ISCED has nine reference levels of qualification from 0 to 8 (Table 1).

Table 1. Hierarchy between qualifications granted by tertiary education programmes specified in ISCED [6]

Level of HE	Cycle of HE	Duration of studies
Level 5	Short-cycle tertiary programmes	At least 2 years
Level 6	Bachelor or equivalent first degree programmes	3-4 years
Level 6	Bachelor or equivalent long first degree programmes	More than 4 years
Level 7	Master or equivalent long first degree programmes	At least 5 years
Level 8	Doctoral or equivalent ISCED	n/a

Levels and content of competence in context of European Qualifications Framework

The European Qualifications Framework (EQF) [7] was formally adopted by the European Parliament and the Council on 23 April 2008 as a recommendation, which assists in comparing the national qualifications systems [8]. The objective of this Recommendation is to create a common reference framework which should serve as a translation device between different qualifications systems and their levels, whether for general and higher education or for vocational education and training. The EQF has eight reference levels of qualification, including general education, vocational training and higher education. Four of them (from 5 to 8) correspond to higher education system (Annex).

In accordance with EQF competence is the proven ability to use knowledge, skills and personal, social and/or methodological abilities in work or study situations and in professional and personal development (Figure 4). In the context of the European Qualifications Framework, competence is described in terms of responsibility and autonomy.

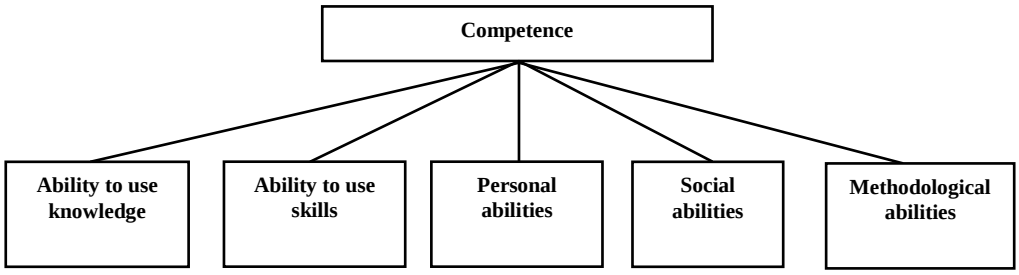

*Figure 4.*Competence elements in the context of European Qualifications Framework

Correspondence between levels of seafarers' competence and levels of education

Analysis and comparison of European Qualifications Framework levels of competence and comparison with levels of competence (responsibility) specified by STCW 78 reveals clear correspondence between levels of competence of seafarers and adequate levels of education (Table 2).

Table 2. Correspondence between levels of seafarers' competence and adequate levels of education

Levels of competence specified by EQF	Corresponded levels of education	Levels of responsibility (competence) specified by STCW 78
Level 4	Abitur, vocational school diploma	Support level (rating)
Level 5	Short cycle diploma	Operational level officer
Level 6	Bachelor Degree	Management level officer, chief engineer, master
Level 7	Master of Science Degree	Lecturer, researcher*
Level 8	Doctor of Science Degree	Lecturer, researcher*

* This positions in the table are not a matter of STCW 78

A holder of vocational school educational diploma (level of competence 4) should be competent to exercise self-management within the guidelines of work contexts that are usually predictable, but are subject to change [7]. This level of competence corresponds to support level of responsibility (rating seafarer) [12]. If a holder is competent to supervise the routine work of others, taking some responsibility for the evaluation and improvement of work activities [7], it corresponds to able seafarer level of responsibility [12].

A holder of a short cycle educational diploma (ISCED level of education 5), providing exercise management and supervision, reviewing and developing performance of self and others (EQF level of competence 5) [7] in terms of responsibility and autonomy corresponds more to an operational level officer, but not to a management level officer, "bearing in mind that the master has ultimate responsibility for the safety and security of the ship, its passengers, crew and cargo, and for the protection of the marine environment against pollution by the ship, and that a chief mate shall be in a position to assume that responsibility at any time" [12, p. 48]. Similar explanation could be used regarding responsibility of engine department officers.

A holder of bachelor degree educational diploma (ISCED level of education 6) should be competent to manage complex technical or professional activities, taking responsibility for decision-making in unpredictable work contexts, taking responsibility for managing professional development of individuals and groups (EQF level of competence 6) [7], in terms of responsibility and autonomy is suitable for management level officers.

Master of Science and Doctor of Science educational levels correspond to EQF levels of competence 7 and 8) and are specified as oriented to formation of specialised problem-solving skills required in research and/or innovation activities [7]. These educational levels provide competences which are necessary to take a position of a lecturer or a researcher in higher educational or research institution, but seem to be excessive for routine on-board job.

Conclusions

The analysis of levels of competence specified by European Qualifications Framework and the levels of competence (responsibility) specified by STCW 78 reveals clear correspondence between the levels of competence of seafarers and adequate levels of education.

The holder of vocational school educational diploma (ISCED level 4) corresponds to support level of responsibility - rating seafarer. If the holder is competent to supervise the routine work of others, taking some responsibility for the evaluation and improvement of work activities, he corresponds to able seafarer level of responsibility.

The holder of a short cycle educational diploma (ISCED level 5), providing exercise management and supervision, reviewing and developing performance of self and others in terms of responsibility and autonomy corresponds to an operational level officer, but not to a management level officer, bearing in mind that the master has ultimate responsibility for the safety and security of the ship, its passengers, crew and cargo, and for the protection of the marine environment against pollution by the ship, and that a chief mate shall be in a position to assume that responsibility at any time. The short cycle educational level is obviously insufficient for management level position on-board.

Management level officers and master in terms of responsibility and autonomy corresponds with a bachelor degree educational level diploma (ISCED level 6), when holder should be competent to manage complex technical or professional activities, taking responsibility for decision-making in unpredictable work contexts, taking responsibility for managing professional development of individuals and groups.

Master of Science and Doctor of Science educational levels are specified as oriented to formation of specialised problem-solving skills required in research and/or innovation activities. These educational levels (ISCED levels 7 and 8) provide competences necessary to take a position of a lecturer or a researcher in a higher educational or research institution, but seem to be excessive for routine on-board job.

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ANNEX

Levels of competence specified by European Qualifications Framework and relevant levels of education

Levels of competence	Knowledge	Skills	Competence	Example
	In the context of EQF, knowledge is described as theoretical and/or factual	In the context of EQF, skills are described as cognitive (involving the use of logical, intuitive, creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments)	In the context of EQF, competence is described in terms of responsibility and autonomy	Diploma or certificate
Level 4	Factual and theoretical knowledge in broad contexts within a field of work or study	A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study	Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change; supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities	Abitur, vocational school

Level 5	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems	Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others	Short cycle diploma
Level 6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups	Bachelor Degree
Level 7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research	Critical awareness of knowledge issues in a field and at the interface between different fields	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams	Master of Science Degree
Level 8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	The most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research	Doctorate

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