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ASSESSMENT OF CONTRIBUTION OF MARITIME EDUCATION INSTITUTIONS IN LATVIAN SEAFARERS POOL

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Abstract
Latvia has become a seafarers' supply country for others by lacking own shipowners. Only about 4% of merchant fleet seafarers are employed under Latvian flag. However, seafarers' resource is important for Latvian economy as the employment of seafarers contributes to Latvian economy by money brought from abroad and spent here. Maritime education institutions plays important role at inflow processes of seafarers' pool, which are involved in training of future ships' officers as the demand for merchant fleet officers is growing in industry. Assessment of the contribution made by maritime education institution is done by comparing statistical information about the graduates from different institutions to have clear view on future of Latvian seafarers' resource and the sustainability of present conditions. This approach provides objective and sound basis for conclusions about the contribution made by different maritime education institutions. Therefore the aim of this article is to show the methods and results of contribution analysis made by Seamen Registry of Latvian Maritime Administration.
Keywords: *shortage of seafarers, maritime education, seafarers' pool*

Introduction

Shortage of ship's officers is one of the main topics discussed in the maritime society. In 2008 International Maritime Organization (IMO) launched campaign "Go to Sea" [1] with aim to attract new entrants to the shipping industry. The worldwide supply of seafarers in 2010 was estimated to be 624,000 officers and 747,000 ratings while the current estimate of worldwide demand for seafarers (in 2010) is 637,000 officers and 747,000 ratings [2]. According to BIMCO (Baltic and International Maritime Council) the supply data is based on the number of seafarers holding STCW certificates. BIMCO states that while demand for ratings is more or less balanced in the same time there are still some shortages for officers. IMO places emphasis that the global pool of competent and efficient seafarers is prerequisite to meet future demand which will give possibility to present seafaring to younger generations as a viable career choice. While the term "shortage" is widely used it is important to understand that the difference between demand and supply figures is calculated by comparing results of two different approaches. The demand figures are calculated mainly by modelling the world's ship stock in terms of ship type, size range, vintage and registry in order to calculate the number of officers and ratings that are required for safe operation of these vessels. The supply figures are estimates and based on information provided by different sources such as questionnaires, data from administrations, education institutions and others [3]. Organizations apply various methods therefore it is common to see different figures provided from different sources. In reality, the amount of details recorded varies therefore the precise figures are difficult to achieve. The main reasons are the globalised nature of the shipping industry and its flexibility, including temporary employment which has become increasingly common [4]. Task Force on maritime employment and competitiveness of European Commission states that it is clear that detailed data on maritime employment is scarce, sometimes out-dated and often not reliable [5]. In their report about employment of EU seafarers they tried to collect available information from various sources to have picture on the EU seafarers.

The shortage of seafarers for EU maritime sectors has additional scope as the seafarers and especially merchant marine officers' play recognised role not only for shipping sector but also for other maritime sectors (marine services, shipbuilding, port services etc.) where they experience and skills are viewed as sustainable input factor for the development of those industries. This view is supported in K. Mitroussi analysis about challenges and opportunities for seafarers' employment [6]. Therefore detailed information about maritime education system and its capability to contribute to seafarers' pools plays important role for maritime policy decisions at various levels.

1. The aim of research and methodological approach

Importance of maritime education system depends on its capacity to supply maritime industry with people meeting industry needs. Maritime education is economically viable only if sufficient demand (or critical mass) exists due to large fixed costs, but once in-place it can service a large number and wide range of actors [7]. Not only seafarers can be educated in maritime training institutions but also port personnel and others whose employment and therefore educational background is linked with ships, shipping etc. The demand for seafarers' maritime education can be viewed as international even if it is related to demand for seafarers of particular country as the education system is local and in line with countries' education system. As the maritime education supplies local and global seafarers' pool at the same time it is important to determine factors which are linked with maritime education system and influences graduates in the seafarers' pool. Science Direct and Springer Link databases was used for searching of articles related to this issue, however, the articles which combine detailed information about seafarers' employment and their educational background were not presented. The databases contain articles which discuss the shortage of seafarers and factors influencing the supply and demand of seafarers labour. For example: "Crew study of seafarers: a methodological approach to the global labour market for seafarers" written by Bin Wu and Nik Winchester [8] discusses the context of the complexity of the global labour market for seafarer. The authors of the article propose the crew study of seafarers (CSS) as a mean to access, analyse and compare information on active seafarers world-wide. However, crew lists which serve as main source for input data used in analysis doesn't reflect seafarers' educational background. Other articles such as „Employment of seafarers in the EU context: Challenges and opportunities" [6] explore challenges that can be seen to have a negative effect on the employment of EU seafarers and examine forces that can be regarded as opportunities for the seafaring profession in the EU. However, those forces are described in general focussing on qualitative not quantitative aspects. In article „A method for estimating world maritime employment" written by Li and Wonham [9] authors establishes a method to estimate maritime labour worldwide. Even this article tackles the issues of the pool of seafarers it doesn't discuss the contribution of maritime education and capability of maritime system to supply labour required on ships. Looking at the articles related to the maritime education it wasn't possible to find articles where the role of maritime education is analysed in quantitative aspects for context of supply side of maritime labour. It can be assumed that even if such researches exist they are not easily accessible and specific search methods should be applied to find them.

Looking at the methods utilised in previously mentioned researches it can be seen that methodological approaches and data sources used in those researches are not suitable for analysing two different blocks such as pool of active seafarers and education system even if the links between them exist and have major importance. In most cases the primary data source is provided by different kinds of surveys, therefore the researches which use published results of surveys or researches are based on secondary data sources. For example, survey to collect necessary data is used in cluster analysis of the maritime sector in Norway [7] or in determination of land-based jobs for ex-seafarers in UK [10]. Other way to get access to primary source is to use questionnaires. This approach is linked with particular qualitative aspects and for example was used in 1996 for ITF (International Transport Worker's Federation) questionnaire survey of seafarers with aim to get information about all aspects of seafarers working lives [11]. These approaches don't allow drawing direct links between maritime education system and seafarers' pool. Therefore micro data analysis is required to overcome problem of accessibility of data. For example, this approach was used for inflow-outflow analysis of labour in Danish maritime cluster [12]. The database containing information about employment of particular persons is prerequisite to get such a micro data. However, access to such a registers often is limited as usually they contain sensitive information about persons included in database.

Seamen Registry of Latvian Maritime Administration maintain seafarers' database of Latvian seafarers with entries about the seafarers their education, qualification, seagoing services and other data required for certification according requirements of STCW Convention. Although the main purpose of database is to serve for certification of seafarers it gives possibility (by analysing content of it) to look on the historical development of seafarers' education and training system in Latvia.

The main aim of this research is the determination of the contribution parameters and their values of maritime education system in Latvia. This aim is achieved by using micro data analysis of seafarers' education and employment. The micro data analysis covers information about all seafarers included in database and is a combination of 280 000 entries about employment with 23 000 entries about education. Combining of the data sets individual persons were separated and group of 11 000 people where extracted as base. The persons included in base have entries about maritime education gained in particular time period. Data about their employment was added for analysis of their work on board after graduation.

The research consists of four steps:

1. identification of size and composition of active seafarers' pool and determination of main age groups for entrants and seafarers who leave the pool by analysing average age structure of seafarers in the pool;
2. determination of overall contribution of Latvian maritime training and education institutions looking to supplied qualifications and numbers of new seafarers;
3. comparison between the total numbers of graduated persons with graduates who worked on board the ships after graduation;
4. determination of time period graduates worked in active seafarers' pool to determine leaving rate for shore jobs after graduation. Additionally the career growth on board is determined and compared between graduates from different institutions taking into account the level of particular programme.

The limitation of this research lies in fact that it is difficult to validate the outcome of those analysis again other data source as there is limited possibilities to get similar data covering whole seafarers' pool in Latvia. The outcome probably can be validated again the results of extensive and expensive survey therefore it is not credible that it will be done in foreseen future. Also the data about employment cannot be considered as 100% exact as part of Latvian seafarers are employed directly by foreign companies and the data of this employment is entered in database when person comes to seamen registry for certification reasons. However due to the number of persons included in sample it can be assumed that values are close to average values and therefore they are fully usable.

2. Basic concept of seafarers' pool

Figure 1 shows simple seafarers' resource model. Maritime education, active seafarers and ex–seafarers are considered as the main three blocks of model. Maritime education system provides the entrants for active pool and main parameters of maritime education system are qualification gained in educational process and number of graduates. Most of the persons join the pool at age 20 - 29 years as most persons graduate from maritime education institutions within this age range.

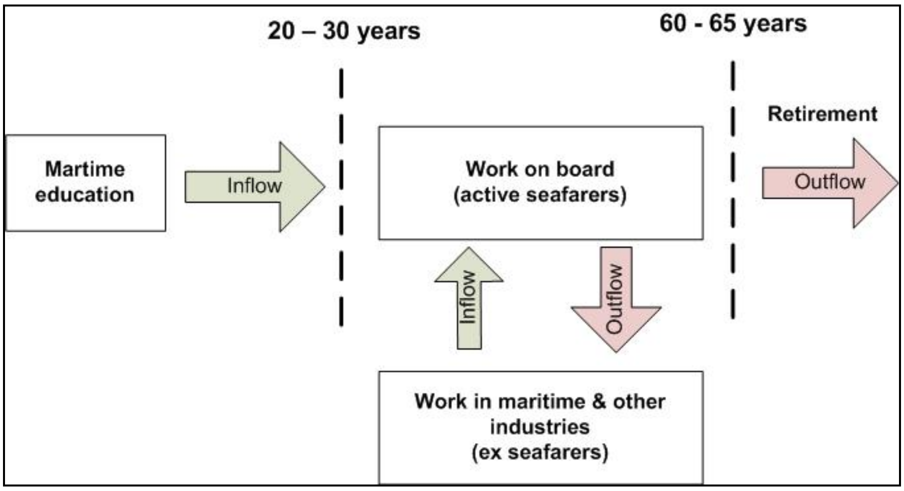

Figure. 1. Model of seafarers' resources (author)

The assumption of entering age is also supported by the average age structure of merchant seafarers (Figure 2). The relative number is increasing till age group 25 – 29 years when it reaches highest value. Also retirement age can be derived from age structure of seafarers and considered at age 60-64 years as there is drop by 4% comparing with age group 55-59 years. Only 2% of seafarers are represented in age group over 65 years.

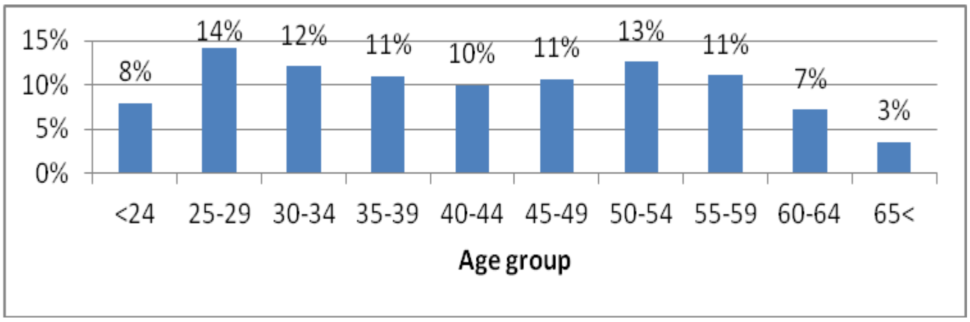

Figure 2. Age structure of merchant fleet seafarers
Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

Active pool consists of seafarers which are employed on board and hold valid STCW certificate. The pool of active seafarers is linked with pool of ex-seafarers as seafarers can leave work on board for several years (when they are considered as ex-seafarers in data) and then go back to work on ships (become active again). Persons can be considered as ex-seafarers who have gained maritime qualification and are in age group from 20 - 29 years but presently they are not actively employed on board ships and don't hold valid STCW certificate. The outflow from active pool to maritime or other industries ashore is continuous and linked with external factors such as employment possibilities ashore, economic development (pull factors) or internal factors such as demand for qualification represented by persons or employment conditions on board (push factors). As main factors (which influence the attraction of seafarers and also the outflow to other industries inflow) are often mentioned: opportunities of employment ashore, education and the closing gap between salaries on board and ashore, the growth in availability and ease in procurement of cheap lower crews from low-cost countries. These factors are directly related to cost/benefit ratio and therefore can influence growth or decline of number of seafarers in particular country [13]. The employment possibilities for ex-seafarers depend on the size of maritime cluster in the particular country. Traditional employment pathways after work at sea for ex-seafarers differs from country to country as it can be seen in research about career paths in maritime industries [14].

The main problem in modelling the supply side of seafarers lies in fact that present size of active seafarers' pool is influenced by the number of graduates and the attraction of shore industries which has different impact on different groups of seafarers at different period of time

3. Active pool of Latvian seafarers

Table 1. Size and structure of seafarers' pool (2013)

Total number of seafarers	12,970
1) Merchant fleet seafarers:	11,960
1.1) Deck department	5650
Officers	2500
Ratings	3150
1.2) Engine department:	4890
Officers	3040
Ratings	1850
1.3) Catering department (cooks, stewards)	1400
2) Inland fleet seafarers & personnel of fishing vessels	1010

Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

Composition of the pool of active Latvian seafarers is given in Table 1. 92% of seafarers are merchant fleet seafarers. 47% of them are classified as deck department seafarers, 41% are classified as engine department seafarers, but 12% are classified as catering departments' seafarers. The number of seafarers in Latvia is calculated every year with the reference date 1st January. The base for the number of seafarers is taken by the number of valid documents of competence or qualifications such as certificates of competency or certificates of qualification. The validity period of endorsement or qualification document is five years, therefore it is assumed that if the endorsement is not revalidated seafarer leave the pool. The data about employment cannot provide complete picture of the active number of Latvian seafarers as approximately 10% of seafarers are employed directly or through foreign crewing companies, which are not obliged to provide data about employment to Latvian Seamen Registry. Also part of seafarers doesn't sail regularly, therefore it is difficult to assess employment data accuracy level and they are used as secondary indicator. The last valid certificates are taken as indicator in calculations showing the qualification as person can have two or more valid certificates on hand at the same time.

4. Analysis of graduates from Latvian maritime education institutions and their qualifications

The available data in time period from 1995 - 2012 is analysed (see fig.3.) to obtain data about graduates and maritime education institutions. As the maritime education system in this time period had experienced changes in structure the maritime education institutions are grouped in three main groups:

1. Latvian Maritime Academy (LMA) including branches such as college and maritime school;
2. Liepaja Maritime College (LMC) including maritime school;
3. maritime educational and training centres (MET) who mainly provides further vocational educational programmes for deck and engine ratings.

As graduates are considered persons who obtained education during considered time period which allowed them to pretend on particular qualification such as deck or engine officer, deck or engine rating etc.

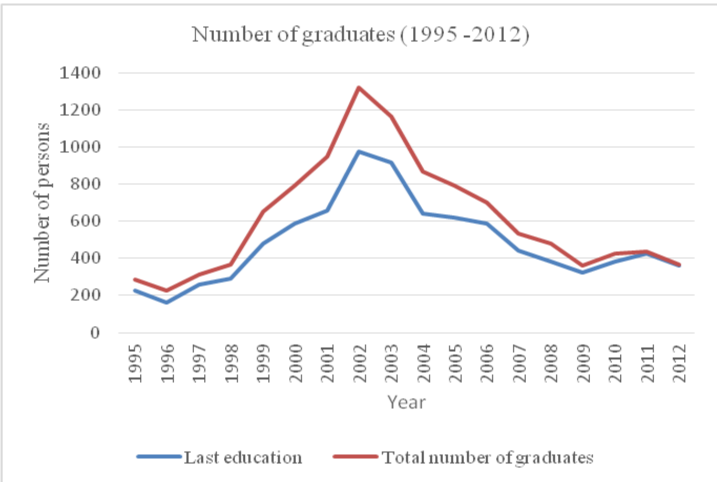

Figure 3. Number of graduates from Latvian maritime education institutions
Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

There were 11 000 entries about the persons and their graduation in database of Seaman Registry of Latvian Maritime administration for the time period 1995 - 2012. The considerable increase from 1999 – 2004 with peak values in 2002 (Figure 3) is linked with high number of ratings obtaining their education. Each year part of graduates rejoins maritime education system to obtain other qualification or to continue their studies at different level. For example 47% of graduates from LMA maritime school during 1995-2008 continued their studies. Therefore to assess real inflow from maritime education system the term "last education" is used in this article. Last education means that for particular person this is last gained maritime education with particular qualification. For example, if person graduated deck rating programme in 2002 and graduated deck officer programme in 2005 as last education for this particular person is counted deck officer programme in 2005. As it can be seen in fig.3 the number of persons with 'last education" in particular is lower than number of total graduates year from 1995 -2008. From 2009 - 2012 those values are almost equal which means that persons who continue their studies are not graduated yet. On average 75% (standard deviation 7%) of total graduates gained their last education in particular year during 1995 – 2008 considering the total number of graduates. Part of the graduates, who do not continue their maritime education, takes decision to work on board (join the pool of active seafarers) or to leave pool without working on board as it can be seen in Figure 4.

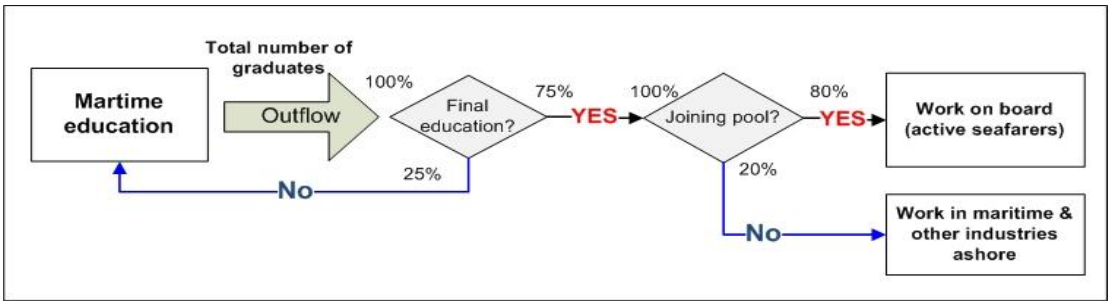

Figure 4. The model of graduates' decision process (author)

Illustrative concept of the model of graduates' decision process shows average values of decision takers. Detailed assessment of education programmes and institutions is given in Table 2.

Table 2. Contribution to outflow from maritime educational institutions (1995 - 2008)

Final educational programme	LMA*	LMC*	MET	Total number of persons (100%)	Share of particular programme
Deck officer	43%	57%	0%	1 990	28%
Engine officer	29%	71%	0%	1 840	25%
El. Engineer	15%	85%	0%	140	2%
Deck officer < 500 GT	88%	6%	6%	280	4%
Engine officer < 750 kW	51%	14%	35%	70	1%
Deck rating	0%	38%	62%	1 730	24%
Engine rating	0%	32%	68%	1 010	14%
Deck/engine rating	0%	1%	99%	170	2%
Total	23%	49%	27%	7 230	100%

*including branches and programmes which are not active anymore
Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

53% of all graduates graduated from deck or engine officers programmes. Most of those graduate come from Liepaja Maritime College (LMC). Approximately 35% of deck and engine ratings also graduated from LMC however those programmes are not carried out in LMC anymore. Therefore those data reflect historical contribution of maritime educational institution which contributed to composition of active seafarers' pool. Not all graduates from those programmes and institutions worked on board after graduation therefore the relative number of graduates who worked after completion the last educational programme is showed in Table 3.

Almost 80% percent of those graduates joined active seafarers' pool. This parameter differs comparing various educational programmes and different maritime educational institutions. For example, the value for this parameter is higher if compare deck and engine officers graduating from LMC with LMA, but lower comparing graduates from LMC deck or engine rating programmes with graduates graduating from further vocational institutions.

Figures given in Table 4 reflect the share of active graduates who joined active seafarers' pool after completion their last education programme (deck or engine officer) and are still active. If compare time periods it can be seen that main differences comparing educational institutions can be found in years 2005 - 2008. The lowest value of this parameter is determined for graduates of LMA comparing with other institutions in this time period. The data shows that relatively more graduates from Liepaja Maritime College are still active comparing with graduates from Latvian Maritime Academy and its' branches.

Table 3. Share of graduates who worked on board after graduation (1995 - 2008)

Final programme	**LMA**	**LMC**	**MET**	**All institutions**
Deck officer	79%	87%		84%
Engine officer	82%	86%		85%
El. Engineer	90%	57%		62%
Deck officer < 500 GT	55%	50%	56%	55%
Engine officer < 750 kW	44%	20%	64%	48%
Deck rating		62%	82%	74%
Engine rating		49%	81%	71%
Deck/engine rating		100%	79%	79%
Total	**76%**	**77%**	**81%**	**78%**

Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

Table 4. Share of active graduates taking into account graduation period

Graduation year	Average	LMA	LMA College	LMA maritime school	LMC College	LMC maritime school
Deck officers' programmes						
2005-2008	80%	75%	83%	-	89%	80%
2000-2004	64%	62%	63%	64%	64%	66%
1995-1999	56%	46%	59%	51%	60%	-
Engine officers' programmes						
2005-2008	77%	68%	80%	-	78%	77%
2000-2004	66%	56%	58%	57%	82%	71%
1995-1999	55%	38%	55%	33%	64%	-

Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

To obtain information about the dropout from active pool to shore industry (Figure 5) the year after graduation is considered in combinations with number of persons leaving the pool in particular year after graduation from the last educational programme. Only persons who have worked on board after graduation are included in particular analysis. Cumulative percentage shows that more ratings are leaving the pool than officers.

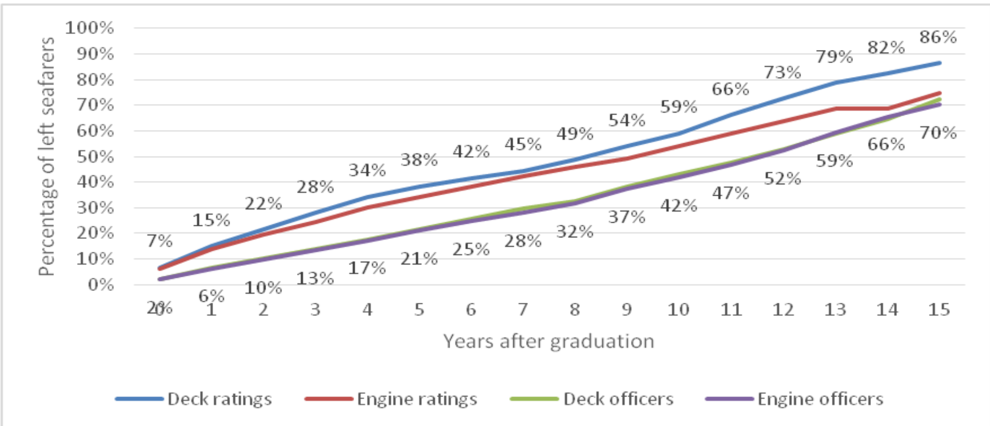

Figure 5. Cumulative percentage of leaving seafarers from active pool
Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

Therefore it can be concluded that ratings are more mobile switching from active seafarers' pool to shore industry comparing with officers. Cumulative percentage comparing deck ratings with engine ratings are higher for deck ratings while the cumulative percentage for officers are almost equal comparing deck and engine officers. On average 50% of ratings leave the active pool within 8,5 years while for officers this parameter can be considered as 11,5 years.

Table 5 shows the relative number of graduates leaving the work on board. Maritime educational institution and the education programme are separated in this analysis. Again it can be seen that for graduates from Latvian Maritime Academy this parameter is higher comparing with graduates from its branches or Liepaja Maritime College. Comparing officers with ratings it can be seen that approximately 1/3 of ratings will leave the pool within 5 years while for officers this amount is less than 1/5 of graduates who worked on board after graduation. In following years this difference between officers and ratings diminishes.

Table 5. Relative number of graduates leaving active seafarers pool (years after graduation)

	Deck officers			Engine officers		
	0- 5 years	6-10 years	11-15 years	0- 5 years	6-10 years	11-15 years
Average	18%	25%	29%	17%	25%	28%
LMA	23%	23%	29%	28%	21%	22%
LMA College	19%	23%	33%	21%	27%	34%
LMA Maritime school	19%	27%	23%	24%	23%	34%
LMC	10%	20%	28%	8%	19%	26%
LMC Maritime School	18%	30%	-	17%	34%	-
	Deck ratings			Engine ratings		
	0- 5 years	6-10 years	11-15 years	0- 5 years	6-10 years	11-15 years
Average	34%	25%	32%	30%	24%	25%
LMC	28%	24%	28%	27%	22%	32%
MET	38%	25%	25%	32%	26%	9%

Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

As it can be seen from previous analysis the graduates from Liepaja Maritime College stays longer in active pool therefore the career growth of graduates from different institutions is assessed. It could be assumed that considerable differences are linked with the quality of education. The results of those analyses are showed in Table 6. It can be seen that there cannot be distinguished considerable differences related to final educational programme and the average career growth. The results are fluctuating but not considerable. From these results hypothesis can be derived that career growth is influenced more by pull factors (demand for persons with particular qualification) than by push factors (brand of maritime educational programme and institution).

Table 6. Average career growth of graduates (years)

	3rd off - 2nd off	2nd off - Chief off	Chief off - Captain	4th Eng- 3rd Eng	3rd Eng- 2nd Eng	2nd Eng - Chief Eng
LMA	2,4	3,3	4,2	2,3	3,2	4,3
LMA College	2,3	3,3	5,3	2,1	3,0	4,0
LMA Maritime school	2,3	3,3	4,4	2,1	3,3	4,7
LMC	2,7	3,5	4,9	2,1	3,3	4,6
LMC Maritime school	2,3	3,8	4,2	1,9	3,8	4,4
Average	2,4	3,4	4,6	2,1	3,4	4,5

Source: author's calculations based on data obtained from Seamen Registry of Latvian Maritime Administration

Conclusions

It can be assumed that global shortage of officers will remain one of the topics for maritime society at least for few next years. Supply side of demand/supply equation should be considered by taking into account not only the number of graduates from educational institutions but also the level of maritime educational programme, number of persons continuing their education, number of persons leaving pool and dropout rate from active seafarers' pool and its relation to previous educational level. It can be concluded that educational institution and received education has impact on probability that person will join the active seafarers' pool and how long they will stay there. Careful consideration can be derived that graduates completing higher level maritime educational programmes are attracted to shore industry in larger extent than others and for them it is easier to find employment ashore. However this can be linked to differences in individuals and differences in their motivation to study in one or another maritime education institution as those parameters cannot be analysed by using the bulk data from database. Historical analysis of graduates provides information about factors which are influenced by received maritime education and therefore those parameters can be applied in modelling future supply of Latvian seafarers even the structure of maritime educational system is different. Those analyses also show that such parameter as career growth on board cannot be directly assigned for received maritime education and are influenced more by demand side than by supply side. In future additional data analysis is prerequisite to consider influence of external factors such as unemployment, average salary ashore in Latvia and other factors to provide data for complete supply model of Latvian seafarers.

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MULTI ZONES HVAC SYSTEMS' CONTROL IN SHIPS WITH SIMULINK APPLICATION

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Abstract
Ships around the world are operated at all weather conditions. Therefore HVAC systems for ships are very significant and these systems have to work in limit conditions of outer climate temperature and moisture. To this end, ship heat load should be known. Therefore necessary heat load is calculated for various air conditions and ship speeds. In this paper, the ship's characteristics having the HVAC system are studied. Moisture, velocity and energy equations are derived. Firstly Simulink model is created for one location by Matlab Simulink. For the entire ship's HVAC system simulation, heat transfer of the locations with each other and outer climate are also considered. All locations' simulation with each other and the outer climate are integrated and the HVAC system model of the ship is created. Desirable temperature and moisture conditions for locations are derived by adding a PID controller to the model.
Keywords: *HVAC, PID control, Simulink*

Nomenclature

HVAC	Heating Ventilating and Air Conditioning
PID	Proportional, Integral, Derivative
C_m	Heat capacity of steel sheet material
C_a	Specific heat of dry air
C_S	Specific heat of water
C_V	Specific heat of water vapor
f_k	Flow rate air mixture
R_a	Gas constant of dry air
R_v	Gas constant of water vapor
T_a	Temperature of fresh air
$\bar{T}_k$	Absolute temperature of mixed air
q_v	Enthalpy of water vapor saturation temperature
w_k	Specific humidity of the mixed air
$\bar{W}_a$	Absolute specific humidity of fresh air
$\bar{W}_k$	Absolute specific humidity of mixed air
h_k	Enthalpy of mixed air

Introduction

Due to the difficulty of working conditions on the ship, air conditioning and ventilation systems are more important instead of other systems. The external air conditions are likely to be changeable according to the motion of the ship. This situation increases the importance of the control systems in air conditioning applications. The heating or cooling loads change depending on the changes in external weather conditions on the ship and the ship speed. In this study, after derivation of the mathematical model, the simulation with PID controller is aimed to be made in order to determine the air conditioning system that achieves the desired thermal conditions depending on the change of the air conditions. Reaching to the saturation of the temperature and humidity response of the system, distortion effects and dynamic responses are modeled and controlled for each room individually. Therefore, the system performance of the ship is observed in an integrated way.

In the last two decades, numerous studies have been made related with the modeling and controlling of the HVAC systems. The simulations with on-off control method using the transfer function of the system for the control of the air conditioning room temperature has been carried out by Cherchas [1]. Zhang has modeled a transfer function of an environment of livestock. With the acceptation of the linearity of the system, the simulation results belonged to the heating and ventilation system has been achieved by Zhang [2].

House has carried out a discrete time optimal control method for the control of the temperature in any air-conditioning system and energy saving has been obtained from this method according to the other control method; on/off control [3]. Dexter has designed a self-adjustment controller for air-conditioning system applications [4].

Kamimura has controlled the temperature of the room, which has specific transfer function, with PID controller by using CAT software, which determines the most suitable PID coefficients for any air-conditioning system [5]. William has suggested to control the damper of mixture air at the air conditioning system using PID controller due to the using microprocessor based electronic controller is better for the energy efficiency for the control of the buildings [6]. Atkinson and Martino have used a PID controller which he has designed with analog circuit elements, for the control of the humidity, pressure and temperature and air purity in a factory [7].

Krakow has controlled the velocity of the compressor and cooling fan by means of PID controller. Then the temperature and humidity of a room have been controlled and after that he has made a study to determine the PID coefficients analytically [8, 9]. Kaya has presented a model utilizing from the analytical techniques to solve the control problems of the air conditioning of the complex systems such as workplaces and buildings [10].

In this study, PID controller which is used commonly with successful results in the literature has been used. On the other hand, mathematical models and Simulink blocks gathered in the study are common and they make the assessment of the system performance possible with using any controller.

Multi-zone air-conditioning systems

The most prominent air conditioning system used in ships is multi-zone configuration. Central air conditioning source distributes the air to all localities in multi-zone systems. Each region has its own dampers and desired air conditions are obtained by controlling dampers' ducting openings via thermostats. Air, returning from ducts of each zone, combines and re-enters the central air conditioning system in a single channel. The principle of the system is shown in Figure 1 Multi-zone systems compensate the advantages of dual duct systems with a lower cost.

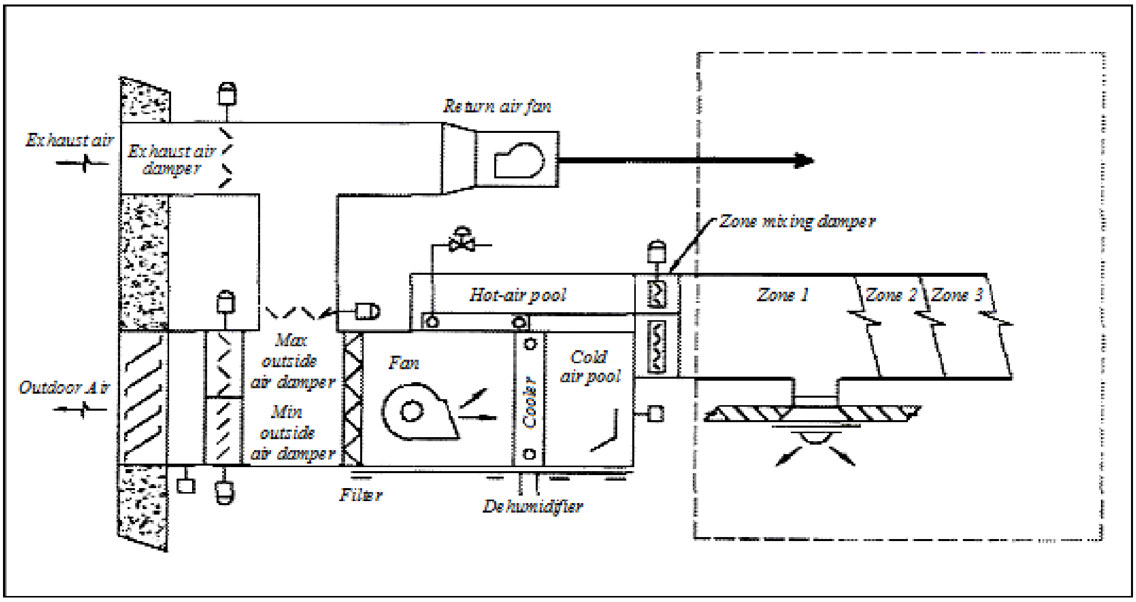


Figure 1. Multi-zone air-conditioning systems [11]

Mathematical Model

Basic expressions like humidity balance, energy balance and velocity balance equations are used for the establishment of the mathematical model.

Humidity balance

The sum of humidity of entering air and water vapor given to the system is equal to the sum of humidity of exiting air and difference of humidity in the chamber. Mathematically speaking, equation of humidity is represented as follow [12]:

$$\frac{dw}{dt} = \frac{1}{V}\left[K_1 \bar{T}\bar{W}\dot{m} + K_2 f_k \bar{T}\bar{W} - Av(\bar{W} - 0,622) \right] \tag{1}$$

$$K_1 = \frac{R_a}{0,622\,P} \quad , \quad K_2 = \frac{w_k}{\bar{T}_k \bar{W}_k} \quad , \quad K_3 = \frac{\bar{W}_k + 0,378}{\bar{T}_k \bar{W}_k} \tag{2}$$

Energy balance

It is considered that difference between the energy input to the control volume and energy output from the control volume represents energy gain or loss. The change of energy is defined as subtraction of air enthalpy leaving the control volume and heat escapes from the control volume walls from the sum of heat given by the heater to control volume, enthalpy of the air given to the control volume and water vapor enthalpy given for moisturizing. If the temperature is mathematically obtained from balance of energy, then we get the following expression [12]:

$$\frac{dT}{dt}=\frac{1}{(C_a+C_V w)V}\left[\begin{array}{l}(\dot{Q}+m_S C_S T_S-Q_k)K_1\dfrac{\bar{T}\bar{W}}{\bar{W}+0,378}+\dfrac{K_3 f_k h_k}{\bar{W}+0,378}\bar{T}\bar{W}-AC_h(\bar{T}-273,15)v \\ \\ -q_V(K_1\dot{m}+K_2 f_k)\bar{T}\bar{W}-C_V(K_1\dot{m}+K_2 f_k)(\bar{T}-273,15)\bar{T}\bar{W}\end{array}\right] \qquad (3)$$

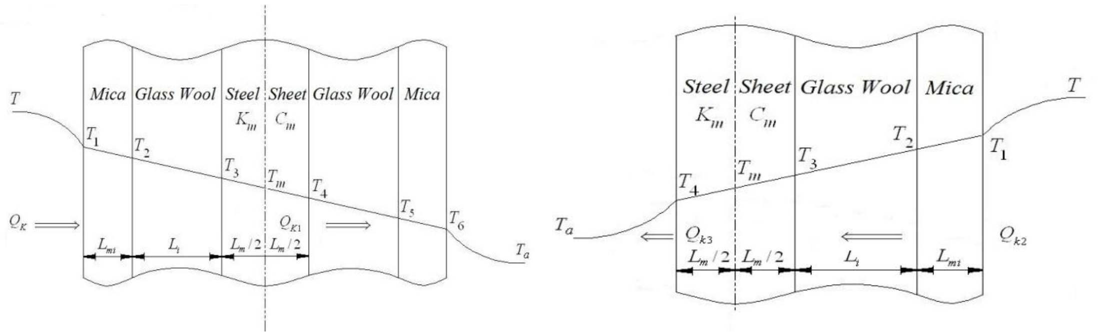
Velocity balance

While deriving the mathematical model for the control volume, following assumption is considered: "Pressure inside the control volume is constant and equal to the atmospheric pressure". The difference of the dried air amount that is entering and leaving the control volume is equal to the mass difference caused by the temperature and humidity change in the control volume which results with density variation. Air velocity in the control volume is achieved by isolating the velocity from this equation [12].

$$v=\frac{f_k}{A\bar{T}_k\bar{W}_k}\bar{T}\bar{W}+\frac{V}{A}\frac{1}{(\bar{T}\bar{W})^2}(\bar{W}\frac{d\bar{T}}{dt}+\bar{T}\frac{d\bar{W}}{dt}) \qquad (4)$$

Typical heat transfer of the chambers

For our system is a ship, the wall internal section between localities is accepted as formed by metal plate at the innermost, isolation material on it and mica coating at the outmost. According to these specifications, while temporal heat loss equation is obtained, it is assumed that heat isolation material is not capable of heat absorption.



(a) (b)

Figure 2. Heat transfer of the chamber sections: (a) inner chamber, (b) outer chamber, ceiling and floor

Heat transfer occurs by convection and conduction from the locality to the outer environment. While the mathematical expression of this heat transfer is formed, it is assumed that only steel plate has the capacitive effect and this effect is in the middle of the material. And regarding this assumption, heat transfer equations of the compartments are obtained as follows:

$$\frac{d\dot{Q}_k}{dt}=\frac{1}{R_{d1}}\frac{d\bar{T}}{dt}+\frac{T-T_a}{R_{d1}C_m R_{d2}}-\dot{Q}_k\frac{\left(1+\dfrac{R_{d1}}{R_{d2}}\right)}{C_m R_{d1}} \qquad (5)$$

$$\frac{d\dot{Q}_{k2}}{dt}=\frac{1}{R_{d3}}\frac{d\bar{T}}{dt}+\frac{T-T_a}{R_{d3}C_m R_{d4}}-\dot{Q}_{k2}\frac{\left(1+\dfrac{R_{d3}}{R_{d4}}\right)}{C_m R_{d3}} \qquad (6)$$

The control mechanism of the mathematical model that is used in Simulink is chosen as PID effective control mechanism.

PID (Proportional, integral, derivative) effective control

A proportional-integral-derivative (PID) controller is widely used in industrial control systems that involve three constant parameters. These parameters are the proportional, integral and derivative values. A PID controller calculates the error value as the difference between the desired input value and the actual output. The controller minimizes the error according to process control inputs.

In PID controller, P represents the proportion to the present error at the instant t, I represents the proportion to the integral of the past error up to the instant t while D is representing the proportion to the derivative of the future error at the instant t [13]. In PID effective control system, transfer function, $u(t)$ is as given in Eq. 7.

$$u(t) = K_p \left(e(t) + \frac{1}{\tau_i} \int_o^t e(t)dt + \tau_d \frac{de(t)}{dt} \right) \tag{7}$$

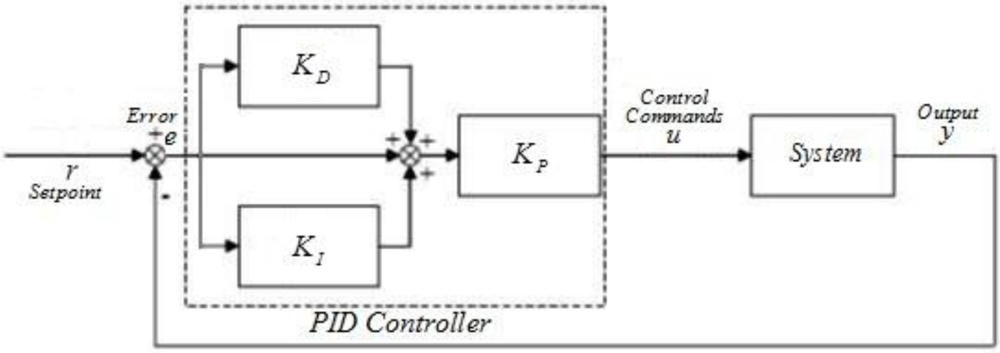


Figure 3. Schematic structure of PID effective control system [14]

Establishment of simulink model

Due to the fact that ships are consisted of different localities, each locality is modelled individually in Matlab-Simulink model. After, these models are integrated together in order to create a total solution for the ship air-conditioning system. Because of same method is used in all localities, a Simulink model for only one locality (Cabin No. 1) is given in Figure 4 as an example.

Simulink models are created for all cabins. The model for three cabins and one corridor is given in Figure 5 for the illustration of the model. Simulations are carried out via these models.

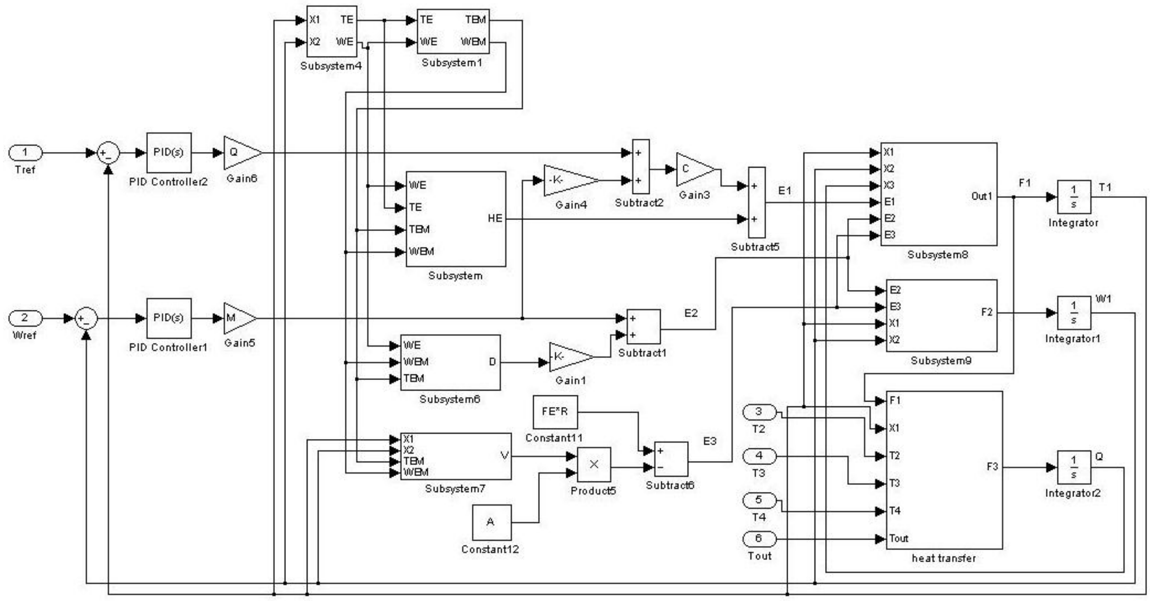


Figure 4. Matlab – Simulink model of Cabin No. 1

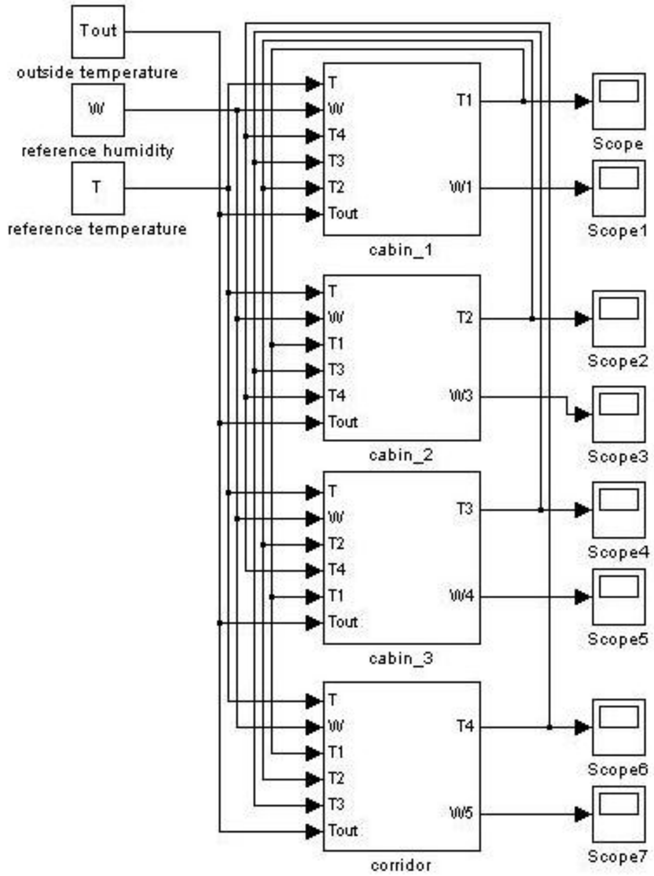


Figure 5. Matlab – Simulink model of three cabins and one corridor

Results and discussion

The temperature and humidity datum before the air-conditioning of all places in the ship are used as input for the simulation 15 °C and 29,5 % humidity, respectively. The result graphs of the air-conditioning to get the 25 °C temperature and 45 % humidity are shown below.

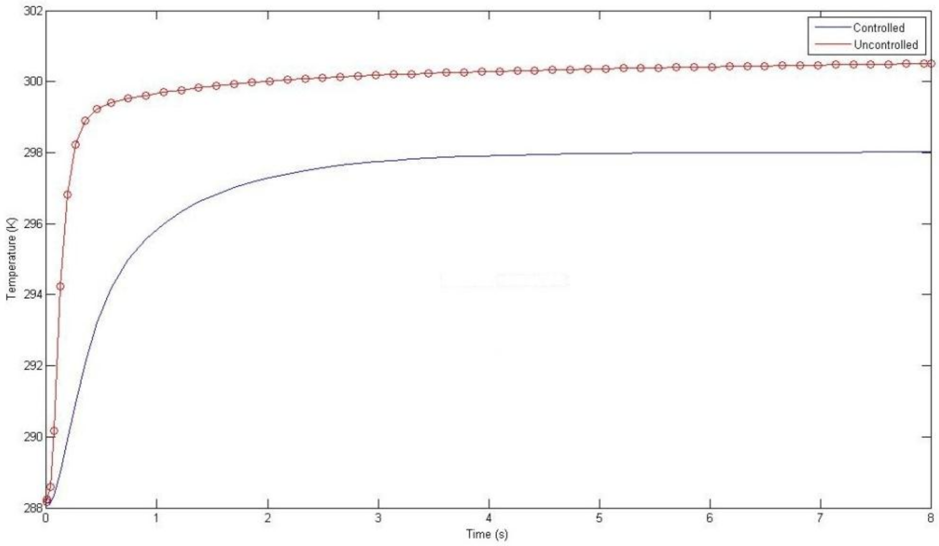


Figure 6. Temperature change in cabin due to time

It is indicated from the temperature and humidity graphs that the desired reference values are reached rapidly without extra exceeding and steady state error.

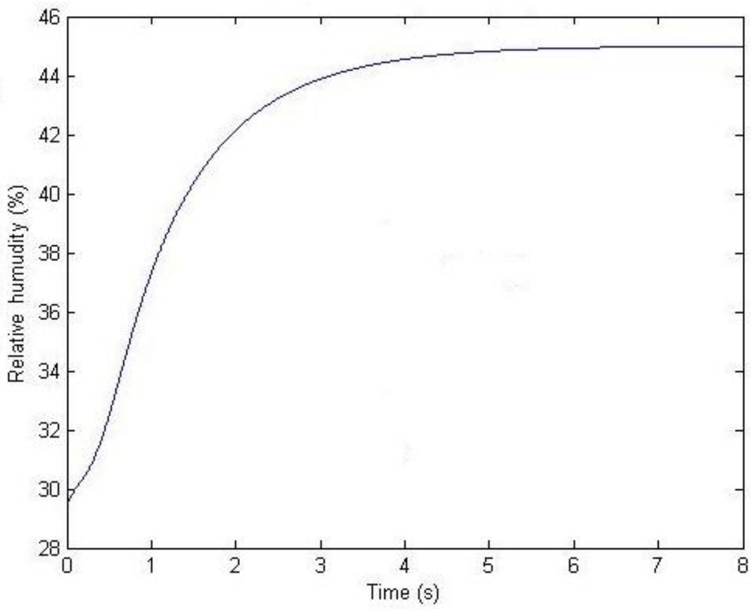


Figure 7. Humidity change in cabin due to time

Changing the external air temperature effects over the total heat load is observed. At first, an increase in the external air temperature decreases the total heat load at the heating side, after the specific temperature increases at the cooling side.

Conclusions

The air conditioning simulation of 4 closed places of a bulk carrier. A mathematical model, included the energy given to the system, humidity and the balance of the mixture of fresh air from the external place with circulated air is established. Some of the heat gain and loss are neglected.

It is accepted that the heat transfer from the ceiling, floor and side walls of the control volume is occurred via conduction and convection. The system equations of heat loss are formed; capacitive properties of the walls are also taken into account. By using these equations, Models are created with Matlab-Simulink for each district. The created models are integrated with each other in Simulink by taking the heat transfers of the districts with each other and with the external environment into account for the simulation of all the ship's air-conditioning system [15].

PID controller obtained by the trial and error method is used in order to bring the indoor humidity and temperature values to the desired comfort conditions, ensures the continuity of conditions to increase the energy efficiency [15].

The temperature and humidity datum before the air-conditioning of all places in the ship are accepted as 15 °C and 29,5 % humidity at the external conditions. The desired 25 °C and 45 % humidity are gained with the simulation. It is observed from the temperature-time and humidity-time graphs that the desired humidity and temperature parameters are reached without exceeding and steady state error.

For future work, human factors and mechanical factors which affect the system disturbance can be taken into account for a new and improved model and solution.

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PREDICTION OF EMISSIONS AND PERFORMANCE PARAMETERS FOR STEAM INJECTED DIESEL ENGINE WITH EGR USING ANN

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Abstract
To achieve less pollutant emissions according to MARPOL Annex VI regulations, various methods inside and outside of the cylinder can be used to reduce these pollutant emissions. In this study, electronically controlled steam injection system coupled with EGR was applied into direct injection diesel engine to investigate CO_2, NOx emissions and specific fuel consumption, effective power. Also, an artificial neural network (ANN) structure using back propagation (BP) learning algorithm has been developed to predict CO_2 and NOx emissions and performance parameters. Moreover, network outputs and experimental results of BP has been compared in order to show ANN performance. These results showed that emissions and performance parameter could be estimated with a very high accuracy by the help of designed Neural Network structures.
Keywords: *diesel engine, steam, EGR, ANN*

Introduction

To improve performance and exhaust emissions of marine diesel engines, engine manufacturers contemplate innovative techniques so as to increasingly strict emission regulations and the extremely competitive market. In this context, it is important to note that estimation and prediction of performance and exhaust emissions of marine diesel engine have great importance. Owing to solve the science and engineering problems, Artificial Neural Networks (ANN) are widely used -models as a predictive model for a performance and exhaust emissions of marine diesel engine.

So as to predict these emissions and performance parameters, Lucas *et al*. investigated the effects of the fuel composition parameters on Particulate emissions and data were fitted along with torque and engine speed using neural networks [1]. Obodeh and Ajuwa studied the capabilities of ANN model as a predictive tool for multi-cylinder diesel engine NOx emissions [2]. Kökkülünk *et al*. developed to ANN structure to predict exhaust emissions and exhaust temperature of direct injection diesel engine running with emulsified fuel [3]. Duran *et al*. estimated the diesel particulate matter composition of diesel engine with transesterified waste oils blends using ANN [4]. Arcaklioğlu and Çelikten determined the performance and exhaust emissions of a diesel engine with respect to injection pressure, engine speed and throttle position [5]. Çelik and Arcaklioglu investigated a mechanism to determine the constant specific fuel consumption (SFC) curves of a diesel engine using ANN [6]. Kiani *et al.* studied to predict the engine brake power, torque and exhaust emissions of a spark ignition engine using Neural Network [7]. Canakci et al. carried out the engine performance and exhaust emissions of diesel engine running with the biodiesel blends produced from waste frying palm oil for five different neural networks to define how the inputs affect the outputs [8]. Oğuz et al. studied a diesel engine running with biofuels and predict the torque, power and specific fuel consumption in relation to input variables as engine speed and biofuel blends with ANN [9]. Ghobadian et al. investigated the ANN modeling of a diesel engine with waste cooking biodiesel fuel to estimate the power, torque, SFC and exhaust emissions [10]. Parlak *et al.* predicted the SFC and exhaust temperature of a diesel engine using ANN [11]. Sayin *et al.* studied with

ANN modeling of gasoline engine to predict SFC, brake thermal efficiency, exhaust gas temperature and emissions [12]. Karonis *et al*. studied the expressions correlating the exhaust emissions from a diesel engine with some of the properties of fuels using ANN approach [13].

Based on previous literature review, it is obvious that the use of ANN approach is a powerful modeling tool to identify relationships from input and output data. However, there is no investigation to predict exhaust emissions (NOx, CO_2) and performance parameters (effective power, specific fuel consumption) of steam-injected diesel engine with exhaust gases recirculation (EGR) using ANN approach. Therefore, an ANN structure with BP was developed to predict emissions and performance parameters. So as to detect network performances, output parameters were compared with a experimental results.

Materials and methods

Experimental details

The experiments were carried out with a single cylinder, naturally aspirated and four-stroke Diesel engine with a bowl in combustion chamber. The engine specification and experimental set-up are shown in Table 1 and Figure 1, respectively.

Table 1. Engine specification

Engine Type	Super Star
Bore [mm]	108
Stroke [mm]	100
Cylinder Number	1
Stroke Volume [dm^3]	0,92
Power, 1500 rpm, [kW]	13
Injection pressure [bar]	175
Injection timing [Crank Angle]	35
Compression ratio	17
Maximum speed [rpm]	2500
Cooling	Water
Injection	Direct Injection

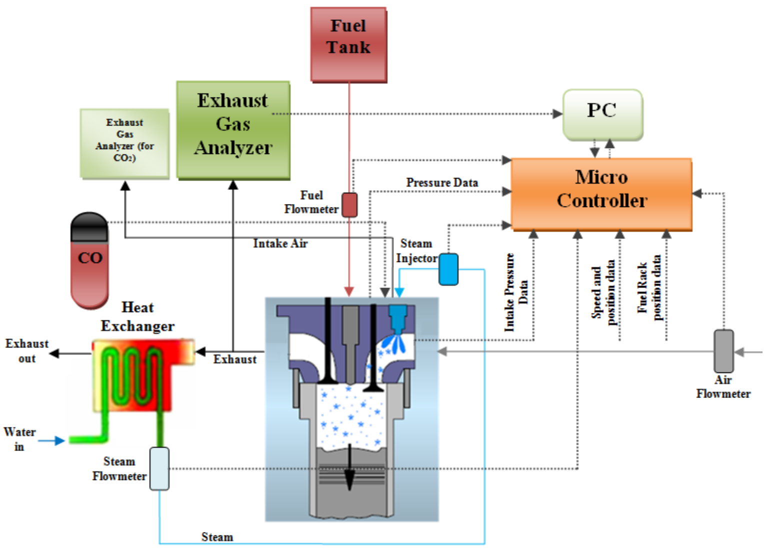

Figure 1. Experimental Set-up

In order to measure brake torque, the engine is coupled with a hydraulic type dynamometer of 50 kW absorbing capacity using an “S” type load cell with the precision of 0.1 N. Before starting the experiments, load cell is calibrated sensitively [14,15].

In this study, MRU Spectra 1600 L type and Bilsa Mod gas analyzers were used so as to measure exhaust gases. Before experiments, emission devices were calibrated.

99% purity Linde Gas brand CO2 gas was used for EGR application due to the most dominant compound in exhaust gases and to calibrate EGR ratio.

Method of Needham *et al*. [16] was used in order to determine the amount of CO2 gas. EGR percentage is [15];

$$EGR(\%) = \frac{CO_{2(intake\_manifold)} - CO_{2(surroundings)}}{CO_{2(exhaust\_manifold)}} x100 \qquad (1)$$

Where CO2(surroundings) is the reference CO2 percentage in surroundings. In this study, this value was neglected owing to being 0.03% in the literature [17]. EGR ratios were determined with a volume ratio of CO2 value. In the experiments, 10%, 20% and 30% EGR and steam ratios were carried out [15].

Neural network structure

ANN has been prompted right from its inception by the recognition that the human brain computes in an entirely different fashion from the conventional digital computer [18]. ANN has been utilized successfully in various fields of engineering, mathematics, economics, medicine, meteorology, neurology and psychology [18]. The engineering application of ANN is increasing day-by-day [19, 20].

Back-propagation (BP) learning method which has appeared as the standard algorithm of ANN for the training of multilayer perceptrons, against which other learning algorithms are often benchmarked [3,21]. Also, BP algorithm is an extension of the Least Mean Square (LMS) algorithm which can be used to train multilayer networks. The BP algorithm uses the chain rule in order to compute the derivatives of the squared error concerning the weights and biases in the hidden layer [3, 22]. On the other hand, the major problems of BP algorithm have been the long training times. The Levenberg-Marquardt BP (LMBP) algorithm is the fastest algorithm that we have tested for training multilayer networks of moderate size, despite of requiring a matrix inversion at each iteration [3, 22]. The data effuse from the input layer to the hidden layer(s) in the LMBP algorithm. Thereafter it reaches the final output layer and in the output layer the error signals effuse to the hidden layers and the input layers [3, 23].

In this context, to predict NOx and CO_2 emission and performance parameters (effective power, specific fuel consumption) BP structure which are usually used for parameter estimation were designed in this study. Their performance was compared using performance parameters (Mean Absolute Percentage Error and Root Mean Square Error). These networks have 3 inputs (engine speed, steam and EGR ratio) and 4 outputs (NOx, CO_2 emissions and effective power, specific fuel consumption). Therefore, as can be shown in Figure 2, the input layer consists of 3 neurons whilst the output layer has 4 neurons in BP. In the hidden layer, 10 neuron were used. Purelin function in output layer and tanjant sigmoid function in hidden layer were used [24].

Results and discussion

In this study, designed ANN (BP) structure was used so as to predict NOx, CO_2 emissions and SFC, effective power for Steam Injected Diesel Engine with GR. Experimental results were used for learning phase of ANN. Engine speed, Steam and EGR ratios as inputs of structure, NOx, CO_2 emissions and SFC, effective power as outputs of structure were used.

BP structure having a single hidden layer was developed. In the hidden layer, 10 neuron were used. Purelin function in output layer and tanjant sigmoid function in hidden layer were used [24].

The experimental and predicted/simulated results of NOx in ppm, CO2 in %, Specific Fuel Consumption (SFC) in g/kWh and effective power in kW are given for BP in Figure 3-6. As can be seen from Figure 3-6, the experimental and predicted/simulated values are very close. It is obvious that prediction of emissions and performance parameters of Steam Injected Diesel Engine with EGR can be accurately modeled using ANNBP.

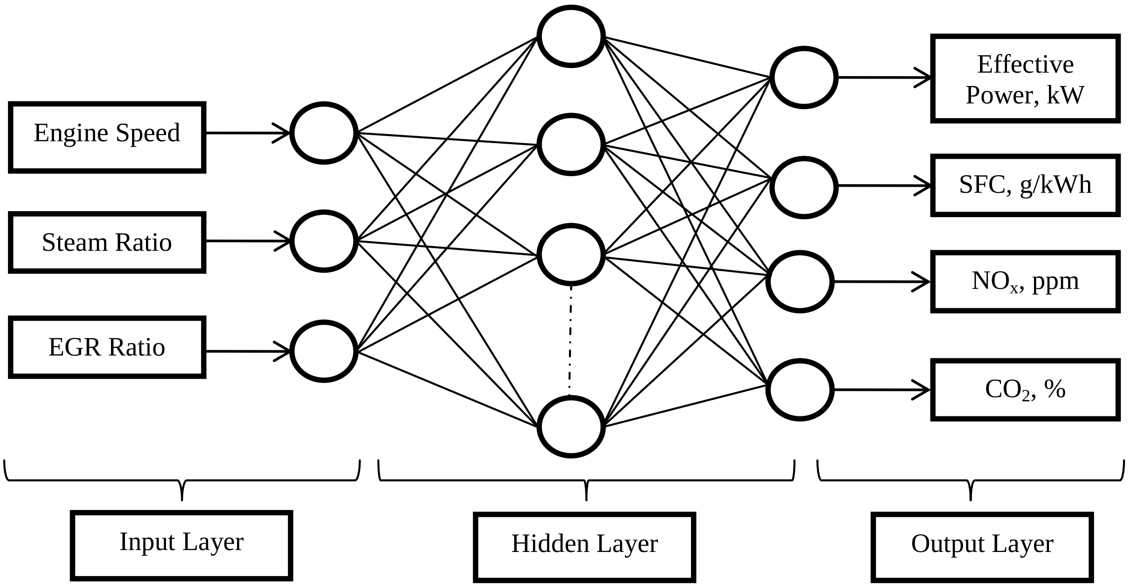

Figure 2. Multilayer neural network structure of BP

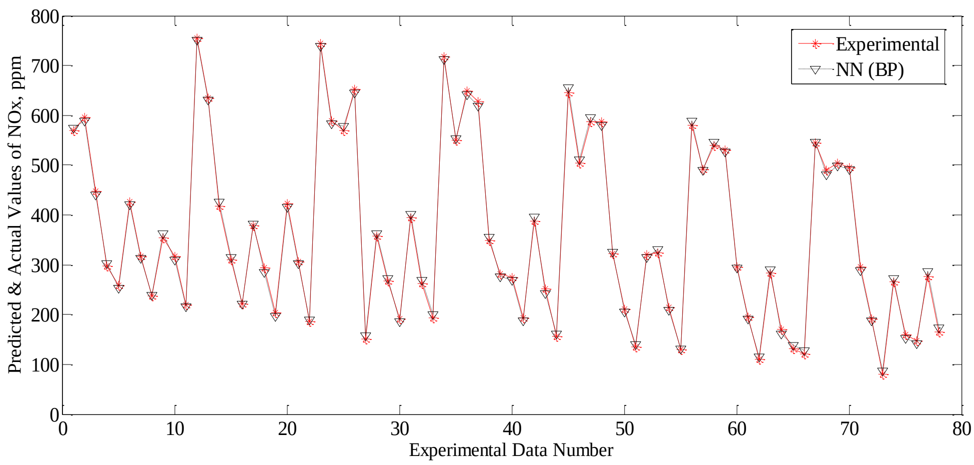

Figure 3. Comparison of predicted output and measured values of NOx

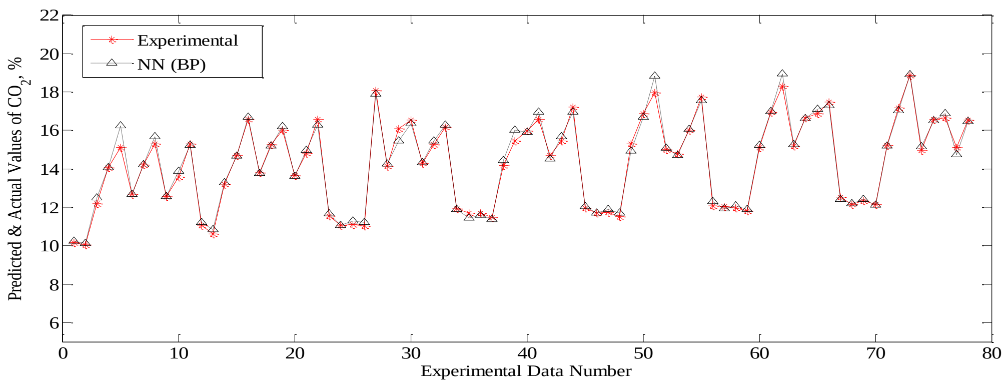

Figure 4. Comparison of predicted output and measured values of CO_2

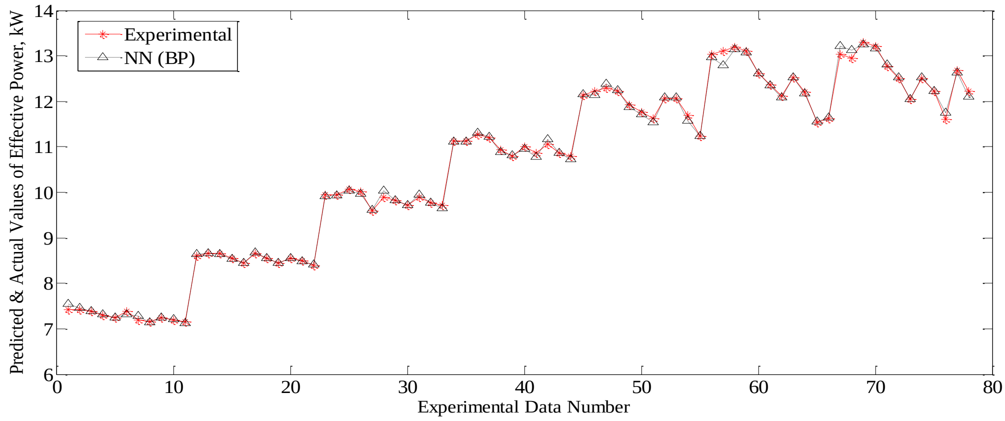

Figure 5. Comparison of predicted output and measured values of Effective Power

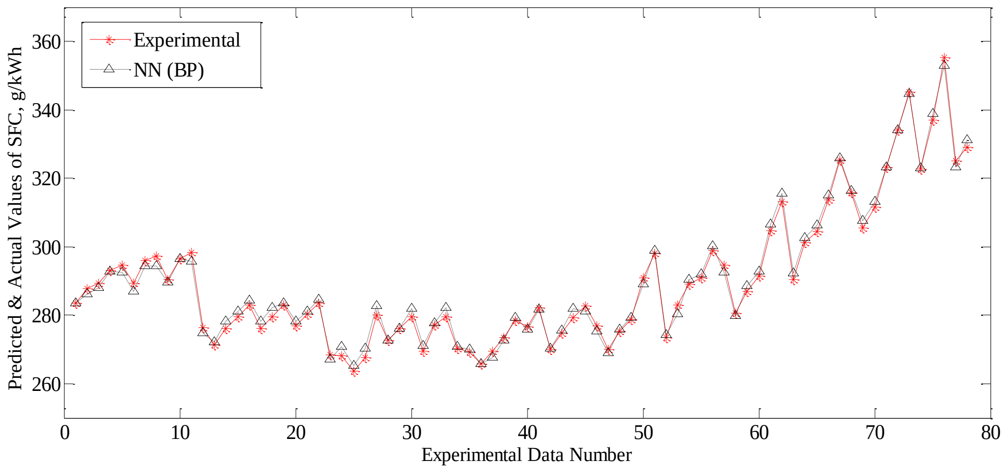

Figure 6. Comparison of predicted output and measured values of SFC

So as to illustrate, NN structures performance Root Mean squared error (RMSE) and Mean Absolute Percentage Error (MAPE) were used. They are formulated as follows:

$$MSE(x,y) = \frac{1}{n}\sum_{i=1}^{n}(x_i - y_i)^2 \quad (2)$$

$$RMSE = \sqrt{MSE} \quad (3)$$

where, n is the number of samples and x_i and y_i are the values of the i_{th} samples in x and y, respectively.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{f_i - y_i}{f_i}\right| \quad (4)$$

where, f_i is the predicted value, y_i is the actual value, n is the number of pattern.

In this context, in order to compare network performance of BP, Mean Absolute Percentage Error (MAPE) and RMSE (Root Mean Squared Error) were used. Analysis results are shown in the Table 2.

Table 2. MAPE & RMSE for Output Values of Network

	NOx (87.2-751.9 ppm)	CO_2 (10.1-18.9 %)	SFC (265.2-352.8 g/kWh)	Effective Power (7,1-13,2 kW)
RMSE	6.26	0.26	1.57	0.07
MAPE	0.0214	0.0120	0.0047	0.0040

In conclusion, with using of ANNs excellently predicts the four output parameters for the entire range of the experiments. The performance and exhaust emissions of the internal combustion engines can easily be determined by performing only a limited number of tests instead of a detailed experimental study [12].

Conclusions

An artificial neural network (ANN) was developed and trained with the data of this research work of steam injected diesel engine with Exhaust Gas Recirculation (EGR). The results illustrated that the training algorithm of Back-Propagation was sufficient enough in estimating effective power, specific fuel consumption, NOx and CO_2 emissions for different engine speeds and different steam and EGR ratios. Analysis of the experimental data by the ANN revealed that there is a well agreement between the predicted data resulted from the ANN and experimental ones. Thus, the ANN proved to be a desirable prediction method in the evaluation of the tested diesel engine parameters [10]. In order to compare network performance of BP, MAPE values were found in the range of 0.0040-0.0214 and RMSE in the range of 0.07-6.26.

Since other mathematical and numerical algorithms might fail owing to the complexity and multivariate nature of the problem, there is also a priority in using artificial neural network. In general, ANN provided accuracy and simplicity in the analysis of the diesel engine performance under test [10]. In conclusion, the performance and emissions of internal combustion engines can be easily determined by performing only a limited number of tests instead of a detailed experimental study, therefore saving both engineering effort and funds [12].

Acknowledgement

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E-LEARNING AND ECONOMISM IN REGARD TO THE PSYCHIC HEALTH AND DEVELOPMENT OF SEAFARERS' LEADERSHIP

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Abstract
The article analyses the problems of e-learning and economism in regard to the psychic health and development of future seafarers' leadership. The research object is maritime professional development. The object has been researched at the scientific level of e-learning, economism and leadership. The research goal is identification of the problems of maritime professional development from the ideological and psychosocial point of view of e-learning, economism and leadership. Tasks are as follows: characterization of e-learning as a problem at the level of development of psychic health of the personality, revelation of protestant - Calvinistic - ideology as the eventual factor of maritime economism, and description of the valuable possibility of development of future seafarers' leadership. The research methodology is based on the STCW convention, the paradigm of universal upbringing, idealism, humanism, existentialism and existential phenomenology. The universal upbringing of the future seafarers is substantiated anthropologically and should be the main valuable direction of the maritime education of leadership in regard to the seafarers' work reality.
Keywords: *e-learning, economism, seafarer's personality, psychic health, leadership*

Introduction

Modern maritime professional training is based on technologies and especially on e-learning. The use of technologies must be naturally associated with psychic health of the personality. The scientists maintain that over-confidence in technology-focused professional training can raise problems in professional development and damage the person's health and abilities in social communication and socialization [20]. The education policy is seen as problematic, because of its priority of e-learning. The EU higher education conventions require the development of personality, creativity and critical thinking in particular. This goal is almost unrealistic in case the priority is not a natural and positive relationship with oneself and the teacher, but rather with e-technology. This relationship, including distance learning and web-based learning, must be harmonized.

Another dimension of this problem is maritime economism as an eventual historical result of the protestant - Calvinistic - ideology. Economism depersonalizes a human. However, the seafarer is a personality and a value of social life. The STCW convention requires training in leadership and teamwork [23]. The future seafarer must become a leader after the maritime training and development of the maritime student's leadership. But the combination of economism and leadership in terms of the socially responsible maritime business is very difficult.

It is important to organize a universal upbringing of students at the higher maritime school, at the levels of conventional requirement of social responsibility [16], and the perception of dangers of the economistic education in psychosocial reference to their long-term professional development. The European history knows a threat of misanthropic personalities at individual and socio-cultural levels. However, threats of the economistic training of maritime students, and their universal upbringing are almost not discussed in science [19].

The human is all considered as a personality, i.e. physic and spiritual entity from the integrated point of view. The universal upbringing of the future seafarer's personality, physic and spiritual dimensions and faculty is important at the level of psychic health and professional leadership.

The grade of the exploration

Technology-focused professional training and e-learning were examined in regard to personality's dignity, health and the problems of professional development [2, 9, 10, 14, 18, 20, 21, 22, 24].

The EU higher education policy was analyzed at the level of upbringing of the personality, his / her creativity and critical thinking [6, 12, 17].

The sociological data of economism as an eventual historical result of the protestant ideology was analyzed [3, 4, 5, 7, 15, 25].

It is appropriate to systemize the scientific data of e-learning as a problem at the level of the personality's psychic health, protestant ideology as the eventual factor of maritime economism and a valuable possibility as a direction of the future seafarers' leadership development from the point of view of work at sea.

Goal and tasks of the research

The research goal is identification of the problems of the maritime professional development in ideological and psychosocial reference to e-learning, economism and leadership.

Tasks are as follows:

1. Characterization of e-learning as a problem at the level of development of the personality's psychic health.
2. Revelation of the protestant - Calvinistic - ideology as an eventual factor of maritime economism.
3. Description of the valuable possibility of the development of future seafarers' leadership.

The research object is maritime professional development. The object has been researched at scientific levels of e-learning, economism and leadership.

The research methodology

The methodology of the research is based on the STCW convention, the paradigm of universal upbringing, idealism, humanism, existentialism and existential phenomenology.

Methodological attitudes are as follows:

- The STCW convention is the basis for the development of seafarers' leadership.
- The paradigm of universal upbringing highlights the development of full power of the personality.
- Idealism accentuates the spiritual nature of the human. Ideology is universal principle of human. Everyone makes decisions in regard to the own ideology. Enrichment of the personality is based on the transcendental ideal at axiological level of the maritime self-concept.
- Humanism highlights the spirituality that is an inherent basis for the development of personal spiritual culture.
- Existentialism refers to the human fear on land and at sea. Existential psychology is a cause for hope. This psychology denies an attachment to life pleasures and promotes the personality liberation and purification of his / her existence. The development of the maritime self-concept expands the horizon and helps people overcome the tragedy of existence, improve the emotional state and find unique comfort.
- The existential phenomenology highlights the self-education of valuable attitudes through the existential experience, artistic creativity, imagination, insight and reflection of values. Education through experience is very important in relation to the marine phenomenon.

The methodological type of the research is theoretically descriptive.

Methods of the research

The research methods, such as retrospective, comparative, extrapolative, heuristic analysis and meta-analysis of scientific literature, interpretation, systemization and synthesis were used.

E-learning as a problem at the level of development of the personality's psychic health

The problem of e-learning is analyzed from the point of view of the personality's psychosocial development, his / her psychic health, creativity, responsibility and critical thinking.

The secular technocratic approach was a factor that led the trend of economism. Educational outcomes are quickly achieved, often by applying the industrial criteria and the lowest cost. The laws of educational psychology are ignored. We can see indicators of the primitive objectification and exploitation of the personality at the level of behaviorism. The education system with the laws of educational psychology is not a priority of business. The professional maritime self-concept is too much limited at the New Times. Psycho-emotional stress and occupational disease are prevailing.

The scientific research and practical experience of neurobiologists, psychiatrists and educators highlight the technologically standardized and computerized education that causes impoverishment of imagination, reduction of creativity and originality, and deterioration of vision, concentration, observation, critical thinking and ability to distinguish colors, and competencies of socialization [20, 21]. When people accept superficial communication, their communication with a living man will be worse.

Direct relationship with the personality of the professional educator creates the psychosocial climate for deep analytic thinking. This relationship influences the professional self-concept and self-creation of the student at the level of formal education. Long-term and deep analytical thinking consistently determines the cognitive self-development of the personality from the psychologically didactic point of view. The images cause a rapid and short-term effect without influencing the mentioned self-development.

So, many employees of the USA major companies - *Apple, eBay, Google, Yahoo, Hewlett-Packard* - send their children to the Silicon Valley school, where computers are prohibited [18]. Great attention is given to the natural and authentic socio-cultural life of children and the academic youth.

Education policy requires the students' relationship with e-technologies. This relationship must be harmonized with the development of their psychic health. The above-mentioned factors (concentration, imagination, creativity, etc.) are extremely important for learning.

The scientists note that teenagers and adolescents become passive, impatient and are frequently unable to tell a three-minute story about the picture shown and develop their imagination hygiene, physic and psychic health [14, 21, 22]. The development of patience is very important for work at sea under extreme conditions. When e-learning technologies are used too often, personal relationship with the lecturer is weakened. However, only this relationship determines the development of the personality.

Sometimes students prefer discussions without using e-technologies. However, this is more important for socio-humanitarian subjects of the maritime studies. Technological subjects are in a closer relationship with the monitor. The computer marks the student's everyday life. So, the creation of a human relationship at socio-humanitarian subjects expresses a positive contrast to technological subjects and the student's technological everyday life, in reference to anthropology, psychic health, hodegetics and management of the maritime leader's attention (it is usual, when people are reading on the Internet, various types of additional information are distracting their attention).

Most people are visuals. Naturally, the mentioned positive contrast must be related with clear and aesthetic models or illustrations of the studied ideas in the textbooks, handouts, flipcharts, etc. at the didactic level. The development of the reflective writing competence is very appropriate from the point of view of maritime self-concept, self-creation and seafarers' work reality.

Reflective writing is creativity, which helps to realize the management of attention, liberation and management of emotions, structuring of ideas, self-orientation, imagination of the practical sense of life, finding of solace, deepening and maturing of the personality's relationship with oneself, and a hopeful planning of duties and recreation at the existential and psycho-therapeutic levels. Professor Juozas Girnius (1915–1994), the most famous Lithuanian existentialist, recommended to his students to write one line of the text daily. Writing stabilizes a human psychologically. It is important, because the seafarers experience difficulties under extreme conditions of work and specific relationships.

We can note a problematic relationship between two fundamental ideas of the Bologna process in the mentioned context in psycho-educational reference to:

– E-learning by applying new technologies;
– Development of critical and creative thinking [8].

Technology is characterized by a template and a standard. However, scientifically grounded education seeks to develop critical thinking, focusing on the non-standard, individual, innovative and responsible thinking. The Bologna process requires respect to different needs of the students.

It is natural that scientists value the Bologna process differently. They note problematic issues, which are almost eliminated from the process of studies. These issues are: the students' social isolation, the sense of learning, the abilities of self-orientation in non-standard situations at work, etc. [6, 17, 12].

Most valuable scientific works analyze the situation of *Homo informaticus* in the culture, the students' protests, technique as a depersonalized political ideology, and ambivalence of the nature of technologies that relates to the power and responsibility of a human [2, 9, 10, 24].

Therefore, e-learning must be purposefully and carefully harmonized with the natural needs of the personality and his / her health at the level of psycho-social development.

Protestant ideology as an eventual factor of maritime economism

One of the factors of economism is protestant ideology, which originated in the 16th century. The problem of the protestant ideology and maritime economism is analyzed in regard to protestant socio-cultural context, school education, influence of pietism to rocking lullabies, protestant economism, Calvinistic moral control, the importance of the universal upbringing of future seafarers, mentality of Calvinistic moralism, rigorous psychology, protestant predestination, excessive diligence, minimalism, atheistic moralism, secular technocratism, education and culture of seafarers in Eastern Europe.

A great progress in the modernization process of seafarers' training ideologically occurred in the protestant countries located in the north of the Old Continent. Protestantism has enriched the Christian heritage in Europe. On the one hand, it is very important for ecumenism. On the other hand, protestant, especially ultra-protestant approach has narrowed the human nature and purpose.

The spread of Protestantism has determined bankruptcies of schools. The deserted monasteries closed colleges and universities. Schools were neglected. Individualistic needs overshadowed social needs from the point of view of school education [15].

Decoration of the churches interiors and school education were impoverished in the protestant part of Europe. Ideological transformation of theology narrowed the approach to the personality and his / her education. The protestant pietism of the 18th century promoted religious songs, but eliminated rocking lullabies, which were characterized by maritime topics. Rocking lullaby develops the maritime spirit of a child. It promotes the natural maritime vocation from the integrated and hodegetical point of view.

The traditions of puritan upbringing in Protestantism have influenced professional training. The protestant asceticism marked the ethics and spirit of capitalism [25]. The theological doctrine of the origin of capitalism and labor was developed. This doctrine highlights the relationship of large saving and economism. Technology is emphasized. Vocational education, which is characterized by creative freedom, cultural, educational and socio-psychological value of the personality, is overlooked.

The social isolation phenomenon occurred in the protestant countries. Social responsibility was reduced to individualistic happiness, modesty and large saving. Indifferentism, religious individualism and suicidal tendencies began to manifest themselves [7].

Calvinism pioneer John Calvin - the church reformer after Martin Luther - imposed a strict moral control over public life [5]. Calvinism of the Netherlands was characterized by the disciplinary action - windows without curtains. The people had the right to see, for example, that the seafarer's wife was faithful, waiting for her husband and properly behaving at home, or that lifestyle of the families is correct and modest. When there appeared more pieces of furniture at home, the taxes were raised. The Protestants showed hospitality. They were afraid of being richer than others and of negative gossip [11].

The protestant mental isolation determined the elimination of the idea of maritime students' universal (holistic) training. However, this idea and the free expression of the personality in his / her life are very important, because the EU conventions in relation to higher education require educating professional creativity, especially creativity of the seafarers, working under extreme conditions. The scientists have found that non-standard situations are most frequent working at sea [26].

Maritime businessmen in the protestant countries of North-West Europe are characterized by psychological compensation manifesting arrogance, rigorism and desire to teach others, especially Eastern Europeans how to work and how to train a seafarer. The Dutch Calvinist tradition evolved the mentality "we know better" that stimulates the improvement of the world and predestinationally "bad humanity" [4]. It was theologically believed that a human is not justified by works but by faith. However, the fear of condemnation promoted to work in all forces. A protestant life was characterized by the industrial mentality.

On the one hand, industrial mentality was associated with success and entrepreneurship. The Netherlands, Switzerland, England, Scotland and the USA (Harvard, Princeton, Yale universities) blossomed in New Times [13]. On the other hand, the Calvinistic North-West Europe was characterized by very persistent and increased pace of work in reference to the Nordic character. However, another extreme is poverty, which is often related to laziness, for example in some southern regions of Catholic Italy.

Erosion of professional vocation and of love for work raised an egocentric tendency of salvation. It narrowed the professional vocation and satisfaction at creative work. Minimalism of the joy of life transformed a noble work to nearly a slavish duty. This duty is related to a higher stress, excessive fatigue, lack of recreation and concern about predestination. The Calvinists reduced the concept of rest to lounging. So, they invested the profit into production [3].

Later the atheistic moralism started to spread in the post-protestant Western civilization as well as in general European civilization. We have identified a negative approach of North West European seafarers and maritime businessmen to seafarers of Eastern Europe. It may indicate a latent dissatisfaction, because the seafarers of Eastern Europe are characterized by better education. Intellectually cultural climate was created on boards 20 and more years ago. The Eastern Europeans had a positive attitude to professional sense of higher education and the value of a seafarer's personality. The seafarers had a gym, a library, a concert hall, musical instruments, etc. on board.

The seafarers' recreation usually included and includes so far reading, blog writing, poetry creation, music, painting and photography in regard to their psycho-prophylactics. This is a psycho-educational counterweight to the pornographic trend, at the level of imagination hygiene. Such high level of the personal and communication culture of seafarers was not achieved in the fleets of the Northwest European protestant countries. The STCW convention requires social responsibility on board [16], but the trends of xenophobia and discrimination at the levels of sex, ethnicity, politics and religion dominate on their ships so far. The extremes of the Calvinistic Reformation influenced a decline of the value of seafarer's personality in the formation of the professional maritime self-concept.

In conclusion, the future seafarers' training should be based on the universal upbringing, because they must become leaders.

Valuable possibility of the development of future seafarers' leadership

Autonomy, independent thinking, planning, decision-making, strong and responsible operation are most important features of seafarers' leadership. Seafarer's autonomy is a part of his self-management, self-regulation, self-control and self-confidence. These features help to shape the seafarer's authority in the crew, adequately communicate with different members of the crew, create a team from the group of different members, make a positive influence and educate them. A leader takes care of own and another person's dignity.

Education of the wide maritime self-concept, regular professional improvement and flexible relationship with other people from the point of view of professional challenges is very important for leadership. These professional challenges may be strategic or may relate to the challenging maritime policy, and comparatively minor. E-learning and the reality of protestant maritime economism as a historical result of ideological development in Europe form the problem of valuable direction of the leadership development of future seafarers in the context of this article.

Higher psycho-emotional stress dominates in the working conditions of the seafarers. It is appropriate to educate the maritime students' leadership, respect for laws of the educational psychology and teach how to avoid primitive objectification of the personality at the level of behaviorism. The personality must unfold freely. A man is alive not by bread alone. Socio-cultural education of maritime students helps to harmonize physical and spiritual elements.

Technologically standardized and computer-based training is very important. However, it has limits in regard to psychosocial education. The leader must have interpersonal and multi-cultural competences and be able to properly communicate with oneself and others. People are living beings, but not robots. Psychosocial education helps to develop imagination, creativity, observation and critical thinking. Every human has aspiration for self-realization in reference to naturally and authentically socio-cultural life.

The future maritime leaders must learn to speak maritime English and develop rhetoric skills, imagination hygiene, physical and psychic health. Technology-based education can and should be harmonized with the development of communicational competencies. The future seafarers need teachers - leaders, especially older seafarers, whose leadership is characterized by authority in a positive sense from the point of view of the maritime students.

The seafarers experience difficulties at the extreme work and relationships on board. It is very appropriate to develop the reflective writing competence in regard to the leadership self-education. The traditional blog writing as a natural silent self-expression under the conditions of loneliness is an effective measure of self-management. It was mentioned earlier, that reflective writing is a creativity that helps to realize management of attention, liberation and management of emotions, structuring of ideas, self-orientation, imagination of the practical sense of life, finding of solace, deepening and maturing of the personality's relationship with oneself, and hopeful planning of duties. These functions are very important at the cognitive level and can psychologically stabilize the personality.

The future maritime leader must develop relevant competencies of creativity in non-standard situations, manage the psycho-emotional stress and bravely take responsible actions. So, it is appropriate to develop critical thinking of maritime students alongside with e-learning and its standard. Critical thinking is innovative, responsible and integrated. The studies of adequate and positive philosophy of the personality and psychological mechanisms of leadership are important.

Maritime students note that learning with a simulator does not develop responsibility, because "nothing happens by mistake". The future seafarers are permanently taught to look around on board and only then trust devices, which are always far overdue, at the level of professional practice [1]. The modern and classical paradigms are applied at the level of the sense of learning in regard to the integrated upbringing of students. The modern paradigm highlights e-learning and a simulator training. The classical paradigm expresses valuable and experiential education. The students can develop universal and integrated (personal, valuable, psychosocial and special-professional) competencies and achieve results of higher maritime studies.

The maritime sector enhances economic growth at the global level. It may be the most important condition for the development of civilization. However, not ships, but people carry cargo. Their characteristics, quality of performance and personal attitude (towards themselves, others and work) determine development and welfare of the whole maritime sector. The tendencies in economism (when saving becomes more important than the conditions of the seafarers' training, working, recreation and social guaranties) damage the whole maritime economic system.

The seafarer is a personality who has his / her own life history and experiences, develops his / her career and dreams of the future. The training of the seafarer's leadership, which is characterized by the motto - *as soon as possible and as much as possible,* is anthropologically impossible. It is very important the ideology of development of the future seafarer, sea captain and crew leader, which is characterized by democratic orientation. It is the leader who can manage emotions at the cognitive level, be patient and able to motivate and ensure discipline.

It is not possible to universally develop the seafarer's personality following the historic ideology of the protestant economism. The personality becomes spiritually autonomic on condition that the education system helps him / her to cultivate personal confidence and trust in the maritime system, the employers and social guarantees. Education provides acceptable results only if the educational and maritime systems trust in the educators and the seafarers, and when a self-conscious person performs well unattended. Too strict control reduces creativity of the personality, self-confidence, trust in the maritime system and development of leadership. Control and supervision must be combined with trust. It is very important that the seafarers and maritime students have trust in the maritime sector and the maritime academies. So, they can estimate their personal value, take responsibility and become leaders.

A narrow approach to the personality and its development creates the slavish system and poses various risks to the maritime sector. The challenges are numerous. An increasing number of the non-Europeans, including Muslims, are working at the maritime sector. It may be very difficult to manage them. They may be completely uncontrollable at sea under extreme conditions. The maritime policies and the STCW convention require development of the seafarers' leadership. However, the maritime higher schools must be able to critically evaluate the situation in the maritime labor market and global trends. The maritime students can become free, creative and industrious personalities without extremes. So, they must be able to combine work and rest, and take care of their physical and psychic health, leadership culture, professional vocation and its development, positive sense of their freely chosen personal and socio-cultural life.

The development of leadership stimulates respect and tolerance for others. It is an important subject of the socio-humanitarian and multi-cultural education of seafarers. The development of maritime leadership in general is art. It is appropriate to help the students understand that the leader is not a super-individual and indifferent or socially insistent in the crew. He is supposed to have trust in others and never violates the privacy of others, meddling in other peoples' private lives.

Modern maritime economism is characterized by a rapid handling of cargoes, decrease in the number of crewmembers and opportunities for seafarers to go ashore. The presence on board mostly determines all their professional life. Seafarers have to do a hard work. They are experiencing a frequently unlimited regime of work and recreation, long work time, noise, vibration, change of weather conditions, isolation from their family and friends, psycho-stress and psychological terror [19].

So, investment into the anthropologically grounded conditions of the psychosocially and universally professional development of the future seafarers helps to ensure the leadership development and is appropriate as a preventive measure of higher conflicts, deliberate mutilation and suicide at sea.

Conclusions

1. E-learning as a problem at the level of the development of the psychic health of the personality expresses excessive confidence in technology. The psychic and social development may become worse. It is appropriate to harmonize e-learning with the natural needs of the personality and his / her health. The priority of the technological education is problematic in reference to the health. Global technological trends are important for the maritime higher education. However, the development of psychosocial relationships of the student with oneself and others is important, too. Only the direct personal relationship determines the development of personality. It is appropriate to adequately apply didactic measures in regard to the seafarer's personality coherence.

2. Calvinism ideology as an eventual factor of maritime economism expresses an excessive austerity and a primitive approach to a human as a dependent and permanently controlled psycho-physiological system at the New Times. The maritime leadership requires that the seafarers' training be based on the universal upbringing from the anthropological point of view. Economism as the ideology of quantity and a quick result is useful only for a short period of time. However, quality and anthropological, psychological and didactic laws are of the greatest importance in training of seafarers in accordance with requirements of personal characteristics in a long-term perspective.

3. The valuable possibility of the leadership development of the future seafarers consists of the opposition to the narrow approach to the higher maritime education in regard to economism. We need universal upbringing for the development of leadership abilities. The universal upbringing of maritime students is grounded anthropologically. It is appropriate to realize the universal maritime upbringing at the higher professional maritime education and other forms of the future seafarers' development at the level of leadership-abilities. It should be the main valuable direction of the maritime development of leadership from the psychosocial point of view of seafarers' work reality.

The theoretical results can be applied to the professional development of the future seafarers, maintaining a coherence of the technological and socio-humanitarian upbringing, at the level of the universal and at the same time differentiated higher maritime education.

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COMPARISON OF FLOWS OF LIQUID CARGO IN THE PORTS OF KLAIPEDA AND VENTSPILS

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Abstract
Nowadays development of a seaport is an important factor of economical development for all maritime countries. The purpose of every port is to be the first and to attract more and more flows of cargo. Ports of the Baltic Sea have appropriate geographical location and compete with each other. Statistical and factorial analysis of flows of liquid cargo in the ports of Klaipeda and Ventspils supports an opinion that the flows of liquid cargo in the ports are shaped by geographic location, political and economic situation of the countries, relationship with neighbouring countries, belonging to the trade unions, port specification, port development and marketing policy.
Keywords: *liquid cargo flows, port development*

Introduction

The research describes the requirements for the development of the ports, which are associated with port infrastructure – port terminals and marine transport, rail transport, road transport and their interactions [1]. So, at present, Lithuania and Latvia aims to create attractive technological, technical, organisational and legal conditions [3]. Constantly changing flows of liquid cargo in the ports of Klaipeda and Ventspils, increasing shipping, growing ships tonnage oblige to adjust the long-term port development plans. The object of research is the volume of handling of liquid cargo in the Klaipeda and Ventspils port terminals. The purpose of the research is to compare the volume of liquid cargo in the ports of Klaipeda and Ventspils.

The objectives of the research are:

1. To describe specification of the ports of Klaipeda and Ventspils;
2. To compare liquid cargo turnover in the ports of Klaipeda and Ventspils;
3. To make predictions for liquid cargo turnover in 2013.

The methods of the research: analysis of scientific literature, statistical analysis, factorial analysis, comparative analysis, correlation, regression.

The analysis of liquid cargo in the ports of Klaipeda and Ventspils on theoretical and statistical basis states that the port of Klaipeda has been leading in recent years although all existing parameters (area, capacity of liquid cargo tanks, quay length) of the port of Ventspils are better.This article reveals an opinion that the flows of liquid cargo in the port are shaped by geographic location, political and economic situation of the country, its relationship with neighboring countries, belonging to the trade unions, port specification, port development and marketing policy [18].

Similarities and differences of Klaipeda and Ventspils port specification

The ports of Klaipeda and Ventspils are the transit ports and belong to the IX East West corridor – it passes through Belarus, Russia and Ukraine, traffic of cargo flows is carried by rail, road and port. Transit cargo transportation through ports is especially difficult. Cargo is transported through several countries and territories, by various means of transport. Cargo transportation depends on many factors: macro econnomic, geographical, political, and legal [5]. Ports are not isolated from the environment; they are affected by competing ports [2]. Nevertheless, transit cargo in the ports of Klaipeda and Ventspils increase cargo volume and improve economies of the countries [16].

Comparing the ports of Ventspils and Klaipeda, the following factors were taken into account: geographical location of ports, destination, and the area of liquid cargo storage capacity, quay length and depth, liquid cargo handling companies, the railway distances. The ports of Klaipeda and Ventspils are ice free deepwater seaports on the Eastern Baltic Sea coast. This is the premise of competition between the two ports in flows of liquid cargo. Comparing the Klaipeda and Ventspils ports, it is suggested, that the Klaipeda port area is 80% larger than the Ventspils port area. Having a larger area the port of Venspils could handle more cargo than the Klaipeda port (Table 1).

Table 1. Similarities and differences of Klaipeda and Ventspils port specification [10, 19]

No.	Specification	Klaipeda State Port	Ventspils Free Port
1.	Purpose	Transit	
2.	Geographical location	Icefree deepwater seaports	
3.	Area (ha)	498	2,451
4.	Liquid cargo tank capacity (m^3)	482,500	1,500,000
5.	Liquid cargo terminal quay length (m)	2,908	3116
6.	Quay depth (m)	14.5	17.5
7.	Liquid cargo handling companies	9	9
8.	Railway distance toMinsk (km)	450	600

Liquid cargo tanks capacity, terminal quay length and depth are indicators of handling equipment, transport infrastructure and quality [12]. There is a big difference between volume of liquid cargo tanks in the Klaipeda and Ventspils ports, e.g. in the port of Venspils there are tanks more than 3 times larger than in the port of Klaipeda [9]. The length of liquid cargo handling quays in both porta are approximately similar: in the Venspils port - 3,116 m, in Klaipeda - 2,908 m. The depth of liquid cargo berth in the Klaipeda port is up to 14.5 metres, and the depth of berth in the Ventspils port is from 11.5 to 17.5 metres. The depth of quay in the Klaipeda port is less than in the Ventspils port but in order to increase the depth of the existing quay of the port the additional investment would be the only solution since depth of individual quay is not possible, and in order to deepen the harbour waterfront, it must be reconstructed. Stevedoring companies plays a key role in handling process as they carry out cargo handling operations and attract port shipping lines, so stevedoring companies in the port are the main port elements [4]. The ports of Klaipeda and Ventspils have the same number of companies - 9, which carry out handling of liquid cargo. The handling technology of these companies is different, equipment and cargo traffic differs. The form of cargo-handling equipment employed is basically determinated by the nature of the actual cargo, the type of packing used and the environment in which it operates such as modern computer-controlled warehouse [2].

In summary, parameters of the port of Ventspils, significant liquid cargo handling, are more favourable than those parameters of cargo handling of the port of Klaipeda. However, the analysis of the total turnover (Figure 1) shows, that the turnover of the port of Venspils from 2008-2012, is declining in comparison with the port of Klaipeda.

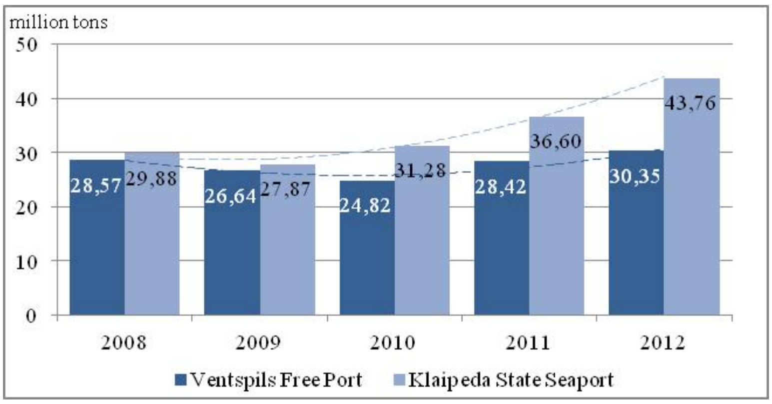

Figure 1. Klaipeda port (with Butinge terminal) and Ventspils port cargo turnover 2008-2012 [10, 19]

All shipments having the same origin and destination points and moving on the same mode are not necessarily in transit for the same length of time due to the effects of weather, traffic congestion, number of stop-offs, and diffences in time to considate shipments. Transit time variability is a measure of the uncertainty in carrier performance [8]. The Klaipeda port has more than 80% of the cargo flows from or to Belarus, due to the distance between Klaipeda and Minsk: cargo transportation by rail 450 km (Table 1). From Ventspils to Minsk the length of railway line is 600 km, the distance is 1.3 times longer. Moreover, transporting cargo from KSS to the territory of Belarus, more favourable railway rate is established. Thus, the cargo from KSS to the territory of Belarus is much faster and cheaper in transportation, and it attracts the cargo flows from this country, comparing to the Ventspils port on this route.

The creation of favourable conditions is achieved by endeavouring to make the port area itself as accessible as possible (maintaining the draught of channel, etc.) and by minimising the length of a ship stay in the port (communication technology, etc.) but also by controlling external influencing factors as much as possible [6]. Intermodalism changes the nature of port investment. Ports are used to invest for the benefit of the entire country [7]. So, the ports of Klaipeda and Venspils make development plans, for example, the Klaipeda port has been implementing the project of building LNG terminal (2010-2014) which will help port to attract more flows of cargo [10]. Based on the capacity of the terminal the elements of the terminal should be chosen: quay length and depth at the berths, terminal equipment, etc. [15].

So, the similarities of the ports of Klaipeda and Ventspils which make influence on liquid cargo handling, are geographical location, purpose and liquid cargo handling companies, the differences are status, liquid cargo quay depth, area of the liquid cargo tank capacity and rail distance to Minsk.

Statistical analysis of liquid cargo volume in port of Klaipeda and Ventspils

The statistical analysis of flows of liquid cargo in the ports of Klaipeda and Ventspils was compared between indicators of descriptive statistics (average minimum, average maximum, and median), base and the chain statistical indicators. These parameters describe trends in the growth of liquid cargo flow. The assessment rates set target from 2003 to 2012 period. Base year was selected in 2003, because this year the flow of liquid cargo was similar (Figure 2), and since 2004 the cargo flow has begun to change.

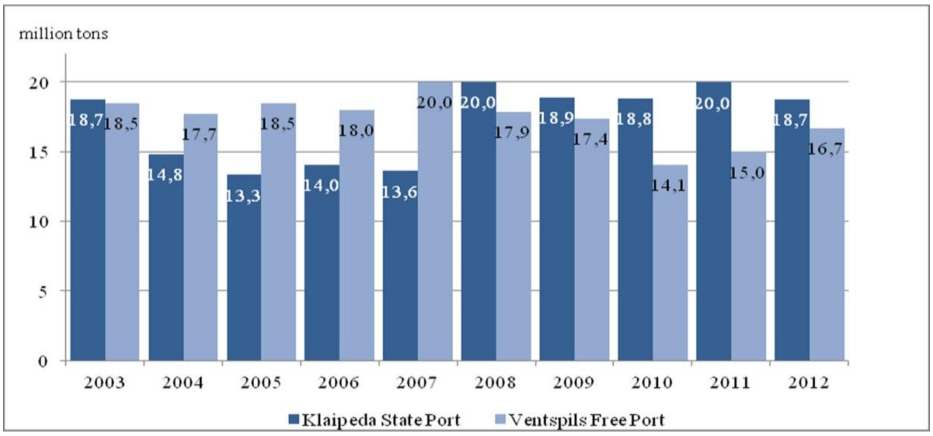

Figure2. Comparison of liquid cargo flows [10, 19]

The flow of liquid cargo in the Klaipeda port during the period of 2003-2007: decreased – in 2007 compared with 2003 turnover decreased by 27%, but in Ventspils – increased by 8% (Figure 2). The total handling of liquid cargo in the port of Ventspils is 23% higher than the volume of handling of liquid cargo in the Klaipeda port. The situation has changed since 2008: results of liquid cargo handling in the period from 2008 to 2012 in the Klaipeda port have been growing rapidly – increased by 32% compared with 2007 and just in 2012 liquid cargo flows slightly decreased. In the period of global economic crisis, economy of Lithuania and Latvia had the emergence in 2008. The liquid cargo in the Ventspils port decreased significantly (30%) in 2008-2010 (from 17,864.8 to 14,062.8 thousand tons). However, visible growth trend of liquid cargo flows in the Ventspils port during 2011-2012: from 14,982.8 to 16,690.3 thousand tons, but the cargo flows in the Klaipeda port remains higher (Figure 2).

Tendencies of cargo flows volume analyzed by chain statistical indicators. The chain of absolute and relative change shows fluctuation of handled liquid cargo volume (Table 2). Data in Table 2: base year 2003, liquid cargo volume, empirical data, collected from port statistics reports [11, 17]; relative change (increase or decrease, with minus) – in load percent of the change in.

Table 2. Base rates of liquid cargo flows in port of Klaipeda and Ventspils [10, 19]

Year	**Liquid cargo volume, thousand t**		**Relative change (increase, - decrease), %**	
	Klaipeda State Seaport	**Ventspils Free Port**	**Klaipeda State Seaport**	**Ventspils Free Port**
2003	18,748.3	18,489.3	base	base
2004	14,801.0	17,714.3	-21%	-4%
2005	13,341.4	18,484.6	-29%	0%
2006	14,046.6	17,989.4	-25%	-3%
2007	13,613.3	20,018.9	-27%	8%
2008	20,023.7	17,864.8	7%	-3%
2009	18,903.1	17,369.3	1%	-6%
2010	18,826.6	14,062.7	0%	-24%
2011	19,981.4	14,982.8	7%	-19%
2012	18,746.3	16,690.3	0%	-10%

According to comparative analysis every year with base year (Figure 2, Table 2):

in 2004 the rate of the absolute growth in both ports was negative, but the decline was the largest in the Klaipeda port – 21% while turnover of the Ventspils port decreased only to 4%;

in 2005 Klaipeda port experienced the largest decrease in all 9 years -29%, while Ventspils experienced such a small decrease in turnover, which didn't affect indicators (0%);

in 2006 handling capacity of the Klaipeda port continued to decline and the rate of reduction was 25% and handling in the Ventspils port also had slight decrease (-3%);

in 2007 handling in the Klaipeda port decreased to -27%, cargo handling in the Ventspils port increased by 8%;

starting from 2008, cargo trends of the Klaipeda port and the Ventspils port have changed to the contrary – cargo handling in the port of Klaipeda began to increase rapidly and in the port of Ventspils bagan to decrease;

during the period from 2008 to 2012 handling handling in the Klaipeda port reached the largest absolute increase to 7% and in the port of Ventspils it has achieved the lowest absolute increase -24%.

The Ventspils port statistical indicators were higher in 2004-2007, and in the Klaipeda port – in the year 2008-2011.The reason for decreasing of liquid cargo volume in the Ventspils port was due to the oil supply pipeline suspension. The official reason for termination of oil supply was Russian cargo transport policy and oil diversion to the port of Primorsk. Considering the fact that the price of oil on the market was extremely high and Russia's lack of oil export capacity, it could be concluded that the crisis situation was made artificially, in order to influence the Latvian oil transit company privatization.

Dynamics of changes of liquid cargo volume in the Klaipeda and Ventspils ports is characterized by descriptive statistics indicators – average minimum, average maximum and median (Figure 3).

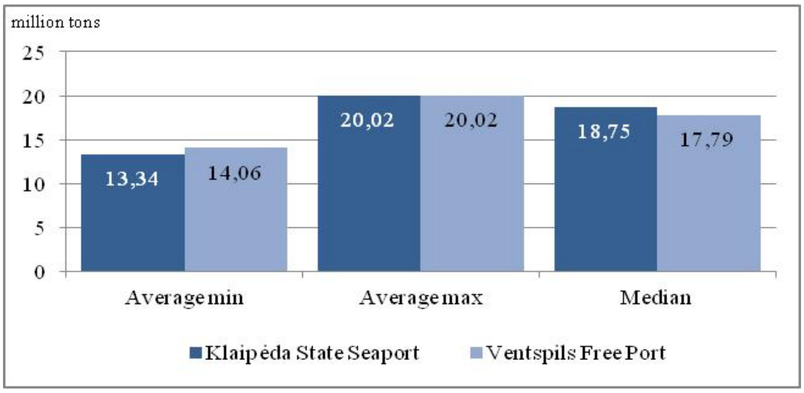

Figure 3. Descriptive statistics indicators of liquid cargo volume 2006-2012

According to dynamics of changes indicators, Klaipeda port liquid cargo flow rates over the 10 years varied from 13,341.4 thousand tons to 20,023.7 thousand tons, increase 50%, yearly averaged 16,920.6 thousand tons, at the same time median (average cargo increasing rate in period of 5 years) was no more than 18,747.3. At the same period rates of liquid cargo in the Ventspils port ranged from 14,062.7 to 20,018.9 thousand tons, the average was 17,441.8 and the median – 17,789.6 thousand tons. Descriptive statistics indicators of liquid cargo volume improve that in the Klaipeda port liquid cargo flows increase faster than in Ventspils. At the beginning of the period the flow of liquid cargo in the Klaipeda port was lower, but at the end of the period the cargo flow was slightly higher than in Ventspils.

Also, changing indicators for analysis of liquid cargo handling were collected (Table 3). Explanation of data: changing indicators – indicators that show the intensity of the change from period to period; empirical data is collected from ports reports [10, 19]; absolute gain – the difference between the two levels of dynamic queue and describes the extent to which this row exceeds the level which was adopted for the base; increase (with minus – decrease) – in load percent of the change in.

Table 3. Changing indicators of liquid cargo volume in ports of Klaipeda and Ventspils [10, 19]

Year	**Empirical data, thousand t**		**Absolute gain, thousand t**		**Increase, (-) decrease, %**	
	Klaipeda State Seaport	**Ventspils Free Port**	**Klaipeda State Seaport**	**Ventspils Free Port**	**Klaipeda State Seaport**	**Ventspils Free Port**
2003	18,748.3	18,489.3	*basic*	*basic*	*basic*	*basic*
2004	14,801.0	17,714.3	-3,947.3	-775	-21%	-4%
2005	13,341.4	18,484.6	-1,459.6	770.3	-10%	4%
2006	14,046.6	17,989.4	705.2	-495.2	5%	-3%
2007	13,613.3	20,018.9	-433.3	2,029.5	-3%	11%
2008	20,023.7	17,864.8	6,410.4	-2,154.1	47%	-11%
2009	18,903.1	17,369.3	-1,120.6	-495.5	-6%	-3%
2010	18,826.6	14,062.7	-76.5	-3,306.6	0%	-19%
2011	19,981.4	14,982.8	1,154.8	920,1	6%	7%
2012	18,746.3	16,690.3	-1,235.1	1,707.5	-6%	11%

Comparison between Klaipeda and Ventspils changing indicators (Table 3) explains the situation: in the Klaipeda port the biggest liquid cargo growth was in 2008 and amounted to 6,410.4 thousand tons, where the increase was by 47%. The least Klaipeda port liquid cargo growth was in 2004 -3,947.3 thousand tons, the decrease was 21%. The largest VFP liquid cargo increase was in 2007 and amounted to 2,029.5 thousand tons, the increase was 11%. The least Ventspils liquid cargo growth was in 2010, and the absolute increase was -3,306.6 thousand tons, the decrease was 19%. Compared the changing indicators maximum and minimum of the Klaipeda and Ventspils ports, it can be concluded that the largest increase of liquid cargo in Klaipeda was one year later than in Ventspils, but the increase was significantly greater in Klaipeda port – 6,410.4 thousand tons, and Ventspils – just 2,029.5 thousand tons, load differential is 4,380.9 thousand tons. Klaipeda port handled liquid cargo more intensively compared to Ventspils, and compared to changing indicators decrease in both ports, in Klaipeda port decrease 3,947.3 thousand tons, in Ventspils – 3,306.6 thousand tons. The difference is not significantly big – only 640.7 thousand tons.

Statistical analysis of fluctuation of changes indicators, dynamics of liquid cargo volume changes and cargo turnover chain, proves that in the Klaipeda port volume of cargo has increasing trend, increasing effectively than in Ventspils port.

Correlation models of liquid cargo volume and macroeconomical parameters for Lithuania and Latvia

The correlation analysis of flows of liquid cargo in the Klaipeda and Ventspils ports was compared between economical indicators of Lithuania and Latvia import and export, gross domestic product (GDP) and inflation rates. These parameters have the largest effect on liquid cargo handling. Correlation is statistical evidence of the indicators interface and its strength depends on the factor between minus 1 to 1 (Table 4).

According to the correlation analysis (Table 4), it can be concluded that economy of Latvia and Lithuania depends on import – GPD strongly relates on import – factor r = 0.94 (Latvia, No. 4), r = 0.96 (Lithuania, No. 9). Liquid cargo flows in Latvia correlate with inflation, factor r = 0.48 (No. 5) stronger than in Lithuania (r = 47, No. 10). This dependence can be described as follows: when cargo flows increase, inflation decreases, because cargo flows make positive economic effect. Macro index of the countries directly affects port handling capacity and opportunities to expand their business. Correlation between import, export and liquid cargo flows describes the flow direction. In Latvia model dependence of liquid cargo flows on export (r = 0.3, No. 2) is bigger than on import (r = -0.48, No. 3). Correlation characterises transit or export status of liquid cargo in Latvia. Quite different situation demonstrates Lithuanian model: strong correlation between liquid cargo flow and import (r = 0.76, No. 8), and between GPD (r = 0.66, No. 9) possibly characterises liquid cargo as an import and shows flow direction to the country.

Table 4. Correlation model for Latvia and Lithuania [13, 14]

No.	Correlation parameters	Liquid cargo	Export	Import	GDP	Inflation
			Latvia			
	Liquid cargo handling, thousand t	1	-	-	-	-
	Export, mln. EUR	**0.3**	1	-	-	-
	Import, mln. EUR	**-0.46**	-0.24	1	-	-
	GDP, %	-0.2	-0.07	**0.94**	1	-
	Inflation, %	0.48	0.05	0.04	0.32	1
			Lithuania			
	Liquid cargo handling, thousand t	1	-	-	-	-
	Export, mln. EUR	-0.5	1	-	-	-
	Import, mln. EUR	0.76	-0.05	1	-	-
	GDP, %	**0.66**	-0.07	0.96	1	-
	Inflation, %	0.47	-0.4	0.32	0.39	1

Comparing handling of liquid cargo in the Klaipeda and Ventspils port, two data time series of liquid cargo flows in ports were made, which helped to determine the changes in the loading in the ports during the same periods of time. According to analysis of data time series (Figure 4) it was found, that at Klaipeda port cargo traffic 2003-2007 dropped sharply and in 2008 began to rise, and Ventspils cargo traffic 2003-2006 ranged evenly, and since 2007 decreased rapidly and fell all time.

Changes of the liquid cargo flows (decrease and increase) are determined by economical factors as nominal GDP, export, import and inflation.

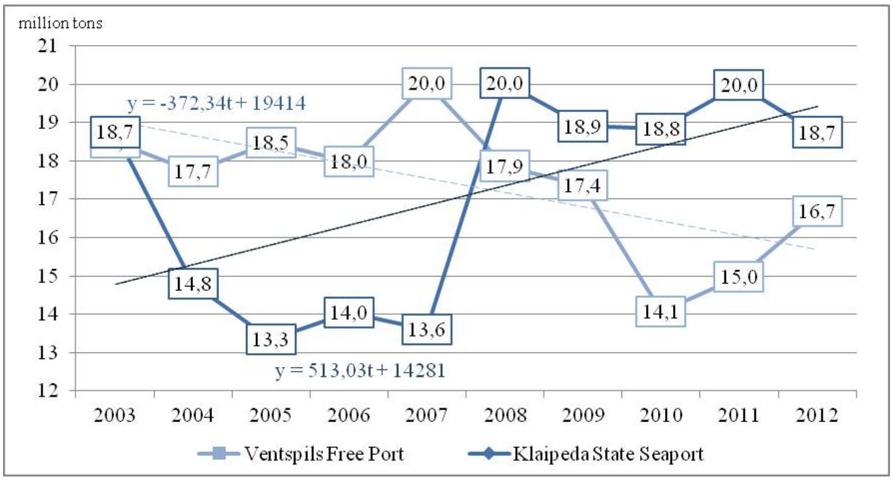

*Figure 4.*Trend analysis of liquid cargo flows in ports of Klaipeda and Ventspils 2006-2012 [4, 5]

After evaluation of changes and factors of cargo handling in the port that affect the handling, the regression equation can be created in order to predict results of each port as well as factors affecting interface.

Klaipeda port trend defined by (1) the trend equation.

$$y_{Klaipeda} = 513.03t + 14,281 \quad (1)$$

Ventspils port trend defined by (2) the trend equation.

$$y_{Ventspilis} = -372.34t + 19,414 \quad (2)$$

Obviously, (2) trend model confirms declining trend in Ventspils port. So, according to these models predictions to 2013 liquid cargo turnover were calculated.

In industrial practice, the results of forecasts are generally expressed in deterministic form, either by a value chart, or by graphical representation [20]. According to Klaipeda port forecast data (Table 6) it can be concluded, that in 2013, when liquid cargo and import increases to 7.2% and liquid cargo and export increases to 6.5%, liquid cargo and inflation increases just to 2.4% and liquid cargo and GDP increases to 3.4%. Following the Venspils port data prognosis, it may be be considered, that in 2013, when liquid cargo and import increases to 7.6% and liquid cargo with export increases to 7%, liquid cargo and inflation increases just to 2% and liquid cargo and GDP increases approximatelly to 3.8%.

Table 6. Forecast for liquid cargoes in ports of Klaipeda and Ventspils 2013 [10, 19]

Port	Parameters	Cargo quantity	Increase in comparison with 2012
Klaipeda State Port	Liquid cargo and GDP	17,012.5	3.4 %
	Liquid cargo and export	17,927.6	6.5 %
	Liquid cargo and import	17,748.7	7.2 %
	Liquid cargo and inflation	16,692.6	2.4 %
Ventspils Free Port	Liquid cargo and GDP	17,559.7	3.8 %
	Liquid cargo and export	15,767.6	7 %
	Liquid cargoand import	16,970.7	7.6 %
	Liquid cargo and inflation	16,402.7	2 %

The assumption was made that both ports will be approximately equal. However, Klaipeda port cargo forecasts is slightly better than the Ventspils port forecast and Klaipėda port will have the biggest success of handling, projected in 2013.

Conclusions

1. While comparing the ports of Ventspils and Klaipeda the following specifications were taken into account: geographical location of ports, area, liquid cargo storage capacity, quay length and depth, number of liquid cargo handling companies, railway distances to Belarus. Analysis of specifications of the port of Ventspils (area, capacity of liquid cargo tanks, quay length) proves that the port of Ventspils is more suitable for liquid cargo handling. Nevertheless, the port of Klaipeda has been leading in recent years, due to geopolitical and transport infrastructural reasons: (1) Lithuanian foreign policy towards developing relationships with Belarus, (2) Lithuania has more developed rail network, (3) in Lithuania the former economic crisis has had less impact on the port in total.

2. According to statistical analysis (absolute, relative changes, dynamic queue, averages) were set the port of Ventspils statistical indicators were higher in 2004-2007 and the port of Klaipeda – in 2008-2012. In the year 2008 it was determinated that flows of liquid cargo in the port of Klaipeda increased up to 47% (in comparison with 2007) and decreased to 11% in the port of Ventspils.The reason for decreasing of the volume of liquid cargo in the port of Ventspils was due to the oil supply pipeline suspension, related to the Russian cargo transport policy and diversion of flow of oil to the port of Primorsk. Statistical analysis of fluctuation of changes indicators, dynamics of changes of liquid cargo volume and cargo turnover chain proves that volume of cargo has an increasing trend in the port of Klaipeda and it increases more effective than in the port of Ventspils.

3. Comparing forecast of flow of liquid cargoes in the ports of Klaipeda and Ventspils it was set, that forecast of the port of Klaipeda is slightly better than of the port of Venspils and that the port of Klaipeda will have bigger success in cargo handling projected in 2013. This forecast was predicted with correlation which showed that in the ports of Klaipeda and Venspils the biggest increase would be in liquid cargo and import (KSS 7,2%, VFP 7,6%) and in liquid cargo and export (KSS 6,5%, VFP 7%).

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PECULIARITIES OF SOUND PROPAGATION IN SEA WATER

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Abstract
Influence of volume concentration of gas, surface tension of liquid and equilibrium radius of bubble to pressure value as well as density of bubble mixture were researched under barotropic equation of state. Influence of liquid compressibility to equation of bubbly liquid state in thermodynamic equilibrium was analyzed.
Keywords: *barotropic equation, volume concentration, surface tension, liquid, bubble, pressure, density*

Introduction

As physical environment, water creates certain specific difficulties for spreading of sound and light. Even in the most transparent oceanic water of green and blue color it is possible to see an object at a distance of just several tens meters. Application of radiolocation is limited due to resistance of water to penetration of electromagnetic waves.

As yet sound is the only reliable means for information transfer under water although there are problems here too. For example, submarine crew makes decisions and acts with much less information volume than aircraft crew.

Sound speed in water is about 1500 meters a second. It is much lower than speed of electromagnetic waves spreading that is why information from big distances arrives with a great delay. Besides, sound wave in water in comparison with wave in air spreads subject to high pressures and characterized by small shifts.

There are a lot of small bubbles in water column and, particularly, near sea surface. Generally, they occur owing to choppiness and other reasons. In spite of small volume, their influence to sound spreading is enormous. If, for example, a bubble with diameter 1 millimeter is the share of 1 cubic meter of water in average this decreases spreading speed 4.5 times for a depth of about 10 meters. The reason of this is a significant condensability of bubbles in comparison with water which distorts acoustic characteristic of environment.

Bubbles have an effect of dispersing centers for energy. This creates great interferences for getting exact information under water by means of sound.

Just at first sight water in ocean seems homogenous environment. In fact, its temperature, salinity, and density are not identical everywhere. Therefore, sound speed changes as well. Temperature conditions in the first hundred of meters above sea level impact spreading of sound waves especially strongly. This layer is the most dependent on season, time of day, cloudiness, wind speed and other meteorological factors. Temperature leaps here could be so sharp that whole areas of sea become almost impenetrable for sound signals.

Sound waves with comparatively small energy consumptions to their excitation are able to spread in water environment to distances of several kilometers and in favorable conditions – event to tens, hundreds and even thousands of kilometers. Besides, as a speed of sound spreading in water is approximately 200 thousand times lower than speed of radio waves spreading a length of sound wave will be 200 thousand times less than radio wave length with the same frequency. Consequently, overall dimensions of hydroacoustic antenna will be quite acceptable for location on vessel. Therefore, hydroacoustic means will have exceptional role for submarine observation in near future if, of course, humanity does not reveal any unknown kind of energy capable for transfer in water to more distances.

In connection with the mentioned the results obtained while solving of the problem on influence of vibratory effect to speed of spreading and attenuation in bubble environments are extremely important while tool control of terms of vessel traffic control. Equation of bubbly liquid state has to be deduced for solving of these problems.

Description of research

If volume content of bubbles in a unit of mixture volume $\alpha_2 \sim 1\%$, stable bubble structure of environment will form. Typical peculiarity of such liquid with general pressures when real density of dispersed phase ρ_2^0 much more less than real density of carrying phase ρ_1^0 is high average density:

$$\rho = \alpha_1\rho_1^0 + \alpha_2\rho_2^0 \approx \alpha_1\rho_1^0 = (1-\alpha_2)\rho_1^0,\ (\alpha_1 + \alpha_2 = 1) \qquad (1)$$

closely approximated to density of carrying phase due to $\rho_2^0 << \rho_1^0, \alpha_2 << 1$, subject to high (in comparison with pure liquid without bubbles) compressibility [4,6].

Gas compressibility is much higher than liquid condensability. Therefore, mixture compressibility is defined by gas compressibility in bubbles and liquid compressibility could be neglected that is liquid would be considered incompressible:

$$\rho_1^\circ = \rho_{10}^\circ \qquad (2)$$

Let us assume also that mass of gas dissolved in water could be neglected in comparison with liquid mass. Then, subject to (1) we will get:

$$\rho = (1-\alpha_2)\rho_{10}^0 \qquad (3)$$

Let us deduce barotropic equation of bubble mixture state $p = p(\rho)$ which is in thermodynamic equilibrium. The latter means:

$$v_1 = v_2,\ T_1 = T_2,\ p_1 = p_2 = p$$

Here, v_i, p_i, T_i $(i = 1,2)$ – speed, pressure and temperature of *i* phase. Indexes 1 and 2 mean parameters relating liquid and gas, relatively.

Let us consider that bubbles have equal radius and spread evenly for volume [4,6]. Two-phase environment of bubble structure differs from other two-phase environments by the fact that thermal capacity of carrying phase $\rho_1 c_1$ exceeds significantly thermal capacity of dispersed phase $\rho_2 c_2$ due to predominant mass content of carrying phase in unit volume [4,6]:

$$\rho_1 c_1 >> \rho_2 c_2 \quad (c_1 \sim c_2, \rho_1/\rho_2 >> 1)$$

In this regard, liquid is a thermostat and has permanent temperature that is

$$T_1 = T_2 = T_0$$

Then, from Clapeyron-Mendeleev equation for gas in bubbles

$$p = \rho_2^\circ R T_0$$

follows

$$\frac{p}{p_0} = \frac{\rho_2^\circ}{\rho_{20}^\circ} \text{ or } \rho_2^0 = \rho_{20}^0 \frac{p}{p_0} \qquad (4)$$

Here, p_0 and ρ_{20}° is pressure and density of gas in initial state. Volume content of bubbles α_2 is connected with number n of bubbles with radiuses R in unit volume of gas-liquid mixture by formulas

$$\alpha_2 = \frac{4}{3}\pi R^3 n \qquad (5)$$

As processes of crushing, adhesion and formation of new particles are absent in gas-liquid mixture, numerical concentration of dispersed particles in one-velocity dispersed mixture is proportional to mixture density that is

$$\frac{n}{n_0} = \frac{\rho}{\rho_0} \qquad (6)$$

From ratios (5) and (6) it follows that

$$\alpha_2 = \alpha_{20}\left(\frac{R}{R_0}\right)^3 \frac{\rho}{\rho_0} \qquad (7)$$

Let us assume that gas is insoluble. Bubbles dynamics subject to solubility of gas in liquid was considered in [2, 3, 5,7]. Gas solubility will not practically influence equation of gas-liquid mixture state. This is explained by the fact that due to $\rho_2^0 << \rho_1^0, \alpha_2 << 1$ mass concentration of dissolved gas is significantly less than mass concentration of liquid.

Let us consider equation of conservation of individual insoluble bubble mass:

$$\frac{d}{dt}\left(\frac{4}{3}\pi R^3 \rho_2^0\right) = 0 \text{ or } \frac{\rho_2^0}{\rho_{20}^0} = \left(\frac{R_0}{R}\right)^3 \qquad (8)$$

If we take into account equations (4) and (8) correlation (7) could be transformed as

$$\alpha_2 = \alpha_{20} \frac{\rho}{\rho_0} \frac{p_0}{p} \qquad (9)$$

If we substitute (9) in (3), we will get state equation [1,6]:

$$\frac{\rho}{\rho_0} = \frac{1}{\alpha_{10} + \alpha_{20} \dfrac{p_0}{p}} \text{ or } \frac{p}{p_0} = \frac{\alpha_{20}}{\dfrac{\rho_0}{\rho} - \alpha_{10}} \qquad (10)$$

Dependence of dimensionless values of pressure and water mixture density with gas bubbles is stated in Fig. 1. Curves 1-4 correspond to bubble mixtures with volume content of gas 3 %; 5 %; 7% and 1 %. As it is shown from figure, while increase of pressure $p / p_0 > 1$ density of bubble mixture increases $\rho / \rho_0 > 1$ and on the contrary while $p / p_0 < 1$ $\rho / \rho_0 < 1$.

Behavior of the curves in Fig. 1 shows also that increase of volume content of gas results in growth of mixture compressibility in whole. The higher gas content α_{20}, the lower values of pressure $p / p_0 > 1$ are required for compression of mixture $\rho / \rho_0 > 1$. And on the contrary, increase of gas content α_{20} results in more pressure values $p / p_0 < 1$ required for mixture exhaustion $\rho / \rho_0 < 1$.

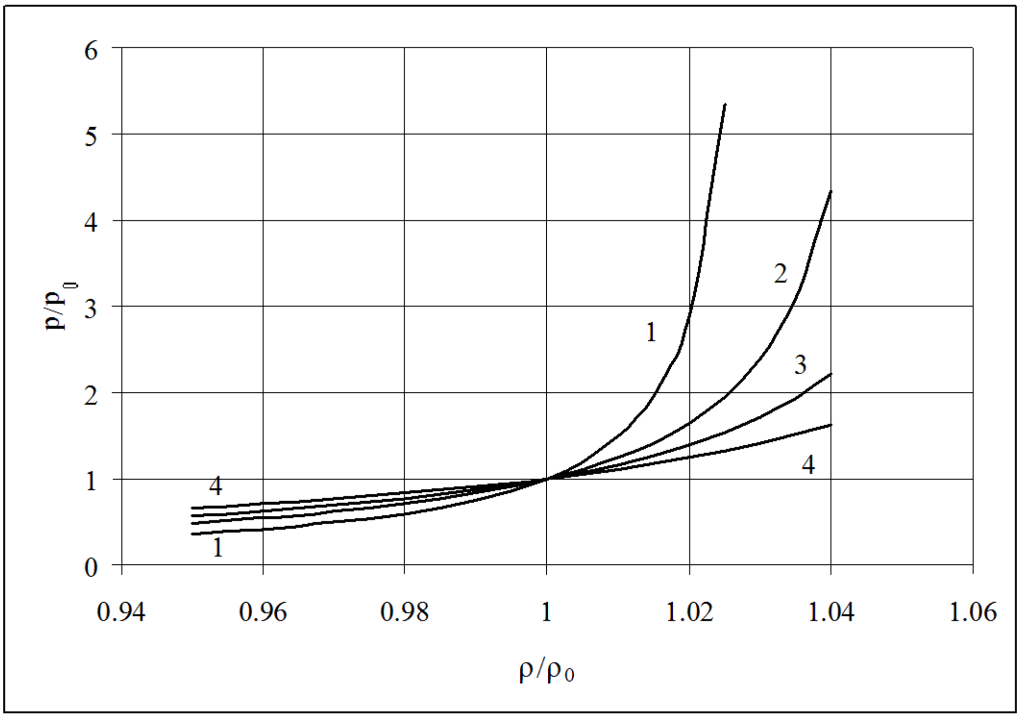

Figure 1. Dependence of pressure on bubbly water density.

Let us deduce equation of bubble liquid state in thermodynamically equilibrium approximation subject to compressibility of carrying phase and surface tension. Let us replace expression (2) to acoustic equation of liquid state:

$$\rho_1^{\circ} = \rho_{1\,0}^{\circ} + \frac{p - p_0}{C_1^{\;2}} \qquad (11)$$

Here, C_1 is a speed of sound in liquid. Then, expression (3) will take on form:

$$\rho = (1 - \alpha_2)\left(\rho_{10}^{0} + \frac{p - p_0}{C_1^2}\right) \qquad (12)$$

Let us replace volume gas content α_2 in equation (12) by its value from equation (9). Then, for insoluble gas bubble we will get:

$$\frac{\rho}{\rho_0} = \frac{\dfrac{p}{p_0} + C}{1 + C\left(\alpha_{10} + \alpha_{20}\dfrac{p_0}{p}\right)}, \; C = \frac{c_1^{\;2}\rho_{1\,0}^{\circ}}{p_0} - 1 \qquad (13)$$

Equation (13) is just equation of bubble liquid state subject to liquid compressibility. It is obvious that while $C \to \infty$ $(C_1 \to \infty)$ (13) turns into (10).

Calculations show that while small changes of densities and pressures the account of carrying phase compressibility influences weakly equation of gas-liquid environment state.

We will get one more equation of bubble liquid state subject to surface tension (Laplas pressure $2\sigma / R$) with consideration carrying phase as incompressible.

If gas volume concentration is little $\alpha_2 \approx 1$ % pressure in mixture may be approximately considered equal to pressure in liquid:

$$p = p_1 \qquad (14)$$

Then, ration between pressure of gas and liquid will take on form:

$$p_2 = p + \frac{2\sigma}{R} \qquad (15)$$

Equation of gas state (4) will be recorded as:

$$\frac{p + \dfrac{2\sigma}{R}}{p_0 + \dfrac{2\sigma}{R_0}} = \frac{\rho_2^{\circ}}{\rho_{2\,0}^{\circ}} \text{ or } \rho_2^0 = \rho_{20}^0 \frac{p + \dfrac{2\sigma}{R}}{p_0 + \dfrac{2\sigma}{R_0}} \qquad (16)$$

Subject to (3) and (7) equation regarding density will take on form:

$$\frac{\rho}{\rho_0} = \frac{1}{\alpha_{10} + \alpha_{20}\left(\dfrac{R}{R_0}\right)^3} \qquad (17)$$

Let us substitute ratio (8) instead of ρ_2^0 / ρ_{20}^0 in equation (16). Then, we will get:

$$\frac{p}{p_0} = \left(\frac{R_0}{R}\right)^3 (1 + S) - S\frac{R_0}{R}, \; S = \frac{2\sigma}{R_0 p_0} \qquad (18)$$

Expressions (17) and (18) form together parametric form of recording equation of bubble liquid state with no account taken of carrying phase compressibility but subject to Laplas pressure.

If we rule out parameter R_0 / R from equations (17) and (18), we will get the following equation of state:

$$\frac{p}{p_0} = \frac{\alpha_{20}(1 + S)\rho / \rho_0}{1 - \alpha_{10}\rho / \rho_0} - S \cdot \sqrt[3]{\frac{\alpha_{20}\rho / \rho_0}{1 - \alpha_{10}\rho / \rho_0}} \qquad (19)$$

Dependencies of dimensionless density and pressure on bubble dimensionless radius are stated in Fig. 2 and 3 calculated under formulas (17) and (18) when gas volume content is accepted equal to $\alpha_{20} = 5$ %.

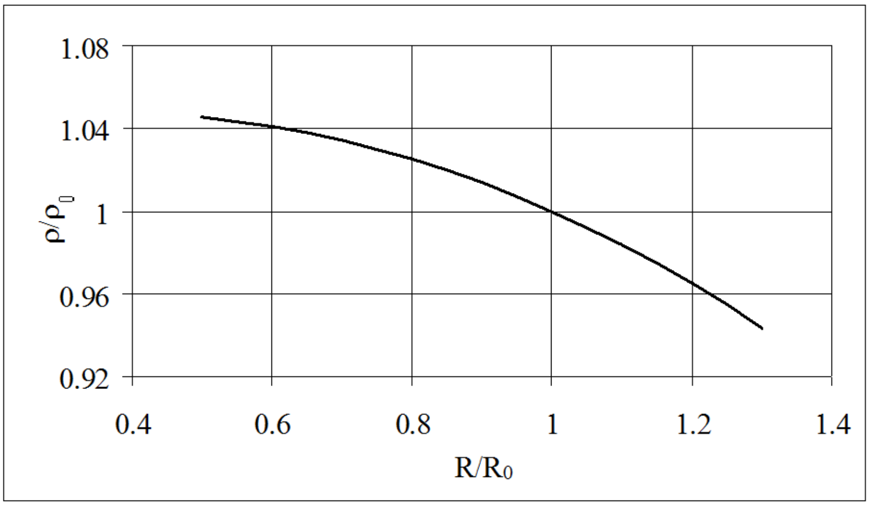

Figure 2. Dependence of mixture density on bubble size.

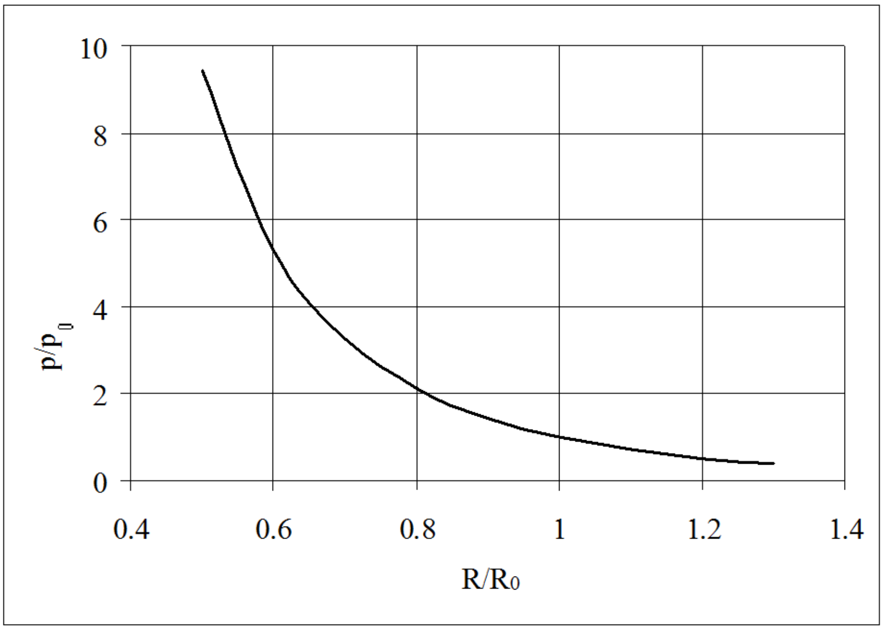

Figure 3. Dependence of mixture pressure on bubble size.

Dependence of pressure on density calculated under formulas (19) (solid curve) and (10) (dotted curve) for variant corresponding to the curves in Fig. 2 and 3 is stated in Fig. 4. Behaviour of curves shows that surface tension does not practically influence equation of gas-liquid environment state near equilibrium value of bubble $R/R_0 \sim 1$. But subject to $R >> R_0$ and $R << R_0$, role of surface tension becomes significant.

Dependence of pressure on density calculated under formula (19) for various values of S parameter is stated in Fig. 5. Curves 1-3 are built for S values equal to 2; 1; 0,2 relatively. Decrease of $S = 2\sigma / R_0 p_0$ corresponds to decrease of surface tension factor or increase of equilibrium value of bubble radius. Increase of surface tension results in increase of pressure of steam and gas mixture.

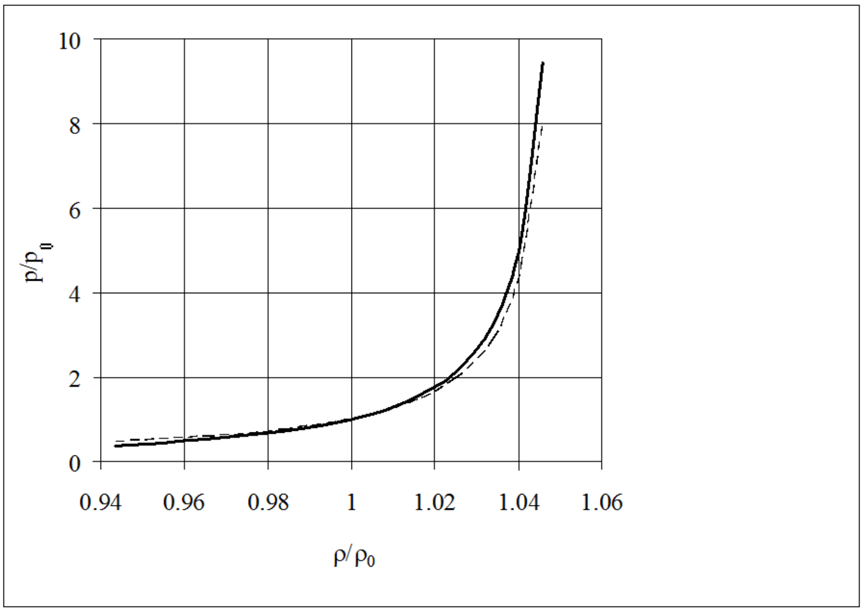

Figure 4. Dependence of pressure on bubbly water density.

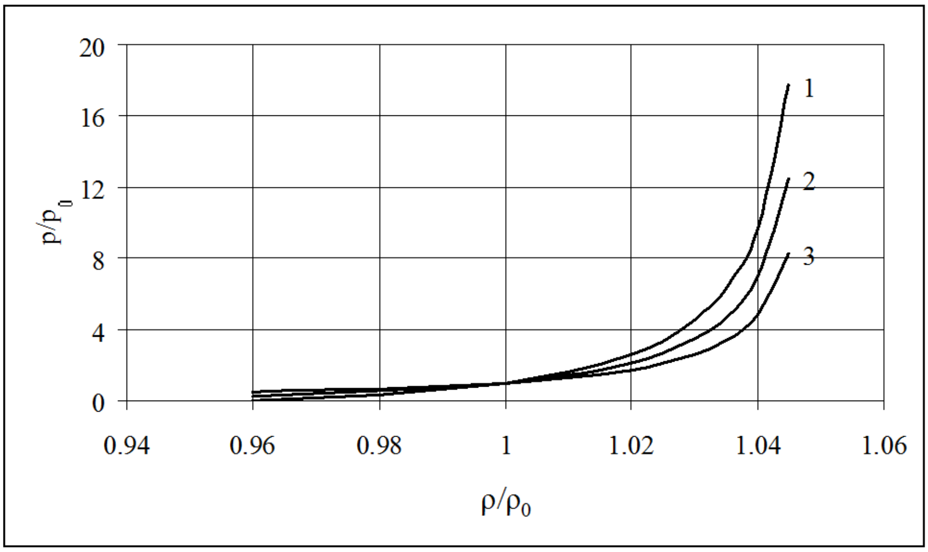

Figure 5. Dependence of pressure on bubbly water density.

Conclusions

Calculations based barotropic equation of state shows that while pressure increase, bubble mixture density increases, and vice versa.

Growth of gas volume content results in growth of mixture compressibility in whole. The more gas content, the less values of pressure are required for mixture compression. And vice versa, increase of gas content results in more values of pressure are required for mixture exhaustion.

Calculations show that subject to little changes of density and pressures the account of carrying phase compressibility influences weakly equation of gas-liquid environment state.

Surface tension practically does not influence equation of gas-liquid environment state near equilibrium value of bubble radius. But subject to significant changes of bubble radius a role of surface tension becomes significant.

Increase of surface tension results in growth of steam and gas mixture pressure.

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EXPERIMENTAL INVESTIGATIONS OF IC DIESEL ENGINE AND VGT WITH VANELESS TURBINE VOLUTE

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Abstract
Based on experimental data, the present study investigates the influence of turbine adjustment in a turbocharger with vaneless turbine volute on diesel combustion efficiency indices. Experimental investigations were conducted on the high load and low engine speed mode and also on torque and power curves modes. For these modes the influence of turbocharger adjustment with vaneless turbine volute on the diesel combustion efficiency indices was investigated. In present research only VGT adjustment was investigated, the factors like fuel injection timing and EGR were not analyzed. As a result we were able to make a comparison of the engine combustion efficiency for VGT and a common turbocharger running on different modes.
Keywords: *VGT, experimental investigations, combustion efficiency*

Nomenclature

P_e : Engine power
n : Engine speed
η_i : Engine indicated efficiency

1. Introduction

It is known that from the thermodynamic point of view, the turbocharger system is attractive because it makes use of the exhaust gas energy [1]. Thus, turbocharging systems are widespread not only in traditional internal combustion engines (such as diesels and gasoline) but also in engines running on alternative fuels such as natural gas [2, 3]. It favors the constant development of supercharger technologies.

On the other hand, internal combustion engines with non-adjustable turbochargers have acceptable fuel efficiency and emission characteristics in a narrow range of operation modes. Matching the operation of an engine and a turbocharger in a wide range of loads and rotation speeds is an effective method of improving the technical and economic indices of engines and a necessary condition for conforming to up-to-date emissions standards.

Various methods of compressor or turbine adjustment may be used to match an ICE and a turbocharger over a wide range of loads and speeds.

Following advanced research with full access to the International patent base WIPO [4], the problem of turbochargers adjustment was investigated. New electric supercharger technologies were not taken into account because they have no commercialization yet. It was established that turbine adjustment of the turbocharger is more efficient than compressor adjustment. The recent trend in turbocharger adjustment technologies is next. From 1998 up to now the major method is the nozzle ring variable geometry.

World experience shows that nozzle ring adjustment is the most effective method of turbocharger adjustment as it allows air supply tweaking to achieve the optimal engine output across the full range of operation modes: from idle speed to the maximum value. However, the main drawback of this method is a complex actuation mechanism for nozzle rings that result in a high cost and low reliability of such turbochargers.

Hence, a new method needs to be developed to allow turbocharger adjustment of centripetal turbines which would minimize the losses in turbine efficiency when changing (reducing) the flow. At the same time, the new design must offer simplicity and lower costs in comparison with the nozzle ring method and have enough adjustment depth in order to provide an optimal Lambda (the ratio of actual air-fuel ratio to stoichiometry for a given mixture) across the full operating range of the engine.

A new patented method of adjustment (control) for centripetal vane machine with vaneless turbine volute [5-7] satisfies the above requirements and has passed all the stages of "scientific implementation" from the idea up to a prototype. The basic design of the new method is shown in Figure 1. Prototype of variable geometry turbocharger is shown in Figure 2. The new method is based on the cross-section variation of the turbine volute acceleration section end *A* by means of a specially shaped element *1* located in the inlet part of the volute *2*. The adjustment is carried out by curvilinear progressive motion of the shaped element *1* in the direction of incoming gas flow or in the opposite direction, whereby the geometrical shape, location and the size of the flow area of the volute acceleration section are determined according to the curvilinear progressive motion of the shaped element. Position *I* of the shaped element corresponds to the minimal cross-section of the end of volute acceleration section A_{min} and, accordingly, to the maximal depth of turbine adjustment. Position *II* of the shaped element corresponds to the maximal cross-section of the end of volute acceleration section A_{max} and, hence, to the minimal depth of adjustment.

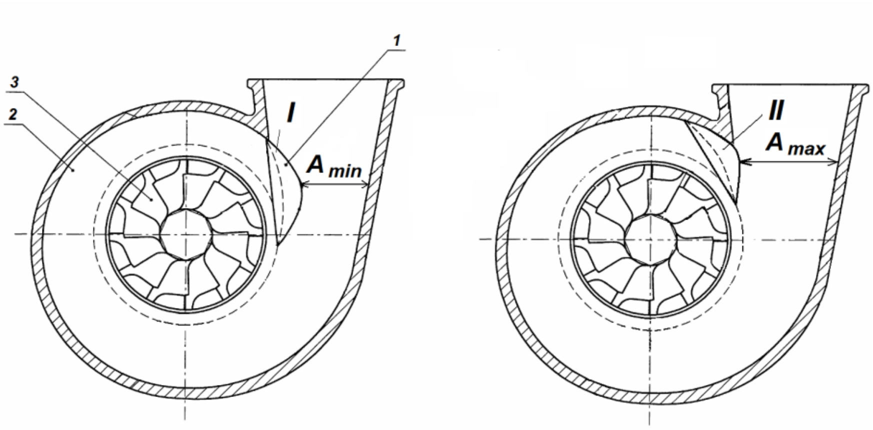

Figure 1. Method for adjustment of a centripetal turbine with vaneless volute (vaneless distributor)
1 – specially shaped element; 2 – turbine volute; 3- wheel

The influence of turbine adjustment in a turbocharger with vaneless turbine volute on a diesel indices by means of computer simulation was also conducted and described in [8]. As a result a comparison of engine indices for VGT and a commercial nonadjustable turbocharger was made.

It is also remarkable that the proposed method provides practically the same efficiency as that of a turbine with fixed geometry over a wide range of flow rate characteristic adjustments, which was proved by testing the adjustable turbine on an experimental stand [9].

The proposed method has clear advantages in comparison with the method of adjusting of turbine by the wastegate method. In comparison with the widespread method of adjusting with nozzle blades, implemented, for example, in BorgWarner Variable Turbine Geometry concept [10], Honeywell VNT turbochargers [11] or in Variable Geometry Turbochargers produced by Mitsubishi Heavy Industry Corporation [12], this method has the following advantages. The nozzle ring itself is absent and the mechanism of adjustment is much simpler. This significantly reduces the turbocharger cost and makes it more reliable in exploitation. Moreover, small size turbochargers can be easily adjusted using new method.

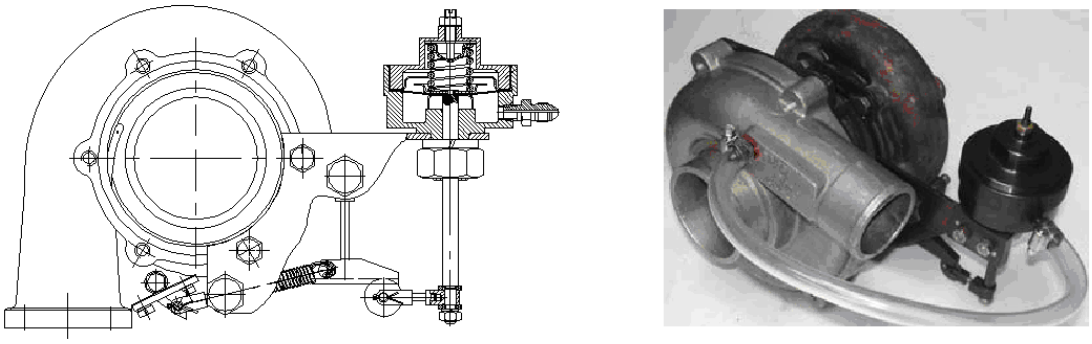

Figure 2. Prototype of variable geometry turbocharger

2. Design features of the turbocharger prototype with vaneless turbine volute

Based on the method of adjustment described above, a VGT prototype (see Figure 2, b) was created on the basis of a commercial turbocharger TKR-7H1. Four cylinder diesel engines can be equipped with the prototype. Taking into account the possibility of adjustment system installation in a commercial turbine housing of the turbocharger TKR-7H1, dependences were established between the effective cross-section area of the end of turbine volute acceleration section *A* from relative displacement of the shaped element (adjustment element) $\bar{h}$. This dependence is shown in Figure 3.

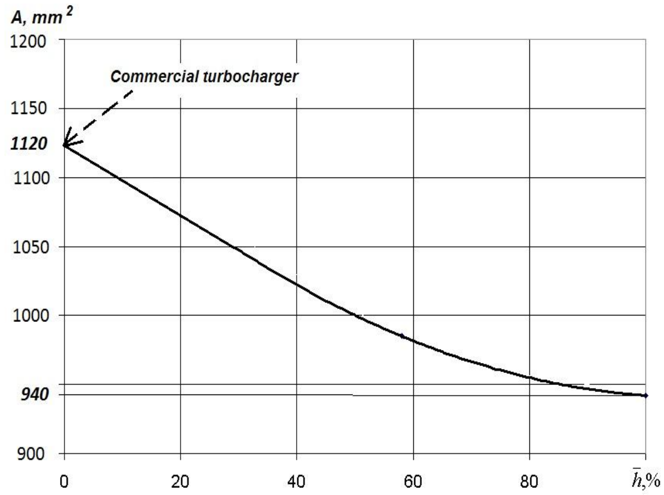

Figure 3. The dependence between the effective cross-section area of the end of the turbine volute acceleration section *A* and relative displacement of the shaped element $\bar{h}$

As seen in Figure 3, the depth of adjustment (the difference between minimal and maximal cross-section area *A* as percentage) for TKR – 7H1 is 16%. This value is limited by the possibility of installation of the adjustment elements in the commercial turbine housing but allows for a qualitative evaluation of the influence of adjustment in a turbocharger with vaneless turbine volute on the indices of diesel in various operating modes.

3. Methodology of experimental investigation

An experimental investigation was conducted on a four-stroke four cylinder turbocharged diesel engine. The short specification of the engine is shown in Table 1.

Table 1. Engine specification

Rated power	125 kW
Engine speed at rated power	2000 rpm
Number of cylinders	4 in line
Bore	120 mm
Stroke	140 mm
Boost system	Turbocharger with intercooler
Fuel delivery	Direct injection system with the BOSCH type high-pressure fuel delivery pump
Displacement	6.3 liters
Specific fuel consumption (rated power mode)	224 g/kWh
Length	1769 mm
Width	826 mm
Height	1167 mm

The engine was tested on an engine dynamometer. The specified speed was held to within ±50 rpm, and the specified torque was held to within ±2% of the maximum torque at the test speed. On the high load mode and low engine speed with P_e = 67.8 kW and n = 1250 rpm and on the torque and power curves modes, indexing of the 4th cylinder was performed as well as measurements of all main indices for the different values of the effective cross-section area of the end of turbine volute acceleration section A. An exception was made for the modes with n = 1800 and 2000 rpm. For this mode, the value of A remained intact. The reason is sufficient air supply to the cylinder delivered by the compressor of commercial turbocharger and thus no need to reduce A value (for increasing Lambda) to have an improvement in combustion efficiency.

Turbine, compressor, and turbocharger characteristics were calculated according to equations 1 to 5. All equations were taken from [8].

The initial data for defining the characteristics were obtained during tests of the diesel engine with a commercial and an adjusted turbocharger.

Turbocharger efficiency is calculated by an empirical expression as

$$\eta_{turbo} = 1{,}045 \cdot (t_{01} + 273) \cdot \left(\frac{\pi_{\hat{e}}^{0{,}2857} - 1}{1{,}119 \cdot (t_t + 273)} \right) \cdot \left(1 - \frac{1}{\pi_{\grave{O}}^{0{,}2593}} \right), \qquad (1)$$

where t_{01} is the ambient temperature in degree Celsius, t_t is the exhaust gas temperature in degree Celsius, π_κ is the compressor pressure ratio, and π_T is the turbine pressure ratio.

The compressor pressure ratio can be calculated as

$$\pi_{\hat{e}} = \eth_{\hat{e}} / p_a, \qquad (2)$$

where p_k is the boost pressure after the compressor, and p_a is exhaustion before the compressor wheel.

The turbine pressure ratio is calculated as

$$\pi_{\grave{O}} = p_T \; / \; p_{ex}, \qquad (3)$$

where p_T is the exhaust gas pressure before the turbine, and p_{ex} is the exhaust gas pressure after turbine.

Compressor efficiency can be calculated as the isentropic compression enthalpy gauge divided by the isentropic expansion enthalpy drop:

$$\eta_{\hat{E}} = -6.202 + 11.86 \cdot \pi_{\hat{E}} - 0.003001 \cdot \omega - 3.903 \cdot \pi_{\hat{E}}^2 - 0.09591 \cdot \pi_{\hat{E}} \cdot \omega + 0.0008224 \cdot \omega^2$$
$$+ 0.7655 \cdot \pi_{\hat{E}}^3 + 0.07534 \cdot \pi_{\hat{E}}^2 \cdot \omega - 0.0007262 \cdot \pi_{\hat{E}} \cdot \omega^2 + 0.0000005358 \omega^3, \qquad (4)$$

where ω is the rotor speed of turbocharger.

Turbine efficiency is calculated as

$$\eta_{\grave{O}} = \eta_{turbo} / \eta_k \qquad (5)$$

4. Experimental equipment and software used to obtain performance indicators of the experimental diesel

The following performance indicators were obtained in the course of the study: average indicator pressure p_i; indicated efficiency η_i; and in-cylinder pressure p_z. To evaluate the performance indicators, a piezoquartz sensor AVL was mounted on the engine cylinder head. An optical sensor of the crankshaft rotary angle and induction sensor for top dead center definition were also mounted. The sensor data was transmitted through an amplifier system to the PCI bus of an analog-to-digital converter (ADC) where it was registered in the Power Graph 3.2 software package [13]. Data post-processing was conducted in the mathematical modules of Power Graph and MATLAB® software. As a result, the indicated indices, the integral and differential heat generation characteristics, were obtained.

Processing of the data saved in binary files in Power Graph® was carried out using the DieselAnalyse software package [14]. The data processing algorithm is shown in Figure 4.

The DieselAnalyse software package finds the top dead center after processing input data and pressure ordinates are split into 720 values during one engine operating cycle. The average values for a set number of operating cycles (number of cycles measured for each test was optimal and equal 125 according to recommendations [14]) is found, and the mean value of crankshaft rotation speed is found for a set number of operating cycles. Interpolation and smoothing are performed. The absolute pressure is found, and pressure reference line correction is performed.

The software obtains the array of in-cylinder pressure values in a cycle, performance indicators, the law of effective heat release, and rate of pressure rise. DieselAnalyse can also save the calculated data as a MATLAB® data file for further analysis and comparison of various engine modes. Data obtained in this way can be processed in a variety of ways through powerful mathematical and graphical abilities of MATLAB®.

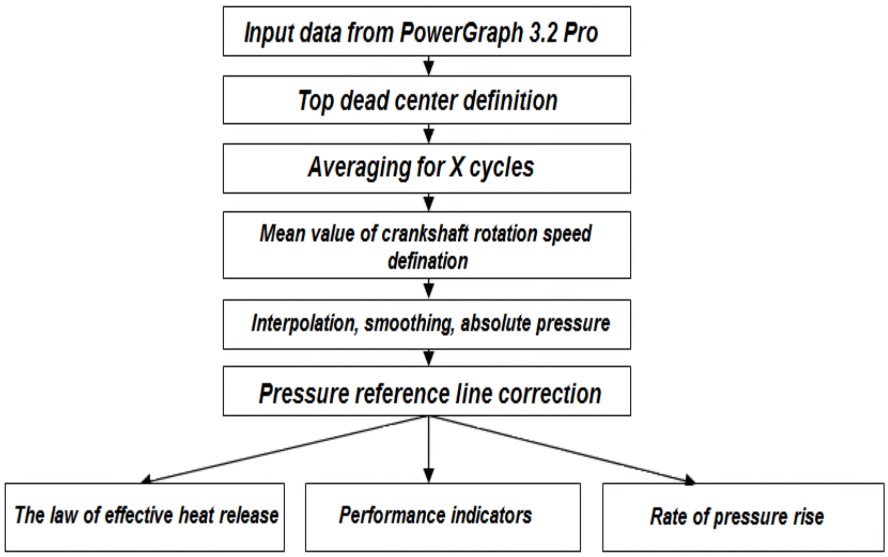

Figure 4. Algorithm of data processing

5. Results and Discussion

5.1. The influence of turbocharger adjustment with vaneless turbine volute on the diesel combustion efficiency indices and ecological characteristics on the high load mode

Operation mode with P_e = 67.8 kW and n = 1250 rpm is characterized by the high load and low engine speed for investigated diesel engine. It is known that the amount of air delivered into the cylinder affects the quality of the diesel combustion efficiency. It will be also best seen in the peak torque and power curves modes (farther described) with high load and low engine speed. The quality of the combustion efficiency in these modes significantly deteriorates due to the insufficient air supply delivered by the compressor stage of the commercial (non – adjustable) turbocharger to the cylinder.

Here, we review the special features of the combustion efficiency in the diesel engine with an adjustable turbocharger prototype with vaneless turbine volute in mode with P_e = 67.8 kW and n = 1250 rpm. The reduction of the effective cross-section area of the end of the turbine volute acceleration section A improves the in-cylinder mixture formation and combustion processes in this mode. It is confirmed by the shape of the averaged indicated diagram shown in Figure 5.

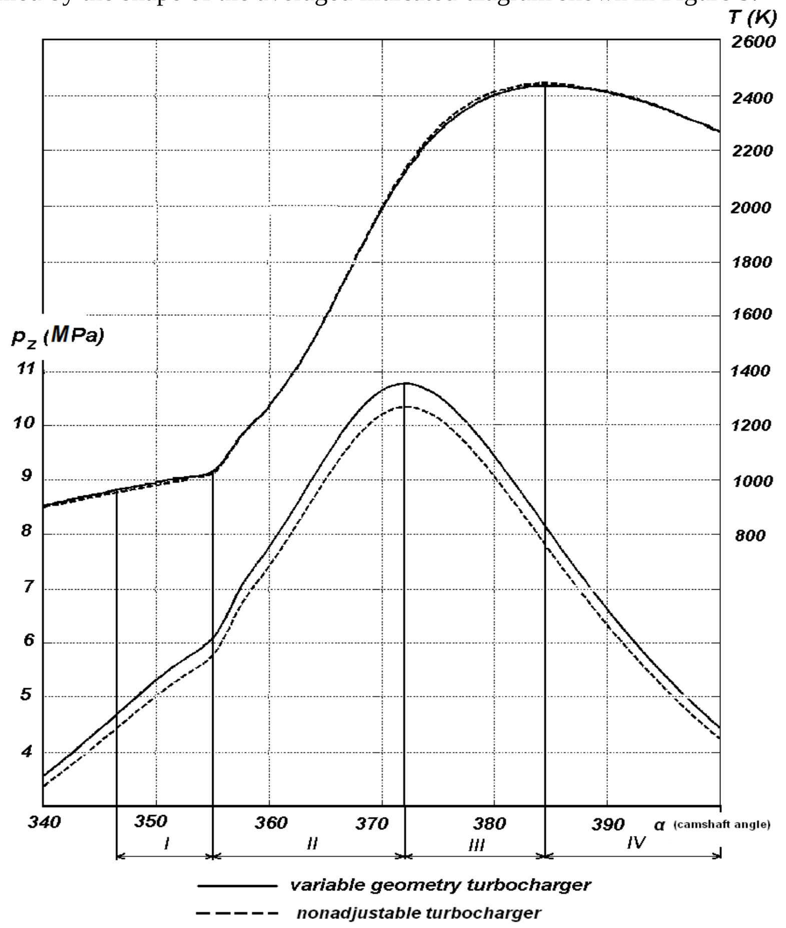

Figure 5. Dependence of temperature and pressure in the cylinder of the engine on the mode with P_e = 67.8 kW and n = 1250 rpm

The change in the main indices of the experimental diesel engine in relation to the value of effective cross-section A, is shown in Figure 6. As seen in the figure, a reduction in the value of A leads to improvement of all indices that characterize the combustion efficiency. Here, SCF improved by 4.5% g/kWh, the Lambda increased from 1.26 to 1.38 (Figure 6 *b*), and the indicated efficiency rose by 3.5% (Figure 6 *f*).

Therefore, in the case of studded mode, the efficiency of turbine adjustment with vaneless turbine volute is mostly evident in modes with high load and low engine speed. In such modes it is necessary to decrease the value of A thus increasing the Lambda and improving the quality of the combustion efficiency as seen in Figure 6.

5.2. Results of experimental investigation of diesel engine with the prototype of VGT running on torque and power modes

Experimental investigations were held on a four cylinder diesel engine specified in section 3. Engine was running on a torque and power curve modes. Adjustment of VGT was conducted in the range of engine speeds from 1250 to 1800 rpm. Two algorithms of VGT adjustment were used: to get a constant power curve for diesel engine and a constant torque curve for it.

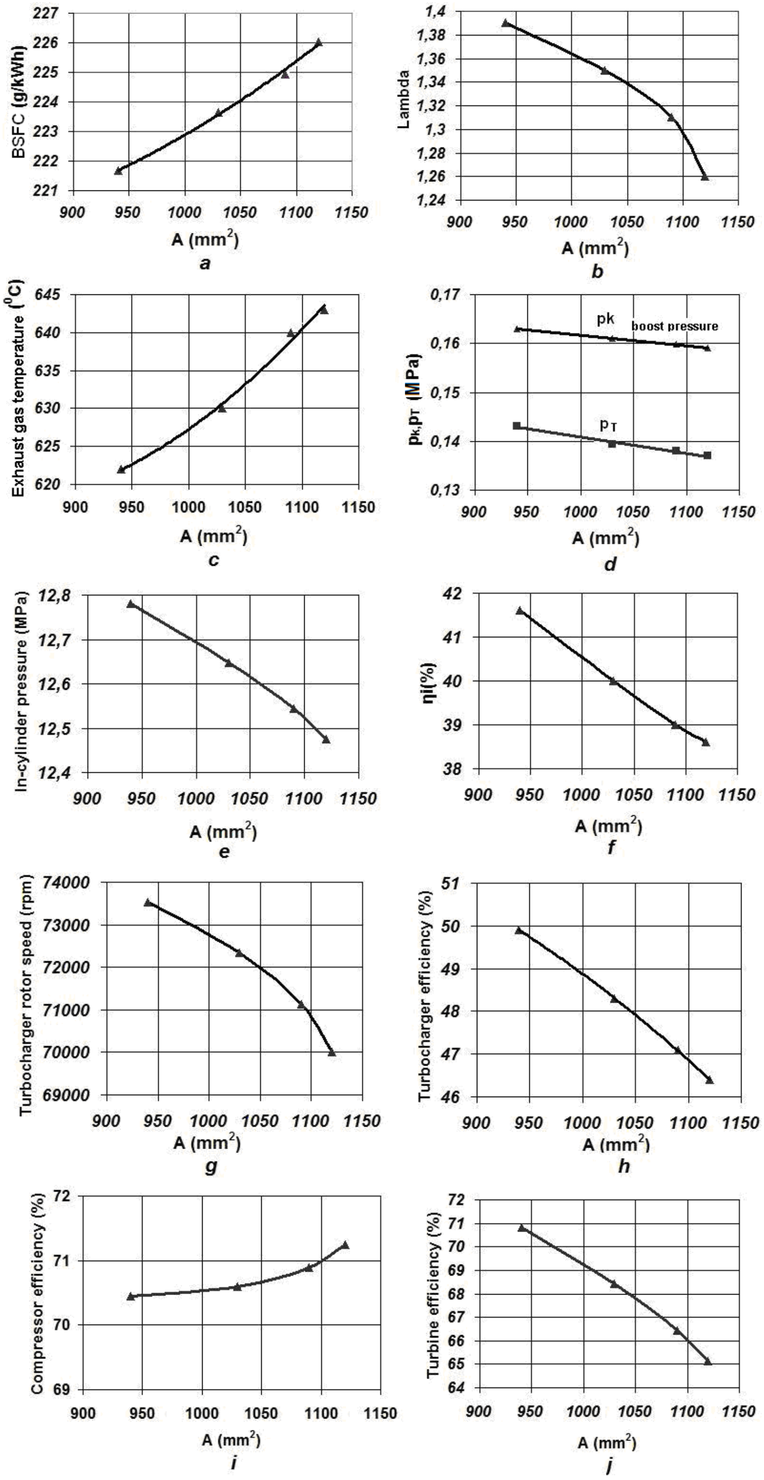

Figure 6. Dependence of main indices of experimental diesel on the value of effective cross-section *A* on the mode P_e = 67.8 kW and *n* =1250 rpm

Figure 7 shows the results of experimental investigation as dependences of main diesel indices equipped with commercial and adjustable turbochargers. Prototype of VGT turbocharger was adjusted for constant power curve. As seen from Figure 7 *b*, VGT adjustment allows not only to improve BSFC but also to increase adjustability factor by 9.7 % (from 674 Nm to 747.2 Nm). As a result the constant power curve was obtained in the range of engine speeds from 1500 to 2000 rpm. Higher power output in the range from 1250 to 1800 rpm was managed by VGT adjustment that allowed reducing exhaust gases temperature and thus high powered the engine up to the limit in exhaust gases temperature.

On the mode n = 1250 rpm VGT adjustment in comparison with commercial turbocharger has increased the boost pressure p_k for 12 kPa (Figure 7 *b*), which led to an increase in Lambda and decrease in BSFC by 5 g / kWh. At peak torque mode with n = 1500 rpm application of VGT adjustment has led to an increase in p_k (by 17 kPa), and, consequently, an increase in Lambda by 0.15 and a decrease in Break Specific Fuel Consumption by 3 g / kWh. Based on the values of Lambda and BSFC for the two regimes of torque curve described above it can be seen that even smaller increase in the value of Lambda on the mode with n = 1250 rpm leads to greater fuel economy compared to the regime of maximum torque with n = 1500 rpm. This can be explained by the following statement. The closer the value of Lambda to the lower limit (Lambda = 1), the more sensitive BSFC to an increase in Lambda.

Power curve shown in Figure 7 is typical for traction engine. For automobile engine it is more important to obtain the curve with a constant torque. Figure 8 shows the external characteristic of experimental diesel when setting the prototype of VGT for constant torque curve. As seen from Figure 8 *b* the constant torque curve was obtained in the range of speeds from 1250 to 1500 rpm by using VGT adjustment. Also, it can be seen from Figure 8 that main indices of a diesel engine with variable geometry turbocharger prototype is significantly better than those of a commercial one. This can be explained by the fact that VGT adjustment allows to achieve high Lambda in the high loads and low engine speeds modes and, consequently, improve the fuel combustion efficiency of the engine on these modes.

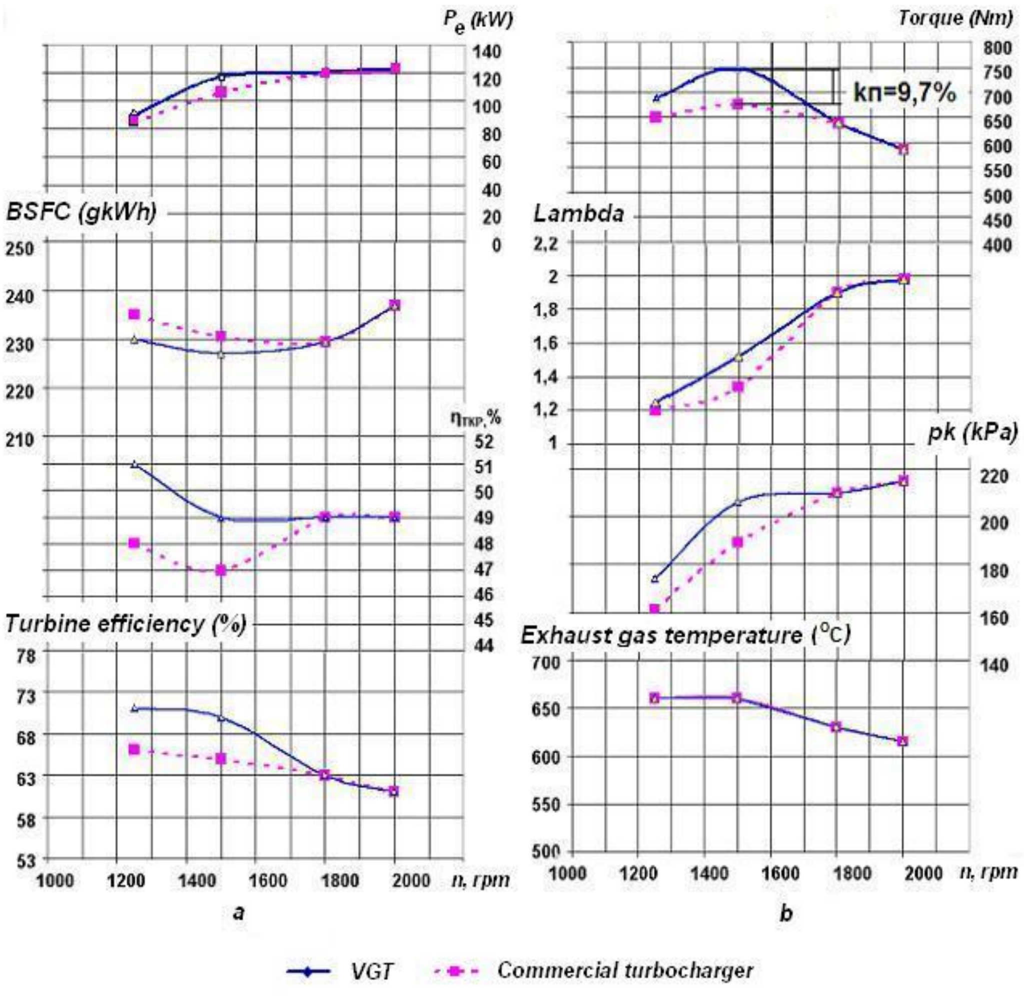

Figure 7. Dependence of main indices of experimental diesel with commercial and VGT turbocharger which adjusted for a constant power curve

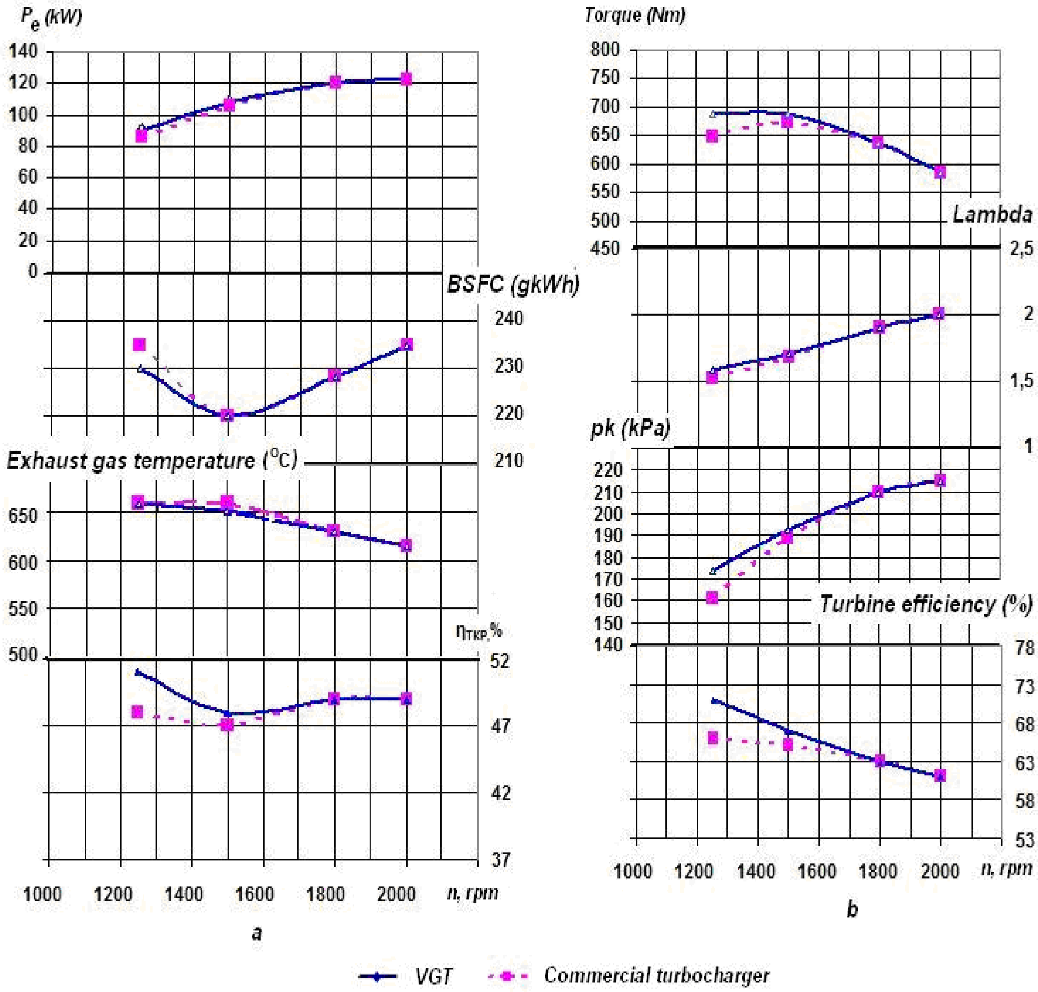

Figure 8. Dependence of main indices of experimental diesel with commercial and VGT turbocharger which adjusted for a constant torque curve

6. Conclusions

1. The present study evaluated the influence of adjustment on combustion efficiency and fuel consumption characteristics of the diesel engine in a prototype of VGT turbocharger with vaneless turbine volute. The study used special experimental techniques. Combustion efficiency main indices and averaged indicators diagram were analyzed.

2. In the case of the mode P_e = 67.8 kW and n =1250 rpm it was demonstrated that efficiency of turbine adjustment with vaneless turbine volute is most evident in external engine characteristic modes with high load and low engine speed. In this mode, BSCF was improved by 4.5 g/kWh, the Lambda increased from 1.26 to 1.38, and the indicated efficiency rose by 3.5%.

3. Dependence of main indices of experimental diesel with commercial and VGT turbocharger which adjusted for a constant power curve were established. On the mode n = 1250 rpm VGT adjustment in comparison with commercial turbocharger has increased the boost pressure and thus decrease in BSFC by 5 g / kWh. At peak torque mode with n = 1500 rpm application of VGT adjustment has led to an decrease in Break Specific Fuel Consumption by 3 g / kWh. The constant torque curve was also obtained in the range of speeds from 1250 to 1500 rpm by adjusting VGT.

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DEVELOPMENT AND APPLICATION OF SIMULATOR ALGORITHM IN ACCORDANCE WITH SHIP MAIN ENGINE AUXILIARY SYSTEMS

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Abstract
Ship engine room has a detailed structure so that it should meet all the requirements related to operating conditions simultaneously. According to naval statistical analyses, one of the most important causes of shipwrecks is human error. Because of this reason, if precautions are not applied, both engine room's complicated structure and human errors may cause bigger problems and engine breakdown which may lead to irreparable failure. An effective expert system is necessary for early intervention to prevent all kinds of engine breakdown immediately. This study aims to manage troubleshooting in main engine auxiliary systems which cover cooling, lubricating and cooling oil and fuel systems. The study is also thought to be a good reference for maintenance processes for ship engine officers.
Keywords: *engine room simulator, expert system, troubleshooting, central cooling system*

Introduction

The engine room includes; main engine and auxiliary engines such as boiler, fuel systems, lubrication system, exhaust system and cooling system. The engine room designed to be able to work for multiple needs in different operating conditions. In this point, the effects of variable operating conditions and various kind of scenarios depends on both operators and structural features.

According to the Naval Statistics Analyses; shipwrecks happened mostly due to human errors. Since human factor is very important, Naval Industry to search for safer solutions (1) (2) (3) (4). Except this motivation, especially on maneuvering positions and engine troubles in special areas also necessitated emergency solutions strategies.

Engine trouble could be explained as; if the engine or the systems being worked improperly exceeding the engine values or suddenly stopped working, and to loss all the control of engine operations. In the engine room, all engines work in an integrated manner and due to this reason, any fault happening in any system can quickly affect the whole system. A small fault may grow to a fault of the whole system to turn the situation into a life-threating danger. This shows that in any case of engine breakdown or failure, the crew needs to address the problem as quick as possible. To prevent faults happening or to resolve an existing problem, the most educated and experienced engineers must work and to determine the faults earlier, expert diagnosis system must be used. Besides, directing all the crews properly will create a safer work environment leading to the minimization of the economical losses.

In this study, expert diagnosis system is developed for cooling, lubrication and fuel systems of main engine auxiliaries. Furthermore, the developed system may also play a role in preventive maintenance processes. The main principle of diagnosis system is based on the following logic: The system will alarm any faults that may happen during an operation and serve the basic causes that exists inside the program's database to the user and the user will be able to select any one of them according to his/her experience. In the expert system, the user will determine the faults according to the selected cause and see the reasons of the fault with all the possible intervention methods. The information established to the program's database for determining the faults are derived from the catalogues and manuals supplied from the main engine manufacturers and experiences gained while operation.

Plug-in softwares, especially softwares related to engine system maintenance processes, reduce errors arising from work load and fatigue of engine operators. Addition of diagnosis modules to these softwares will prevent errors growing bigger.

Artificial intelligence softwares named PROLOG and LIPS were found to be used when a brief literature work is done about this subject [5]. In this study, information based expert system is developed using C# coding language for lubricating, cooling and fuel main engine auxiliary systems and is mentioned below with examples for main engine cooling system.

Main engine expert diagnostic and evaluation system

Main engine central cooling system

The central cooling system consists of three lines; a sea water (SW) line, a low temperature (LT) line and a high temperature (HT) line. Main engine cooling water system of ocean-going vessel is based on three-level-cooling method to cool main engine cylinders. Firstly, high temperature fresh water (HTFW) is used to cool the cylinders; after low temperature fresh water (LTFW) is used to cool the HTFW. Finally, seawater is used to cool the LTFW. HTFW cooling is the most important and the most complicated part in three-level-cooling method because it is related with lots of factors. HTFW system working diagram is given in Figure 1.

The main devices of main engine HTFW system always consist of cylinders, desalination machine of seawater, remaining steam condenser and main cooler. HTFW brings away partial heat quantity of main engine and simultaneously is heated by the main engine cylinder. Then the heated HTFW goes through desalination machine and heats the seawater. Afterwards, the HTFW passes through remaining steam condenser. Finally, HTFW goes into the main cooler and is cooled with LTFW [6].

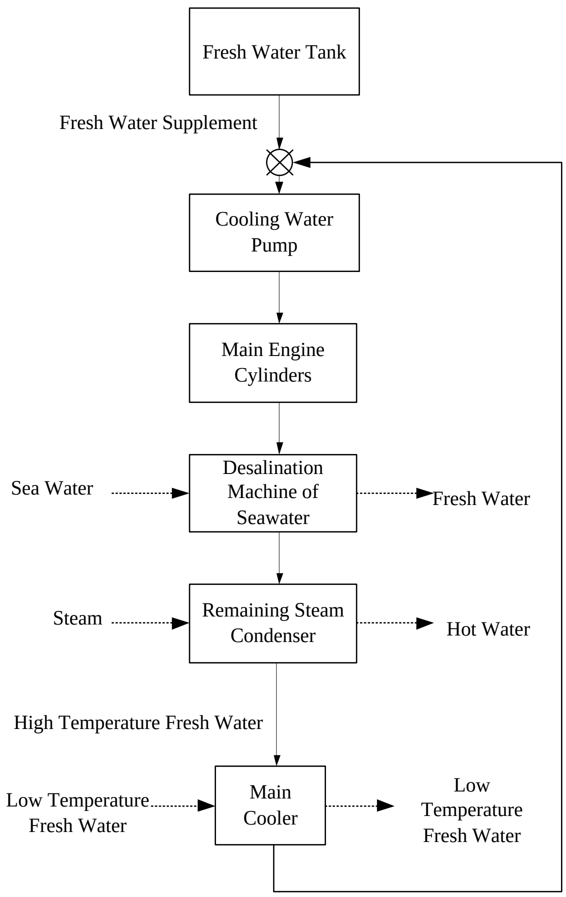


Figure 1. Structure of main engine HTFW system [6]

General structure of the system

During the development of the expert system for lubricating, fuel and cooling systems for diagnosis and evaluation, MAN B&W 7S50MC-C main engine is used which, is commonly used in merchant ocean going ships. This engine has 7 cylinders, 2 strokes, 127 rpm period and has 10.500kW power [7]. The program was developed regarding the main engine's cooling, lubrication and fuel auxiliary systems for pressure, temperature and viscosity alarm boundary values and ideal working conditions. These are shown in Table 1.

Table 1. MAN B&W 7S50MC-C alarm boundary values and optimum working conditions

						Set Points							
						Alarm				Slow Down		Shut Down	
Measuring Points		Pressure (Bar)		Temperature (°C)		Pressure		Temp.		Pressure	Temp.	Press.	Temp.
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Cylinder Cooling Water	Inlet	3.5	4.5	65	70	2.0		57	75	1.5			
	Outlet	1.0	1.5	78	82		2		85		90		95
Cylinder Cooling Water T/C	Outlet			75	80				85				
M/E Preheating				35	50			30					
Sea Water		1.9	2.5	10	32	1.0	3.5		40	0.5			
LTFW		2.0	4.5	30	36	1.0	5.5		44				
LTFW Air Cooler	Inlet	2.0	4.5	10	36	1.0	5.5		40				
	Outlet			10	63								
Lubricating Oil	Inlet	2.0	2.3	40	47	1.6		35	55	1.4	60	1.2	
	Outlet			50	60				65				
Piston Cooling Lubricating Oil	Inlet	1.4	3.0			1.4				1.2		0.8	
	Outlet			50	65				70		75		
Lubricating Oil T/C	Inlet	1.5	2.2			1.2							
	Outlet			70	90				95		120		
Cylinder Lubrication	Inlet	40	50	40	60	35	60		70				
Main Bearing Lubrication				55	70				75		80		90
F/O After Filter	Inlet	7	8	120	130	6.5		100	150				

FO Viscosity (CST)		Alarm	
Min.	Max.	Min.	Max.
10	15	7	20

The general flow diagram of the expert system is shown in Figure 2.

Main engine central cooling system alarms

In accordance with the observations made on engine room automation system that has MAN B&W 7S50MC-C main engine; alarms that M/E central cooling system has, are determined. Eleven main alarms are identified and taking notice of the conditions of high, low, low – low, high – high alarms; a total of twenty three alarms exist in the program. These alarms are referred below and they are identified as F1 - F23. F, at the beginning of the alarm code is due to the capital letter of the word "failure"[10].

- F1: Main Engine (M/E) Cylinder Cooling Water High Inlet Temperature
- F2: M/E Cylinder Cooling Water Low Inlet Temperature
- F3: M/E Cylinder Cooling Water High Outlet Temperature

- F4: M/E Cylinder Cooling Water Outlet Temperature High High (Slow Down)
- F5: M/E Cylinder Cooling Water Low Inlet Pressure
- F6: M/E Cylinder Cooling Water Inlet Pressure Low Low (Slow Down)
- F7: M/E Cylinder Cooling Water High Outlet Pressure
- F8: Cooling Water High Temperature Turbo Charger (T/C) Outlet
- F9: M/E High Temperature Fresh Water (HTFW) Low Level Expansion Tank
- F10: M/E HTFW High Level Expansion Tank
- F11: High Sea Water Pressure
- F12: Low Sea Water Pressure
- F13: Sea Water Pressure Low Low (Slow Down)
- F14: High Sea Water Temperature
- F15: M/E Low Preheating Temperature (Don't Start the Engine)
- F16: Low Temperature Fresh Water (LTFW) Low Level Expansion Tank
- F17: LTFW High Level Expansion Tank
- F18: LTFW High Temperature
- F19: LTFW High Pressure
- F20: LTFW Low Pressure
- F21: M/E LTFW Air Cooler High Inlet Temperature
- F22: M/E LTFW Air Cooler Low Inlet Pressure
- F23: M/E LTFW Air Cooler High Inlet Pressure

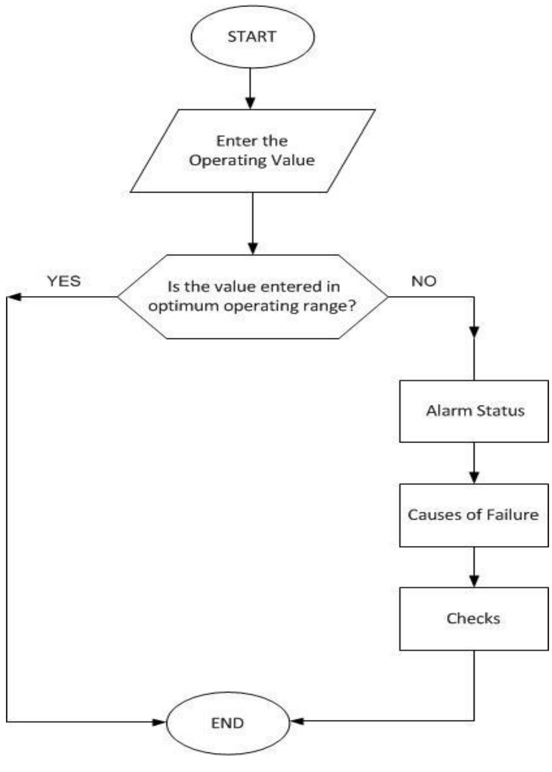


Figure 2. General flow diagram [10]

Causes of failures

The causes of the failures are coded as C1, C2, C3, ..., Cn and controls and interventions that must be made in accordance to these causes are coded C1A1, C1A2, ..., C1An. This coding system is shown and exemplified with an alarming condition that is given below. F is the alarm condition in the system that is explained before and C refers to the reason of the alarm and A is the order of the action that must be made to resolve the alarming condition.

F11: High sea water pressure alarm

Figure 3 shows the flow diagram of the sea water pressure alarm according to developed software.

F11C1: Pressure monitoring device failure.
C1-1: Pressure transmitter failure (Mechanical failure in pressure switch).
C1-2: Feedback fault in pressure monitor, electronic failure.
F11C2: Discharge valve is semi-closed.
F11C3: The occlusion that prevents the flow of sea water after pump on sea water line.
F11C4: Improper installation of LT cooler plates during cleaning or maintenance.

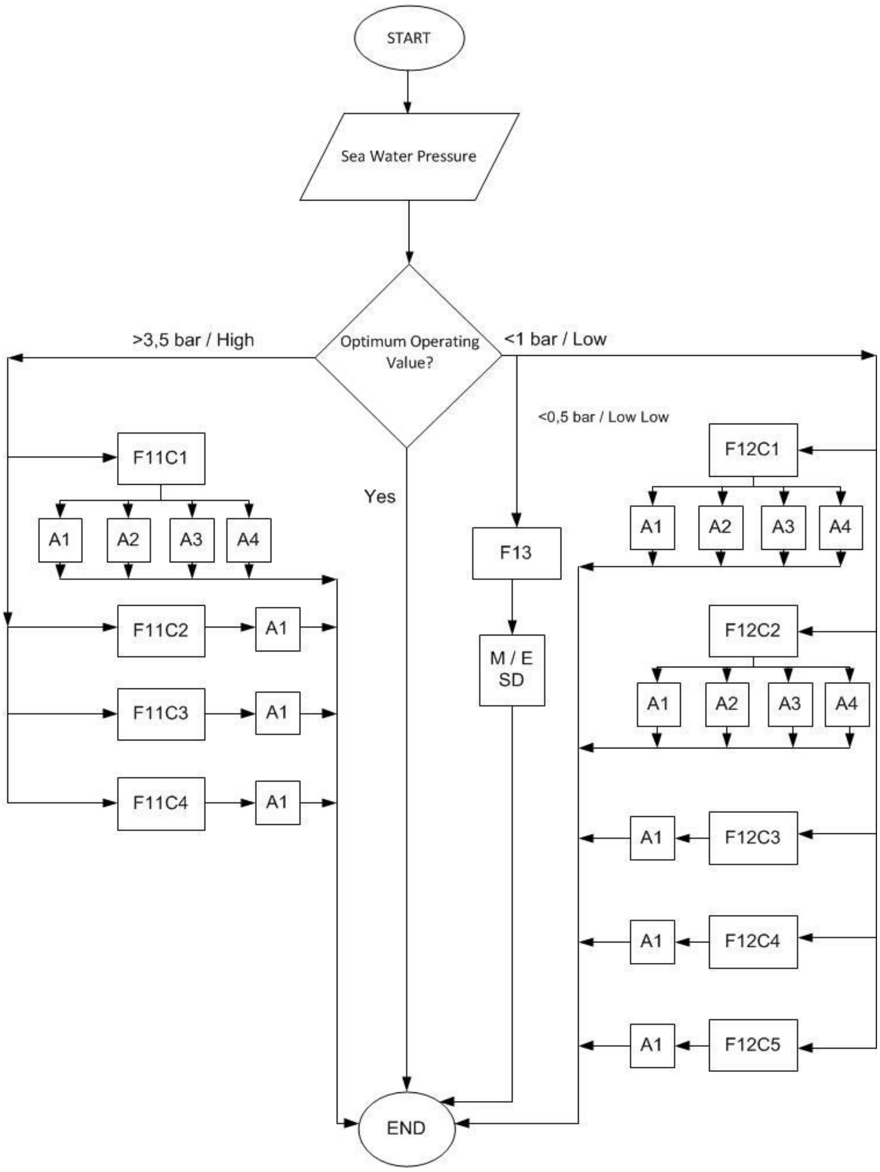


Figure 3. Sea Water pressure alarm flow diagram [10]

F12: Low sea water pressure alarm

F12C1: Pressure monitoring device failure.
C1-1: Pressure transmitter failure (Mechanical failure in pressure switch).
C1-2: Feedback fault in pressure monitor, electronic failure.
F12C2: Insufficient sea water supply.

C2-1: Clogged sea chest filter.
C2-2: Sea water feed pump failure.
C2-3: Sea water inlet valve is semi-closed.
C2-4 Clogged filter within sea water inlet area.
F12C3: Air in the system.
F12C4: Sea water leakage in the system (Sea water line and externally mounted auxiliary systems).
F12C5: Occlusion of pressure measurement point.

Controls for failures F11-F12

F11C1A1: Pressure monitoring device control.
F11C1A2: Pressure transmitter control.
F11C1A3: Ship within the 24-volt electrical leakage control.
F11C1A4: The electronic control of pressure monitoring device monitors.
F11C2A1: Check discharge valve.
F11C3A1: Check and remove the occlusion that prevents the flow of sea water after pump on sea water line.
F11C4A1: Check the installation of LT cooler plates.
F12C1A1: Pressure monitoring device control.
F12C1A2: Pressure transmitter control.
F12C1A3: Ship within the 24-volt electrical leakage control.
F12C1A4: The electronic control of pressure monitoring device monitors.
F12C2A1: Clean sea chest filter.
F12C2A2: Check sea water feed pump (ampere - electric motor – mechanical controls).
F12C2A3: Check sea water inlet valve.
F12C2A4: Clean sea water inlet filter.
F12C3A1: Remove air from the system.
F12C4A1: Check water leakage in sea water lines and externally mounted auxiliary systems.
F12C5A1: Check and remove occlusion at pressure measurement point.

Introduction of expert diagnostic system

In this section, an application of ‘How to Use’ of the program is demonstrated with a short introduction of the developed software with interfaces.

Main interface figure of the expert system encoded by C# programming language for MAN B&W 7S50MC-C main engine auxiliaries is shown in Figure 4. In order to operate the main engine system without any trouble, the auxiliaries which should be checked periodically are cooling, lubricating and fuel systems. The working principles of the developed system are described below with an example of “System 1 – Main Engine Cooling System”. Other two systems also function with same principles. The algorithm of the system is defined with cause and effect relation [10].

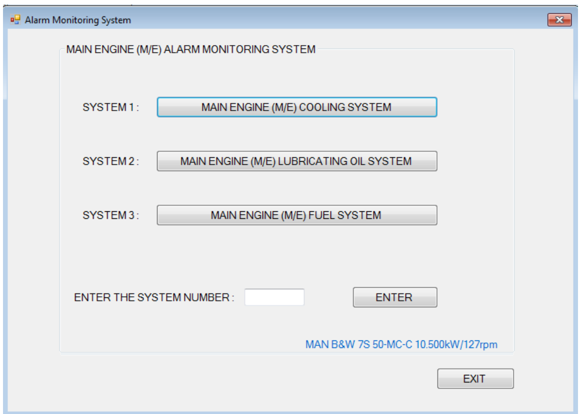


Figure 4. Ship machinery system selection screen

In the main interface as given in Figure 4, if the related system is selected, working parameters input display can be seen as given in Figure 5. As the system is selected, database of the chosen system is saved in the memory. In the current system, these parameters are input manually. Besides, these parameters can be gathered by sensors in a real engine room system. In a manual input, the parameters can be saved in the memory by "Save" button.

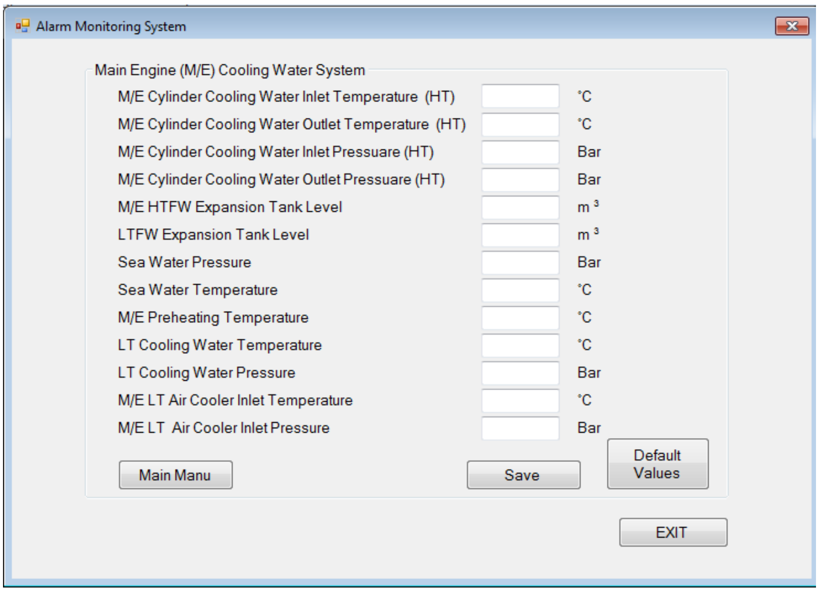
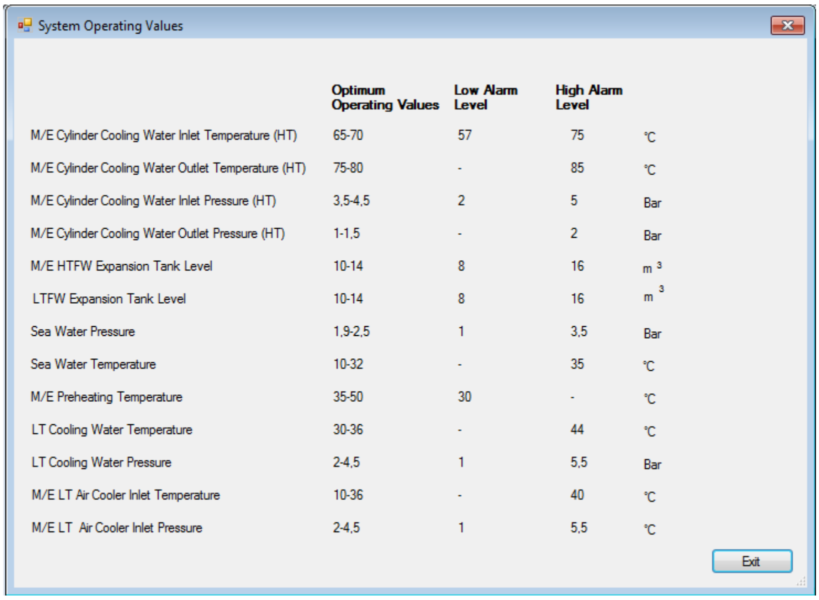


Figure 5. Operating parameters input screen of central cooling system

When the "Default Values" button is selected (shown in Figure 5), the ideal operating values of the system is screened as is the case shown in figure 6. The given values are the ideal running and alarm limit values of the central cooling water system of MAN B&W 7S50MC-C. These values are shown in detail in Table 2. If desired, the program can accept the ideal running values of different model and type of main engines as well.


System Operating Values

	Optimum Operating Values	Low Alarm Level	High Alarm Level	
M/E Cylinder Cooling Water Inlet Temperature (HT)	65-70	57	75	°C
M/E Cylinder Cooling Water Outlet Temperature (HT)	75-80	-	85	°C
M/E Cylinder Cooling Water Inlet Pressure (HT)	3,5-4,5	2	5	Bar
M/E Cylinder Cooling Water Outlet Pressure (HT)	1-1,5	-	2	Bar
M/E HTFW Expansion Tank Level	10-14	8	16	m ³
LTFW Expansion Tank Level	10-14	8	16	m ³
Sea Water Pressure	1,9-2,5	1	3,5	Bar
Sea Water Temperature	10-32	-	35	°C
M/E Preheating Temperature	35-50	30	-	°C
LT Cooling Water Temperature	30-36	-	44	°C
LT Cooling Water Pressure	2-4,5	1	5,5	Bar
M/E LT Air Cooler Inlet Temperature	10-36	-	40	°C
M/E LT Air Cooler Inlet Pressure	2-4,5	1	5,5	°C

Exit

Figure 6. Optimum operating parameters screen of central cooling system

Table 2. MAN B&W 7S50MC-C alarm boundary values and optimum operating parameters of central cooling system

Caution	Measuring Point	Optimum Operating Values	ALARM VALUE	UNIT	SLD	SHD
I - AL Y	Cylinder Cooling Water Inlet	3.5 - 4.5	2	Bar		
			1.5	Bar	L	
Z	Cylinder Cooling Water Inlet	3.5 - 4.5	x	Bar		L
I - AL	Cylinder Cooling Water Inlet	65 - 70	57	° C		
I - AH			75	° C		
I - AH	Cylinder Cooling Water Outlet	78 - 82	85	° C		
Y			90	° C	H	
Z			95	° C		H
I - AH	Cylinder Cooling Water Outlet	1.0 - 1.5	2	Bar		
I - AH	M/E Preheating	35 - 50	30	° C		
Z			25	° C		
I - AH	Cooling Water T/C Outlet	75 - 80	85	° C		
I - AH	LT Cooling Water	30 - 36	44	° C		
I - AH	LT Cooling Water	2.0 - 4.5	5.5	Bar		
I - AL			1.0	Bar		
I - AH	Sea Water	1.9 - 2.5	3.5	Bar		
I - AL Y			1.0	Bar		
			0.5	Bar	L	
I - AH	LTFW Air Cooler Inlet					
	•Sea Water Cooling System	2.0 – 2.5	3.5	Bar		
	•Central Cooling System	2.0 – 4.5	5.5	Bar		
AL			1	Bar		
I - AH	LTFW Air Cooler Inlet					
	•Sea Water Cooling System	>10 - 32	40	° C		
	•Central Cooling System	>10 - 36	40	° C		
I	LTFW Air Cooler Outlet					
	•Sea Water Cooling System	>10 - 50		° C		
	•Central Cooling System	>10 - 63		° C		

A: ALARM Z: SHUT DOWN AL: LOW ALARM
I: INDICATION Z: SLOW DOWN AH: HIGH ALARM
H: HIGH
L: LOW

If the working parameters in Figure 5 are out of optimal range, it can be observed that all the alarms are active as given in Figure 7. Several alarm conditions can be seen related with the input data.

The alarms enabled are colored in red as shown in Figure 7 and a warning symbol appears beneath it, denoting that the alarm is enabled. If none of the alarms are enabled (the entered values are parallel to the ideal running values of the system), the trouble-free condition shown in Figure 8 will be monitored. As seen, the system has returned to the normal condition and this can be understood from the text of the alarm system written in black and from the symbols beneath the alarm.

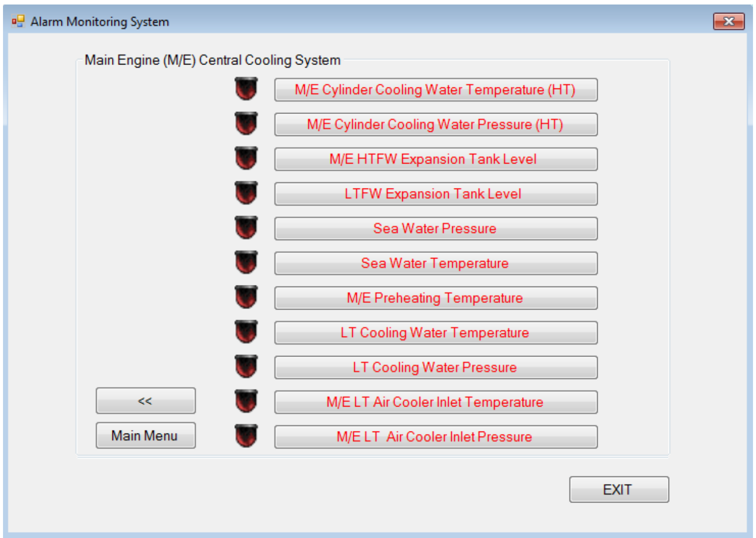


Figure 7. Failure mode selection screen

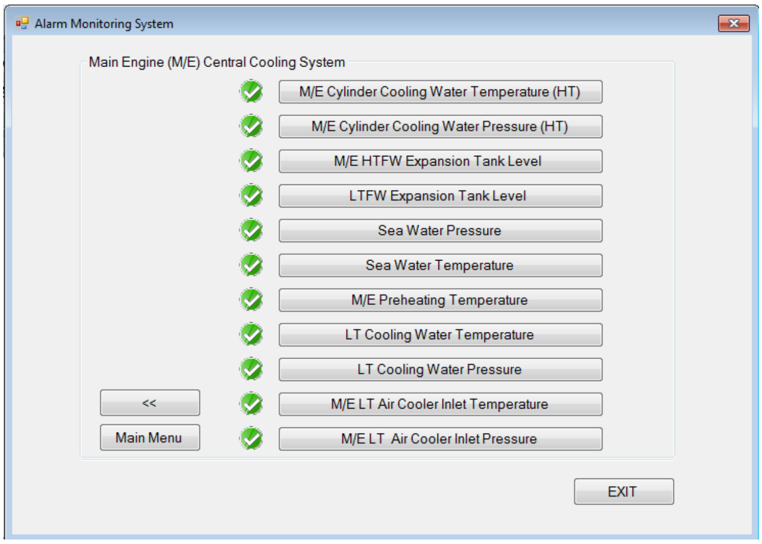


Figure 8. Trouble-free mode screen

Application of expert diagnostic system

The application executed in this study is for MAN B&W 7S50MC-C ship main engine central water cooling system. If the seawater pressure is entered below 1 bar which is maintained as the low pressure alarm level beforehand, the program alerts for the alarm as seen in Figure 9.

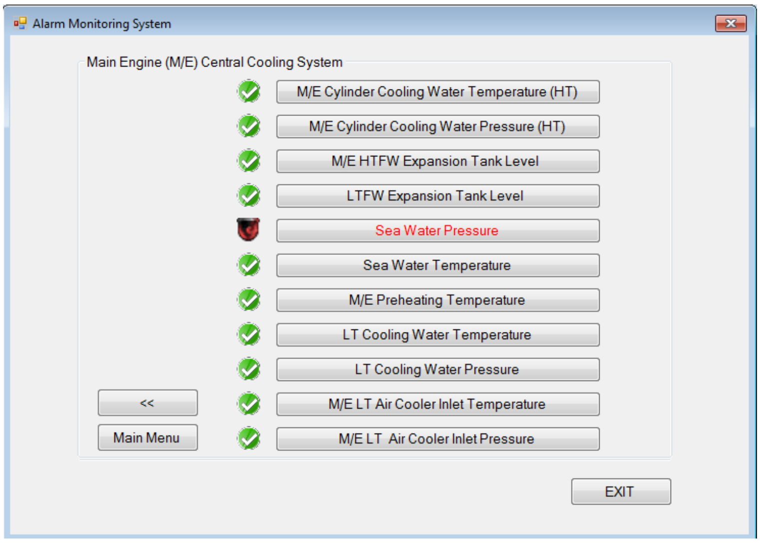


Figure 9. Sea water low pressure failure selection screen

The warning condition in Figure 9 is selected to learn the possible causes and controls to be made for the existing alarm dealt with the seawater pressure. The predescribed code and the name of the alarm in red is shown on the screen which is viewed in Figure 10. The "F12: Low seawater pressure" alarm is present in the system in accordance with the values entered to the system.

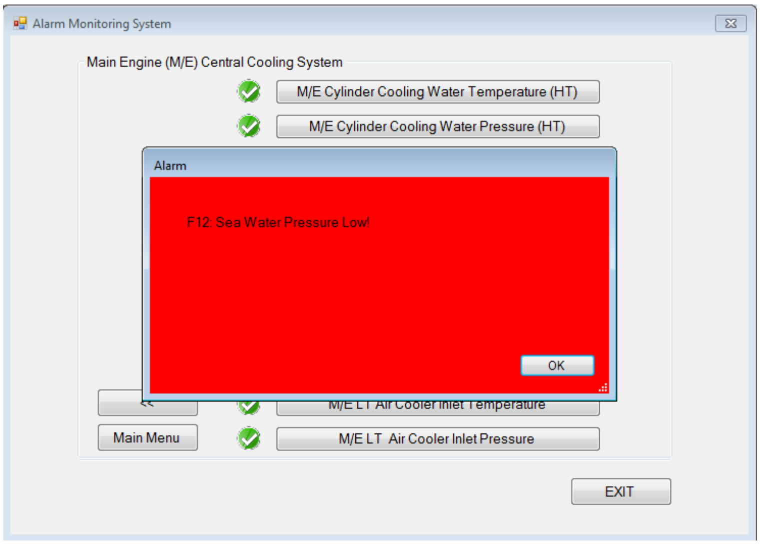


Figure 10. Sea water low pressure alarm state screen

If the "OK" button in red in the alarm screen is selected, the program gives the possible causes of the fault using the database existing inside the system. The reasons of faults which are recorded in the program's database in C1, C2, …., Cn order will be shown on the screen as is the case in Figure 11. The information supplied from the database of the program in usage of the determination of the fault, is acquired from one on one interviews with chief engineers, oceangoing watch keeping engineers and engineer officers.

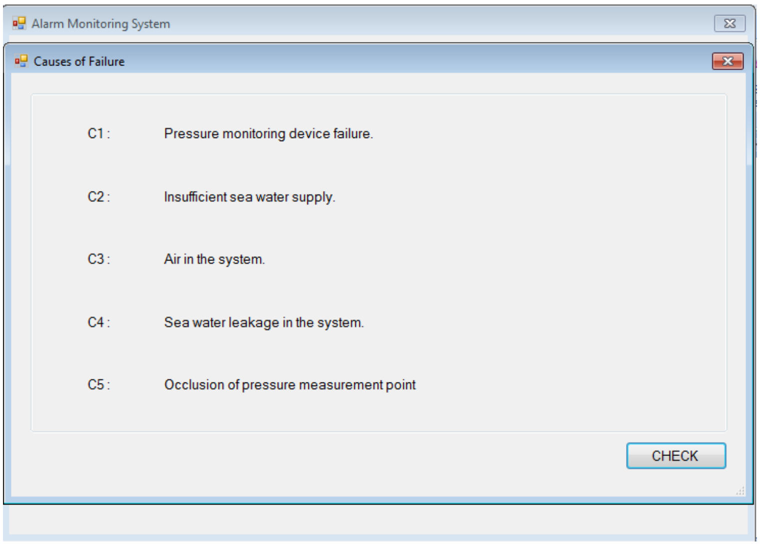


Figure 11. Causes of failure selection screen

In order to learn how to intervene to the reasons of the failures listed in Figure 11, C1 is selected and controls that must be made are listed as seen in Figure 12. To explain shortly, when an option listed in Figure 11 is selected, possible interventions that must be made will be listed as in Figure 12.

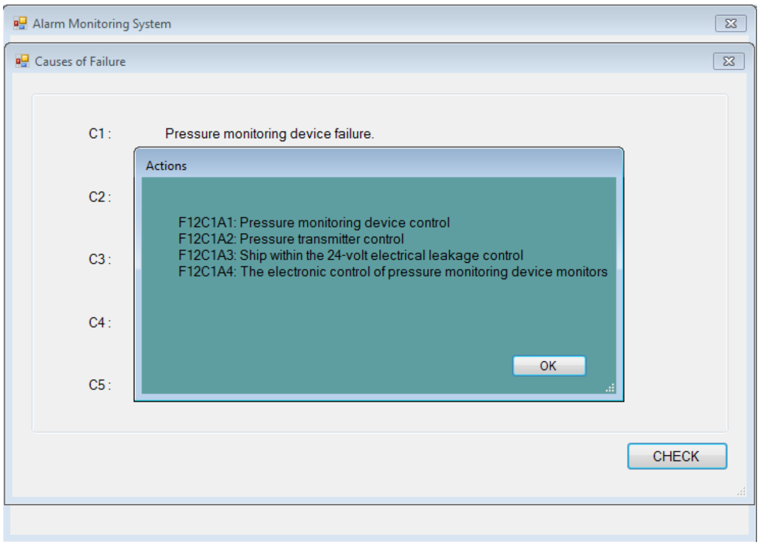


Figure 12. Action code screen

If it is desired to show all the possible interventions that must be made in just one screen, the "CHECK" button shown in figure 11 must be selected and this button leads to the screen display given in Figure 13.

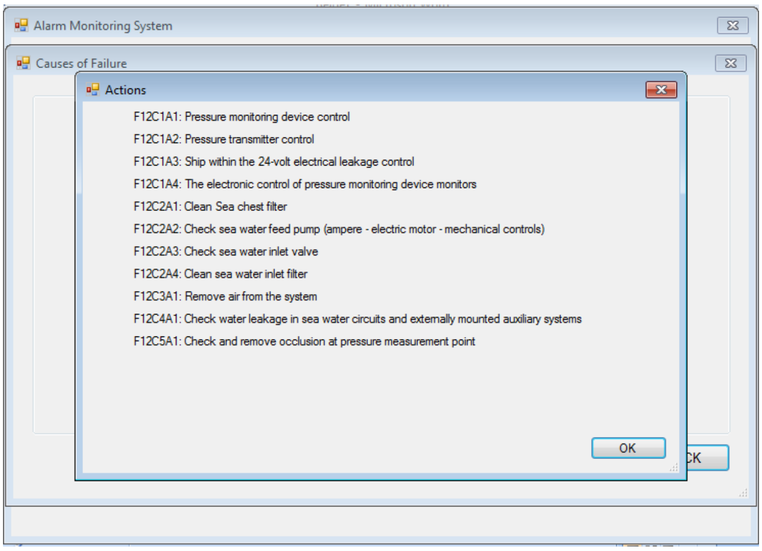


Figure 13. Actions of failure code screen

Conclusions

In maritime education, application of engine room simulators could reduce the risk of human errors by understanding engine room systems, engine procedures and safety precautions during operations. An effective expert system is necessary for early intervention to prevent all kinds of engine breakdown immediately. Performances of the engine room could change with having well educated ship crews, experience, well supervised management team, besides related to how they handle situations between normal day routines and emergency cases.

Because of the code is developed for an educational purpose, all causes related with the failure are shown in case of an alarm situation. It can be used as an educator and an advisor expert system in desktop based system by integrating to the engine room simulator. However, the only way to make the software more professional on the real engine can be achieved by reporting one possible cause for one failure by the expert system.

As of another research project, it can be applied to all main engine and auxiliary engines of modern oceangoing merchant ships by extending this study. The study is also thought to be a good reference for maintenance processes for ship engine officers.

Acknowledgement

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ANALYSIS OF SHIPBUILDING INDUSTRY MARKET IN LITHUANIA AND POLAND

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Abstract
Lithuanian and Polish shipbuilding industry can be compared according to the external and internal factors which affect the market. Polish ship building scale exceeds Lithuanian about hundred times. In that way authors were looking for main reasons which influenced the increase of shipbuilding in Lithuania and decrease in Poland. The process of ship building from drawings to a complete ship is briefly presented. Data is being analyzed and compared using statistical and graphical analysis. Article reveals the internal and external factors that affect data variations.
Keywords: *shipbuilding, shipyard, evaluation, shipbuilding market analysis*

Introduction

First ships, that people built, were timbers powered by hands. Later timbers were tied together and people invented rafts, in lands without forests people used reeds instead. First real ships were built somewhere about X age B.C. by Phoenicians. These ships were powered by vaulting poles or paddles which were fitted in one, two or three rows. Later shipbuilding technologies started developing rapidly. Scandinavian ships were distinguished by great marine properties. In VII century engineers of Venice started building Galleys. These narrow and fast ships were used by Europian navies for military purposes. After medieval paddles were replaced by sails, ships were shorter and wider, pole number increased to three and more [16].

In XVIII century vessels appeared with four or even six heights sails like “Kruzenshtern”. Also area of sail increased to 0.5 hectare and vessels speed increased to 14 knots, so ships were more manoeuvrable and faster. First steel ship was built in England in 1787. It was 21.5 meters length steamer. Sailboats were replaced by steamers in late XIX century since propellers were perfected. Since middle XX century ships were fitted with gas turbines or even nuclear reactors.

These main historical facts reveal that shipbuilding industry developed side to side with technology development. Navigation safety and reliability, increasing concern about environment problems and demand for fast and efficient transport of goods makes shipbuilders apply latest technologies [12]. But not everywhere shipbuilding develops in equal rates, because of many factors which affect the process. Consequently it is interesting to analyse what are those factors, that affects industry, shipbuilding process and why there is positive or negative shipbuilding indicators, dynamics and development trends [15].

Research purpose – to evaluate development trends of Lithuanian and Polish shipbuilding market.

Main tasks:

- to make shipbuilding market overview;
- to compare Lithuania’s and Poland’s shipbuilding market indicators;
- to evaluate dynamics trends of Lithuanian and Polish shipbuilding industry.

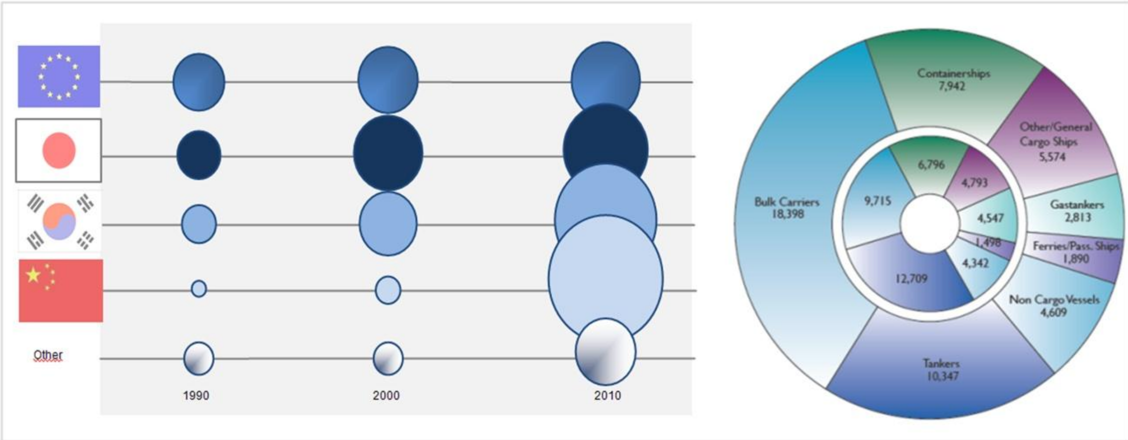
Research used comparison, statistics analysis, mathematic modelling, results interpretation and generalization methods.

Review of shipbuilding market

Shipbuilding industry produces one of the most important transport tools in the world – ships. Even 90% of worldwide trade is based on marine transport, therefore it is being developed according to globalization conditions. [8].

In the 1980s South Korean shipbuilding output grew rapidly, challenging Japan’s dominant position and finally establishing the Far East as the centre of the world shipbuilding [15]. Community of European Shipyards Associations (CESA) annual report of 2010-2011 years shows that China and all south east

Asia region is fastest developing not only in marine trade routes insurance, but in shipbuilding area too, which set itself a task to conquer shipbuilding industry worldwide. Over the last 20 years shipbuilding industry in China grew dozens of times and in 2010 consisted one third of the world's shipbuilding industry (Figure 1), according to the annual tonnage of ships being under construction. This rapid and intense China's and south east Asia's regions growth caused confusion in shipbuilding industry.



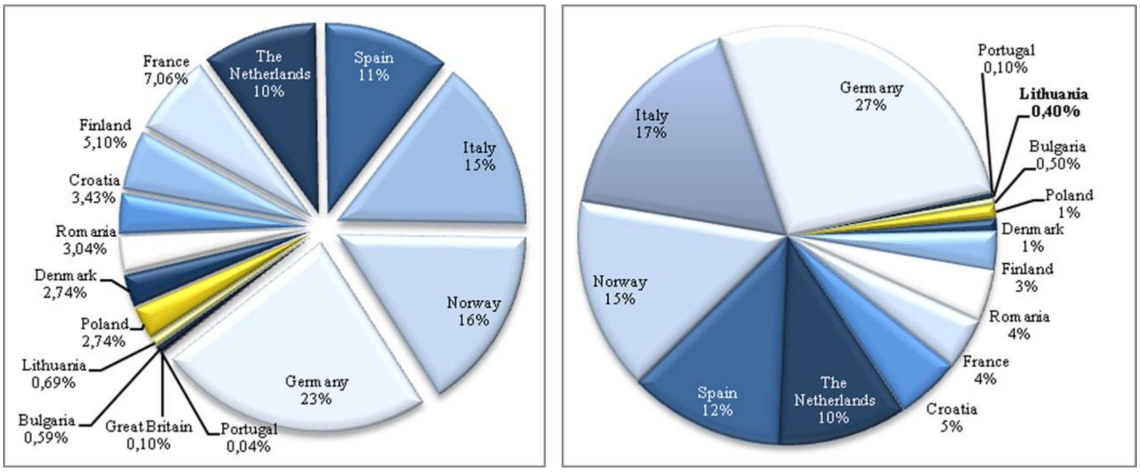
a) b)

Figure 1. Shipbuilding market distribution (CESA)
a) market dynamics 1990 – 2010 periods; b) competition based on ships under construction types in 2009 year (inner circle) and 2010 year (outer circle) [2].

Less rapidly grew Japanese and South Korea's shipbuilding industries. European shipbuilding part of overall world wide industry keeps it steady grounds for last 20 years, because eastern ship builders orientate to big tonnage shipbuilding, and even 65% of ships that were built are adapted to eastern region ports, which can service 20 meters draft ships. Shipbuilding market competition analysis is based on the types of produced ships, over one year period demand for bulk cargo ships industry almost doubled [1].

Therefore these reasons listed above European shipbuilding market is stable. Dynamics of shipbuilding sector mostly depends from European region economic and international trade development in this region.

European shipbuilding industry during 2011 years earned almost 20 thousand billion euro. In Europe most of all profited country was Germany (23%), then Norway (16%), Italy (15%), Spain (11%) and Netherlands (10%). Lithuania makes 0.69% profit of overall CESA countries shipbuilding sector, but that is not the least. Lower profits were generated by Bulgaria (0.59%), United Kingdom (0.1%) and Portugal (0.04%).

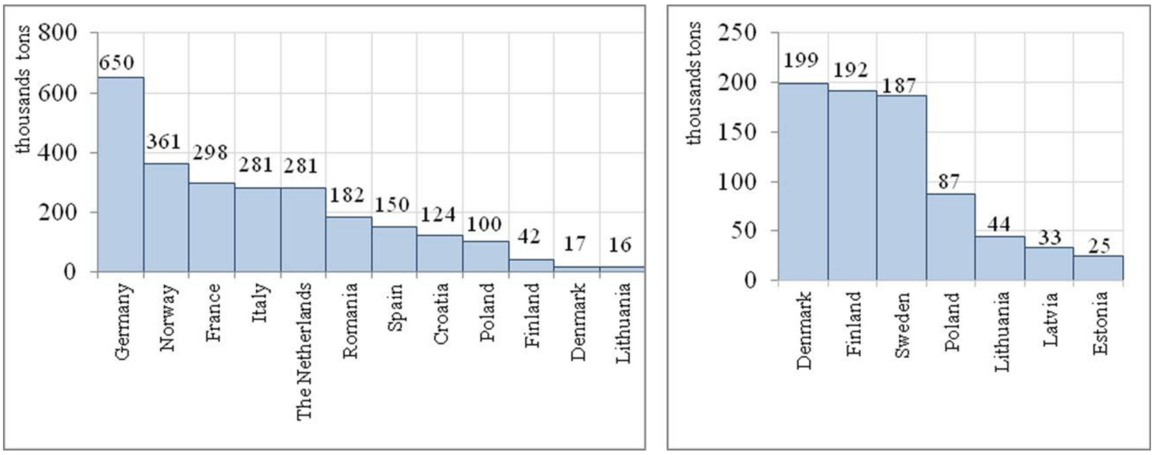


a) b)

Figure 2. CESA countries profit and new orders indicators in 2010-2011
a) countries profit percentage; b) new countries order percentage [2]

Also during three years period from 2009 till 2011 according by CESA new orders in European shipbuilding companies increased by more than 40% and consisted of 27 thousand billion euro, of which Lithuania's shipbuilding companies captured 0.4%. Most of the new orders were made in Germany, Norway, Spain, Italy and Netherlands (Figure 2) because of bigger capabilities. Amount of new ship orders in Lithuania is one of smallest in CESA countries in 2010 years.

Shipbuilding sector in 2010 were quite small. Only Germany got new orders that overall tonnage were about 650 thousand tons, less got the Norway shipbuilders – 400 thousand tons, and Lithuania's shipbuilders had just over 16 thousand tons (Figure 3a).



a) b)

Figure 3. New and executed orders dynamics in shipbuilding sector
a) new orders in CESA countries in 2010, thousand. t.; b) built ships by tonnage
in 2011 in Baltic Sea region, thousand t [2]

While analyzing market it is very important to evaluate its geographic position and companies in market. Analyzing CESA countries shipbuilding market we can see that there are no such factors as geographic position or conditions of competition. From all CESA countries which are located in Baltic sea region and also have shipbuilding facilities, only Poland, Denmark, Finland and Lithuania have the least new orders of all CESA countries (Figure 3a).

Analysing shipbuilding market of Baltic Sea region, we can see that Scandinavian shipbuilders hold leading positions, Denmark (199 thousand t), Finland (192 thousand t) and Sweden (187 thousand t) (Figure 3b). These countries have huge technological capabilities and experience (Scandinavian shipbuilders are the oldest shipbuilding countries in Baltic region) therefore they are able to build huge, technologically advanced and powerful vessels, that aspire to leadership positions trough European region. These countries shipbuilders have built over 400 types of ships.

Polish shipyards built 87 thousand t., Lithuanian shipyards - 44 thousand t., Latvian shipyards - 33 thousand t and Estonian shipyards - 25 thousand t. and all these take the lowest positions. This kind of countries positioning indicates that in different Baltic Sea region locations are different conditions of marketing and competition [11]. Scandinavian countries shipbuilders are close to North Sea, where are more CESA shipbuilding countries. Poland's Shipbuilding companies are at the south of the Baltic Sea and closer to the trade spots, than Eastern Europe countries like Lithuania, Russia, Latvia and Estonia [10]. Because of huge competition in Baltic Sea region it can be said that shipbuilding in this region according to CESA will grow, but because of geographic factors increase will not be huge [3].

Identification of main influencing factors of shipbuilding process

Ship building starts with proposal of requirements. It is when customer and manufacturer of the ship, based on the specifications (simplified specifications) provided by customers, we lay out a broad design to get a rough overall picture of the ship. Than the manufacturer suggests their offer about the design of the ship, specifications and price that based on the customer's desire. The proposal is a very important step for the manufacturer since customers largely depend on this proposal to decide whether to place an order to produce or not. Once proposal is accepted, manufacturer proceeds to discuss the specifications in detail and settle on the final price of the ship. Once the ship price, shipbuilding process, general layout, specifications are determined, an agreement is made. Then it‘s time to test the performance of design. Speed is the most significant factor of any ship. By repeatedly adjusting the hull form and tank testing, manufacturer ensure that the ship they are building can sail at the speed stipulated in the specifications. When the preliminary design has been selected the following information is available: dimensions, displacement, stability, propulsive characteristics and hull form, preliminary general arrangement, principal structural details. Each item of information may be considered in more detail, together with any restrains placed on these items by the ships service or other factors outside the designer's control. Also ships build in CESA countries must pass the standard form of contract between builders and purchasers to ensure relationships between them. This contract includes:

Subject of contract (vessel details, etc.); inspection and approval; modifications; trials; guarantee (speed capacity, fuel consumption); delivery of vessel; price; property (rights to specifications, plans etc. and vessel during construction and on delivery); insurance; default by the purchaser; default by the contractor; guarantee (after delivery); contract expenses; patents; interpretation, reference to expert and arbitration; condition of the contract to become effective; legal domicile (of purchaser and contractor); assignment (transfer of rights); limitation of liability [13].

There are three main factors affecting the technical feasibility and profitability of a ship. The deadweight/displacement ratio indicates the carrying capacity, the speed and power in relation to the total displacement, and third factor is lightweight density, which is an easy way to a first a first weight estimate for different ship types [14]. The key function of basic design is to design the ship so that all those factors comply with the specifications that the customer desire. Based on the information obtained from the basic design, the detailed design plays the role of clarifying the design of components and parts of the ship to be built. The key point of this step is to work out drawings that are accurate enough to facilitate the actual shipbuilding operation on-site without compromising the ability or performance of the ship.

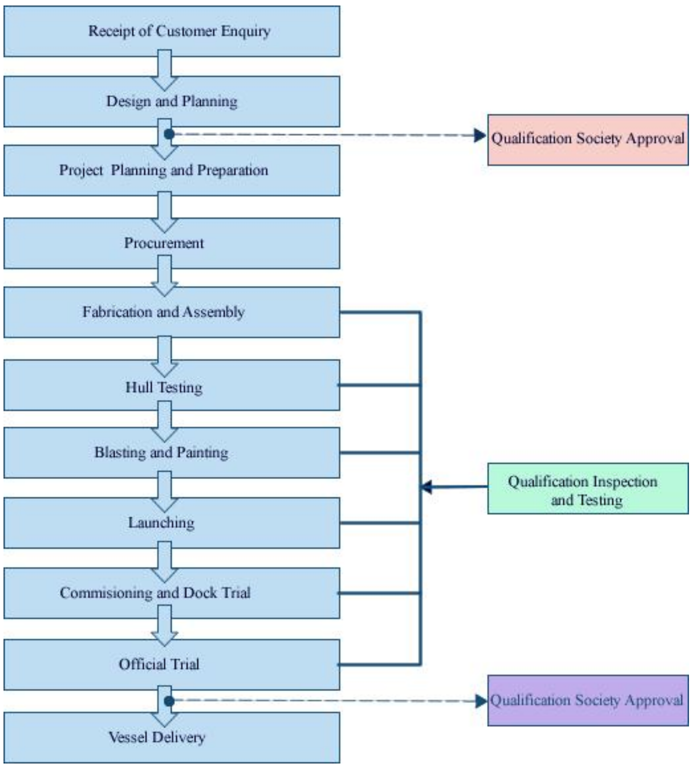


Figure 4. Shipbuilding process scheme [13]

Then the production design is organized as the information in the detailed plans into respective component information. The production design enables the field staff to carefully control a large amount of components on site. Then the material ordering take place. After it the production process starts. It has a critical impact on manufacturing efficiency because of the enormous amount of components, and the large number of workers involved on the job site. It is vital, therefore, to plan thoroughly so the process would go fast and efficient. After production plan steel plates are being cut, bent, curved, shaped and other how processed according to the blueprint. The cut and processed components are assembled by blocks starting from small ones and assembling to the large ones to increase manufacturing efficiency.

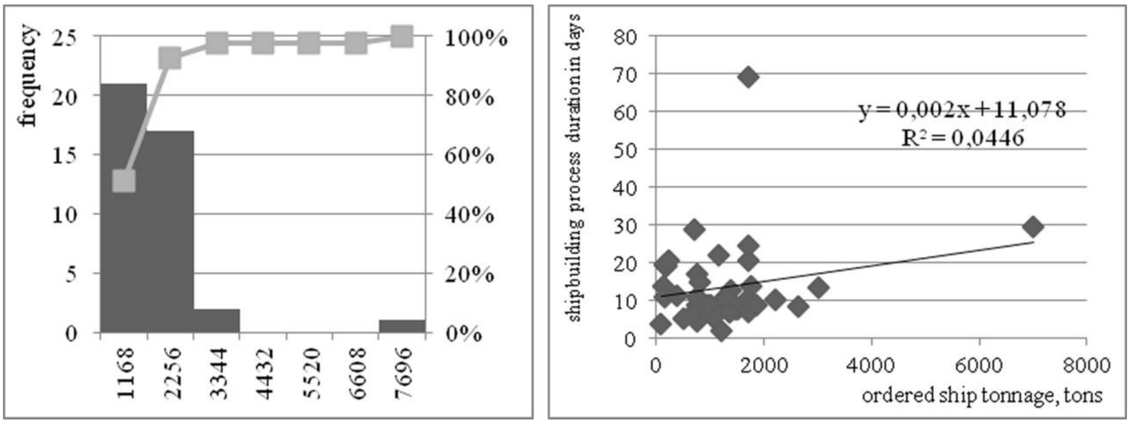
Assembled blocks are joined together to make huge blocks and, at this point, rigging pipes, electric wires and other. Most of this is being done while block is still on the ground to make job more efficient [5].

Following step is to accurately mount these blocks together to make them in to a vessel. After assembling blocks together following stage is launching the ship in to the water. It is the most thrilling and exciting moment of all shipbuilding process. The finishing operation is carried out with the launched hull at the quay. Starting with finishing work of accommodation and control sections, every equipment and instrument is checked and re-examined in practice. The trial cruise includes tests of speed, engine performance and operation of all equipment and instruments. The test results are kept as the performance record of the vessel. A new ship is born. Complexity and number of processes is displayed further in the article (Figure 4).

After the delivery ceremony, the captain, chief engineer and crew embark for the ship's maiden voyage. Lately ships mostly built in docks. Docks in our days is a complicated hydro technical structure with flat bottom. Docks can be up to 1000 meters in length and width up to 100 meters with depth about 14 meters. Overall length of dock can be built partitions and in one dock can build a few ships at once [6].

Process complexity, ship type and function, educated engineers, port infrastructure and technologies have main impact on shipbuilding process. Moreover high quality materials are needed and the most important is experienced workforce. As an example we can analyze indicators of shipbuilding in JSC "Western Baltic shipbuilding" company [7].

While analyzing 1998 – 2011 years period it was found that the average shipbuilding tonnage of JSC "Western Baltic shipbuilding" reached 1248 t. Biggest ship tonnage was about 7 thousand tones , and smallest was just about 80 tones. Half of all shipbuilding tonnage was lower than 1150 t of which half ships that were built was not more than 654 t. Half of ships which were built by JSC "Western Baltic shipbuilding" tonnage was between 1150 and 7 thousand tones, of which half of the ships were over 1700 tones. During 1998 – 2011 years period most ships that were built by JSC "Western Baltic shipbuilding" was 1700 tonnage (Figure 5).



a) b)

Figure 5. JSC "Western Baltic shipbuilding" ships built by tonnage
a) statistic histogram; b) ship construction time dependence of tonnage under construction

It is possible to see that JSC "Western Baltic shipbuilding" frequently build ships which do not exceed 2256 t (93%). According to the JSC "Western Baltic shipbuilding" and market analysis determined that company operates sufficiently in specific sphere. There were noticed two exceptions in the whole practice – low tonnage ship took even 70 months to build and high tonnage ship building process was twice faster than the previous one. This shows us that this ship building process exceeded normal and defined term of shipbuilding (observed process of similar size), and in these ships were spotted allot of factory spoilage.

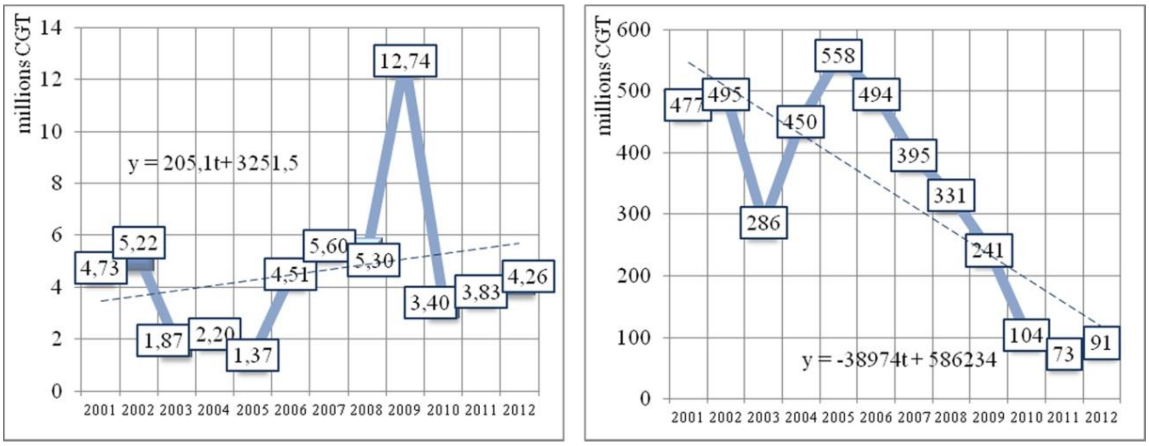
Regression analyze showed that JSC "Western Baltic shipbuilding" have got efficient shipbuilding line and advanced in aspects, technology and organization of work. Therefore it could be said that shipbuilding process duration is determined not by ship size, but by advanced technology and resources. Manufacture spoilage analyse revealed that spoilage reasons can be linked to unusual manufacture technology, bad installation of building facilities or the human factor because spoilage was spotted when ship didn't defined in the usual technological production standards.

In summary, it can be said that worldwide shipbuilding industry forms into sectors based on scale of manufacturing, geographic positioning, infrastructure capabilities to build certain ships, ordering demands, logistics factors and many others.

Evaluation of Lithuania's and Poland's shipbuilding trends

At the beginning of researched period Lithuania's ship construction's average index were compared to the whole analyzing period which was 4732 CGT. In 2002 ship construction's industry started to show signs of recovery after the Soviet Union collapse and reached 5215 CGT and that is about 10% more than last year. Ship construction industry in Lithuania didn't take too long to recover (Figure 6).

In 2003 the worldwide ship construction's market was invaded by East Asia counties such like Chine and South Korea which can offer up to three times cheaper labour price. Due to this ship construction's orders number significantly decreased. In this period 1870 CGT was built, and it decreases more than 63% in ship construction's industry in comparison to 2002. Lithuania's government refused to help to recover Lithuania's shipbuilders. Joining EU has led to connivance of its politics and in 2004-2006 a decision was made that ship construction's repeating and conversions are not going to be funded by the county or the EU. Because of this decision most companies found themselves on the brink of bankruptcy. In 2004 220 CGT was built. In following 2005 years industry didn't show any signs of recovery. During these years there was the least 1365 CGT built throughout the whole period.



a) b)

Figure 6. Shipbuilding indicators comparing a) Lithuania's shipbuilding sector by CGT; b) Polish shipbuilding sector by CGT

In order to avoid financial trouble and bankruptcy shipbuilding companies began to specialize in complex shipbuilding market and at the same time reorganization of western ship construction companies group was started. These efforts to revive the industry provided well results and already in 2006 years there were seen signs of recovery. Lithuanian's shipbuilding companies built over 4506 CGT and this amount is three times more compared to the year before. In 2007 rates also increased and reached 5600 CGT.

The following year ship building industry was affected by the beginning of the economic crisis. During the crisis orders decreased but this didn't affect the production too much and 5300 CGT were built. In 2009 Lithuania's ship building industry began to recover a big amount of income was gathered and a record number of orders was achieved. In that year, was built the largest amount of ships during the analysis period, even 12735 CGT.

As it was shown in the ship building descriptive statistical indicators Lithuanians market is dominated by ships up to 6629 CGT constructions and these kind of ships make 80% of the ships built in whole period. Due to companies specialization processes in ship building sector, in the near future there are no expectations of significant change in Lithuanian's shipbuilding sector, because of existence of statistical distribution right asymmetry, it allows to expect smaller than 4688 CGT per year of finished ships rate.

At the beginning of analysing period the Poland's shipbuilding rates were really high. Even though the collapse of Soviet Union negatively affected it's shipbuilding rates: in 2001 ship builders still managed to holdout in international market's top 5 and had built over 477000 CGT ships per year. At the beginning of the analyzing period, Korea, China, Japan and Germany wear ahead of Poland (Figure 6). Despite fact that standards were high, polish shipbuilders often needed financial support, not only from the country itself, but from private investors as well. In 2002 Poland managed to build 495000 CGT but even high rates didn't save the shipbuilders. In 2002 one of the biggest Poland's ships building company called Stocznia Szczecinska Porta Holding gone bankrupt. Polish shipbuilder's financial stability was lost in 2003. It affected the whole shipbuilding market, there was built only 286100 CGT which makes almost 60% decrease of shipbuilding in Poland per year [4]. Because ship building industry in Poland was one of the highest rates, when joining the EU Poland was in danger of losing financial stability. Because of that before joining EU in 2004 subsidy was given from Poland's government in order to revive ship building industry. Applied methods worked and over 450000 CGT was built [9].

The following year EU once again subsidized the market so that competition with Korean manufacturers would be maintained equal and in that year 558000 CGT was built which is the highest amount through the whole analysing period [4]. In 2006 494000 CGT was built which is 15% less than in 2005 and in Poland shipbuilding sector annual rates decrease started.

Later the rates chronologically decreased because of Gdynia and Szczecin ship building companies closure in July, 2008. This decision was made by European Commission. In 2007 395000 CGT was built and that is almost 20% less than 2006, in 2008 331000 CGT was built, in 2009 241000 CGT was built and in the last analyzed period years was built the least throughout the whole analyzed period, only 104000 CGT. Throughout the whole analysing period polish shipbuilding experienced 500% decrease of shipbuilding rate compared to the beginning of the period.

In conclusion we can declare that Lithuania's and Poland's shipbuilding data are significantly different. Lithuania's industry signs of recovery were bigger because of the newer technologies and equipment. Also the ability to adapt quickly to customer's needs and build new and complicated vessels which are more attractive to new investors. We can forecast that Poland's shipbuilding industry will decrease till there will be left most modern and adapted shipbuilding companies.

Conclusions

Comparing shipbuilding and navigation sectors we can say that data spreads accordingly to the shipping intensity and needs of certain region. For instance China's shipbuilders took lead worldwide. According to types of cargo and trade intensity bulk carrying ships and tanker shipbuilding takes up more than half of whole shipbuilding market. Last position in shipbuilding market takes line ferries, in which specializes Lithuania's shipbuilding companies. On the basis of this data dynamics we can explain Lithuania's shipbuilding sector competition.

After analysis of the most stable shipbuilding market in the world – ES countries, we can say that Lithuania's shipbuilding profit holds only 0.69% of all ES countries profit from shipbuilding. Poles shipbuilders however make 2.74% in 2009. Baltic Sea region shipbuilding companies comparison show us that 44 thousand t. of all ships built at Lithuania in 2011 takes up 6% overall market. Poland has almost twice bigger data which is 11%. In Baltic Sea region as shipbuilding countries dominates Denmark, Finland and Sweden which however are main customers of line ferries and barges [5].

Because every kind of ship has different purpose, size, length and other specifications shipbuilding becomes very complicated process and not every port is able to produce these complicated vessels. Shipbuilding companies specialize in certain ships determined by the technology, infrastructure, resources they have and customer needs in their region. Moreover shipbuilding companies are highly affected by the political organizations and associations, to which they belong, decisions and agreements.

All of these factors are perceived in Lithuania's and Poland's shipbuilding market. Lithuania's shipbuilders dynamics is positive (+431.17 thousand CGT every year), but it is supposed that it will not exceed more than 5000 CGT. Poland, because of intense negative dynamics (-31 million CGT each year) supposed that indicator should be about 373000 CGT next year. Over evaluated period Poland's decrease seeks up to 500%. Therefore we can conclude that intense restructuring of shipbuilding process is happening in Poland.

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THE ASSESSMENT OF GRAIN HANDLING TRENDS AT KLAIPEDA AND RIGA PORTS

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Abstract
Grain is one of the bulk cargo type, characterized by the fact that the load factor depends not only on the technological cargo handling, technology, but also on the environmental conditions that affect grain yield. The survey results show, that technological equipment and sufficiently large grain export and transit of indicators in the Sea port of Klaipeda rate is more bigger than Sea port of Riga, but the average load factor a year increase in the period of 2005-2012 period is 4% (12.2 million t), what compare with the sea port of Riga is almost 5 time less (68.71 million t). Klaipeda port is arranging new grain terminals which allow increasing grain cargo volumes.
Keywords: *grain handling, bulk cargo, Riga port, Klaipeda port*

Introduction

Grain production is the key to growing human populations. Yield of grain crops increased from the beginning of the agricultural revolution. Thomas Malthus, (1798) the British economist, noticed that the population is growing exponentially, while food production grows only arithmetically, until it reaches the amount of arable land dictated to a certain ceiling. T. Malthus says that, if unchecked based on a voluntary approach - population growth, which may eventually overtake the possibility to produce the required amount of product to the mankind. For these forecasts economic science is known as grim [15].

Grains are Poaceae family fruit, which distribute by both the wind and animals. Grain is very rich in minerals, proteins and fats. Grains are one of various Poaceae families of plants, such as corn, millet, oats, rye, wheat, barley, and others. Sue Becket said: "Hundreds of people claim that using more grain feels much healthier." In this group of plants on earth are not these important products: flour, bread, starch, alcohol. Also, scientists have established that whole grains are very important to the human body [4]. Penn State's scientists demonstrated that a large amount of grain can reduce chronic diseases such as diabetes and cardiovascular disease risk [10].

The number of relevant population is increasing, so needs for grain production are increasing too [2]. It is to analyze, what situation is in grain handling market, is it possible to identify main ways of grain transportation and see them at the main indicators in the East Baltic Sea ports. Was analyzed five years of the same period, Riga and Klaipeda ports grain handling volumes. In these periods the port of Klaipeda handled several time more grains than the port of Riga. The investigation will determine that causes these variables that influence the grains handling.

The main research purpose – evaluate main tendencies of grain cargo handling in Klaipeda and Riga Seaports. Research objectives**:**

To find out the differences in productivity, port transshipment cargo capabilities;

To reveal the problems why Klaipeda seaport handles more than the port of Riga, though its handling is very unstable;

To cover a wide range of tasks, which show possible future prospects and compare them to current port handling performance.

Grain cargo life cycle

Grains are carried by a variety of ways, ranging from the simplest bags, to the cargo ships [12]. At present it is estimated that 80% of the goods of the world are moved by maritime transport [1]. The major capital investment that a water carrier makes is in transport equipment and, to some extent, terminal facilities [2]. The latter mode of transport uses a lot of different tools, such as: co-operation between producers and consumers, a balanced work of transportation equipment, grain storage terminals, equipment they reboot and of course people's work. Port users are transportation carriers, shippers that provide their cargo to transportation carriers and individuals who present themselves as passengers to transportation carriers and utilize ports as part of the process of creating freight and passenger transportation trips [14].

The analysis of grain as a raw food life cycle, it can be seen that the transport of grain and raw materials transportation is an integral part of the life cycle of grain to ensure grain-based foods for the end-user access (Figure 1). Grain cultivation is common in many countries, including Lithuania and Latvia, but the grain yield is directly dependent on the weather conditions and climate change factors are analyzed in more detail in modeling grain handling trends for the coming times. World watch Institute says that it has been grown about 2 billion tons of grain in recent years. Grains grown by various harvesters and other machines are thrashed and delivered to the grain storage towers, where they considered staying a short period of time. In addition to the main tower rails, grain outgoing movements of trains in port grain terminals, where they are kept in silos or domes. Grains are loaded with special equipment on cargo ships, which navigate yields to other countries. Then, the opposite action occurs the cargo ship loaded in the port terminal storage, and one goes to the trains. The latter brings the crop grown in the various processing plants, where the grain is processed and are produced by their various products that end up on store shelves. Maybe this way, at first glance, it seems simple, but it requires exceptional and special equipment, coordinated schedule that do not get too containers, factories or trains. As a result of a trade transaction, goods are physically transferred from the seller‘s premises to the buyer‘s. Transport systems comprise the different transport modes available to move the goods, together with their associated interfaces [11].

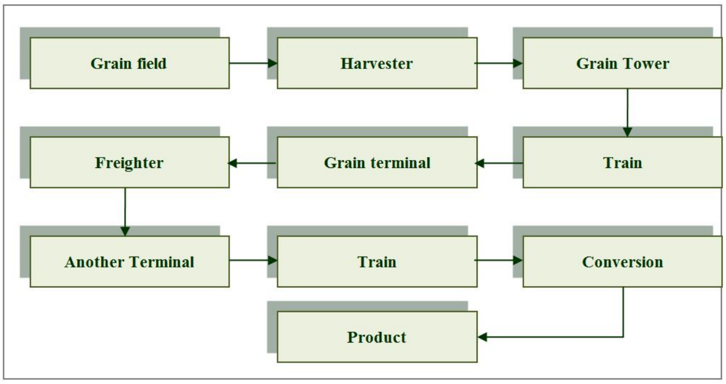


*Figure 1.*Logistical grain life cycle

Grain physical properties, such as density, moisture, content may have significant impact on grain handling characteristics. Grains are one of several bulk cargo types and cargo handling, storage and transportation technology and operating efficiency depend on the physical properties. Grain terminals are used to reload the gantry cranes with grobs. Because the terminals are not specialized to store bulk cargo, environmentally sensitive cargo are loaded directly: wagon - the ship, the ship - the wagon. Dry goods are exported in large lots by special vessels (bulk carriers), they are loaded with special port complexes. Specialized reloading equipment is designed to handle high-throughput and the lowest cost. All modes of international freight transport went through a painful phase of global expansion during the last who decades of the 20th century [6].

As shown by the grain life cycle, it intersects a number of economic activities: it is agriculture, transport system and the grain processing industry. It can be seen that the transport system is essential for ensuring a flexible agricultural sector and processing industry cooperation. Transport system depends not only on the performance of the sector, but also on macroeconomic indicators, grain imports and exports; as statistical indicators may allow modeling of grain cargo flows in transport sector.

One of the main parts of logistical transporting is ship. There are two main parts to a ship: the hull and the machinery. The hull is the actual shell of the ship including the superstructure, while the machinery includes not only the engines required to drive it, but also the ancillary equipment serving the electrical installations, winches and refrigerated accommodation [5].

Ports come in all shapes and size. They can fulfill various functions, ranging from offering a safe haven in a storm, to providing a location for processing freight and passengers of offering support services to ship, to functioning as a basis for industrial development, to forming a central distribution point for various chains of transport.

The most important part of the logistics chain - the port. Each port, charging grains must have specialized bulk handling, storage terminals adapted to the specialized bulk cargo handling equipment, specials containers. Whereas the grains are transported by sea of bulk cargo ships, each port, serving such goods must provide to accept and handle this type of craft.

The ports infrastructure elements quay length and depth at the berths and the port entrance channel depth have a direct impact on the bulk cargo handling performance.

Klaipeda and Riga sea port infrastructure comparison

Major transport technological systems forming factor - the optimal transportation method development through shipping, handling and logistics technologies that are optimized by the type of ship and cargo, cargo handling equipment and technology and other settings [9].

The biggest part of bulk cargo consisted of bulk fertilizers in Klaipeda and Riga ports in 2005-2012. Largest bulk export was recorded in the third quarter of 2011 and amounted to 3123.7 thousand tons in Klaipeda state seaport (it was a record loaded bulk cargo). The largest bulk exports in the port of Riga were recorded later in the second quarter of 2012 - 4881 thousand tons that is 36% more than the Klaipeda seaport recorded maximum bulk export performance. Both ports lowest bulk export values were recorded in 2005, when cargo exports in Klaipeda seaport 2005 second quarter amounted to 989.9 thousand tons, and the port of Riga in 2005 in the first quarter amounted to 2609 thousand tones. Average bulk export ratio in the seaport of Klaipeda are 2010.6 thousand tons and the port of Riga - 3926 thousand tons, which is 95 percent more than Klaipeda seaport. This indicates that the Riga seaport bulk export performance significantly higher than the Klaipeda State Seaport, and such differences of bulk freight market can be explained not only the country's macroeconomic indicators, but also elements of the infrastructure for technological advantages.

Klaipeda seaport is one of the largest ice-free ports in the Baltic Sea on the east coast. Riga free port is as well as the Eastern Baltic region. He alienated much of the residential areas and is in the bay.

Table 1. Klaipeda State Seaport and the Riga seaport comparison of infrastructure elements

	Klaipeda seaport	Free port of Riga
Water area	897 ha	4386 ha
Port (land) area	519 ha	1962 ha
Depth	13 m	16 m

Klaipeda State Seaport is up 14 bulk cargo terminals can charge. Grain handling customize specialized terminals are called domes or elevators.

Riga port is bigger, but it handled an average of 3 times less grain. Both ports shipping routes are almost identical, because ships are sailed to countries, such as: Denmark, Belgium, Germany, Sweden, United Kingdom, Russia, Finland, the Netherlands, the only difference being that the ships from the port of Riga are not shipping to Estonia and third parties. Of course these ports cooperate and communicate with each other.

At the rapid growth of economics of Asian countries and at the increase of their cargo flows to Europe, special role falls on Lithuania which is at the eastern coast of the Baltic Sea with well-developed connections with Middle and North Europe, Russia, other CIS countries and West European states [8]. In terms of infrastructure, the port of Klaipeda is the trans-European transport corridor IXB component. Lithuania is the East - West transport corridor comprising Klaipeda state seaport, road and rail infrastructure complex be recognized by an important economic project. Motorways of the Baltic Sea, linking the European Union ports are among the priorities of the EU-funded projects. These strategic decisions show the importance attached to ports extend the foreign trade and transit transport options. In most segments of the shipping industry today, the critical underlying success factors are evolving very fast [7].

Maritime law is made and enforced by nation states; the next task is to examine the legal framework which determines the rights and responsibilities of nations for their ocean-going merchant ships [13].

Transit cargo transported between the East and the West, accounted for 44% of the Klaipeda port handled cargo in 2011. For transit cargo going tense competitive struggle between the eastern coasts of the Baltic ports. It is necessary to emphasize the fact that Latvia has more developed railway infrastructure, so the main transit countries in Asia grain cargoes to the end of the year 2012 saw an increase in routed through the Latvian port of Riga.

Meanwhile, the capital of Latvia, located in the port is not in a favorable position to Klaipeda, because it is the country's capital, where money is paid not only to port development and needs, but also for the improvement of urban infrastructure. Also, the port of Riga is not the only one port in Latvia.

The Baltic Sea region wants to serve the transit of freight and passenger traffic between the European Union and its neighbors to the east - the Russian Federation and Belarus. These neighbors are cargo suppliers (exports of raw materials) and the destination (consumer product imports from the west). On the other hand, there is a possibility to serve the Asian markets (especially China). Lithuania and Latvia, competing for these cargo handling.

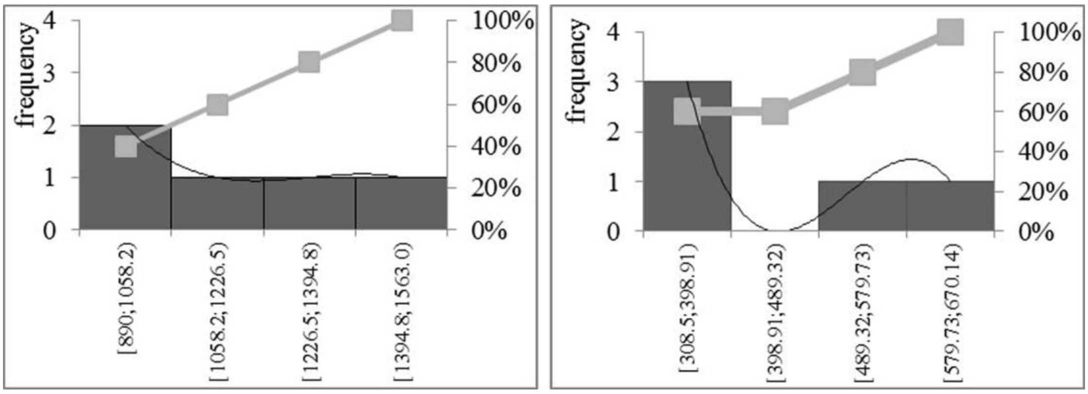
Carried out in accordance with the market and port infrastructure analysis grain handling point of view, it can be said that the ports grain handling characteristics affected by such factors as the annual grain harvest in the country and the transit of goods through the territory of the country transport of countries quays depth (greater depth allows for a ships can transport and transshipment of a larger amount of grain), macroeconomic indicators of exports and imports, port bulk terminals (able to accept more ships to reboot), terminal capacity (the ability to store and keep the grain). The analysis of causal relationships between the factors, not all factors had a strong and significant impact on grain handling characteristics, and the assessment of trends in grain handling in Klaipeda and Riga ports used exclusively and strongly with the grain handling indicators correlating features: exports, imports, grain harvest in the country, the average purchase price of grain.

Grain handling trends assessment at Klaipeda and Riga seaports

According to the National Soybean Research Laboratories' forecasts suggest that by 2030 the global grain harvest will amount to 1.5 billion tons. The increasing demand for grain around the world is based on the increasing number of people these days that exceed 7 billion. Grain - the food pyramid that makes a diet, so grain handling ports is a viable business that requires a proper infrastructure deployment.

Analyzing the period of five years, it is for the 2008-2012 period. The maximum period of grain handling in both ports was recorded in 2012: Klaipeda seaport was 1437 thousand tons, and the Riga seaport 602,4 thousand tons, which was 1.4 times less than the Klaipeda seaport. Meanwhile, the lowest grain handling Klaipeda seaport was 890 thousand tons, and was recorded in 2010, and the Riga port-only 308.5 thousand tons in 2009. Over this period, the average annual grain handling Klaipeda seaport is slightly more than 1.5 times higher than in Riga port ranges at 1150 thousand tons. For two years, the Klaipeda State Seaport grain handling ranged from 890 thousand tons to 1058.2 thousand tons.

A minimum one year of grain handling ranged from 1058.2 to 1226.5 thousand tons thousand tons, in other periods, the average over the handling of grain handling. Therefore, it can be said that in the coming periods Klaipeda seaport grain will handle more than 1150 thousand tons.



a) b)

Figure 2. Klaipeda seaport (a) and Riga Seaport (b) grain handling characteristics of statistical frequency histograms

For three years the Riga port handling ranged from 308.5 thousand tons to 398.91 thousand tons per year. The first eighteen months of the period did not exceed 378.64 thousand tons (Decile2=378,64), therefore, it can be said that the Riga port handling a longer period of time, was less than the average annual grain handling, so in future periods is most likely that the Riga port will handle less than 444 thousand tons of grain.

Klaipeda seaport loading rates fluctuated (V_σ =21%) in 2011 reduction reached 25% compared to 2010, but in 2012, the load factor increased by 54%, which means that the annual growth rate was 154%. During whole period the absolute annual average increases to 14.2 thousand tons. Riga port during the analysis period, steadily loaded almost every year, more and more, an average of 68.71 thousand tons annually from 2009, when it was recorded in a reduction in grain handling. It must be emphasized that although the Riga port grain handling descriptive statistics indicators are significantly lower than the Klaipeda seaport, however, the grain growth rate is faster than the Klaipeda seaport and grain handling growth rate of more than 4 times who has a big effect on grain yield transit from Kazakhstan.

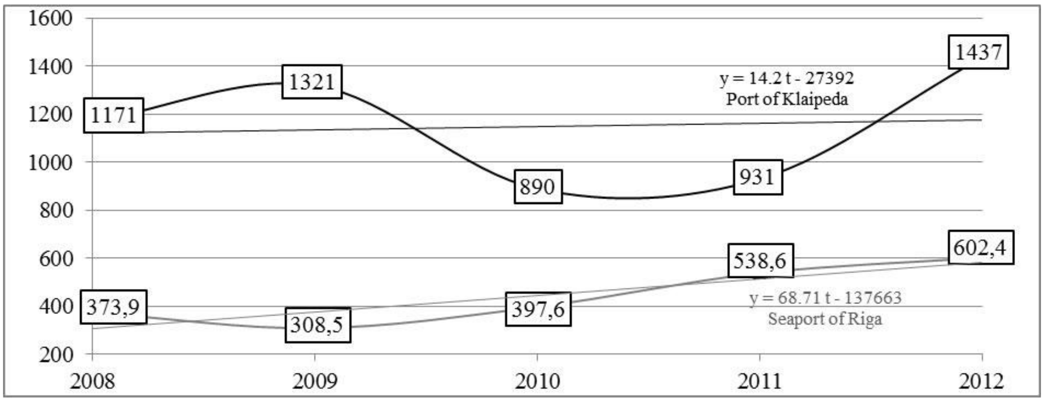


Figure 3. Grain handling trends at Klaipeda and Riga seaports

According to the linear trend method of grain handling trends in both ports and holding the corresponding periods of the next economic development patterns in respect of the investigation period it can be said that after 10 years of Klaipeda and Riga seaport grain handling will be the same – 1337.33 thousand tons.

However, a grain handling development trends of Sea port of Klaipeda depend varied extensively and prediction error can be greater than the allowed 10 percent, and such fluctuations can be explained by changes in grain import and export performance dynamics and changes to infrastructure and investment in bulk cargo terminals. The causation analysis allowed establishing the fact that the Klaipeda seaport handling is not linear over the import, than the export macroeconomic indicators, while Riga sea port indicators directly depend on the export and import values.

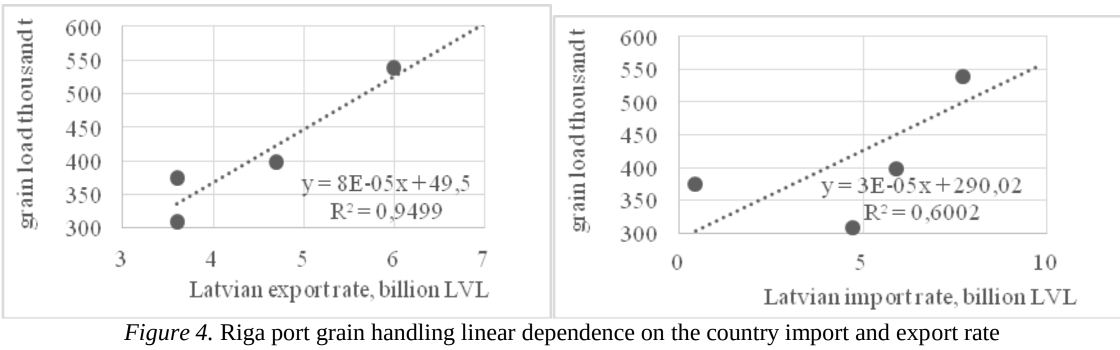
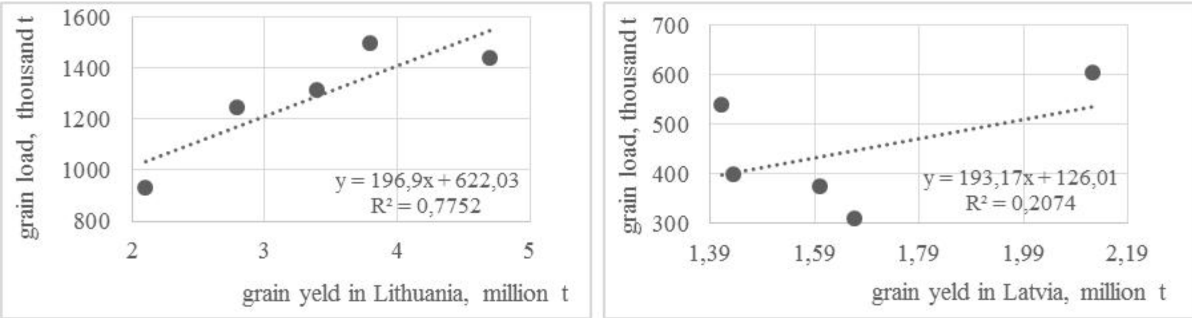


Figure 4. Riga port grain handling linear dependence on the country import and export rate

According to Figure 4 Regression models suggest that the relationship between macro-economic indicators are very strong, but significant changes in the handling of grain does not predict: exports increased a thousand LVL, grain handling changes are not significant, increase in turnover in just 800 kilograms, and the increase in imports of one thousand tons. Forecasting the growth of imports by 1 percent can be predicted that the grain handling at the port of Riga increased only 0.5 percent Such dependence indicates that the Riga seaport intensively served by transit cargoes of grain from Eastern

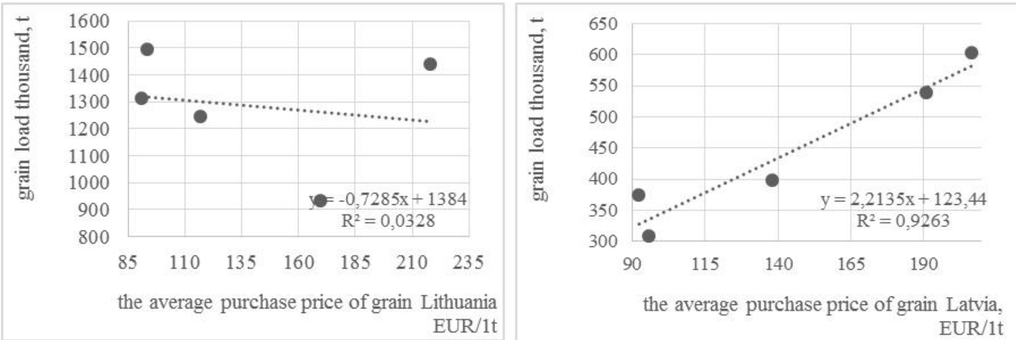
European and Asian countries, and exports more than Klaipeda seaport Port Lithuania harvested grain yield.



a) b)

Figure 5. Grain handling linear dependence of the grain produced in Lithuania (a) and Latvia (b)

While every million tons of cereal production in the country has an impact on grain handling and port of Riga (193,17 thousand tons) and Klaipeda seaport (196.9 thousand tons), however, the seaport of Klaipeda cereal production effects seen 78 percent signal strength, which means that only 22 percent of the effect of grain handling port goes to the other factors. The fact that the port of Klaipeda intensive export crops grown shows and the first quarter of 2013 the port report, which states that 70 percent of all cargo handling during this period amounted to Lithuania harvested grain residue exports.



a) b)

Figure 6. Grain handling dependence on grain purchase prices in Lithuania (a) and Latvia (b)

The analysis of grain prices in the countries, it was found that the entire analysis period, grain purchase price of Latvia was higher on average by 8 percent by 2012. The Latvian grain purchase price was less than 5 percent, when Lithuania average price of grain increased by 10 percent. However, the Riga port grain handling increased an average of 2 thousand tons of grain purchase price of an average increase of EUR 1 per ton of feed grain price increases, and increased grain handling characteristics, which shows that in Latvia grain are exported directly at farms owners and collectors, while Lithuania grain exports farmers directly for purchase to receiver which suggests grain export system is flexible Lithuania.

Conclusions

After the grain handling Klaipeda and Riga ports infrastructure elements comparison, was found that the Riga seaport inefficient use of its infrastructural and technological feasibility of grain handling, as practically all indicators infrastructure elements much better than Klaipeda seaport, except for the land areas of performance. Therefore, it can be said that it is 4.2 times higher in Klaipeda port productivity leads to higher grain handling (port performance recorded in 2011: Klaipeda seaport - 71 thousand tons/ha, Riga port 17 thousand tons/ha). Such figures are determined by the port of Klaipeda seaport efficiently organized and united railway infrastructure. Klaipeda seaport grain handling conclude an average of 10% of the bulk, while the Riga port grain handling accounts for only 3% of the bulk.

After the grain handling Klaipeda and Riga ports descriptive statistics compared data found that the Riga port grain handling is characterized by stability, but the expected load factor does not exceed the average, reaching 444 thousand tons annual turnover. Meanwhile, the Klaipeda port grain handling, although very unstable and can vary significantly likely significantly higher turnover in excess of 1150 thousand tons. However, the dynamics of Riga seaport captured significantly more than 4 times faster grain handling rate, which suggests that the economic development of events in line with the time-run dynamics around year 2023 analyzed grain handling ports equalized and reach 1337.33 thousand tons.

Linear trend forecasting adjustment linear regression suggests that the Riga port handling is significantly dependent on transit cargo of grain, especially after the increase of grain transported by rail from Kazakhstan flows, while 70 percent of all cargo in Klaipeda seaport 2013, the first quarter amounted to Lithuania harvested grain handling exports. Causal analysis, it was observed that Lithuania is more developed export environment, because grain growers directly exported grain to Western European countries, while in Latvia the trend is deduced that the grain exported via grain purchasers.

Another significant difference between the neighboring ports is storage options. Riga port can simultaneously store 52.8 thousand tons of grain, while the port of Klaipeda-based company “Klasco” with two grain handling terminals can simultaneously store 105 thousand tons. Only this company ahead of all its possibilities in Riga port, while the port of Klaipeda is still three companies with one terminal and of course the containers in which to store grain. “Achema” group belonging to the port cargo company “Klasco” per day can handle up to 33 thousand tons of grain, while the entire port of Riga only 8 thousand tons. These disparities suggest that the Klaipeda seaport of grain per year, handles an average of 2.59 times, even more than the Riga seaport what is largely due to the fact that the port of Klaipeda extended grain export market, increasing the number of grain export countries.

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EVALUATION OF IMO SECOND GENERATION INTACT STABILITY CRITERIA

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Abstract

Vessels must have sufficient stability in order to sail safely. Vessels need to provide necessary stability criteria during entire voyage. First international stability regulations have been applied to vessels in 1968. The criteria proposed within these regulations are recommended to the vessels over 100 meters by IMO (International Maritime Organization). The criteria in the proposal have not considered any dynamic effects. Hence, IMO constituted weather criteria in 1985. IMO first constituted the previously applied stability criteria in 1993, and afterwards collected the current stability regulations under the IS CODE headline in 2008. In spite of all applied stability criteria, vessels those capsized lead IMO to consider new regulations. These potential regulations are mostly about dynamic effects that vessels are exposed to. Since 2005, subcommittee of IMO, SLF (Stability, Loading Lines and Safety of Fishing Vessels) has started to study over Second Generation Intact Stability Criteria. SLF subcommittee has stated the primary mode of stability failures, which is parametric roll, pure loss of stability and broaching. In this paper, the primary mode of parametric roll, which is Level 1 Vulnerability Criteria, was evaluated and the criteria was applied for a selected midsize container ship. The criteria gave the same results with the ABS Susceptibility Criteria.

Keywords: *vessels, stability criteria*

Introduction

All type of vessels has to comply sufficient intact stability criteria to sail safely. Many national stability standards and classification society rules have been developed for intact stability since the 1930s. The first international stability regulations were formulated in the 2008 Intact Stability (IS) code and they can be traced to the pioneering work of Rahola (1939) [1]. Many researchers have been worked on ship stability, developed regulations which came into force, are mostly based on static conditions. These conditions do not truly represent high risk cases for ships. Ships may capsize due to nonlinear effects ignored in the existing regulations; even they comply with all static and quasi-static regulations [2].

Capsized ships have led to significant changes in the design and operation of commercial ships. These significant changes, and their impact on the intact stability performance of ships, have motivated the development of the second generation intact stability criteria by the IMO Subcommittee on Stability and Load Lines and on Fishing Vessels Safety (SLF). The development of the second generation intact stability criteria started in 2002. IMO Subcommittee SLF established a working group to work on new criteria. Parametric roll, pure loss of stability, dead ship condition and surf-riding/broaching were considered as primary modes of stability failures [3].

Second generation intact stability criteria has a multi-tiered structure. Figure 1 shows the structure of the multi-tiered approach for intact stability criteria. First of all 2008 IS Code is applied for all ships covered under IMO instruments. Then ship is checked for vulnerability to pure loss of stability, parametric roll, and surf-riding/broaching phenomena using Level 1 Vulnerability Criteria. If the ship is vulnerable, then the Level 2 Vulnerability Criteria are applied, followed by direct stability assessment, if necessary. If the direct stability assessment shows high risk for mode of dynamic stability failure, then the ship specific operational guidance may be improved. If the ship do not show vulnerability to each mode of dynamic stability failure, or the risk of stability failure is not excessive, then no additional requirements must to be applied.

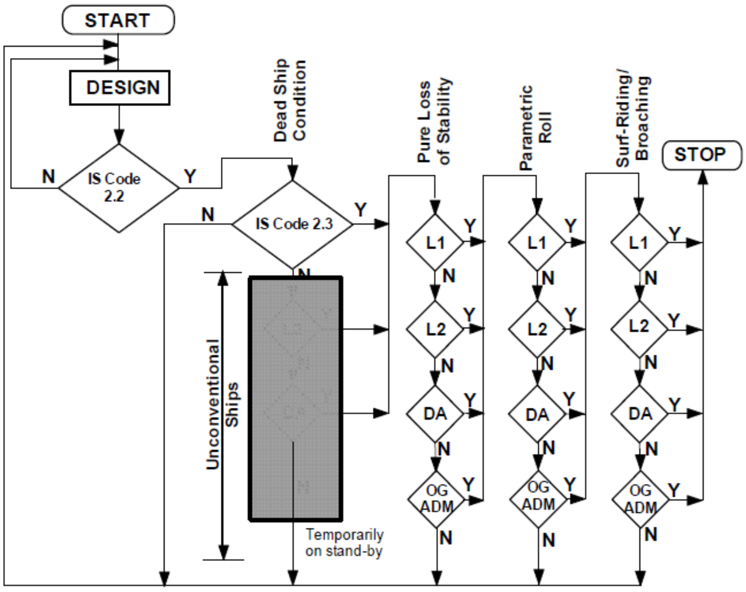

Figure 1. Multi-tiered approach for the second generation of intact stability criteria [3]

The working group started to develop procedures and prepared proposals for each mode of stability failures. The most important part of the work is the verification of the proposed criteria. Therefore, the members of the working group have applied the criteria for many existing vessels [4, 5]. In this work, for a selected midsize container ship, Level 1 Vulnerability Criteria on parametric roll was applied to the ship and also ABS Susceptibility Criteria was applied to verify the new criteria [6].

Level 1 vulnerability criteria on parametric roll and application

When considering the motion of a ship in waves, parametric roll is known as one of the most important phenomenon. There have been so many accidents reported as a result of parametric roll. Many researchers have studied to find a solution to this phenomenon for many years. After an incident in the North Pacific which resulted in heavy loss of containers, ABS prepared a guide for the assessment of parametric roll resonance in the design of container ships. Taylan investigated the parametric roll susceptibility of container ships according to ABS Susceptibility Criteria [7]. ABS Susceptibility Criteria became an important background for Level 1 Vulnerability Criteria on parametric roll. Both criteria require calculation of stability of the ship in waves, but Level 1 vulnerability Criteria is more practical.

In order to give rise to parametric roll, the parametric excitation (change of stability in waves) must satisfy two conditions: its frequency (the encounter frequency) must be within the range and its magnitude must be above the threshold (resulting from damping). The Mathieu equation (and Ince-Strutt diagram) is the simplest mathematical model that can be used to check if these conditions are satisfied. ABS Susceptibility Criteria are based on this approach [8, 9].

K. Spyrou proposed more advanced and practical version of the criteria based on the Mathieu equation [9]. This idea was further used as a background for second generation intact stability criterias and proposed as Level 1 Vulnerability Criteria. Criteria is based on the stability change in waves and defined as below in sum.

$$\frac{GM_a}{GM_0} \geq 0.49 \qquad (1)$$

This value is very close to the standard proposed in SLF 53 by Japan, the value of 0.51 was determined for the criteria, while the general form of the criteria is similar to Eq.(1). Many sample calculations were practiced to verify Level 1 Vulnerability Criteria. Criteria were applied to capsized ships due to parametric rolling and these verifications supported the proposed criteria.

Sample vessel: a container ship

A container ship is taken for verifying feasibility of the Level 1 Vulnerability Criteria on parametric rolling. It is calculated that the containership is vulnerable to parametric roll or not. Moreover, ABS Susceptibility Criteria is applied to support the Level 1 Vulnerability Criteria.

The container ship used here as an example is designed in Maxsurf. Its principal parameters and the body view are shown in Table 1 and Figure 2, respectively.

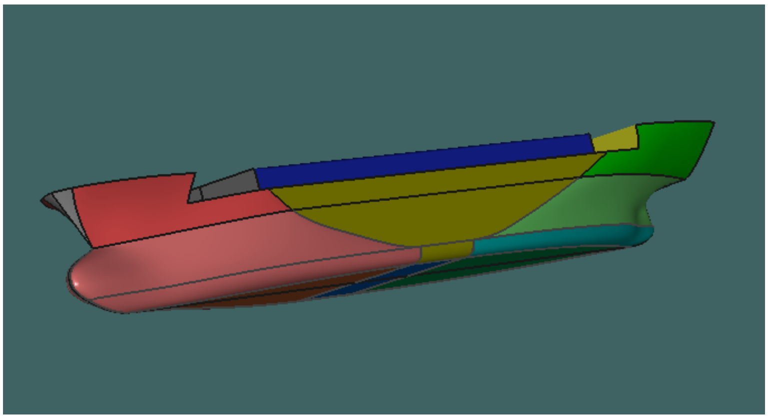

Figure 2. 3D body view of the container ship

Table 1. Principal parameters of the container ship

Length, L_{BP}, m	105.0
Breadth, B, m	19.5
Depth, D, m	9.94
Design Draught, T, m	7.239
Metacentric Height, GM, m	0.760
Displacement, W , ton	11174

First of all, ABS Susceptibility Criteria is applied to the container ship. Environmental conditions like wave parameters are defined. The length of the wave, λ , is equal to length between perpendiculars, LBP. The wave height is calculated from Table 2, which is based on wave scatter table from IACS Recommendation No. 34, "Standard Wave Data" and represents waves of different lengths with the same probability of encounter (ABS). Wave parameters were calculated according to Table 2 and shown in Table 3.

Table 2. Wave heights depend on wave lengths [3]

Wave Length, λ , m	50	100	150	200	250	300	350	400	450
Wave Height, h_w , m	5.9	11.6	14.2	15.1	15.2	14.6	13.6	12.0	9.9

Table 3. Wave Parameters

Wave Length, λ , m (Equal to ship length)	105.0
Wave Height., h_w , m (Calculated from Table 2 by interpolation)	11.86
Wave Period, T_w , sn	8.20
Circular Wave Frequency, ω_w , rad/sn	0.766

ABS Susceptibility Criteria for the container ship is estimated depends on these results. Firstly, the wave crest is fixed along ship length (Figure 3) and the GM values for different position of wave crest are calculated.

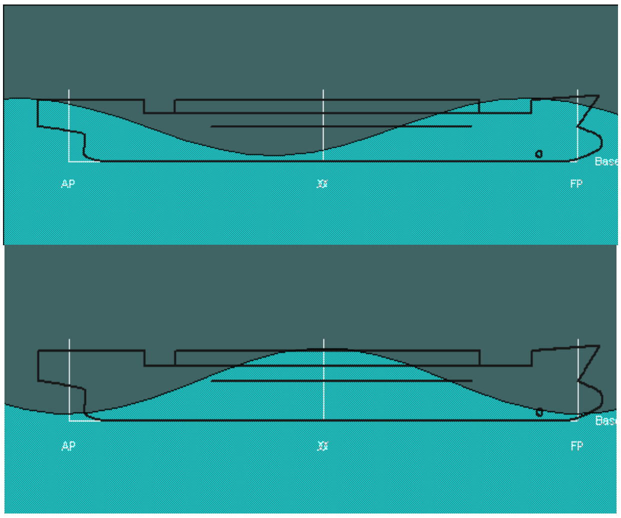

Figure 3. Different wave crest positions along the ship hull

Calculated GM values for different position of wave crest are shown in Figure 4.

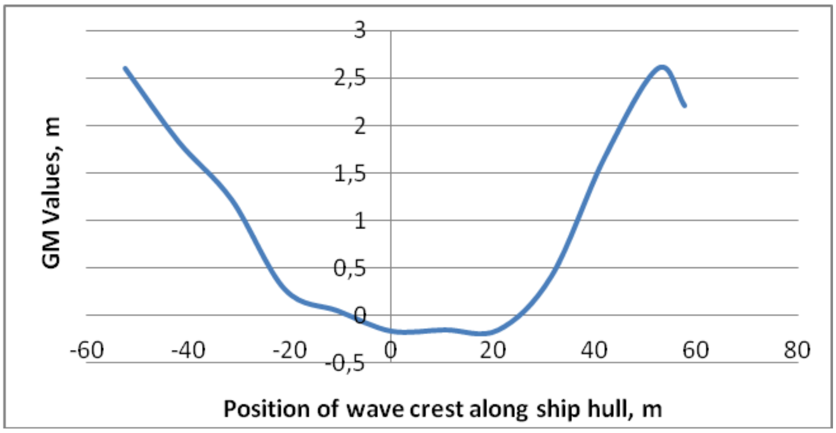

Figure 4. GM values for different position of wave crest

All required parameters were defined and ABS Susceptibility Criteria were calculated for the container ship (Table 4).

Table 4. ABS susceptibility criteria results for container ship

Value	Symbol	Formula	Result
Minimum GM value, m	GM_{min}		-0.166
Maximum GM value, m	GM_{max}		2.605
Amplitude of parametric excitation, m	GM_a	$GM_a = 0.5(GM_{max} - GM_{min})$	1.385
Mean value of GM, m	GM_m	$GM_m = 0.5(GM_{max} + GM_{min})$	1.219
Amplitude of stability change in longitudinal waves expressed in terms of frequency, rad/sn	ω_a	$\omega_a = \frac{7.854\sqrt{GM_a}}{B}$	0.474
Mean value of stability change in longitudinal waves expressed in terms of frequency, rad/sn	ω_m	$\omega_m = \frac{7.854\sqrt{GM_m}}{B}$	0.445
Forward speed most likely for development of parametric roll, kn	V_{pr}	$V_{pr} = \frac{19.06\lvert 2\omega_m - \omega_w \rvert}{\omega_w^2}$	4.028
Frequency of encounter, rad/sn	ω_e	$\omega_e = \omega_w + 0.0524 * V_S * \omega_w^2$	0.890
GM value in calm water, m	GM_0		0.760

Natural roll frequency in calm water, rad/sn	ω_0	$\omega_0 = \frac{7.854\sqrt{GM_0}}{B}$	0.351
Roll damping coefficient expressed as a fraction of critical damping	μ		0.1
Parameter of susceptibility criterion	p	$p = \frac{\omega_m^2 - (\mu * \omega_0)^2}{\omega_e^2}$	0.248
Parameter of susceptibility criterion	q	$q = \frac{\omega_a^2}{\omega_e^2}$	0.284

$$0.25 - 0.5q - 0.125q^2 + 0.03125q^3 \leq p \leq 0.25 + 0.5q \quad (2)$$

$$\mu\frac{\omega_0}{\omega_e} < qk_1k_2\sqrt{1 - k_3^2} \quad (3)$$

Inequality (2) and (3) were checked for the calculated p and q values. The results were shown in Table 5.

Table 5. ABS susceptibility criteria results for container ship

Value	Formula	Result
Left boundary of inequality	$0.25 - 0.5q - 0.125q^2 + 0.03125q^3$	0.099
Right boundary of inequality	$0.25 + 0.5q$	0.392
Susceptibility inequality outcome	**Positive**	
Coefficient *k*1 of damping criterion	$k_1 = 1 - 0.1875q^2$	0.985
Coefficient *k*2 of damping criterion	$k_2 = 1.002p + 0.16q + 0.759$	1.053
Coefficient *k*3 of damping criterion	$k_3 = \frac{q^2 - 16 + \sqrt{q^4 + 352q^2 + 1024p}}{16q}$	0.194
Boundary of damping criterion inequality – damping threshold value	$qk_1k_2\sqrt{1 - k_3^2}$	0.289
Effective damping	$\mu\frac{\omega_0}{\omega_e}$	0.039
Susceptibility inequality outcome	**Positive**	

Both of inequalities were checked for the container ship and susceptibility criteria calculated as positive. It means that the container ship is susceptible to parametric roll and the ABS severity check has to be applied for detailed control.

After ABS Susceptibility Criteria control, Level 1 Vulnerability Criteria for parametric roll was checked for the container ship. Results for Level 1 Vulnerability Criteria were shown in Table 6.

Table 6. Level 1 Vulnerability Criteria results for container ship

Value	Symbol or Inequality	Result
Amplitude of parametric excitation, m	GM_a	1.385
Mean value of GM, m	GM_m	1.219
Level 1 Vulnerability Criteria	$\frac{GM_a}{GM_m} \geq 0.49$ veya $\frac{GM_a}{GM_0} \geq 0.49$	1.136 $\geq$ 0.49
Vulnerability inequality outcome	**Positive**	

As a result of calculations for Level 1 Vulnerability Criteria, calculated value was bigger than threshold value and it means that container ship is vulnerable to parametric roll.

Conclusions and recommendations

Many accidents as a result of parametric roll have been occurred for many years. It was hard to find an exact solution to check parametric roll vulnerability of the ship at the design stage. Therefore, researchers have tried to find a solution to this phenomenon at the design stage. Firstly, ABS prepared a criterion for container ship and then Sub-Committee on Stability and Load Lines and on Fishing Vessel Safety (SLF) has started to develop new criteria at the name of Second Generation Intact Stability Criteria. Level 1 Vulnerability Criteria on parametric roll was one of the proposed criteria and further version of ABS Susceptibility Criteria.

The present study illustrates the verification of Level 1 Vulnerability Criteria on parametric roll comparing with ABS Susceptibility Criteria. For a selected midsize container ship, parametric roll vulnerability was calculated with two different criteria. As a result of calculations, the container ship was said to be vulnerable to parametric roll, but calculations regarding Level 1 Vulnerability Criteria is easier and more practical than ABS Susceptibility Criteria. The ship is vulnerable, so that the Level 2 Vulnerability Criteria has to be applied, followed by direct stability assessment, if necessary. Although, it was verified that Level 1 Vulnerability Criteria gives the same results with the ABS Susceptibility Criteria. It should be kept in mind that, the container ship is theoretically vulnerable to parametric roll, for more accurate and exact solutions data, model tests and supporting computer simulations need to be considered.

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