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LJA PĒTNIECĪBAS INSTITŪTS

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Ūdens transports un infrastruktūra
2012

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Maritime Transport and Infrastructure
2012

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PRIEKŠVĀRDS

Latvijas Jūras akadēmijas ikgadējās konferences rakstu krājuma 14. izdevums norāda uz tradīciju turpināšanu. Konference tiek organizēta, lai sekmētu ūdens transporta nozares attīstību Latvijā un Baltijas reģionā kopumā, kā arī veicinātu starptautisko sadarbību. Konferencē piedalās Jūras un citu transporta nozaru speciālisti no Beļģijas, Igaunijas, Lielbritānijas, Lietuvas, Polijas, Somijas, Turcijas, Vācijas un Zviedrijas. No Latvijas konferences dalībnieku vidū ir pārstāvji no Latvijas Jūras administrācijas, Latvijas Jūras spēkiem, Vides attīstības biedrības, Rīgas Tehniskās universitātes, Latvijas Universitātes un Latvijas Jūras akadēmijas mācību spēki un studējošie, kā arī citi jūrniecības un ar to saistīto nozaru profesionāļi.

Konferenci atbalsta Latvijas Jūras administrācija, AS SPRINT, Lloyd’s register, AS Swedbanka.

Rakstu krājumā ir apkopoti un publicēti LJA 14. starptautiskās konferences *Ūdens transports un infrastruktūra – 2012* dalībnieku iesniegtie materiāli. Rakstu krājums ir starptautiski recenzēts.

Konferences galvenā tēma – **Jūras transports un vide**

- Kuģošanas drošība, ostu un kuģu aizsardzība
- Ostu un kuģošanas bizness šodienas apstākļos
- Kuģu būve, remonts un ekspluatācija
- Jūrniecības cilvēkresursu attīstība un izglītība
- Jūras tiesības
- Citas jūras transporta nozarei aktuālas tēmas

Latvijas Jūras akadēmija pateicas Latvijas Jūras administrācijai par iespēju izmantot Latvijas Hidrogrāfijas karti konferences materiālu noformēšanai.

PREFACE

The fourteenth edition of the Conference Proceedings of Latvian Maritime Academy is indicative of preserving traditions. Conference proceedings are internationally reviewed. We hope that the Conference and its outcome wil give a fresh impetus to the development of the transport industry within the Baltic region and elsewhere in the world. Among the conference participants are Maritime specialists from Belgium, Estonia, Finaland, Germany, Great Britain, Lithuania, Poland, Sweden and Turkey. On behalf of Latvia the conference is atended by representatives from Latvian Maritime Administration, Latvian Naval Forces, Environmental Development Association, Riga Technical University and teaching staff and students of Latvian Maritime Academy along with the specialists from maritime and other related industries.

The conference is supported by the Latvian Maritime Administration, AS SPRINT, Lloyd's register and AS Swedbanka.

The Conference Proceedings include internationally reviewed papers submitted for publication for the 14th International conference "*Maritime Transport and Infrastructure – 2012*".

The main topic of the conference –
Maritime Transport and Environment.

Other topics:

- Navigation safety, ship and port security
- Port and maritime business today
- Ship construction, repair and operation
- Development of maritime human resources and education
- Maritime Law
- Other topical subjects related to maritime transport

MARITIME DELIMITATION OF LATVIAN WATERS, HISTORY AND FUTURE PROSPECTS

Gunārs Šteinerts

Latvian Maritime Academy, Flotes iela 5B, Rīga LV-1016, Latvia, E-mail: steinerts@latja.lv

Abstract

Maritime delimitation of Latvian waters was one of the important issues since the Republic of Latvia has gained independence from USSR in 1991. The UNCLOS 1982 Convention was not yet in force by that time, nevertheless the basic provisions of this convention have been applied when negotiating the sea borders with the Republic of Estonia and Republic of Lithuania. These negotiations resulted in Agreement with the Republic of Estonia in 1996 and Agreement with the Republic of Lithuania in 1999. The letter Agreement still has been applied on preliminary base as not ratified by Latvian Parliament – Saeima because of objections on delimitation of Exclusive Economic Zone and Continental Shelf. As to Latvian and Swedish waters delimitation in the Baltic Sea, bilateral agreement of delimitation the Exclusive Economic Zone and Continental Shelf is still pending, Only tripartite agreement on common point between Estonia, Sweden and Latvia has been signed in 1997. Solution of this uncertain situation of delimitation of Latvian Exclusive Economic Zone and Continental Shelf between Lithuania and Sweden is still an urgent task for Latvia.

Introduction

Delimitation principles for maritime zones have bee prescribed by the United Nations Law of the Sea convention, 1982 which now is in force in Latvia and also in our neighbour States. So in Article 15 of this convention in regard to territorial sea reference is made to the "method of the median line to every point of which is equidistant from the nearest points on the baselines from which the breadth of the territorial seas of each of the two States is measured" and „*The above provision does not apply, however, where it is necessary by reason of historic title or other special circumstances to delimit the territorial seas of the two States in a way which is at variance therewith".*

As to delimitation of the Exclusive Economic Zone (EEZ) between States with opposite or adjacent coasts the provisions of Article 74 of UNCLOS 82 prescribe*:*

1. The delimitation of the exclusive economic zone between States with opposite or adjacent coasts shall be effected by agreement on the basis of international law, as referred to in Article 38 of the Statute of the International Court of Justice, in order to achieve an equitable solution.

2. If no agreement can be reached within a reasonable period of time, the States concerned shall resort to the procedures provided for in Part XV.

3. Pending agreement as provided for in paragraph 1, the States concerned, in a spirit of understanding and cooperation, shall make every effort to enter into provisional arrangements of a practical nature and, during this transitional period, not to jeopardize or hamper the reaching of the final agreement. Such arrangements shall be without prejudice to the final delimitation."

All these provisions have been applied when negotiating with Estonia and Lithuania, partly also with Sweden. When considering term „*equitable solution"* we may look at the Oxfords Dictionary, were *„equitable"* is – fair, just, reasonable, and *"Equity"* – fairness, right judgement, principles of justice outside common law or Statute law, used to correct laws when these would apply unfairly in special circumstances. These principles of "justice outside common law" have been applied in many cases and vast experience gained internationally based on many decisions of International Court of Justice [1].

1. Maritime delimitation with Estonia

Negotiations between delegations of Estonia and Latvia on Maritime delimitation have been started since 1991. Most of the difficulties to reach mutually acceptable agreement on delimitation were in connection with fishery interests. In spring 1995 differences of positions of both countries escalated evens so that navy patrol boats were involved in the control of disputed area. Nevertheless negotiations were not terminated and in 1996 they resulted in „Agreement between the Republic of Estonia and the Republic of Latvia on the Maritime Delimitation in the Gulf of Riga, the Strait of Irbe and the Baltic Sea, 12 July 1996” which soon was ratified by both countries. Details of these negotiations are described in Vol .IV, American Society of International Law, International Maritime Boundaries, 2002 [2]. This Agreement confirmed 15 points of delimitation and from point 15 also a straight geodetic line in the azimuth of 289°19.35' up to the boundary of the exclusive economic zone and the continental shelf of the Kingdom of Sweden [3].

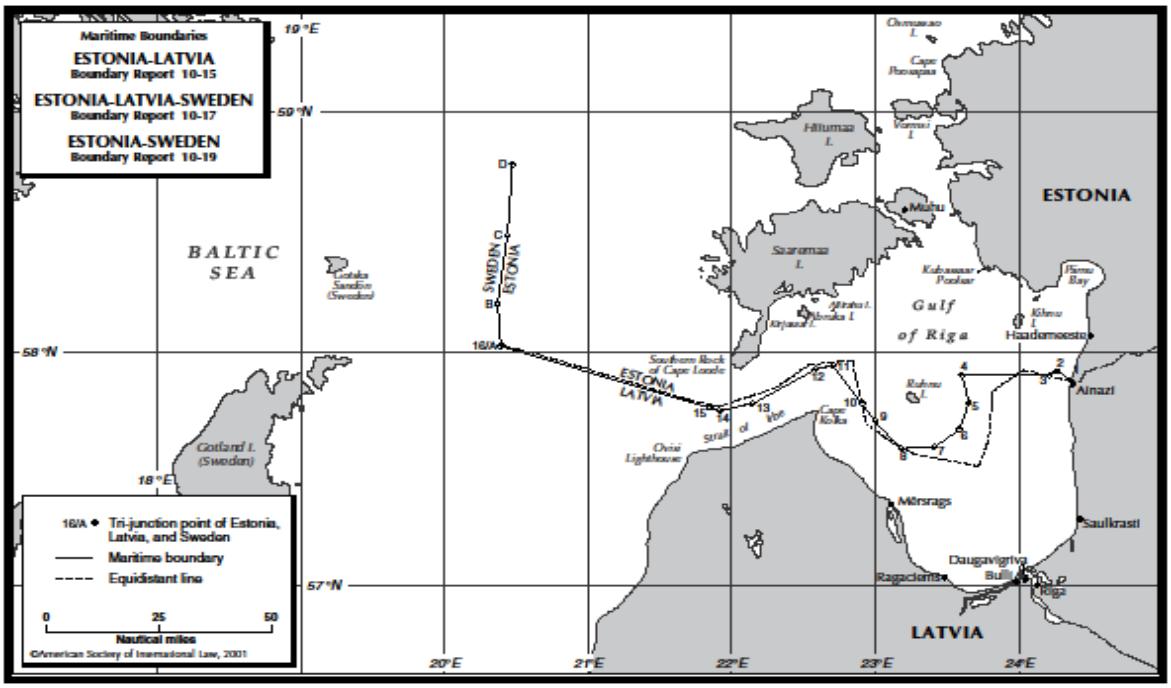

Fig 1. Delimitation map when negotiating Agreement between the Republic of Estonia and the Republic of Latvia on the Maritime Delimitation in the Gulf of Riga, the Strait of Irbe and the Baltic Sea, 12 July 1996.

In April 1997 the Agreement between the Government of the Republic of Estonia, the Government of the Republic of Latvia and the Government of the Kingdom of Sweden on the on the Common Maritime boundary Point in the Baltic Sea was signed confirming this important common point in position 58° 01,440'N 20° 23,775'E [4].

These Agreements are giving solid base for good neighbourhood relations with Estonia and also for further spatial planning of relevant maritime area. At the same time some specific situation in connection with Latvian national legislation, i.e., the Law “On the State Border of the Republic of Latvia” it should be noted in regard to territorial sea outer limit in the Gulf of Rīga area. This issue is discussed more in detail in part 4 of this paper.

2. Maritime delimitation with Lithuania

Negotiations between Latvia and Lithuania on Maritime delimitation have been commenced since late 1993. Drastic differences in proposals of delimitation were noted from both countries from

very beginning of these negotiations. In relation to territorial sea Latvia proposed prolongation of land border direction at sea, so applying historical method. That was declined by Lithuanian delegation. Then Latvian delegation gave in and proposed delimitation of territorial sea by equidistance from the relevant coast method. That proposal also was declined by Lithuanian side.

As to delimitation of EEZ and Continental Shelf (CSh) very different views have been presented. Latvia proposed application of equidistance method but Lithuania insisted on 270° azimuth (parallel) from last point of land border up to EEZ of Sweden. Basic obstacles to reach equitable solution were economic interests as there are substantial oil fields in disputed area (Fig.2) [5].

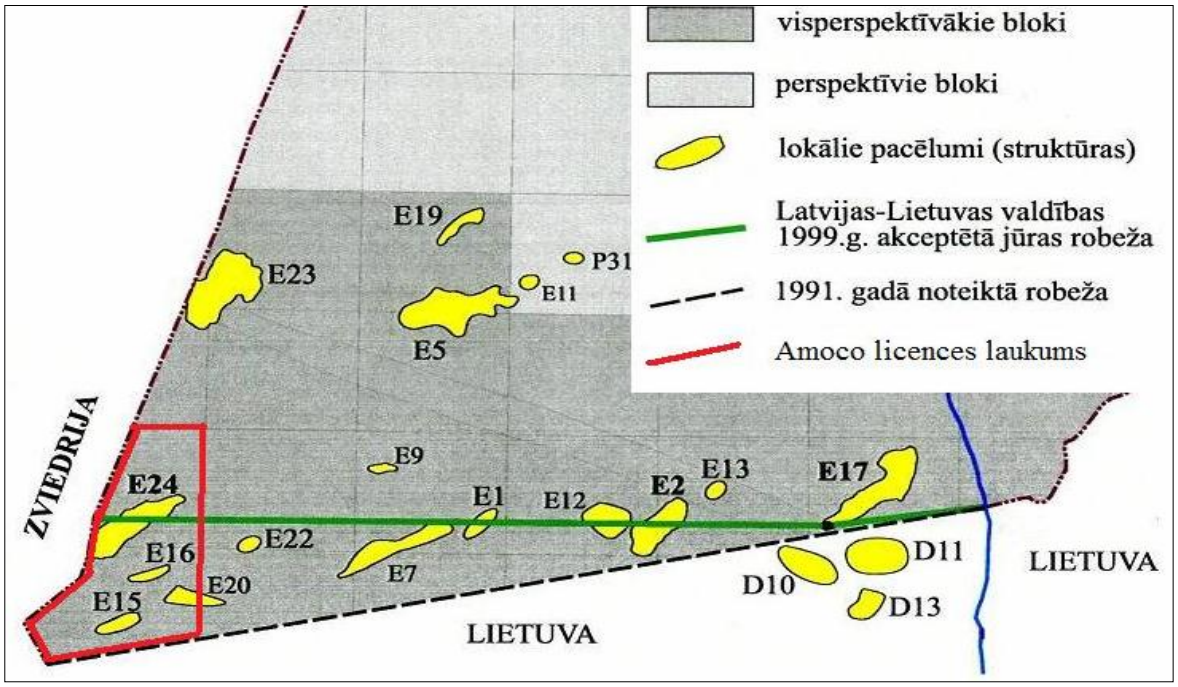

Fig.2. Oil fields on the Lithuanian – Latvian sea border

Some compromise solutions have been reached on later stages of negotiations on delimitation of territorial sea, but Lithuanian delegation was obstinate and persisted on parallel method on EEZ/ CSh delimitation. Negotiations passed many unsuccessful stages. This situation was influenced also by Latvia concluding and ratifying in Saeima agreement with AMOCO oil company in October 1995. Licence for this company was extended up to outer end of disputed EEZ/ CSh area.

In 1999 negotiations were activated in response to political pressure from Latvian ruling parties and President to conclude maritime delimitation agreement with Lithuania without delay, so demonstrating European Union that Latvia has no border conflicts with neighbouring countries.

In May 1999 in Palanga both delegations signed the "Agreement between the Republic of Latvia and the Republic of Lithuania on the delimitation of the territorial sea, exclusive economic zone and continental shelf in the Baltic Sea" [6]. This Agreement on 9thJuly 1999 was signed also by Prime Ministers of both countries. Then Latvian–Lithuanian Maritime Delimitation agreement was sent to Latvian Parliament – Saeima for ratification, but passed only 1st reading, while Lithuanian Parliament – Seimas ratified it in October 1999 by almost unanimous vote.

Numerous attempts to resume the ratification process in Latvia further failed. The 1999 Agreement was used for practical application for cartography, for search and rescue purposes and for fishing. This delimitation was unilaterally also confirmed by Lithuanian national legislation [7] but not by Latvian national legislation.

It is apparent that maritime delimitation as in 1999 Latvia – Lithuania Agreement is not complying nether with the principle of equidistance nor equity. This Agreement was driven by political motives of that time rather than following basic provisions of UNCLOS 82, which shall be

applied now as this convention is ratified by both countries. 1999 Latvia–Lithuania maritime delimitation Agreement is not in national interests of Latvia, need to be denounced and the application for International Court of Justice (ICJ) hearing is submitted. Such proposal of legal expert was recently published in Latvian Journal "Jurista Vārds", where Liene Eglaja, Mg.Sc., has presented excellent analysis of history of this Agreement and proposal for future actions to rectify the situation [8].

There are many ICJ Judgments where the three stage method of testing of delimitation is applied. On the first stage the preliminary equidistance line was drawn. Then this delimitation line may be adjusted to take into account the specific circumstances for reaching equitable solution. During the third stage the proportionality test may be applied if necessary to confirm the equity of delimitation.

Such method was used in ICJ Judgment for Maritime Delimitation in the Black Sea, Romania v. Ukraine case of 3rd February 2009. On the first stage in this Romania–Ukraine case the preliminary equidistance line was drawn, then the relevant coast and relevant marine area was examined and disproportionality test of relevant coast and relevant marine area was made. The final Judgement in fact confirmed the delimitation of the first stage, i.e., made by equidistance method [9]. This ICJ Judgment resolved which country has the right to exploit oil and natural gas deposits in disputed area, which may total about 100 billion cubic meters of natural gas and 100 million metric tons of crude oil. This ICJ Judgment case is a good example for Latvia confirming necessity to be more pro-active and not to be afraid of submission Latvia – Lithuania delimitation case for independent judgment of International body.

3. Maritime delimitation with Sweden

Sweden was the first of two countries who unilaterally established EEZ / CSh delimitation applicable to Baltic Sates. This was also in regard to Latvia. In 1992 Swedish Government adopted the Ordinance on Sweden's Exclusive Economic Zone, 3 December 1992, were in paragraph 6. in the Central and Northern Baltic Sea straight lines (loxodromes) between the 17 points were confirmed [10].

The delimitation line in regard to Baltic States apparently has been taken from 1988 USSR–Sweden delimitation Agreement, where the principles of disputed area delimitation was agreed as 75% in favour of Sweden in exchange of fishing quotas 75% in favour of USSR [11].

Should Latvia inherit USSR-Sweden delimitation of EEZ / CSh the opinions are different. Sweden naturally was positive on that opinion; same internationally recognized legal experts (viz. Erik Frankx) also support this delimitation principle [12].

This is not in line with general rule adopted by Latvian Parliament in 1991 saying that agreements signed by USSS are not binding for Latvia. There were no maritime delimitation negotiations in early 1990 between Sweden and Latvia (at least to the knowledge of author) when theoretically new delimitation could be negotiated. Now that possibility is lost, especially because in 2005 Latvia submitted to UN Law of the Sea commission very similar delimitation points as in Sweden Government 1992 Ordinances. It was confirmed by Latvia submission to UN Law of the Sea Commission that "points A4-A14 are according with the Agreement between the USSR and Sweden 1988 which is *de facto* observed. [13] Even in case this 2005 submission from Latvia would not be made, the 20 year period for fishing quotas revision as in USSR-Sweden Agreement have expired in 2008 and does not apply as now all fishing activities are under European Union ruling. All this make delimitation line with Sweden clearly established and leave no chance to new negotiations.

At the same time official bi-partial Agreement with Sweden need to be concluded but first the common point with Lithuania and Sweden be established.

4. Maritime Delimitation in the Gulf of Riga

Delimitation in the Gulf of Riga in regard to Estonia is clear since 1996 Agreement was in force. Some small problem rose because some Irbe fairway boys are installed in Estonian waters, but this matter has been settled. We may notice some problems of compliance of Latvian National legislation with UNCLOS 82 provisions in regard to State border and territorial sea outer limit in Gulf of Rīga area.

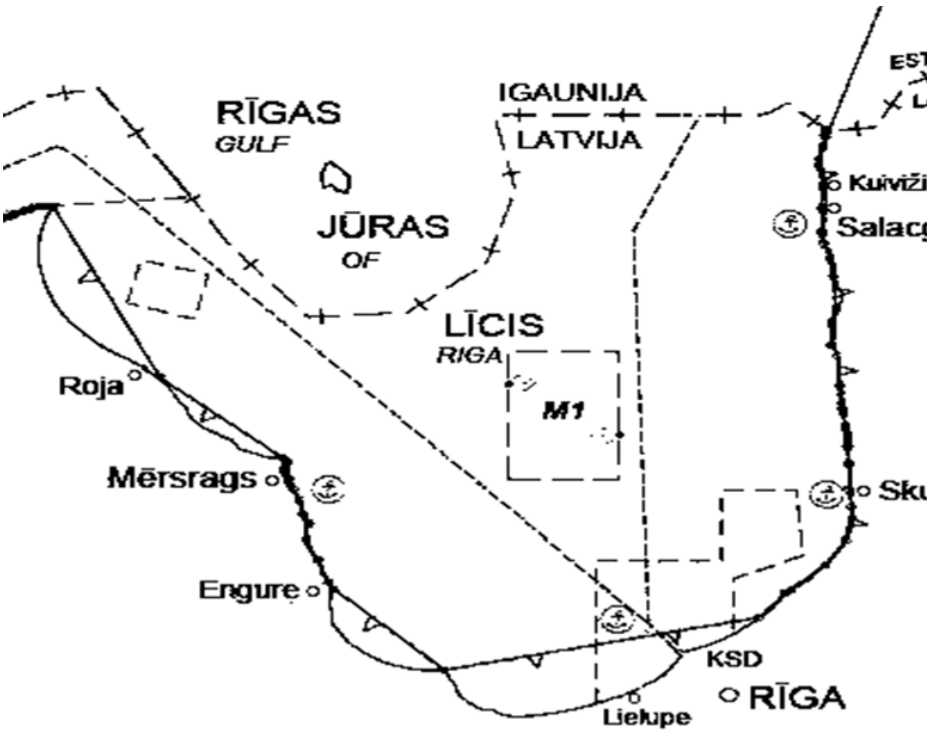

Fig.3 Gulf of Riga area according to Notices of Mariners No.1, 2012

According to Latvian Law "On the State Border of the Republic of Latvia", Section 1 we read, that *"9) territorial sea of the Republic of Latvia (hereinafter – territorial sea):*

a) the waters of the Baltic Sea in width of 12 nautical miles, counting from the base line if it has not been otherwise specified by international agreements,

b) waters of the Gulf of Riga of the Baltic Sea from the base line to the State border which is determined in accordance with the agreement of 12 July 1996 between the Republic of Latvia and the Republic of Estonia regarding determination of the sea border in the Gulf of Riga, the Irbe Strait and the Baltic Sea;"

When looking on the on map published in the Notices of Mariners No.1, 2012 of Latvian Hydrographical Service (Fig.3), where the State border is delimitation line as agreed with Estonia in 1996 Agreement.

Nothing wrong with Latvia- Estonia border line, but according to UNCLOS 82 Article 3 territorial sea shall not exceed 12 nautical miles: "*Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles, measured from baselines determined in accordance with this Convention."*

When examining baseline situation in the Gulf of Riga we may notice some straight baselines drawn not in compliance with Articles 6 and 10 of UNCLOS 82.

These two non-compliances of Latvian legislation with UNCLOS 82 may be discussed more in detail, possibly this is deliberately arranged for strategic purposes.

Conclusions

1. There are no delimitation problems with Estonia, the 1996 Agreement is well serving the purpose
2. Agreement with the Republic of Lithuania is considered as preliminary, but need to be denounced following the procedures of UNCLOS 82
3. Submission to International Court of Justice or to International Tribunal for the Law of the Sea should be initiated seeking for independent judgement on Latvia-Lithuania maritime delimitation.
4. Maritime delimitation Agreement with Sweden should be negotiated to confirm the *de facto* situation, but first tri-point need to be agreed with Lithuania and Sweden.

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THE AGE OF THE ELECTRO-TECHNICAL OFFICER IS HERE!

Gary Hindmarch

South Tyneside College, UK

Abstract

The training programmes that create competent seafarers is a combination of the development of knowledge and demonstration of skills. The content of each training programme is devised to meet the needs of the industry, whilst complying with any external certification required. This training profile has been undertaken by Deck and Engineering Officers for many years.

However as the maritime industry evolves, and new technology based operations expand, these operational demands have created the need for specialists who can operate and maintain the increasingly complex systems and challenges that are faced by all mariners today.

The myriad of electronics devices onboard has always required a specialist role and this was undertaken by the Radio Officers, whose roles expanded from pure communications into maintaining the array of bridge equipment. When the role of Radio Officers across the various Merchant Fleets reduced due to the advent of satellite enabled digital communications, the maintenance of bridge navigation equipment was increasingly undertaken by shore based maintenance personnel. This removal of the electronics expert created a skills gap onboard many vessels, which has led to the demand for the new Electro-technical officer role.

In 1997 South Tyneside College created an Electro-technical officer training programme which provided Engineering Officers of the Watch with additional skills to enable them to undertake a wider range of electrical and electronic maintenance roles onboard. However it was recognised that whilst this original training scheme could provide most of the knowledge and some of the skills required, the increasing role of power electronic devices for propulsion, programmable logic controllers, control bus interfaces and software driven devises meant that a new training programme was required that focussed solely and uniquely on the now established role of Electro-technical officer (ETO).

This paper will detail how the training scheme for Electro-Technical Officer was created in 2008, and reflect on the lessons learnt over the first three cohorts of this training scheme.

In July 2012 the first dedicated Electro-technical Officers trained within the UK will graduate, and these will receive international recognition through the first IMO STCW Certificates of Competency.

The age of the ETO has indeed arrived!

The need for change

An apparent paradox existed in that there appeared to be a need for a change to the existing ETO training schemes whilst a viable demand was present; so what were the drivers for further change?

a) Increased demand for more electrical & electronic fault finding skills
b) Increased network based systems onboard
c) The increase in the number of high voltage systems onboard
d) The increase in use of power electronics in main propulsion systems
e) The need to recognise the role and professionalism of existing ETO's onboard

Whilst many of these drivers could have been achieved by further modifications to the existing engineering based training schemes, it was felt that using the current marine engineering schemes even with an ETO bias would still result in skills and knowledge gaps when compared to the role required onboard.

The existing Engineering scheme was reviewed to select what was considered to be the desirable outcomes of the scheme, which were:

a) Recognition by the national administration, in the UK's case the Maritime and Coastguard Agency (MCA)
b) The range of practical skills assessed within the training scheme
c) The training and training support provided onboard by use of the dedicated Training Record Book

Hence the initial course design was to replicate the existing Engineering scheme but introduce dedicated ETO skills and knowledge. This change would result in a new scheme that would reflect the role of the ETO alone, and not provide the training required for the engineering watchkeeping Certificates of Competency.

What will the ETO certification provide?

Certification alone does not create skills and knowledge. The certification is a measure of the processes by which these skills are learnt and measured to an internally assessed and externally validated standard.

It was recognised that a single programme could not create the range of skills and knowledge required. Thus new academic programmes were created that would provide the level and range of knowledge expected. The content of these courses were a reflection of the specific technical skills required to maintain the equipment fitted to a modern vessel, with the focus on new power switching devices, control infrastructure and developing advanced fault finding techniques.

In addition to the main academic programme, specific practical skills had to be developed that would enable the recipient to use a wide range of repair equipment and undertake complex maintenance operations.

The measure of the skills learnt would be assessed both in the workplace via the use of a specially developed on board ETO Training Record Book, as well as within the College based training programmes.

It was felt that a direct alignment of the ETO programme with established and recognised Deck and Engineering officer programmes was important, and hence the same elements of safety, total programme duration and final MCA viva examination were embedded within the new ETO programme.

Guided by the established National Occupational Standards, an industry Working Group was created involving the industry, the maritime regulator, union representatives, academics and the national maritime sector body.

The main programme elements selected were:

a) Foundation Degree qualification, which is the first two years of a three year Bachelor Honours degree. This is a 240 credit programme has a nominal student workload of 1200 hours, with integral work based elements such as mini-projects that are undertaken by each candidate onboard during the mandatory sea phases. Appendixes B and D contains further information.
b) Diploma in Marine Vessel Maintenance, which is a four month full time programme of practical activities, assessed during the college training. Content included a wide range of electrical wiring installation, electrical power and distribution, electronic devises, communications, computing systems and control systems. Appendixes E and F contains further information.
c) Embedding the knowledge and skills learn in the classroom and workshop in the work environment is an important element of all maritime training. To achieve this each candidate must complete a Training Record Book (TRB) whilst onboard for 8 month. This training record book replicates the existing format of the Deck ad Engineering Training Record Books. Appendix G contains further information.
d) Completion of all marine safety courses that are required by existing deck and engineering officer trainees.

The proposals were accepted by the MCA who supported the creation of a Certificate of Competency to the IMO during the 2008 revisions of the existing Standards of Training and Certification of Watch keepers (STCW) at the next STW meeting.

This proposal was also supported by France, Bulgaria, China, and Malaysia amongst other maritime administrations. There were detractors who did not want the imposition of an extra level of manning onboard, but the STCW proposals did not dictate that the carriage of ETO would be mandatory, only that a new standard of certification be provided for those employers who needed to assess the competence of their ETO employees.

This opposition was resolved by the creation of two levels of electrical technician level within the new stcw regulations, an Electro-technical Rating and Electro-technical Officer.

The level of skills and knowledge required at the two levels are differentiated by the low level of fault finding knowledge required by the Rating and the reduce scope of their expected working environment. The full STCW skills and knowledge tables are replicated in the appendix C, and these illustrate that the ETO would be required to undertake bridge electronic navigation repairs and maintenance, whereas this role is excluded from the Ratings role.

Whilst the STCW 2010 code only includes the Operational level, there was a need, identified by the UK industry representatives, to differentiate certification even further especially for the higher levels of ETO ranks which exist in large cruise liners, where the ranks of Chief Electro-technical officer at the management level are well established. Whilst this rank and responsibility may not yet have been recognised by the IMO through their STCW certification, the UK maritime authority may in future recognise the higher certification that reflect the higher knowledge and skills at the management level.

Experiences to date

The first programme started in September 2009 with 12 entrants from six different shipping companies. The experiences and observations of the students were recorded during the first college training phase.

TRB & Sea phase

- Preparation for sea phase; all candidates know their training officer but have not yet been assigned their ships or onboard training officers
- Concern that they need an ETO on their ship to be able to complete their TRB, but this would only be encouraged for the specialist tasks within one section (C35), otherwise the Chief Engineer could sign the candidate off as competent
- The use of the TRB was raised and the students were made aware of its purpose and that they were to have a briefing session before they leave the first college phase

Foundation Degree elements

- College courses has assumed that a certain level of prior knowledge from students when this is not the case for all students
- Too much overlap between topics when some items are taught more than once
- They do not believe they have missed anything out re theory at the moment
- Query on the inclusion of mechanical theory elements

Workshop skills

- Practical tasks are easier for some candidates than others
- Prior knowledge of practical task theory would assist understanding
- There is a lot of shuffling around for the practical tasks and the time required to complete certain tasks is very tight

General comments

- Course very intense and there are expected to work hard
- Support provided by college has been good

Following the first sea phase, the trainees were asked to concentrate on the electrical elements within their TRB and work experience onboard, as this would align with the knowledge and skills they had been provided with during their first college phase.

During the second sea phase, the electronic elements of the course were introduced and developed, including the fault finding skills that are an important learning outcome.

After the completion of the final sea phase, the student's TRB were reviewed to measure the range of tasks that had been completed. As expected the vessel type that candidates had sailed on dictated the specific onboard tasks completed, with few trainees able to complete the tasks on variable speed drives and high voltage due to equipment within the ship type they had sailed on.

The lack oh high voltage experience would be corrected by the completion of the established Merchant Navy Training Board (MNTB) High Voltage Awareness course that includes the following learning outcomes:

- Understand the functional, operational and safety requirements for a marine high voltage system;
- Assist suitably qualified personnel to carry out maintenance and repair of high voltage switchgear of various types;
- Take remedial action necessary during system faults;
- Select suitable apparatus for isolation and testing HV equipment
- Carry out a switching and isolation procedure on a marine HV system complete with safety documentation
- Perform 5kV insulation resistance and polarisation index tests on HV equipment
- Produce a switching strategy for isolating HV system components

The variable speed drive tasks were assigned as an optional element to avoid restricting the training opportunities available for ETO trainees.

Existing sea staff

Whilst this new programme focussed on the training needs for new entrants to the Merchant Navy, it was also recognised that existing sea staff may wish to become certified under the new STCW2010 certification to recognise their existing role, skills and knowledge.

This certification will need an assessment of the skills across a wide range of existing sea staff against the STCW standard.

Two examples will be provided to illustrate how an existing seafarer could obtain the new STCW 2010 certificate of competency.

Marine Electrician. A serving Electrical Officer would need to show that they have already obtained the following training and skills:

a) Electrical knowledge ability; if a qualification such as HNC is not held then this would be assessed by the current Chief Engineer Electro-technology examination paper
b) Electronic knowledge; if a qualification is not held then this would be assessed by the current AMERC Electronic principles examination paper
c) High Voltage knowledge: if no previous HV experience, then the MNTB High Voltage Awareness course would be undertaken.
d) Electronic skills; if a qualification such as the AMERC Electronic Navigation Equipment Maintenance and the Radio Maintenance course is not held then this would be assessed by completing these courses.

e) Completion on the ETO Training Record Book, with the concession that work over the last five years will be valid, and confirmed by the Chief Engineer or Maintenance Records onboard.
f) The completion of the advanced stcw safety courses of Advanced Fire Fighting, Medical First Aid and Proficiency in Survival Craft and Rescue Boat.

Engineer of the Watch. A serving Engineer of the Watch with STCW III/1 certification, and with HND or similar level qualification. This candidate would need to show that they have already obtained the following training and skills:

a) Electronic knowledge; if a qualification is not held then this would be assessed by the current AMERC Electronic principles examination paper
b) Electrical maintenance skills; if no Marine Electrical Maintenance course has been completed, then a three week practical programme would need to be completed.
c) High Voltage knowledge: if no previous HV experience, then the MNTB High Voltage Awareness course would be undertaken.
d) Electronic skills; if a qualification such as the AMERC Electronic Navigation Equipment Maintenance and the Radio Maintenance course is not held then this would be assessed by completing these courses.
e) Completion on the ETO Training Record Book, with the concession that work over the last five years will be valid, and confirmed by the Chief Engineer or Maintenance Records onboard.

In both cases, the final assessment of competence would be the MCA oral examination.

Conclusions

The certification within the new IMO STCW standard ensures that the important role of the Electro-technical Officer is recognised both internally within the industry and also by other external bodies. This Certificate of Competency will not impose an additional burden of training costs on employers, but supports them in their need to assess seafarer competence within the existing International Safety Management (ISM) Code.

The training programmes devised for the UK market are expected to evolve from this initial structure to reflect the changing needs of industry and the technical driven processes onboard. Other countries have responded to this STCW change by the creation of a new IMO Model Course for ETO's, but this only covers the Operational level training standard. While this may comply with the STCW regulations, the UK industry need for management level training would not be fulfilled.

This training scheme will create graduates skilled seafarers with the skills and knowledge required within today's merchants fleets. Matching industry needs must remain an important consideration of any programme design, to ensure that sufficient competence staff exist. By providing this training programme, graduates will have improved employment prospects, and owners and ship managers will have reduced overall operational costs for their vessels.

ANALYSIS OF STRUCTURE OF CARGO TURNOVER AT LATVIA'S PORTS

Jānis Bērziņš*, Ilmārs Lešinskis, Artūrs Prauliņš*****

** Latvian Maritime Academy, 5B Flotes Street, LV-1016, Latvia, E-mail: janis.berzins@latja.lv*
*** Latvian Maritime Academy, 5B Flotes Street, LV-1016, Latvia, E-mail: ilmars.lesinskis@latja.lv*
**** Latvian Maritime Academy, 5B Flotes Street, LV-1016, Latvia, E-mail: arturs.praulins@latja.lv*

Abstract
Ports play a crucially important role in the development of national economy as they generate stable tax flows and duties, providing direct positive effects on GDP, Balance of Payments and Balance of Trade. Sometimes their impact on regional economy may be significant also. The analysis of the structure of cargo volumes (annual throughput) transshipped by the port and changes in commodity mix can provide an invaluable insight in the trend of port development. The comparative analysis of the structure of cargo volumes at Latvia's ports has been done in the paper and the degree of its dissimilarity was statistically evaluated.
KEY WORDS: *cargo, Latvia, ports, structure*

Introduction

Transport is of fundamental importance to human society, providing mobility and facilitating industry and trade. The essential economic and social benefits, which are so difficult to balance against the high social and environmental costs, make transport a crucial sector for sustainable development, as recognized in the EU sustainable development strategy [1].

Actually, transport is one of the most important and dynamic sectors of economy in the Baltic States. Increasing volumes of export explicitly demonstrate the role of the transport sector in the economic growth of those countries. It is acknowledged that high quality of transport services provides the national economy with various benefits, inter alia improved logistics (reduced level of inventories, more reliable supply of goods, higher delivery quality etc.) and better mobility that leads to the higher profitability of business [2]. However, in spite of the optimal location of transport infrastructure in Latvia, its low quality still influences the competitiveness of the provided transport services [3, 4]. In addition, not only the total volume of throughput determines the effectiveness of port activities and impact on national or regional economy but also the change in the commodity mix as different types of cargo require different handling methods, use of labour, material and service input.

The paper aims to do a quantitative analyze of and to draw conclusions about dissimilarity and changes in the structure of cargo turnover at Latvia's posts. To achieve the aim of the paper several research methods were used, namely, deduction, induction, synthesis and analysis, statistical and monographic methods. The research object is the changes in the structure of cargo turnover at Latvia's ports; the research period is from 2000 to 2010. All the calculations are made by the authors of the paper and based on statistical data obtained from Central Statistical Bureau of Latvia as well as reports of Tallinn and Klaipeda ports.

Impact of ports on regional economy

95% of world trade is transported by ship. Demand for transport can be viewed as deriving from the changing nature of international trade relations. With the growth in world trade, international shipping is expanding [5]. It is pointed out [6] that since international trade is carried predominantly by sea transport major container ports play a crucial role in regional economies. In the past the presence of a port meant not only traffic and transport activities, but also economic activities, ranging

from industries that use mainly raw materials imported by sea and whose land transportation costs would have been too high, to those producing goods to be exported by sea and/or those whose optimal location was where the break of bulk took place. Nowadays it is not longer the case as many of these industries, no technologically restricted to port areas any more, and suffering from the relative scarcity and/or high prices of space and other inputs, have moved to regions where these inputs are available at better conditions [7].

Therefore the general guidelines for conducting analysis of port's economic impact provided by G. R. Yochum and V. B. Agarwal [8, 9] are worth mentioning. The guidelines are based on different linkages between the port and the region's economy and depicture clearly the interdependence degree between above mentioned economic subjects.

1) Port required industry - employment in companies providing services for the movement of waterborne commerce. There are transportation services (e.g. freight forwarding, transport of cargo by rail and road) and port services (e.g. terminal operations, stevedoring, vessel supply, pilotage, towage, ship repair, diving services, insurance, legal services).

2) Port attracted industry - employment in companies attracted to the region because of the presence of the port and its facilities. If the port facilities were closed down, the companies would leave region. Usually these companies export commodities or import products or raw materials for assembly and distribution (e.g. steelworks, chemicals, refineries).

3) Port induced industry - employment in companies that have expanded their markets by exporting through the port due to reduced transportation costs. Such industries are typically located at a substantial distance from port facilities (because theoretically they could be located in the region regardless of the availability of port facilities) and cannot be identified on the basis of a mere geographical criterion.

Some researchers have tried to discover the factors the impact of port on local economy depends on. After performance of empirical studies based on the port of Tampa (USA), J. S. DeSalvo and D. Fuller [10, 11] concluded that the impact of ports depends on the cargo volumes transshipped by the port and on the price elasticity of the demand for imports and exports channeled through that port. Although M. Benacchio et. al. [7] did not reveal an apparent relation between the estimated impact and the total volume of ports throughput, vital importance to distinguish between changes in cargo volumes, and changes in the commodity mix was stressed in their study. Different commodities require different handling methods and thus different use of labour, material and service inputs for their loading and unloading. It means that a rise in the share of containerized traffic would decrease aggregate direct labour inputs (stevedoring services), increase indirect effects due to logistic activities performed on high value goods, increase capital investments and expenditures on items such as fuel oil, in turn indirectly altering the structure of local economy. It is acknowledged [7] also that the employment structure (workers, professionals, engineers etc.) is an important indicator of the quality of the impact in terms of its added value. At the same time the growth in tons does not definitely lead to a comparable growth in terms of employment because the introduction of containerization and standardization of cargo could induce the transformation of ports from main service centres to simple transit points.

According to R. O. Goss [12] there are at least four clear reasons for which port expansion or improvement is likely to be an inefficient tool of economic development strategy:

- Port benefits are likely to "leak" to users in inland locations;
- Assisting and investing public money in a port will probably mean assisting foreign exporters, some of whom will be able to compete more effectively with home producers;
- Any public assistance to a port is likely to lead to higher local taxes (local share of infrastructure financing), running the risk to make the area less attractive to residents and possible businesses too;
- Since the aggregate demand for labour within any given economy is determined by macroeconomics factors, ports are competing among themselves for a share of a reasonably fixed level of business (e.g. the expansion of a port belonging to a range could also be at the expense of lost trade in other regional or national ports belonging to the same range).

M. Benacchio et. al. [7] mentioned several monetary and non-monetary costs of the port impact on local economy:

- The local share of investments in maritime and port infrastructures, transport infrastructures;
- Opportunity costs of port industry inputs: capital, labor, space (coast and landscape);
- Negative "sunk" externalities: environmental aspects (air, water, acoustic pollution), landscape decay, irrecoverable investments in facilities, traffic congestion, costs for "conciliating" the presence of the port in a urban context, the risk of hazardous material handling (chemicals, petrochemicals);
- Eventually loss of managerial and leadership functions for local port economies that are quite no longer among the location selection criteria of holdings, corporations and administrative departments of the firms located within the port region.

P. Gripaios and R. Gripaios (1995, 1999) [13; 14] draw similar conclusions for UK ports and provided empirical evidence that nowadays the existing and potential role of ports in the regional development process is often exaggerated. However, ports still play a crucially important role in national economy generating taxes and duties as well as they often constitute growth centres for national industries (e.g. manufacturing, transport, logistics) and services.

Structure of cargo turnover at Latvia’s ports

There are 10 ports in Latvia. Ports of Riga, Liepaja and Ventspils are mostly focused on transit cargo which accounts for almost 70 % of their total turnover. It can be assumed that the role of ports in logistic cluster is important. [15] Ports of Riga and Ventspils have been granted the status of freeports, but port of Liepaja is an integral part of Liepaja special economic zone. Small ports (Engure, Lielupe, Mersrags, Pavilosta, Roja, Salacgriva and Skulte) primarily service local clients who transport timber and fishing products. All the ports are engaged in various projects and reconstruction works with the aim to expand their activities, improve the quality of service and strengthen their competitiveness. Although co-operation between different ports in Latvia may increase their competitiveness in the Baltic region and the global market, ports demonstrate their reluctance and lack of interest in co-operation. [16]

Ports are usually characterized by their annual throughput (i.e. port traffic in TEU, tons). Other aspects analysts pay special attention to are changes in the commodity mix (for instance, the increase in containerized traffic, the decrease in liquid bulk, etc.) and future forecasts. However, as M. Benacchio et. al. [7] noted, the increase in port throughput does not necessarily mean that the port is creating “value” to remunerate inputs. It just means that port is either more effectively managed in comparison with others or it is more strategically located close to important hinterlands and/or maritime routes.

At Latvia’s ports over the last ten years the volume of loaded cargo reached its peak in the year 2008, whereas the amount of unloaded cargo peaked in the 2007. The total increase in unloaded cargo was much more considerable compared to the one in loaded cargo – by 212 % and 113 % accordingly. However, the volume of loaded cargo demonstrated more stable trend of development since the annual fluctuations were less notable. The volume of the most significant components of loaded cargo decreased during the period in question except for oil products whose gradual growth compensated for the largest drop in crude oil as well as metal and metal manufactures. The components of unloaded cargo demonstrated the trend diametrically opposed to the mentioned previously. All but the volume of unloaded sugar grew during the period from 2000 to 2010 providing the remarkable change in the structure of cargo turnover. If at the beginning of the period the volume of unloaded sugar accounted for almost 20 % of the total unloaded cargo, in 2010 just for 2.5 %. It means that there was a shift in priorities. It resulted in oil products making up 20 % as well as grain and grain products together with mineral construction materials making up other 20 % of the total turnover of unloaded cargo in 2010.

Table 1

Changes in cargo turnover and some of its components at Latvia's ports in 2000 - 2010 (Ktons, increment rate in percent)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Loaded cargo	**49276**	**54372**	**48735**	**50918**	**54101**	**55890**	**53069**	**55178**	**57654**	**57565**	**55724**
Base increment		*110*	*99*	*103*	*110*	*113*	*108*	*112*	*117*	*117*	*113*
Chain increment		*110*	*90*	*104*	*106*	*103*	*95*	*104*	*104*	*100*	*97*
# Oil products	15822	17609	18237	19586	19438	20094	19662	21061	20346	21957	19252
Base increment		*111*	*115*	*124*	*123*	*127*	*124*	*133*	*129*	*139*	*122*
Chain increment		*111*	*104*	*107*	*99*	*103*	*98*	*107*	*97*	*108*	*88*
# Crude oil	13631	14986	7566	3579	2196	423	1192	1233	1016	380	204
Base increment		*110*	*56*	*26*	*16*	*3*	*9*	*9*	*7*	*3*	*1*
Chain increment		*110*	*50*	*47*	*61*	*19*	*282*	*103*	*82*	*37*	*54*
# Dry chemicals	6554	6446	6430	6817	5967	6537	5123	5173	4562	3059	3750
Base increment		*98*	*98*	*104*	*91*	*100*	*78*	*79*	*70*	*47*	*57*
Chain increment		*98*	*100*	*106*	*88*	*110*	*78*	*101*	*88*	*67*	*123*
# Timber	6098	6121	6238	6471	6340	5664	4575	4644	3654	3444	5413
Base increment		*100*	*102*	*106*	*104*	*93*	*75*	*76*	*60*	*56*	*89*
Chain increment		*100*	*102*	*104*	*98*	*89*	*81*	*102*	*79*	*94*	*157*
# Metals and metal manufactures	3439	2619	1926	1293	859	1076	1065	1043	1079	904	839
Base increment		*76*	*56*	*38*	*25*	*31*	*31*	*30*	*31*	*26*	*24*
Chain increment		*76*	*74*	*67*	*66*	*125*	*99*	*98*	*103*	*84*	*93*
# Liquid chemicals	976	878	546	972	976	1114	994	1187	1430	964	686
Base increment		*90*	*56*	*100*	*100*	*114*	*102*	*122*	*147*	*99*	*70*
Chain increment		*90*	*62*	*178*	*100*	*114*	*89*	*119*	*120*	*67*	*71*
Unloaded cargo	**2567**	**2546**	**3420**	**3837**	**3299**	**4152**	**6428**	**7256**	**5995**	**4415**	**5436**
Base increment		*99*	*133*	*149*	*129*	*162*	*250*	*283*	*234*	*172*	*212*
Chain increment		*99*	*134*	*112*	*86*	*126*	*155*	*113*	*83*	*74*	*123*
# Sugar	500	701	988	1107	429	304	473	286	289	73	131
Base increment		*140*	*198*	*221*	*86*	*61*	*95*	*57*	*58*	*15*	*26*
Chain increment		*140*	*141*	*112*	*39*	*71*	*156*	*60*	*101*	*25*	*179*
# Mineral construct. materials	280	171	178	141	135	646	861	970	918	358	574
Base increment		*61*	*64*	*50*	*48*	*231*	*308*	*346*	*328*	*128*	*205*
Chain increment		*61*	*104*	*79*	*96*	*479*	*133*	*113*	*95*	*39*	*160*
# Grain and grain products	170	135	254	215	196	288	412	416	382	322	437
Base increment		*79*	*149*	*126*	*115*	*169*	*242*	*245*	*225*	*189*	*257*
Chain increment		*79*	*188*	*85*	*91*	*147*	*143*	*101*	*92*	*84*	*136*
# Oil products	145	71	223	255	194	503	1076	1126	565	982	1031
Base increment		*49*	*154*	*176*	*134*	*347*	*742*	*777*	*390*	*677*	*711*
Chain increment		*49*	*314*	*114*	*76*	*259*	*214*	*105*	*50*	*174*	*105*

Source: authors' calculations based on data obtained from Central Statistical Bureau of Latvia[1]

Over the last decade the proportion of different cargo in cargo total turnover at Riga port underwent changes (Table 2). The proportion of coal increased notably and accounted for almost 40 –

[1] Available (accessed on 15.03.2012): http://data.csb.gov.lv/Dialog/varval.asp?ma=TR0220&ti=TRG22%2E+AR+J%DBRAS+TRANSPORTU+NOS%DBT%CETAS%2C+SA%D2EMTAS+KRAVAS+PA+KRAVU+VEIDIEM+%28t%FBkst%2E++tonnu%29&path=../DATABASE/transp/Ikgad%E7jie%20statistikas%20dati/Transports/&lang=16

50 % of the cargo flow at the end of the analyzed period. On the contrary, the proportion of mineral fertilizers and timber declined gradually from 12 % to 5 % and from 31 % to 10 % accordingly. The most constant proportion fluctuating at the level of 6 – 8 % (coefficient of variation Vσ = 12 %) was demonstrated by cargo containers. Compared to the year 2000 when the proportion of other cargo made up a fifth of the turnover it was just a tenth in the last years. Thus it indicates that the concentration of cargo assortment has been taking place since the beginning of the century.

Table 2

Structure of cargo turnover at the port of Riga in 2000 – 2010, percent

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Vσ
Coal	0	8	14	24	39	44	42	40	47	47	38	54
Oil products	21	23	29	23	18	14	19	18	18	22	21	19
Mineral fertilizers	12	10	10	9	6	6	5	8	7	7	5	31
Timber	31	29	23	21	18	16	12	11	7	6	10	51
Cargo containers	6	7	6	6	6	6	6	7	6	6	8	12
Woodchip	3	3	5	5	5	5	5	3	3	2	4	26
Roll-on, roll-off cargo	1	1	2	3	2	3	1	2	2	2	2	34
Construction materials	4	2	1	1	1	2	3	3	2	1	1	51
Other	22	16	11	8	5	5	7	8	9	7	11	53

Source: authors’ calculations based on data obtained from Central Statistical Bureau of Latvia[2]

Significant changes were observed at Liepaja port also (Table 3). The proportion of grain and grain products reached a peak of 41 % in 2009 compared to just 2 % in 2000. However, the proportion of other most important cargo groups decreased more or less notably. For instance, since 2004 the proportion of roll-on and roll-off cargo demonstrated a downward trend and resulted in a total drop of 10 percent points (from 15 percent in 2000 to 5 percent in 2010). The proportion of metals and metal manufactures went down by 8 percent points, timber – by 5 percent points, but oil products – by 4 percent points.

Table 3

Structure of cargo turnover at the port of Liepaja in 2000 – 2010, percent

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Vσ
Grain and grain products	2	6	11	11	11	22	24	30	34	41	32	64
Metals and metal manufactures	20	18	22	17	19	18	20	19	14	14	12	18
Timber	25	22	18	18	18	16	14	13	11	13	20	25
Oil products	13	16	17	15	13	10	19	14	13	9	9	25
Roll-on, roll-off cargo	15	17	15	17	16	10	0	0	0	8	5	75
Scrap metal	2	0	0	0	2	4	5	5	9	4	6	79
Crude oil	0	0	2	6	5	5	5	5	7	4	3	58
Chemicals	3	1	1	1	1	1	1	1	2	3	2	60
Construction materials	2	2	1	0	1	2	2	4	3	1	6	81
Other	17	19	13	15	16	12	11	10	8	5	5	40

Source: authors’ calculations based on data obtained from Central Statistical Bureau of Latvia

[2] Available (accessed on 15.03.2012): http://data.csb.gov.lv/DATABASE/transp/Ikgad%C4%93jie%20statistikas%20dati/Transports/Transports.asp

At the beginning of the analyzed period just two equally important cargo groups accounted for almost 70 % of the turnover at Ventspils port, namely, oil products and crude oil (Table 4). However, within 10 years the situation changed dramatically. The upward trend in proportion of oil products was accompanied by gradual decrease in proportion of crude oil. In result, the latter plummeted and was nil in 2010. At the same time the proportion of other cargo either increased or remained almost the same (with the exception of potassium salt which after wild fluctuations and subsequent insignificant decrease leveled off at 10 % in 2010). The proportion of coal demonstrated the most considerable increase of 15 percent points. It was followed by roll-on, roll-off cargo (5 percent points). The conclusion can be drawn that unlike the concentration of cargo assortment which could be clearly observed at the port of Riga, the structure of cargo turnover has become more diversified at the port of Ventspils.

Table 4

Structure of cargo turnover at the port of Ventspils in 2000 – 2010, percent

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Vσ
Oil products	37	36	44	52	53	56	52	54	53	60	54	16
Coal	1	4	5	6	14	15	14	13	16	20	15	53
Potassium salt	14	13	16	18	16	17	13	10	9	4	10	33
Roll-on, roll-off cargo	0	0	0	1	1	2	6	6	5	3	5	89
Liquefied gas	2	2	1	3	3	3	3	3	4	3	2	30
Grain and grain products	0	0	1	0	0	0	0	1	3	2	3	110
Woodchip	0	0	0	1	1	2	2	1	1	2	1	64
Crude oil	39	40	26	12	8	1	7	7	5	2	0	111
Other	6	5	7	7	4	3	4	4	5	4	11	39

Source: authors’ calculations based on data obtained from Central Statistical Bureau of Latvia

In comparison with 2000 the structure of cargo turnover at small ports was more balanced in 2010 (Table 5). Although timber continued to dominate as the most important cargo its proportion was not so large as it used to be at the beginning of the century (91 % and 66 % accordingly). The gradual decrease in proportion of timber occurred at the expense of the rise in woodchip which formed almost a fifth of the cargo transported through small ports at the end of decade. Likewise, the proportion of construction materials climbed from 1 percent to 8 percent.

Table 5

Structure of cargo turnover at small ports in Latvia in 2000-2010, percent

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Vσ
Timber	91	88	88	72	72	60	58	65	62	54	66	18
Woodchip	3	7	8	11	16	16	17	19	25	25	19	47
Construction materials	1	0	1	9	4	15	17	8	6	8	8	81
Peat	1	0	0	5	5	5	5	5	3	6	5	61
Other	5	4	3	3	3	3	2	2	5	6	3	35

Source: authors’ calculations based on data obtained from Central Statistical Bureau of Latvia

The significance of changes in the structure of cargo turnover at Latvia’s ports can be revealed in the result of special quantitative analysis and application of statistical technique. Nowadays several dissimilarity indexes have been proposed [17]. A dissimilarity coefficient is a function that measures the difference between two objects [18]. One of the most commonly used measures is the one (formula 1) invented by Hungarian statistician Sandor Alexander Szalay (1912-1983), who did research on

quality of life and spending of leisure time. Initially the Szalay index was invented to analyze the difference in use of time budget among various groups of people [19]. At present it is vastly applied as an aggregated ratio for quantitative comparative analysis of different structures.

$$I_S = \sqrt{\frac{\sum_{i=1}^{n}\left(\frac{d_2 - d_1}{d_2 + d_1}\right)^2}{n}} \tag{1}$$

n - number of groups in comparable structures
d - proportion of a group in total amount

Another one is an integral coefficient of structure changes which is known as K. Gatev coefficient (formula 2) [20].

$$I_G = \sqrt{\frac{\sum (d_1 - d_2)^2}{\sum d_1^2 + \sum d_2^2}} \tag{2}$$

d – proportion of a group in total amount

The values of both Szalay index and Gatev coefficient lay in the interval from 0 to 1 where the lower bound represents dissimilarity and the upper bound complete identity. Gatev coefficient measures absolute and relative changes of structures in their mutual conjunction. It means that, unlike Szalay index, Gatev coefficient not only takes into account the intensity of changes in a group but also the proportion of that group in comparable periods.

The analysis revealed (Table 6) that changes in structure of cargo turnover at Latvia's ports were much more significant during the period from 2000 to 2005 than from 2005 to 2010. The degrees of dissimilarity assessed by both Szalay index and Gatev coefficient were almost equal with the exception of Ventspils port. At this port Szalay index indicated an extremely high degree of dissimilarity between structure of cargo turnover in 2005 and 2010 whereas according to Gatev coefficient the changes were moderate and did not exceed the similar level in other ports. According to Szalay index the structure of cargo transported though Latvia's ports underwent the most important changes at Ventspils port. However, Gatev coefficients pointed at the most considerable transformation which occurred at Riga port.

Table 6

Szalay index and Gatev coefficient of dissimilarity calculated for structure of cargo turnover at Latvia's ports

Years for comparison	Riga port		Liepaja port		Ventspils port		Small ports	
	Szalai index	Gatev coefficient	Szalai index	Gatev coefficient	Szalai index	Gatev coefficient	Szalai index	Gatev coefficient
2000 & 2005	0,4799	0,7429	0,4683	0,4258	0,6558	0,5460	0,5971	0,3290
2005 & 2010	0,2189	0,1866	0,2887	0,2790	0,5506	0,1396	0,1430	0,1026
2000 & 2010	0,4778	0,6932	0,5453	0,6062	0,7390	0,5647	0,5773	0,2690

Source: authors' calculations

Ports still keep their importance even from a national perspective as they generate stable tax flows and duties, providing direct positive effects on GDP, Balance of Payments and Balance of Trade. For example, according to provisional calculations operation of the port of Riga provides approximately 3 to 3.3 % of the GDP in Latvia [16]. Usually ports are significant growth poles for national industries (e.g. manufacturing, transport, logistics) and services, effective macro-economic tools for development of economically depressed areas as well as a channel to international markets and foreign investments. Port industry plays an irreplaceable role as central links in the logistic chains of the global economy.

Therefore it is vitally important to forecast the future changes in cargo turnover in total as well as at both Latvia's freeports and small ports. For this reason the trend estimation for cargo turnover (Table 7) was made using Microsoft Excel tools. Trend estimation for Klaipeda and Tallinn port was made just for the purpose of comparison. The criterion for the choice from the list of possible trends was the goodness of fit measured by the coefficient of determination R^2. Time series included data on cargo turnover at Latvia's ports from 1993 to 2010[3], at Klaipeda port from 1991 to 2010[4] and at Tallinn port from 1999 to 2011.[5]

Table 7

Trend estimation for loaded and unloaded cargo at Latvia's ports, Klaipeda and Tallinn ports

Loaded cargo		
Total at all Latvia's ports	$y = 10908\ln(x) + 26285$	$R^2 = 0{,}952$
Riga	$y = 2{,}5509x^2 + 1512{,}5x + 733{,}3$ $y = 1561x + 571{,}75$	$R^2 = 0{,}975$ $R^2 = 0{,}9749$
Liepaja	$y = 509{,}45x^{0{,}7504}$	$R^2 = 0{,}9383$
Ventspils	$y = 21{,}153x^3 - 719{,}31x^2 + 6582x + 16898$	$R^2 = 0{,}7753$
Small ports	$y = -1{,}3164x^2 + 97{,}553x - 19{,}956$	$R^2 = 0{,}9329$
Klaipeda	$y = 38{,}529x^2 - 154{,}11x + 10985$	$R^2 = 0{,}9316$
Unloaded cargo		
Total at all Latvia's ports	$y = 21{,}158x^2 - 102{,}51x + 3045{,}6$	$R^2 = 0{,}848$
Riga	$y = 3{,}527x^2 - 8{,}4951x + 2139{,}9$	$R^2 = 0{,}5321$
Liepaja	$y = -3{,}6085x^2 + 102{,}94x - 71{,}387$	$R^2 = 0{,}882$
Ventspils	$y = 249{,}73e^{0{,}1158x}$	$R^2 = 0{,}7097$
Small ports	$y = -0{,}302x^3 + 7{,}6619x^2 - 44{,}842x + 98{,}718$	$R^2 = 0{,}8077$
Klaipeda	$y = 23{,}893x^2 - 264{,}33x + 4084{,}5$	$R^2 = 0{,}8558$
Total loaded and unloaded cargo		
Total at all Latvia's ports	$y = 12328\ln(x) + 27314$	$R^2 = 0{,}9608$
Klaipeda	$y = 61{,}889x^2 - 411{,}32x + 15051$	$R^2 = 0{,}9401$
Tallinn	$y = 50{,}91x^3 - 1210{,}1x^2 + 8163x + 21680$	$R^2 = 0{,}8736$

Source: authors' calculations

According to the coefficient of determination R^2 the equations for loaded cargoes at Latvia's ports (with exception of Ventspils port) demonstrate better goodness of fit compared to the ones for unloaded cargo. As initial data for total unloaded cargo at all Latvia's ports, unloaded cargo at Riga port and small ports did not allow calculating the trends of acceptable goodness of fit some additional processing was applied. Therefore the calculation of trend was based on a simple moving average of the period of four years. A moving average is a set of numbers, each of which is the average of the corresponding subset of a larger set of data points. It is commonly used with time series to smooth out short fluctuations and highlight long-term cycle. The application of this method resulted in trend equations with the coefficient of determination R^2 ranging from 0,5321 for unloaded cargo at Riga port to 0,882 for total unloaded cargo at all Latvia's ports. Similar method of simple moving average of the period of three years was applied to the calculation of trend for total cargo at Tallinn port.

Conclusions

Although the researchers are unanimous that ports contribute to the development of national economy, they have doubts about both their impact on regional economy and determinative factors of impact. It is argued that nowadays role of ports in regional development is often exaggerated. At the

[3] Available (accessed on 15.03.2012): http://data.csb.gov.lv/DATABASE/transp/Ikgad%C4%93jie%20statistikas%20dati/Transports/Transports.asp

[4] Report on cargo handling in Klaipeda State Seaport in the year 2010 Available at (accessed on 15.03.2012): http://www.portofklaipeda.lt/en.php/statistics/annual_reports/7746

[5] Available (accessed on 15.03.2012): http://www.portoftallinn.com/key-figures

same time the importance of analysis of cargo volumes (annual throughput) transshipped by the port and changes in commodity mix are stressed. The analysis revealed that over the last 10 years the diametrically opposed processes took place in the ports of Riga and Ventspils. If at the former the concentration of cargo assortment occurred, at the latter the structure of cargo became more diversified. The structure of cargo turnover at small ports became more balanced in 2010 compared to 2000. However, timber still accounted for two thirds of total turnover. The results of the analysis of structure dissimilarity for cargo turnover at Latvia's ports demonstrated that it was much more significant during the period from 2000 to 2005 than from 2005 to 2010. According to Szalay index the structure of cargo transported though Latvia's ports underwent the most important changes at Ventspils port. Nevertheless, Gatev coefficients pointed at the most considerable transformation at Riga port. According to the coefficient of determination R^2 the equations for loaded cargoes at Latvia's ports (with exception of Ventspils port) demonstrated better goodness of fit compared to the ones for unloaded cargo.

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TECHNICAL DIAGNOSTICS OF THE SHIP ELECTRIC COMPRESSOR INSTALLATIONS ON THE BASIS OF MATHEMATICAL MODEL

Aleksandrs Gasparjans*, Aleksandrs Terebkovs*, Anastasia Zhiravetska**

**Latvian Maritime Academy, 5B Flotes st, LV-1016, Latvia, E-mail: Aleksandrs.Gasparjans@latja.lv, aleksandrs.terebkovs@latja.lv.*
***Riga Technical University,14 Azenes st, LV-1048, Latvia. E-mail: zhiravecka@eef.rtu.lv*

Abstract
The system of technical diagnostics of double-stage electric compressor installation is described. The model is mathematically proved together with the block diagram of the measurement elements.
KEY WORDS: *compressor, induction motor, mathematical model, diagnostics*

Introduction

The obtaining of high pressures in single-stage compressors causes difficulties due to several reasons:

1. gas in a compressor is compressed according to polytrope law with the index of polytrope n>1. The temperature of the compressed gas significantly exceeds the initial. Under this condition it can achieve the temperature of cylinder oil flash, i.e. resulting in "diesel" effect;
2. at high temperatures the process of cylinder oil oxidation is significantly accelerated;
3. increasing of the ratio of initial pressure to its final value P_0/P_2 results in decreasing of the compressor effectiveness factor. For improvement of the effectiveness it is necessary to enlarge the sizes of the stage. This will result in the increasing of the mechanical and dynamic loads as well as compressor sizes and weight;
4. with the increasing of the ratio P_0/P_2 the value of volume factor of the compressor stage is decreasing. Thus all the compressed gas can be located in the volume of the died space and the exhaust valve will not open.

1. Differential double-stage compressor

Fig. 1 demonstrates a differential double-stage compressor. Pistons of the first stage (low pressure) 11 and high pressure 12 are one whole element. Air with its initial pressure P_0 is inhausted through filter 1 and through inhaust valve 2 of the first stage is proceeding to the cylinder space of the low pressure. While piston 11 goes up the compressed air is extruded through the exhaust valve 3 to the pathway of the average pressure P_1. This pathway is equipped with protective valve 5, sensor of instant pressure 6, refrigerator 7, moisture oil separator 8. Cooled and cleaned air of average pressure P_1 goes to the high pressure cylinder through exhaust valve 9. The compression of gas in the high pressure cylinder takes place due to the down movement of valve 11, 12. Relatively to the compressing period in the cylinder of low pressure the compressing period in the second stage is shifted for 180^0 rotation angle of the crankshaft. It allows aligning of the torques on the shaft of the compressor. The compressed gas of high pressure through the exhaust valve of the second stage 10 and refrigerator 13 goes to moisture oil separator 16 and further to receiver 17 and then to consumers. The pathway of the high pressure has protective valve 14 and sensor of instant pressure 15. The flywheel of the compressor has sign of top dead centre (TDC) with sensor of TDC 18. For defining the angular velocity and angular acceleration of the crankshaft the uniformly placed magnetic signs 20 and sensor of angular velocity 19 are used. The compressor is driven by means of three-phase induction motor 21.

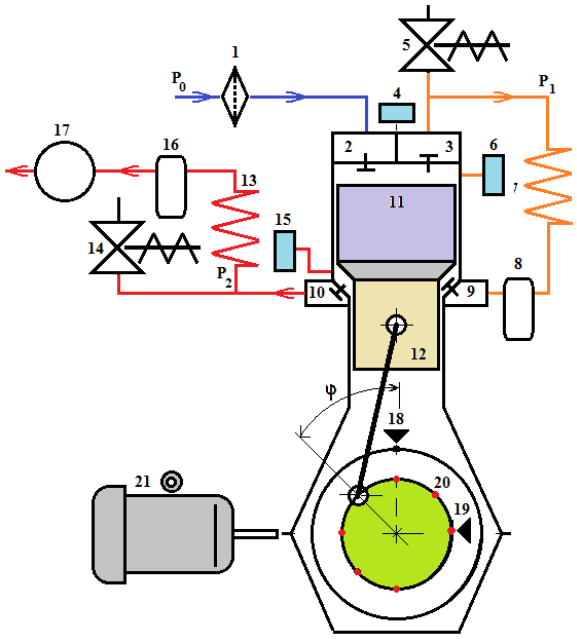

Fig. 1. Electric compressing installation

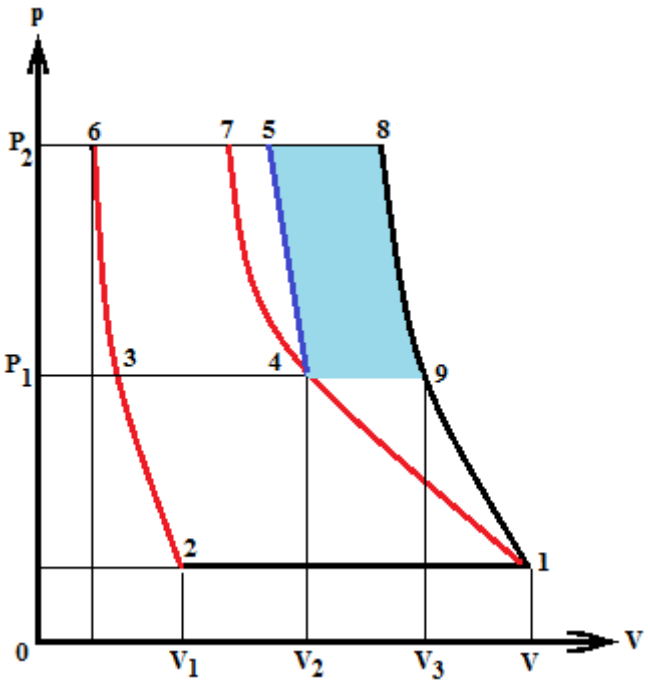

Fig. 2. Theoretical indicating pV diagram

Theoretical indicative pV diagram of the double-stage compressor is demonstrated in fig.2. [1], [2].

At a single-stage adiabatic compressing the expended work would be equal to the square 6-8-1-2-6, that is larger than the square of isothermal compressing 6-7-4-1-2-6. At the double-stage compressing the work of the adiabatic compressing of the first stage is characterised with square 3-9-1-2-3. After being compressed to intermediate pressure P_1 the gas goes to intermediate refrigerator 7 (fig.1) according to adiabatic curve 1-9, where it is cooled at constant pressure P_1 till the initial

temperature. Cooling results in the decreasing of the gas volume for value 9-4 equal to the difference V_3-V_2. The initial point of pressure is back to the initial isotherm 1-4-7. The adiabatic pressure at the second stage will be represented with adiabatic curve 4-5 (straight line).

Work of compressing indicated with square 6-5-4-3-6. Therefore at the double-stage compressing we gain work equal to the square 5-8-9-4-5, shaded in the diagram. The work for gas compressing and movement in the double-stage compressor during one turn of the crankshaft corresponds to the indicating diagram square F_i and indicating work L_i on a scale k_0 of pV -diagram. (Fig.2)

$$L_i = k_o F_i \tag{1}$$

where k_0 - is a scale factor; F_i – square of indicating diagram (Fig.2).
Indicating power N_i is numerically equal to the indicating work per second.

$$N_i = L_i n \tag{2}$$

where n - is a rotation frequency of the crankshaft, sec^{-1}.

The operation processes in the piston compressors take place with the period equal to one turn of the crankshaft. The position of the compressor piston and changing of the cylinder volume is according to the law of a crank gear:

$$dV_{cil} / d\varphi = 0.785[\sin\varphi + \frac{\lambda}{2}\sin 2\varphi](\mathrm{D}^3_{\mathrm{cil}}\phi\omega / 2) \tag{3}$$

According to the rotation angle φ the cylinder volume V_{cil} will be equal to

$$V_{cil} = 0{,}785\,(D^3\phi / 2)\ [2\mathrm{a} + 1 + \lambda/4 - \cos\varphi - \lambda/4 \cos 2\varphi] \tag{4}$$

where $\phi = S/D$; $\lambda = \mathrm{r}/\mathrm{l}$; S - is a piston stroke, r - is a radius of the crank, l - length of the connecting rod, φ - angle of rotation of the electro compressor shaft.

The angle of rotation of the crankshaft φ is measured by means of sensor 19 (fig.1), the instant values of the pressure in the compressor cylinders - by means of sensors 6 and 15 (fig.1). Using the obtained values the current volume of the compressor cylinders is calculated and a real pV-diagram is created. The diagnostics of the compressor is realised comparing the obtained pV-diagram with the reference one - comparing of the squares, calculation of its squares, actual location of the points 1-9 in the reference frame «p» and «V» (fig.2). The difference between the real and ideal pV-diagrams is fixed and input for the comparison into the diagnostic matrix of failures. The matrix forms a report on the current technical condition of the compressor.

The instant resistive torque on the compressor shaft is not constant and depends on the shaft rotation angle φ. Therefore the rotation torque of the induction motor is not constant. The induction motor operates in dynamic mode the parameters of which are strictly connected with the dynamic parameters of the compressor. It is convenient to connect the mathematical model of the piston compressor with that of three-phase induction motor.

2. Mathematical model of three-phase induction motor with squirrel-cage rotor in dynamic regimes.

The investigation and analysis of the induction motors behaviour in dynamic regimes result in the necessity to develop so called vector models of these machines. Mathematical description of electromechanical transformation of power in electrical machines is based on the development of Kirchhoff's differential equations and their solutions [5]. In matrix type the equations of voltages for three phases of stator A, B, C and three phases of rotor a, b, c for the model (fig.3) can be written as:

$$[R]\cdot[i(t)] + \tfrac{d}{dt}[\psi(t)] - [U(t)] = 0, \tag{5}$$

where

$$[U(t)] = \begin{bmatrix} U_A \\ U_B \\ U_C \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{6}$$

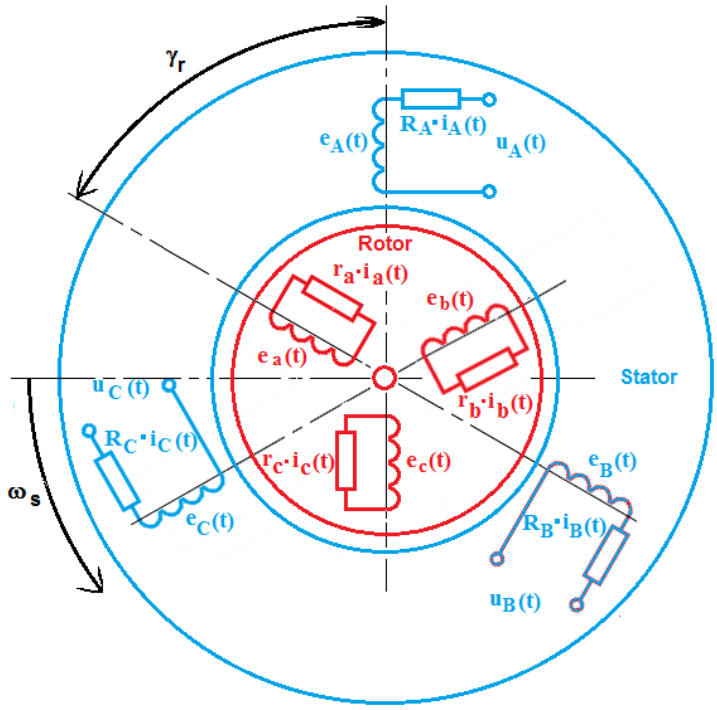

Fig.3. Equivalent physical model of induction motor

[U(t)] - matrix. instant values of the voltages of stator and rotor phases;

$$\begin{aligned} u_A &= \sqrt{2} \cdot E_f \cdot \sin(\omega_s \cdot t), \\ u_B &= \sqrt{2} \cdot E_f \cdot \sin(\omega_s \cdot t - \tfrac{2\pi}{3}), \\ u_C &= \sqrt{2} \cdot E_f \cdot \sin(\omega_s \cdot t + \tfrac{2\pi}{3}), \end{aligned} \tag{7}$$

E_f - phase rms value of the supply voltage;
$\omega_s = p*f*\pi$ - angular velocity of the stator field rotation, with the number of poles pairs - p , at the network frequency f_s,
[R] - square diagonal matrix of active resistances (R_A;R_B;R_C;R_a;R_b;R_c);

$$[\, i\,(t)\,] = \begin{bmatrix} i_A(t) \\ i_B(i) \\ i_C(t) \\ i_a(t) \\ i_b(t) \\ i_c(t) \end{bmatrix}$$ - column matrix of the instant values of the phases currents; (8)

$$[\, \psi\,(t)\,] = \begin{bmatrix} \Psi_A(t) \\ \Psi_B(i) \\ \Psi_C(t) \\ \Psi_a(t) \\ \Psi_b(t) \\ \Psi_c(t) \end{bmatrix}$$ - column matrix of the instant values of the phases flux linkages. (9)

The phases flux linkages can be tentatively divided into the flux linkages produced by the currents being stationary according to the phase under consideration and by those rotating with the rotor speed.

$$\begin{aligned} \psi_A(t) &= \psi_{As}(t) + \psi_{Ar}(t), \\ \psi_B(t) &= \psi_{Bs}(t) + \psi_{Br}(t), \\ \psi_C(t) &= \psi_{Cs}(t) + \psi_{Cr}(t), \\ \psi_a(t) &= \psi_{ar}(t) + \psi_{aS}(t), \\ \psi_b(t) &= \psi_{br}(t) + \psi_{bS}(t), \\ \psi_c(t) &= \psi_{cr}(t) + \psi_{cS}(t), \end{aligned} \tag{10}$$

where:

$$\begin{aligned} \Psi_{As}(t) &= (l_1 + \tfrac{2}{3}L_1)i_A(t) + \tfrac{2}{3}L_1\cos(\rho)i_B(t) + \tfrac{2}{3}L_1\cos(2\rho)i_C(t); \\ \Psi_{Bs}(t) &= \tfrac{2}{3}L_1\cos(\rho)i_A(t) + (l_1 + \tfrac{2}{3}L_1)i_B(t) + \tfrac{2}{3}L_1\cos(\rho)i_C(t); \\ \Psi_{Cs}(t) &= \tfrac{2}{3}L_1\cos(\rho)i_A(t) + \tfrac{2}{3}L_1\cos(\rho)i_B(t) + (l_1 + \tfrac{2}{3}L_1)i_C(t); \\ \Psi_{Ar}(t) &= \tfrac{2}{3}M\cos[p\gamma_r(t)]i_a(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)+\rho]i_b(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)-\rho]i_c(t); \\ \Psi_{Br}(t) &= \tfrac{2}{3}M\cos[p\gamma_r(t)-\rho]i_a(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)]i_b(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)+\rho]i_c(t); \\ \Psi_{Cr}(t) &= \tfrac{2}{3}M\cos[p\gamma_r(t)+\rho]i_a(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)-\rho]i_b(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)]i_c(t); \\ \Psi_{ar}(t) &= (l_2 + \tfrac{2}{3}L_2)i_a(t) + \tfrac{2}{3}L_2\cos(\rho)i_b(t) + \tfrac{2}{3}L_2\cos(2\rho)i_c(t); \\ \Psi_{br}(t) &= \tfrac{2}{3}L_2\cos(\rho)i_a(t) + (l_2 + \tfrac{2}{3}L_2)i_b(t) + \tfrac{2}{3}L_2\cos(\rho)i_c(t); \\ \Psi_{cr}(t) &= \tfrac{2}{3}L_2\cos(2\rho)i_a(t) + \tfrac{2}{3}L_2\cos(\rho)i_b(t) + (l_2 + \tfrac{2}{3}L_2)i_c(t); \\ \Psi_{as}(t) &= \tfrac{2}{3}M\cos[p\gamma_r(t)]i_A(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)-\rho]i_B(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)+\rho]i_C(t); \\ \Psi_{bs}(t) &= \tfrac{2}{3}M\cos[p\gamma_r(t)+\rho]i_A(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)]i_B(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)-\rho]i_C(t); \\ \Psi_{cr}(t) &= \tfrac{2}{3}M\cos[p\gamma_r(t)-\rho]i_A(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)+\rho]i_B(t) + \tfrac{2}{3}M\cos[p\gamma_r(t)]i_c(t). \end{aligned} \tag{11}$$

The sum of the components of equations (10, 11) results in the full flux linkages of the phases. The solution of the phases voltages equations (5) together with the equation of rotor movement allows define the character of the transient process, calculate the currents, flux linkages and the electromagnetic torque of the motor [5, 6]:

$$J[\tfrac{d}{dt}\Omega(t)]+M=M_R,$$
$$\tfrac{d}{dt}\gamma_r(t)-\Omega(t)=0, \tag{12}$$

where:
J - the moment of inertia of rotor;
M - electromagnetic torque influencing the rotor;
M_R – the rotating torque of the electro compressor,
$\Omega(t)$ - the rotor rotation speed.

The values of the windings currents are calculated according to the expressions given in paper [4].

The expression for the electromagnetic torque influencing the rotor:

$$M=\tfrac{p}{\sqrt{3}}\{[\Psi_C(t)-\Psi_B(t))]\cdot i_A(t)+[\Psi_A(t)-\Psi_C(t)]\cdot i_B(t)+[\Psi_A(t)-\Psi_B(t)]\cdot i_C(t)\} \tag{13}$$

On the other hand the rotating torque of the compressor is:

$$M=\frac{N}{\omega}; \tag{14}$$

$$N=\frac{N_i}{\eta_k\cdot\eta_m}, \tag{15}$$

where N_i – indicating power of compressor,
η_k, η_m – is an efficiency factor of the compressor and electric motor.

An algorithm and programming package of the mathematical approach under consideration was developed for analysis and numerical solution of the mathematical model of induction motor in dynamic regimes. For the solution of differential equations systems for the mathematical model under consideration the method of Runge-Kutta is supposed to be the most optimal where the range of the step is defined complying with the pre-set values of local and global quantisation errors.

The full flux linkage of the phases and the position of the main magnetic flux vector can be obtained from the instant values of stator currents and voltages.

3. The block diagram of the measurement part of the compressor diagnostic system

The block diagram of the measurement part of the compressor diagnostic system is given in fig.4.

The measurement part of the diagnostic system has two channels. The channel of measuring of compressor parameters consists of 5 sensors - sensors of instant value of pressures of the first and second stages (P_1 and P_2), sensor of vibration of accelerometer Q, sensor of the top dead centre (TDC), sensor of the angle position φ of the crankshaft. The data in square brackets define positions of these sensors in fig.1. The analogue signals from the sensors of instant pressure of the first (P_1) and the second stage (P_2) come to the inputs of analogue-digital converter CAP. This is the same place where the signals from the vibro-sensor Q come. Pulse (digit) signals from the sensors of TDC and angle position φ of the crankshaft come to the interface I/O. The information in digital form from the CAP output also comes to the interface I/O. The output if I/O interface is connected to microcontroller MK and further to computer C. Computer processes the obtained information. The second channel exists for the measurement of the instant values of the currents and voltages of induction electric motor (21 in fig.1).

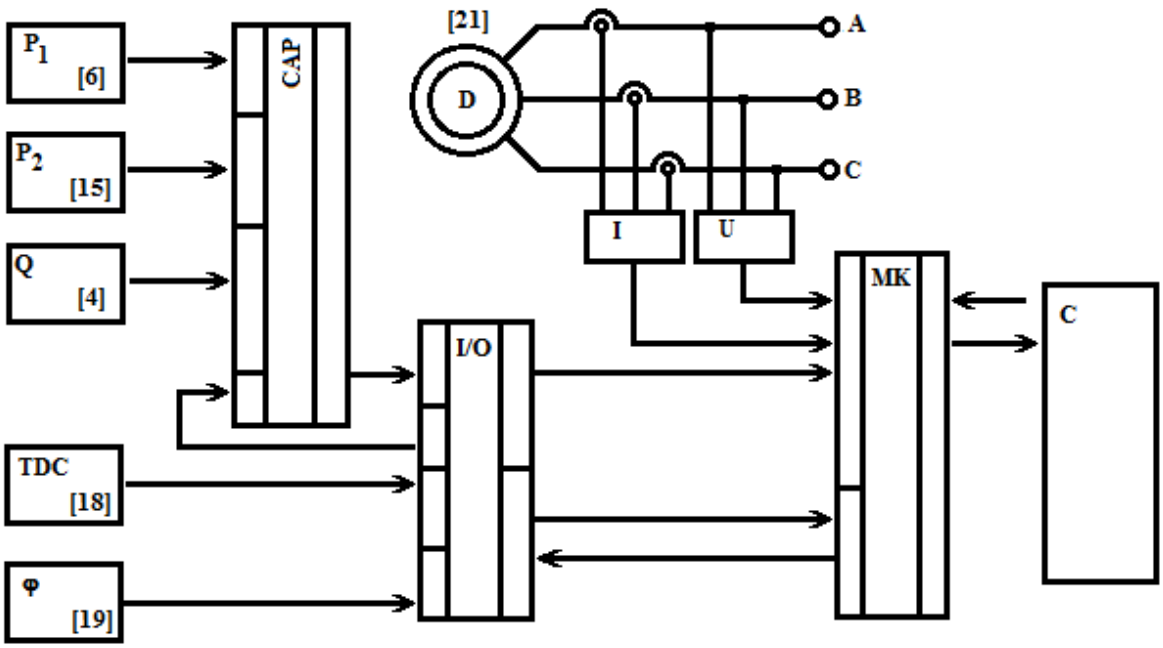

Fig.4. The block diagram of the measurement part

The instant values of the currents and voltages of induction motor stator are measured by means of transformer sensors I and U and with their converters transfer the signals in digital form to microcontroller MK. Computer C (fig.4) calculates full flux linkages of the phases, electromagnetic rotating torque, its comparison with resistive torque of the compressor, etc. The current position of the rotor of induction motor (compressor crankshaft), angular velocity (angular acceleration), and transition through the TDC point is followed by sensors 18 and 19 (fig.1).

Conclusions

A simultaneous investigation of the diagnostic parameters of a compressor and induction motor and their comparison with reference quantities on the basis of a unified mathematical model gives an opportunity of full evaluation of the current technical condition of an electric compressor installation and prediction of its residual life.

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SAFETY OPERATION OF PORT STRUCTURES IN BALTIC REGION, INSPECTIONS AND REPAIRING OF LIGHTHOUSES – PART OF PORTS LIFE CYCLE MANAGEMENT SYSTEM

Victor Burovenko*, Aleksei Usanov**

**GT Projekt AS (GT CORPORATION), Tartu mnt. 65, EE-10115, Tallinn, Estonia, E-mail: burovenko@gtcorporation.com*
**GT Projekt AS (GT CORPORATION), Tartu mnt. 65, EE-10115, Tallinn, Estonia, E-mail: aleksej.usanov@gtcorporation.com*

Abstract
The article provides a broad overview of Life Cycle Management System for port structures and information on the Finnish Code RIL 236-2006 "Satamlaitureiden kunnonhalliinta" ("Technical Condition Management of Port Quays") which is widely used in the Baltic Sea region as a guide for maintenance of port structures. The article also considers experience of GT Corporation on implementation of repairs of port structures and lighthouses in the Baltic Sea region to ensure safety operation, restore bearing capacity and serviceability of these structures.
KEY WORDS: *port structures, lighthouses, repair, inspection, life cycle management*

Introduction

Port structures are considered to be quite expensive facilities with the design life of about 50-100 years. They are subject to intensive damage and deterioration as a result of unfavourable environmental conditions as well as engineering factors.

Port structures are also subject to a life cycle process. Life Cycle Management (LCM) is a management approach to infrastructure construction to achieve cost effective functionality and quality and to enable a structure's owner to generate maximum direct and indirect income for minimal Whole Life Cost (WLC) [1].

The four fundamental phases of LCM are:

- planning and design,
- construction,
- operation & maintenance,
- re-use and/or disposal.

Our company - GT Corporation was founded in 1990 and since then its associated companies have been engaged in design, construction, inspection, repair and reconstruction of port structures and lighthouses. During the years of its existence GT Corporation has designed, built and repaired dozens of marine structures and navigational facilities in different regions of the Baltic, White, Black, Azov and Mediterranean Seas.

GT Projekt AS as an Estonian subdivision of GT Corporation has been working in the field of design, inspection, repair and construction of port structures and aids to navigation since 1990. Activity of GT Projekt AS is concentrated mainly in the Baltic Sea region. As soon as we have over 20 years' experience in all of the four fundamental phases of Life Cycle Management System, we have accumulated a significant knowledge in the integrated approach to the life cycle process of maritime structures.

Complex of negative factors affecting a maritime structure during its operation demands a very attentive approach to technical condition management of the existing port structures. Until recently these questions have been considered only individually for particular problems in special literature. In the European Union there were no general codes and instructions for applying Life Cycle Management System to port structures.

In 2006 Finnish Association of Civil Engineers (RIL) developed and published the Code RIL 236-2006 “Satamlaitureiden kunnonhalliinta”[2] – “Technical Condition Management of Port Quays”. GT Corporation specialists participated in the development of this Code which also includes practical examples of GT Corporation experience in technical condition management of port quays. In 2008 under the editorship of our specialists RIL 236-2006 was translated into Russian and published under the title «Управление техническим состоянием портовых причалов» [3].

Since its publication the Code RIL 236-2006 is widely used by port authorities of Estonia and Finland as well as by private contractors engaged in design, inspection and repair of port structures in Estonia, Lithuania and Finland.

1. Safety Operation and Life Cycle Phases of Port Structures

A brief description of each of the four fundamental Life Cycle phases specified in PIANC Report n° 103-2008 [1] follows below:

1) The planning and design phase encompasses the whole period and all the activities from the initial idea to elaboration into concepts, outline design and pre-design thru to the detailed design stage of a structure.

2) The construction phase commences with the preparation phase followed by on-site construction and finishes with a handover to the owner or operator and ongoing maintenance.

3) The operational and maintenance phase relates on the one hand to operational activities and commercial use of the facility and on the other hand to inspection, evaluation and if deemed necessary appropriate repairs.

4) The re-use and/or disposal phase relates to the end of the service life and /or the technical lifetime. All structures will eventually reach the end of their serviceable life, e.g. due to changes in economic, operational, or environmental conditions or for social reasons.

The operational and maintenance phase is the longest phase during the lifetime of a structure. The performance criteria such as functional quality and technical quality should be ensured during the whole lifetime of a structure.

Safety is the main criteria among the demands to a structure’s technical quality. Minimum safety requirements that a structure must meet are normally documented and codified in law in all countries. Particular safety requirements along with environmental and loading conditions are to be considered at the planning and design phase of every structure and included into the design.

Table 1 illustrates the main activities to be held within lifetime of a structure corresponding to the four fundamental life cycle phases in the context of its safety operation.

Table 1

Management of Structure Condition during its Lifetime

Life Cycle Phase	Monitoring of structure condition
Design (Safety of a structure is established)	Risk analysis Safety requirements development
Construction (Safety of a structure is realized)	Quality control Static tests (optional) Prime survey
Operation (Safety of a structure is ensured)	Preventive maintenance procedures Periodic observation and inspection Evaluation and forecast of technical condition Repair
Reconstruction	Start of new life cycle

One of the main goals of the maintenance is to provide safety operation of a structure during its lifetime. This goal is achieved when a proper maintenance management program is developed and implemented for the structure.

Maintenance of port structures is a regular and consequent activity. It includes proper and periodic inspections of technical condition of a structure which is the basis for planning and carrying out required repair or reconstruction. Implementation of maintenance managing program provides to avoid expensive repair works or early disposal of a structure. It is also one of the main procedure which helps to avoid failures.

Such maintenance managing programs are being implemented in the Baltic Sea region by port authorities of the Port of Tallinn (since 2001), the Port of Klaipeda (since 2003) and the Port of Helsinki (since 2004). GT Projekt AS (GT Corporation), being a long-term and reliable partner of these ports, together with other private companies, is also involved in these programs as a consultant when doing inspections of maritime structures and as a contractor for carrying out repairs and reconstruction.

2. Repairing of Port Structures. GT Corporation Experience in the Baltic Sea Region

Not all defects need to be repaired with the same urgency. Prioritization of defects for repair are to be assigned by inspectors while preparing an inspection report. Guidelines for the inspectors to follow during the field inspections of all the types of quay structures as well as for interpretation of the inspections' results are established in RIL 236-2006.

For owners with multiple facilities requiring repair, a prioritization scheme that considers the structural condition, functional condition, and importance of the facility to the owner's operation are very useful. That is why all the inspection reports issued by GT Corporation contain such prioritization recommendations as well as recommendation for the repair method to choose, whereas safety operation of a structure is always the main criteria.

Particular repair methods have to be defined considering repair objective, repaired structure type, degree of structure damage or deterioration, environmental conditions and customer requirements.

Results of inspections of maritime structures carried out by GT Corporation during over 20 year period show that more severe damages are observed at the zone of the variable water level and in the splash zone. After the first damages occur a further destruction is highly accelerated.

The repair of port structures under the sea water level, and particularly in the tidal or splash zone, provides many difficulties occurring during preparation of the deteriorated structure for repair and during the repair itself. Usually such repairs could be performed using divers and underwater repair methods, although the quality of such works, as well as the checking of quality, efficiency and durability is not satisfactory. Among the disadvantages mentioned above non-usage of a structure for a long period is also a significant negative factor.

For repair and protection of quay structures in the underwater zone and in areas of difficult access GT Corporation has worked out and implemented new technologies. Technical solutions are based on use of special underwater equipment – a hermetic chamber – that facilitates implementation of works in the underwater zone in the air-dry conditions without suspension of the quay structure operations.

A hermetic chamber is a floating metal structure with a special shape which is installed close to a structure and makes it possible to create near the repair site a working area isolated from the water basin. After installation of a hermetic chamber, water is pumped out of the working area and all works below the waterline can be carried out in air-dry conditions.

Repair methods with use of hermetic chambers are developed for quay structures of different types and objectives. Hermetic chambers are used for:

- repair of reinforced concrete piles and piles joints with superstructure elements;
- repair and strengthening of reinforced concrete slabs and capping beams;
- corrosion protection and repair of steel piles and steel sheet piling walls;
- sealing joints and repair of walls in blockwork construction and box caissons;
- strengthening of quay walls by installation of additional anchor ties.

Use of hermetic chambers for repairs provides:

- Steady checking concerning the quality and completion of a particular operation and the whole task;
- Carrying out repair works without suspension of quay structure operations;
- Opportunity to apply for repairs below waterline materials and methods widely used and approved in civil engineering;
- Environmental safety of the repair works.

Special equipment and methods of repair are intellectual property of GT Corporation and are protected by patents. Experience of executed works shows that use of hermetic chambers provides not only high quality of repairs but also gives financial benefits. The efficiency of the suggested technologies appears high, especially when taking into account that the operation of quay structures is not stopped during the execution of repair works.

3. Repairing of Lighthouses. GT Corporation Experience in the Baltic Sea Region

Design service life of lighthouses as a rule is in the range of 50-100 years. Many lighthouses exist even for a longer period of time and are of great architectural, historical and material value.

During operation the lighthouses' structures suffer damages due to severe conditions of open sea, marine moisture attack, temperature fluctuations and frost effects. Remoteness of lighthouses from industrial areas and centres of civilisation as well as severe environmental conditions introduce specific limitations on choice of construction solutions and methods of protection, repair and strengthening of damaged structures.

Over 20 years' experience of GT Corporation on repair of lighthouses in the Baltic region allowed to work out effective methods of undertaking works, to select materials and constructive methods for repair and strengthening of concrete, reinforced concrete and metal structures, to perform special technique and equipment for operations at high elevations and in the underwater zone.

To eliminate damages, restore bearing capacity and serviceability of a lighthouse an integrated approach, i.e. Life Cycle Management System, should be implemented. The main principles of LCM during lifetime of an existing lighthouse according to GT Corporation experience are specified below:

- inspection of technical condition of materials and structural elements;
- expert assessment and statistical analysis of typical damages;
- development of the concept to prevent actions of negative factors;
- working out solutions for repair;
- selection of remedial materials and necessary equipment;
- skilled use of operations on repair and their permanent control;
- monitoring of structure's condition after finishing of repairs.

The experience of GT Corporation was implemented when doing a large scale project in 2009-2010 'Reconstruction, construction and demolition designs of fixed Aids to Navigation located in West-Estonian Archipelago'. The work was organised and financed by Estonian Maritime Administration with participation of the European Cohesion Fund. The purpose of the work was to ensure navigation safety in West-Estonian Archipelago. 116 construction designs were prepared within the work, including 22 new aids to navigation to be constructed, 67 reconstruction or repair of existing structures and 27 demolition designs of outdated and amortised aids to navigation. The construction works under this project start this year.

Conclusions

Periods of non-usage of a structure (partly or totally) due to unplanned urgent repair could result in loss of income or lead to claims from third parties and could even result in permanent loss of customers to other ports. Implementation of Life Cycle Management System for port structures has lots of advantages: it gives the owner reliable information about technical condition of a structure, helps to plan and organise on-time maintenance and repair, consequently to avoid expensive repair works, early disposal and failures of a structure.

The positive experience of the Port of Tallinn (Old City Harbour, Muuga Harbour, Paldiski South Harbour, Paljassaare Harbour) and the Port of Helsinki (Länsisatama, Eteläsatama) confirms these advantages.

The ideal is to set up LCM at the planning stage for a new port structure, but port authority can start implementing it at any time during lifetime of a structure. The guidelines on implementation of LCM provided in RIL 236-2006 are applicable to all types of port structures, including all types of quay-walls, jetties and breakwaters, these guidelines are also applicable to aids to navigation.

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REFRESHER COURSE FOR IMPROVING GRAMMAR SKILLS TO THE FACULTY CONDUCTING SUBJECTS IN ENGLISH

Laimonis Brauns

Latvian Maritime Academy, 5B Flotes st, LV-1016, Latvia, E-mail: info@latja.lv

Abstract

The article discuses to the importance of the application correct grammar forms in case of conducting subjects in English. There are different ways how to refresh grammar.

One of the ways is to attend Refresher Courses in the International teaching Training Centre in Britain but the other one is arranging a seminar- type courses at the institution of higher learning as a type of distant learning tutorial. The faculty is provided with theoretical and practical grammar materials designed by prominent British linguists (in this case) by Michael Swan and Catherine Walters, Ronald Carter and McCarthy. Some methods and approaches are demonstrated in this study.

Introduction

Content and Language Integrated Learning is "a dual – focused educational approach in which an additional language is for the learning and teaching of both content and language."(Online1) For instance Latvian Maritime Academy students learn Navigation, Maritime Law, Celestial Navigation, Ships Maintenance Planning, Ships Technical Management, Mathematics, GMDS, Seaway Geography, Port Management and other subjects in English. Italian students learn Science in French, Swedish students study Mathematics in Chinese. These combinations of languages and subjects are limitless.

The term "Content and Language Integrated Learning" was introduced in Europe in 1994.

In the Latvian Maritime Academy separate Maritime subject teaching has been taking place since the Academic year 2006/07. Since that time integrated learning has become an increasing reality.

Due to the economic development of the logistics, the ports of Latvia in Riga, Ventspils and Liepaja have reached the cargo turnover up to 90 percent, the rail cargo 75percent, the major proportion of oil and oil products have been transported via trunk pipeline systems, more than 9 percent of Latvia's employees have been engaged in the transportation and servicing of transit cargo. Ventspils port as for its geographical placement and technical operation and management in the international valuation have been rated as the seventh in the world. The port managers are going to contribute to future planning to open the transit via ports of Latvia for China, Russia, Belarus, Kazakhstan and the Middle East countries.

All that in total is an attractive incentive for the young people of Latvia and from abroad to study subjects in English either in the Port or Navigation and Engineering departments of the (LMA) Latvian Maritime Academy. Especially challenging is the EU's Erasmus Action program that makes Europe's educational opportunities more accessible to the rest of the world by granting scholarships to all European and non - European students. Good English knowledge encourages LMA students to apply for the Erasmus scholarship for studies abroad.

The global seaborne trade has contributed the English language to becoming the lingua franca. Students' desire of comprehension the content is motivating them to learn more, striving to reach the advanced level of language.

But we have to realize one aspect – the content of the subjects taught can be learned with minimal language but based on the application of faultless grammar forms.

The English language and seafearing

In the history of sea accidents there are particularly very tragic events in the past decades due to poor competence of the English language. There were cases when crew members of different nationalities had minimal or no English language skills at all.

The recent shipwreck of passenger cruiser "Costa Concordia" was a typical example when grammarless English language was used by the crew members (Conant, E. (January 30 2012) Newsweek):

"Workers were often too exhausted to pay attention during safety training sessions, and many didn't speak enough English to even understand what was being said" …"We all got safety training, but even I had difficulty understanding the English of the officers who trained us, who were always Italian with strong accents".

Characteristics of the CLIL course activities for LMA staff

Tutor's and learners' relationship is the main factor in the acquisition of good English proficiency. This is very important in any kind of teaching whether it is secondary school, college, higher learning or English for Special Purposes courses for adults. These relations should be natural and sincere, the tutor is endowed with the talent or prone to hard work as a result having got accomplishments in his or her field of knowledge. The tutor is an actor of a social life as well either conducting a lecture as a guest faculty or a home lecturer.

The class should be planned before, the goal or goals of the class announced .The tutor should know which method he or she will apply. Seafarers can use lyrical digressions mentioning cases of language use, comparing funny grammar or amazing word forms. Lyrical digressions reduce stress and give the chance to have a rest for the brain.

It is important to start the CLIL class at a quick pace, involving the participants, deploying various techniques of teaching, using humor or examples from real seafarer's life

The main aspects of grammer refresher

"Grammar is not the most important thing in the world but if you make a lot of mistakes you may be more difficult to understand" (Swan, M. Walters, C. 1998 Oxford)

"Practical English Usage" is a guide to the faculty who is conducting the subjects in the English language in the Latvian Maritime Academy. The book deals with various points which regularly cause difficulty to non-native students of English. It will be useful to anyone who is not sure how to use a particular structure, or who has made a mistake and wants to find out why it is wrong. It will also be useful for a tutor who is looking for a clear explanation of a difficult language point.

There is another English Grammar Course by Swan and Walters for advanced level of students and tutors. Both books by M. Swan and C. Walters range from relatively simple points to quite advanced problems.

The third grammar manual useful for the course was "Cambridge Grammar of English a Comprehensive Guide, Spoken and Written English Grammar and Usage" by Ronald Carter and Michael McCarthy.

The grammar themes, most important points of the materials for the faculty grammar refresher course were selected from the above books, complemented with, discussed and after applied in the classes conducted by the author of the article.

The fresher course included the following material: Simple Present, Past, Future tenses; Progressive, Perfect and Perfect Continuous aspects; all the tense forms in the Passive voice, Modal verbs – can and could, may and might, must and have (got) to, should and ought to, their meanings, tense; Infinitive and Modals with the Infinitive forms; Prepositions; Numerals and applied terminology in mathematical symbols and numbers.

Much attention is being paid to a sentence whose grammatical structure conforms to the laws of the language – to convey a thought. A sentence is not only a means of communicating something about reality but also a means of showing speaker's attitude to it. An important aspect to grammar

refreshing is to pronounce a sentence with a correct intonation, including the voice pitch and rhythm. A declarative sentence states a fact in the affirmative or negative form, it is generally pronounced with a falling intonation. An Interrogative sentence (general and special), alternative and disjunctive question, imperative sentence they all have their own specific that should be practiced as a refresher grammar.

Communicative pfase in the present tenses

1 It is common knowledge that the most frequently used verb tense forms are the present simple, perfect and progressive used by the academia in their classes.

2 The tutors had been practicing provided exercises of various grammar materials on a daily bases, verifying answers with the given keys.

3 The main task for the tutors is to put the revised grammatical structures into practice to develop accuracy in communication.

4 The aim of the communication phase is:

To master new situations based on or shipboard situations, paying attention to grammar accuracy when conducting the question-answer practice.

To use oral information question drills in real case studies practicing pair and group work.

Presentation art and refresher grammar

"When you have to do a presentation in a language that is not your own, it can become a nightmare" BBC English *(online2)*

At the same time the BBC English is the language providing us with a series of advice and will help us to get a good night's sleep.

Create a wealth of opportunities of using correct language.

Make it meaningful. The language themes and content of lectures must be relevant and of interests to students.

Communication is of primary importance but it is important to communicate having perfect grammar.

Students can take the lead in conducting a conversation.

The audience wants you to do well.

Say what you are going to say (the introduction)

The main body of the presentation…

And say it again! (The conclusion)

Conclusions

The main aim of the refresher grammar course was to introduce the faculty to the theoretical part along with situational application of grammar rules so that the discourse and communication with students were unambiguous in shipboard situations.

The grammar material was involved in various types of discourse.

The faculty was provided with the theoretical material and tasks with keys for practicing and checking the material coping on their own.

In case of misunderstanding everyone was welcome to attend tutorials.

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EXPERIENCE OF TECHNICAL INSPECTIONS IN BALTIC PORTS AS PART OF PORT STRUCTURES LIFE CYCLE MANAGEMENT SYSTEM

Aleksei Usanov*, Victor Burovenko**

**GT Projekt AS (GT CORPORATION), Tartu mnt. 65, EE-10115, Tallinn, Estonia, E-mail: aleksej.usanov@gtcorporation.com*
**GT Projekt AS (GT CORPORATION), Tartu mnt. 65, EE-10115, Tallinn, Estonia, E-mail: burovenko@gtcorporation.com*

Abstract
Optimal maintenance of port structures based on a Life Cycle Management approach is one of the main tasks of ports technical staff. Maintenance procedures and well-timed repairs of port structures based on periodical technical inspections, could ensure uninterruptible usage of port quays and increase benefits from port work.
KEY WORDS: *port structures, quays, inspection, life cycle management (LCM)*

Introduction to LCM Principles for Port Structures

In general terms Life Cycle Management (LCM) is a management approach to infrastructure construction to achieve cost effective functionality and quality and to enable a port to generate maximum direct and indirect income for minimal Whole Life Cost (WLC).

Port authorities are interested in the behaviour of the civil engineering elements of port infrastructure, particularly with respect to the financial, technical, safety and environmental decisions to be taken during the life-time of the structures.

It therefore follows that to avoid unexpected large-scale rehabilitation measures and costly downtimes as a consequence of neglected periodic maintenance, a systematic planning and budgeting of maintenance activities is necessary.

Port quays are considerably expensive and are planned to be in use for a long period of time - usually 50-100 years. Quays are designed for heavy environmental influence such as frosting, melting, salt sea water influence, tidal and ice effects, water movement. Maintenance of port structures, especially underwater inspection of technical condition and underwater repairs demand a special experience, equipment and methods.

Port structures are subject to a life cycle management, LCM will contribute to a realistic approach of maintenance policy, including decision-making, planning, budgeting and funding of inspection and repair activities during the life-time of port structures such as wharves, quays, jetties and breakwaters.

In practice there are many situations where time or budget are far from optimum solutions. For example port owners may not wish to expend additional money on an adaptable or re-useable structure, or may not have the funding to choose more durable or easier maintainable alternatives.

There are four phases of LCM: planning and design, construction, operation & maintenance (including inspection, evaluation and repair), re-use and/or disposal. In this article we will focus on operational and maintenance phase of LCM. The operational and maintenance phase relates on the one hand to operational activities and commercial use of the facility and on the other hand to inspection, evaluation and if deemed necessary appropriate repairs.

Financial Aspects of Maintenance

If during the lifetime of a structure it is put out of use due to problems related to the quality of construction, inspection or maintenance activities, physical damage and/or obsolesce, there will be partial or total loss of income from the asset.

Indirect costs will occur if during the lifetime of a structure it is partly or totally out of use due to lack of quality, poor inspection or maintenance, excessive damage due to impact forces caused by use or mother nature. Such periods of non-usage could result in loss of benefits / income or damage to equipment and could even lead to claims from third parties. Other indirect costs associated with short- or long-term downtime can include associated downtime of industrial facilities depending on the port, or permanent loss of customers to other ports. The above direct and indirect costs or financial risks can and will be faced at any time during the lifetime of the structure.

Considering maintenance generally distinction is made between preventative and corrective maintenance. Preventative maintenance will normally be carried out on a regular programmed cycle, with each year's program being similar to the previous. Examples would include drain cleaning, repainting of metal structures, fender maintenance etc. In spite of the routine maintenance program, defects may occur and be of such nature that e.g. loss of loading capacity, collapse, or loss of safety has to be prevented.

Traditionally it has been difficult to quantify maintenance costs for future years, possibly for as long as 25 years in advance. In many cases, the lifetime cost of maintaining the infrastructure, will be a percentage in the order of 10-25% of the original investment.

Technical inspection of port structures is a main part of theirs maintenance program and the only way to predict collapse of structures due to all reasons caused by enironmental factors such as material deterioration and to possible mistakes done during designing and construction phases.

Technical personnel are usually responsible for appropriate maintenance of port structures. But, in fact, underwater part of structures is not easily accesible for inspections. In a very few cases ports have an own diving group or technical personnel educated for diving works and some outside organisations with diving facilities have to be involved in maintenance process for execution of underwater inspections.

Effective maintenance management typically involves a team approach. A designated maintenance manager is usually assigned to oversee the program. The oversight role involves scheduling and prioritizing of activities and generating required reports to management and other stakeholders.

In addition to the manager, the maintenance management team typically involves engineering inspection and design staff. Often these are the same individuals. The inspectors collect the required information in the field and produce subsequent reports while the designers prepare plans and specifications for repair of facilities.

Inspectability - Important Characteristic of Port Structures

The ability to inspect a structure easily and efficiently, either on a periodic basis or as the result of an extreme event, promotes the inspectability of the structure. Examples of typical inspectability include:

- Avoiding the use of buried elements such as anchorages in bulkhead walls. The structural capability of such elements may be very difficult to assess
- Building in to the structure monitoring instruments to enable this activity to be continuous or intermittent but on a regular basis
- Including a gap at the top of the back row of piles in a pile supported marginal quay such that inspectors can gain visual access to the most vulnerable area of these piles
- Avoiding the sitting of structural members near to the waterline such that access for a small boat to the underside of the structure is blocked
- Ensuring generous pile spacing to enable an inspection boat to gain access beneath the upper structure of the quay
- Promoting ease of access for inspection of structures for security checks
- Ensuring the design can easily accommodate a special inspection vehicle for remote sections of the structure.
- Where unavoidable promote the ease of use of inspection by divers or Remotely Operated Vehicles (ROV)

Types and Frequencies of Inspections

Traditionally seven inspection types may be considered in Maintenance Management:

- New Construction Inspection
- Baseline Inspection
- Routine Inspection
- Repair Design Inspection
- Special Inspection
- Repair Construction Inspection
- Post-Event Inspection

Further we will focus on most frequently used types of inspections: routine inspections, special inspections and post - event inspections:

Routine Inspections are intended to assess the general overall condition of the structure, assign a condition assessment rating, and assign recommended actions for future maintenance activities. The inspection should be conducted to the level of detail required to evaluate the overall condition of the structure. Documentation of inspection results should therefore be limited to the collection of data necessary to support these objectives in order to minimize the expenditure of maintenance resources.

The frequency of Routine Inspections is typically 2 to 3 years for above water structural elements.

Special Inspections are intended to perform detailed testing or investigation of a structure, required to understand the nature and/or extent of the deterioration, prior to determining the need for and type of repairs required. It may involve various types of in-site and/or laboratory testing.

This type of inspection is conducted only when necessary as a result of a Routine or Repair Design Inspection. Typical, failure prone, innovative, members of the structure may sometimes also call for special inspection. The frequency of that type of inspection depends on result of Routine Inspections, but for all quays excluding only the new constructed, a Special Inspection have to be done at list once.

Post-Event Inspections are conducted to perform a rapid evaluation of a structure, following an earthquake, storm, vessel impact, fire, tsunami, or similar event, in order to determine if further attention to the structure is necessary as a result of the event. The safety of personnel and equipment should be assured as well. The inspection is conducted only in response to a significant loading or environmental event having the potential of causing (severe) damage. The frequency of Post-Event Inspections is corresponded with frequency of emergency cases with port structures.

Optimisation of Technical Condition Management of Port Structures

In will to ensure required technical condition, safety and working suitability of port berthing quays and other structures periodical visual inspections of a structure should be done, including both above and underwater zones. In addition, if needed, more detailed inspections could be done using special instrumental methods and equipment to investigate durability and other characteristics of used materials.

Optimisation of maintenance of a port structure is based on regular inspections of its technical condition. Recommended interval for a visual inspection is 3-5 years, it depends mostly on type of a structure and operational stresses. It may differ for a separate quay elements. As a result of inspection detailed reports with recommendations for future maintenance and repair procedures for a period until the next inspection are to be issued.

There are some systems of assessment used for estimation of inspection results. In fact they specify from 3 to 6 levels or classes of technical condition of the structural elements or the whole structure. Classification of technical condition varies from good condition, with no defects discovered to a critical condition that means close-to-collapse situation, for example, due to very advanced deterioration of elements, it's overstressing or breakage of bearing structural components. Corresponding the rating of condition of structures different actions could be implemented.

As an example of guidance for processes of design, maintenance and inspection of technical condition the Code RIL 236-2006 “Technical Condition Management of Port Quays” developed and published by Finnish Association of Civil Engineers can be recommended.

Based on a report's conclusion, port authorities can make a decision about technical condition of a quay. If no technical maintenance, repairing or reconstruction is planned, quay operation proceeds until the next inspection.

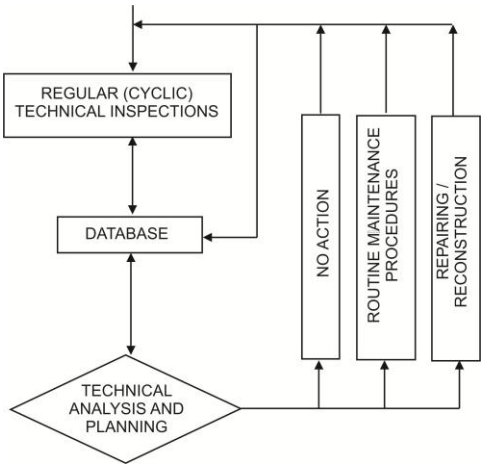

Fig.1 Scheme of Optimised Maintenance Cycle

After making a decision to do repairing or reconstruction of a quay, based on inspection report the phase of developing of repairing work plans is started. If necessary, an additional detailed inspections could be executed at that phase. After developing of working plans and recording results to database implementation of technical maintenance and/or repairing procedures are started. After all planned works are completed data about all the procedures are saved to database and initial point of cycle is achieved.

Database

Some words about management of a technical condition database. All information about quay structure should be stored in database. It should always be used during planning and taking a decision concerning maintenance and repairing works on a quay.

Such database should contain at least the following information:

- identification code (number), location of quay (or other port structure)
- year/years of construction, reconstructions
- dimensions
- structural elements, materials used
- environmental data
- intended use, limitations by loads
- schedule of repairing and preventive actions
- technical condition of structural elements
- damages, caused by environmental influence, vessel impacts, overloading etc.

Database is to be updated permanently during the whole l lifecycle of a quay by recording all the data gathered during design and inspection works as well as the data gained during maintenance and repairing works.

Examples of Implementation of Life Cycle Management Approach in the Baltic Region

During over 20-years of practical experience GT Corporation has made technical inspection of over thousand of port quays with hundreds of kilometres of total length. Following own practical experience, we can conclude that systematic approach to maintenance of port structures, based on principals of Life Cycle Management System helps to avoid losses of income from idle port facilities during emergency cases and unplanned repairs.

Examples of well-functioning systems of technical control and maintenance in the Baltic Sea region could be the following ports:

1) **Port of Klaipeda (LITHUANIA)**

It is one of the few ice-free ports in northernmost Europe, and the largest in Lithuania. It serves as a port of call for cruise ships as well as freight transport. The Port Authority is responsible for the maintenance, reconstruction and modernisation of the port infrastructure, while loading/ unloading operations are managed by separate independent terminals. The port is able to accommodate ships of up to 195 m in length with draughts of 10.5 m. In 2011 handled over 36,5 mln. tn. of cargo. Port has over 165 quays and jetties, with tens of kilometers of berthing line. System of cyclic technical inspections has started in 2003. At present time already the third cycle of inspections is in progress.

2) **Port of Tallinn (ESTONIA)**

Port of Tallinn is the biggest port authority in Estonia and as far as both cargo and passenger traffic are taken into account, the biggest port on the shores of the Baltic Sea. Today port of Tallinn operates as a landlord type of port with no cargo handling operations of its own. It is maintaining and developing the infrastructure of the port and leasing territories to terminal operators through building titles giving the operators an incentive to invest into superstructure and technology.

Port of Tallinn consists of five harbours, most of them are situated on a north seaside of Estonia, close to the capital - Tallinn. Total number of quays - 74, total length of berths about 14,3 km. Cargo turnover in 2010 was 36,6 mln.tn

Periodical technical inspections started since 2001. At present time the third cycle of inspections is in progress.

3) **Port of Helsinki (FINLAND)**

Situated on the south coast of Finland, this port is an important transport hub of numerous of Baltic transport routes. At present time Port of Helsinki consists of 4 harbours, total amount of quays - 55, with total length of 9,7 km. Goods traffic is about 11 mln.tn. (data of 2010). First inspections were made in 2004 and at present time all berth structures are inspected totally and second cycle of inspections has started.

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NEW APPROACH TO USE THE ACOUSTIC EMISSION MONITORING FOR THE DEFECTS DETECTION OF COMPOSIT-MATERIAL'S DESIGN ELEMENTS

Alexander Urbah*, Muharbiy Banov, Vladislav Turko***, Yuriy Feshchuk******

** Rīgas Tehniskā universitāte, Transportmašīnu Tehnoloģiju institūts, Lomonosova iela 1, Rīga, Latvija, LV-1019, E-pasts: aleksandrs.urbahs@rtu.lv*
*** Rīgas Tehniskā universitāte, Transportmašīnu Tehnoloģiju institūts, Lomonosova iela 1, Rīga, Latvija, LV-1019, E-pasts: muharbij@inbox.lv*
****Rīgas Tehniskā universitāte, Transportmašīnu Tehnoloģiju institūts, Lomonosova iela 1, Rīga, Latvija, LV-1019, E-pasts: vladislav.turko@mail.com*
***** Rīgas Tehniskā universitāte, Transportmašīnu Tehnoloģiju institūts, Lomonosova iela 1, Rīga, Latvija, LV-1019, E-pasts:ndt_ae@inbox.lv*

Abstract
The experimental results of the new approach of acoustic emission monitoring are led. To load a design element, the principle of thermal loading has been chosen: rise in temperature of the design element, and its cooling. The destruction of the main rotor blade of the helicopter in operation shown that traditional defect's monitoring isn't effective for the defects detection. The thermal loading of composite material's elements from rise in temperature has shown the bigger efficiency of the defects detection, than long thermal influence of low (minus) temperatures. The offered approach allows applying an acoustic emission method directly in operation.
KEY WORDS: *acoustic emission, composite, starved spot, stratification, thermo loading.*

Introduction

The aerospace branch makes severe requirements to working capacity and reliability of constructional materials.

Recently more and more wide application is found by composite materials which possess a number of unique properties which define their choice instead of metal alloys.

Existing pasting technologies of various materials are insufficiently perfect; therefore in glutinous connections there are defects which reduce durability of glutinous connection. Durability of the last it is caused by adhesive influence of connected surfaces with a glutinous layer. And also cohesion durability of this layer and a connected material with a design of a connecting seam. The commission of the Russia Interstate Aviation Committee (IAC) had undertaken the investigation of the crash of the helicopter Mi-8 which had happened in July, 2009 in the Volgograd region.

Then six persons were lost. The commission has come to conclusion that accident has occurred because of defective blades of the steering screw (blades have been stuck together by a poor-quality gluing film) which in air have simply collapsed. According to an expert estimation [1] change of structure of a gluing film has occurred while in service blades in an arm zone, its destruction whence has begun. On Fig. 1 appearance of a fragment of a covering from the bottom party of the collapsed blade on a site of adhesive destruction of glutinous connection is resulted.

The experts noted that accident was resulted due to that the Plant has made the blade, having stuck together it a glutinous film with unstable physical and chemical characteristics. At existing control methods to find such defect it is impossible - neither at a production phase of glue VK-3, nor at a manufacturing stage of blades, nor in operation use.

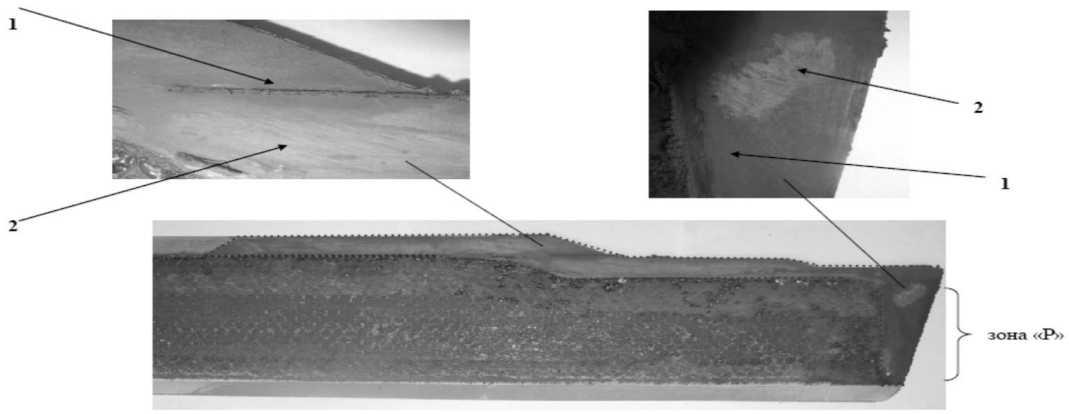


Fig. 1. The view of a blade covering fragment from outside blade "bottom": a zone of the adhesive destruction of a glutinous connection (it is designated by a dotted line). Shooters show zones of a film of glue VK-3, sharply differing among them on colour:
1 – site of glue of dark brown colour, 2 – site of glue of light brown colour

One of IAC recommendations was the following: ” The Designer and the Manufacturer of blades must develop modern, more effective quality monitoring of a condition of blades, including the durability control of stuck coupling together blades surfaces, with application of the devices allowing precisely to define presence starved spots and the *beginning of glutinous connections destruction*.”

As shows the analysis of the collapsed blades with similar defects in 2009 year, the manufacturing technology of these blades haven't been broken by the Manufacturer in Plant. Therefore an origin of such defects to define is rather problematic. Incoming inspection of these blades have realized to the full extent, provided by Technical Requirements. So, for the reasons specified above, it is impossible to define the given defect, which is connected with a chemical compound of a glutinous layer, in the manufacturing conditions of the blade.

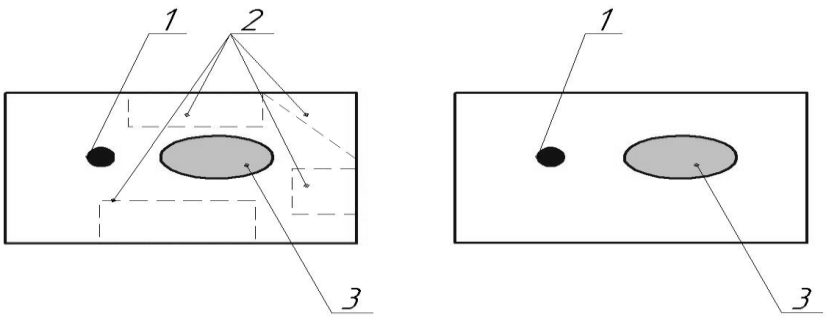
Additionally it is necessary to note, that ultrasonic methods is not effective for operative control to detect the defects of starved spot type in composite materials designs as its demand full scanning the area of design elements and possess enough low sensitivity.

Take into account that the wide application of composite materials in the transport design all the time call for the simple, technological and cheap control methods to detect such defects as starved spot and stratification. So a method of the acoustic emission during thermo loading has been offered as the non-destructive monitoring of composite materials designs.

Test Procedure

The specimens of the composite material design elements with defects and without ones have been chosen for testing under thermo loading.

The specimens have been cut out off the faultless covering of elevator (heat thermo loading). In one specimen artificial defects have been created, but at the same another one would remain faultless (Fig. 2). Also a full scale aileron with defect was loading by high temperature to detect this fault in the construction. The same full-size aileron made of composite material was chosen for cold treatment loading.



a. b.

Fig. 2 The scheme of an arrangement of Acoustic Emission Sensors (1), defects (2) and zones of heating (3) on composite samples: a - with defects; b - free of defects.

Two ways of specimens' thermo loading were chosen to investigate the possibility of defect monitoring: the surface of samples was exposed to heating by a blowtorch (without contact of an open flame with a material) to temperature +70°C and the subsequent natural cooling to room temperature (+18°C of a premise in which experiment was made.

The elevator was taken out from a premise on open space at air temperature - 7°C with where was maintained in a current of 60 mines and further was brought back in a premise with temperature +18°C. The temperature on a surface of samples was supervised by the contactless remote thermometer "Raynger MX".

Equipment

Two-channel portable "Pocket AE" device,

- soft program – "AE Win package",
- piezoelectric detector,
- Pyrometer Raynger MX,
- Portable blowtorch.

The following settings were used:

- threshold - 30 dB,
- High frequency filter - 5 kHz (for an elevator) and 100kHz,
- Low frequency filter - 1000 kHz,
- Internal Preamplifiers –26 dB,
- Frequency of sample – 2 MSPS.

Test Results

Test 1 Preliminary, to determinate the possibilities of the new approach, and to state the need settings, the two specimens (with known detects, and free of one's) were exposed to heating till +70°C by blowtorch and after that natural cooling to room (+18°C) temperature. All the time (heating and cooling) the acoustic emission impulses from the piezoelectric gauges were summarize to „Pocket AE" device.

The results are following (Fig.3):

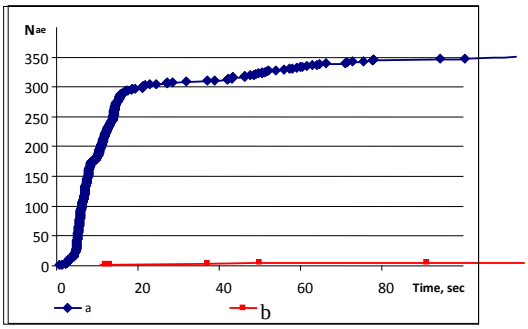


Fig. 3. The summarize (Nae) of acoustic impulses AE vs. Time at heating and cooling:
a - specimens with defects, b – specimen free of defects

We can see, that during the heating the specimen with defects (left side of Fig.3, a) the impulses of acoustic emission begin to intense summarise till finishing of thermo loading (+70°C). And after the heat treatment (the right side of Fig.3) we also see some growth of summarising of AE impulses, but with the less intensity. In opposite, the free of defects specimen (Fig.3, b) practically do not reproduce the AE impulses during the whole time of experiment of heat loading.

Most likely during heating of the defective zone, not making single integral formation yet, occurs further stratification of composite components, as causes the accelerated generating of AE impulses, not fading at natural cooling. In the second case (a faultless specimen), the design element practically behaves as a single formation, which is not reacting to thermal impact.

Test 2 As other object of research has been chosen full scale aileron, which also was exposed to heating to +70ºC. However, due to big size of the new research object versus previously investigated two specimens heating zones were chosen near the defective zone in one case - this zone was determinate as defective by an impedance method (natural peeling was revealed). In another case, as other place of heating also to +70º has been chosen the faultless zone. Also an impedance method detects this free of defect zone (Fig.4).

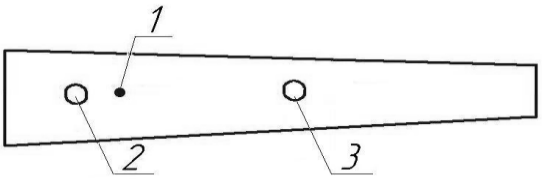


Fig. 4. The arrangement scheme on full-scale aileron:
1- The Acoustic Emission piezoelectric gauge,
2 - heating zones near the defect zone, 3 faultless zone.

The plan of experiment was the same as for the previous Test 1: heating impact till +70 ºC in the zone 2 and 3 (Fig.4) and natural cooling in premise till +18 ºC. The summarising of acoustic emission impulses has the same mode as in the previous case with two specimens in Test 1. More than that, as the settings of the equipment of the experiment do not changing, we see a little less total sum of the acoustic emission impulses (Fig.5).

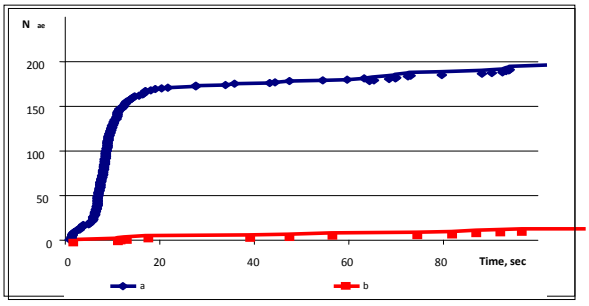


Fig. 5. The summarize (Nae) of acoustic impulses AE vs. Time at heating and cooling:
2 - near the defect zone, 3 - In free of defect zone.

Thus we see that the general character of the accumulation of AE impulses hasn't changed, whereas total value of the AE impulses sum from the gauge near to a defective zone has decreased almost twice. This can be caused or the smaller size of defect or greater remoteness of a place of the defect from AE- gauge, or the bigger sizes of the object of research. Anyway, both at research of samples, and at research of natural object we see significant growth of signals of acoustic impulses at an arrangement of AE gauge near to defective zones at thermal loading of the objects of research.

Test 3 The following object of AE-heat monitoring was the full-size elevator. The use of the impedance method wasn't revealed any peelings though there were «traces of hits of lightning» (fig. 6).

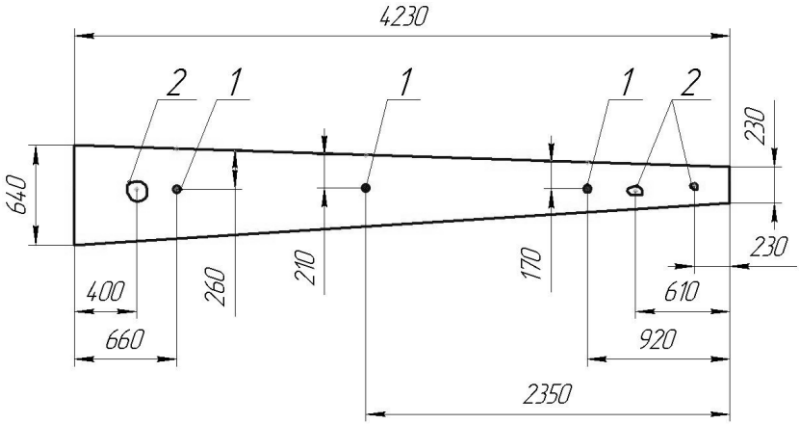


Fig. 6. The scheme of AE- gauges arrangement and the dispositions of defect places, caused by imitation of defeat by a lightning on an elevator covering:
1.-the piezoelectric acoustic emission gauges, 2. – the zones of defeat by lightning

This time another approach was applied. The composite-made elevator has been cooled to temperature - (minus) 7 ºC during 60 minutes on the open air and then has been quickly brought in a lodge (+22ºC) where it has undergone to difference of the temperatures due natural heating. All the time in the premise the AE-monitoring was running to summarize the impulses of acoustic emission. The following results have been received (Fig.7). It appears that in this case the effect of thermal loading is expressed less brightly, than at our Tests 1-3. However it is necessary to consider that the impedance method didn't find any composites defects as starved spot, stratification or peeling types on the elevator. Also the low temperature influence might be insufficiently.

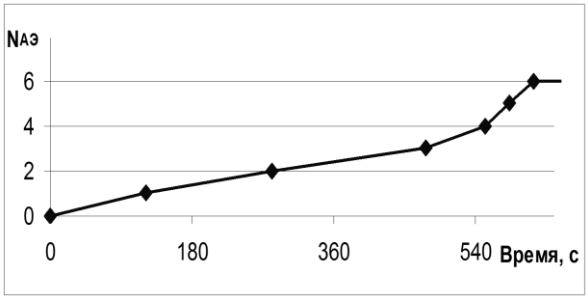


Fig.7. The summarize (Nae) of acoustic impulses AE vs. Time at cooling and natural heating

Nevertheless such approach is especially interesting in operation when fast return of a vehicle from one temperature environment in another allows practically applying in a mode of AE continuous monitoring methods behind a condition of its composite components.

Conclusions

1. For the purpose of the approbation of a new approach to diagnostics of composite-made elements the thermal loading tests for three types of objects were plunged: specimens of a covering with the brought defects and free of ones, aileron with known defect and an elevator with damages from lightning stroke imitation, but free of defects, characteristic for composite materials, such as starved spot, stratification or peeling.
2. Thermal loading was carried out by two plans of experiment: heating of a covering of objects to temperature +70°C with the subsequent natural cooling till room temperature (+18°C) at continuous registration of the acoustic emission impulses sum (for specimens of two types and aileron) and keeping at negative temperature with the subsequent natural heating (also till +18°C) in a room (for an elevator).
3. It is shown that at the AE sensor installation around a defective zone while at heating of object of research, it is observed intensive growth of AE-impulses, up to the completion of natural cooling whereas in the free of defects zones it practically isn't present.
4. It is shown that at long cooling of object of research without damages, characteristic for composite materials, but with external damages of a covering with the subsequent its natural heating, AE sensors also didn't register existence of such defects.
5. An offered new approach of application of the AE monitoring of a condition of composite-made elements allows to lead it in operation almost constantly for those vehicles, that occurs in various temperature environments or conditions.

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ANALYSIS OF MARITIME SPATIAL PLANNING EFFICIENCY IN DEVELOPMENT OF WIND ENERGY ON THE WESTERN COAST OF LATVIA

Aleksandrs Urbahs*, Kristīne Carjova*, Madara Nagaine, Juris Korhs***

* *Riga Technical University, 1 Kaļķu st, LV-1658, Latvia, E-mail:kristine.carjova@inbox.lv*
** *Latvian Maritime Academy, 5B Flotes st, LV-1016, Latvia, E-mail: madara.nagaine@inbox.lv*

Abstract
Wind energy due to the wide spread availability of its resource is one of the most perspective of the renewable energy types, the wind which can be used to produce power in an environment friendly way. The most suitable placement of wind turbines is in sea or on the coasts. “BatlSeaPlan” is the maritime spatial planning pilot project of Baltic coast of Courland that intends a construction of offshore wind farms on the West coast of Latvia, but due to insufficient political support this territory is not utilized and the development of wind energy in Latvia is hindered.
KEY WORDS: *wind energy, maritime spatial planning.*

Introduction

Wind originates from the equalization of atmospheric pressure due to uneven heating of the planet by solar energy. Only a small amount of solar energy is converted to wind energy but this process is very important as the amount of created energy is greater than that of the whole biomass of Earth. Wind energy is one of the most perspective types of “green” power because it does not pollute the atmosphere and does not influence global climate changes. Wind turbines are used, most effectively set up on coasts and flat hills.

According to meteorological observations, the West coast of Latvia is suitable for construction of wind farms, which is intended in the pilot project BaltSeaPlan - Development of Maritime Spatial Planning in Baltic Sea. One of the main tasks of the project is to find the most suitable places for wind farm construction also taking into account all the interested parties, but insufficient political support and absence of favorable legislative framework delays the implementation of the project on the coast of Courland and the development of wind energy in Latvia.

Usage of wind energy

Wind energy derives from solar energy due to the uneven heating of the surface of the planet. Earth receives approximately $1*10^{14}$ kW*h solar energy every hour, and only 2% [2] of this energy is converted into wind energy, but the amount of created energy is very important because it surpasses the energy that can be obtained from all the plants of the world which constitute the biomass of the planet. Nowadays wind energy is mostly used for generation of electric power using wind farms. Since the produced energy of the wind E is [1]:

$$E = cv^3 \quad (1)$$

where
E – obtainable energy, J;
c – area of wind flow, m^2;
v – wind speed, m/s.

Then not only the average speed and direction of the wind is important, but also whether the wind is strong or gusty and is it obstructed by nearby obstacles such as hills, forests or buildings.

The speed of wind required for a wind turbine to operate is at least 5 m/s. The biggest potential of wind is obtainable in territories with little to no obstacles – on coasts and flat hills.

Recently in Europe a construction of offshore wind farms has begun. However there are many territories in Europe, including Latvia, where the obtainable wind potential is sufficient for usage of “green energy”, but these territories are still not being fully utilized due to insufficient political support, thus future production of power is decreasing. From the statistical data of European Wind Energy Association about construction of new wind turbines in the European Union (EU) in the time period from 2001 to 2011[7], it can be deduced that from 2001 to 2009 the amount of constructed wind turbines both offshore and onshore increased, but stayed practically the same in 2010 and 2011. 93 offshore wind turbines were constructed in the EU in the year 2006, 318 in 2007, 372 in 2008, 582 in 2009, 883 in 2010 and 866 in 2011. The results of the last two years could be explained with insufficient support from the government due to the global economic crisis and other political concerns. By the end of the year 2011 all 27 countries of the EU had installed wind farms with the total power of 9616 MW (Table 1).

Table 1

Wind power installed in Europe by end of 2010 and 2011 (MW)[6]

EU country	Installed 2010 (MW)	End 2010 (MW)	Installed 2011 (MW)	End 2011 (MW)
Denmark	315	3 749	178	3 871
Estonia	7	149	35	184
Finland	52	197	0	197
Germany	1 493	27 191	2 086	29 060
Latvia	2	30	1	31
Lithuania	72	163	16	179
Poland	456	1 180	436	1 616
Sweden	604	2 163	763	2 907
Others	6 647	49 828	6 101	55 912
Total	**9 648**	**84 650**	**9 616**	**93 957**
Of which offshore and near shore	883	2 944	866	3 810

The most power generated by wind farms was in Germany (29 060 MW), Spain (21 674 MW), France (6800 MW), Italy (6747 MW) and Great Britain (6540 MW) [7]. The most power generated by wind farms in year 2011 was in Germany (2086 MW) and Great Britain (1293 MW), but Slovakia (3 MW), Latvia (31 MW) and Luxembourg (44 MW) generated the least amount of power.

Usage of wind energy in Latvia

The strongest winds in Latvia (at 10m height) are along the coast of Courland and in the vicinity of Ainazi (6 m/s average), but in the rest of the territory the speed of wind is less than 5 m/s. The required speed of wind for a wind generator to operate is at least 5 m/s, which means that the coast of Courland has enough wind resources to be suitable for construction of wind generators.

Maritime spatial planning (MSP) will contribute to the growth of wind energy industry in Latvia, because it is one of the tools recommended by the EU, which will help carry out an integrated maritime policy, including the implementation of maritime planning in the whole EU, and one of the main planning tasks in Latvia is to find the best suitable sites for offshore wind farms according to

[6] Made by authors based no reference No 7.

Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources the renewable energy industry of the countries of the EU.

According to the Directive 2009/28/EC all type of renewable energy (including electricity, transport and heating) proportion must be at least 20% of all the consumed energy [6] until 2020, thus wind energy has a substantial significance in reaching the goals of the new energy policy. For Latvia, in accordance with Directive 2009/28/EC Annex I, the main goal till 2020 is to produce renewable energy in an amount that is equal to 40% of total consumed energy. In 2009 total proportion of renewable energy resources is 34,3%, but in 2010 - 32,5%.

In compliance with law of 28 October 2010 "Marine Environment Protection and Management Law" [3] maritime spatial planning (MSP) is a long-term process for development planning aimed at protection of marine environment, rational use of the sea and integrated management, as well as balancing the social welfare and economic development with the environmental protection requirements. The main goal of MSP is a marine spatial zoning plan that identifies and manages existing and potential interests of maritime spaces and its coasts in a manner that best meets the priorities and objectives set by the participants. Project "Development of Maritime spatial planning in the Baltic Sea" (BaltSeaPlan) is implemented from 2009 till 2012 in order to support the process of developing, introducing and implementing MSP in the Baltic Sea. There are seven countries: Germany, Poland, Denmark, Sweden, Estonia, Lithuania and Latvia. In Latvia BaltSeaPlan is implemented on the Western coast of Latvia in the Latvian territorial waters and exclusive economic zone from Nida till Ovisrags (total water area is about 20 000 km^2). Wind farms are planned in eight areas:

1. 12 nautical miles (nm) from Uzava in the reserved area;
2. 12 nm from Jurkalne in the priority area;
3. 12 nm from Pavilosta in the reserved area;
4. 12 nm from Pavilosta and Ziemupe in the priority area;
5. About 10 nm from Liepaja in the reserved area together with security and monitoring of the coast and 12 nm from Liepaja in the reserved area;
6. About 8,5 nm from Bernati in the reserved area together with security and monitoring of the coast;
7. 12 nm from Bernati in the priority area;
8. And 12 nm from Pape in the reserved area.

47-80 wind turbines are planned in the Western coast of Latvia. The total budget is about 500 – 600 million euro for wind park construction in the Western coast of Latvia. The project is funded by the EU Baltic Sea Region Programme and part-financed by the European Union (European Regional Development Fund). The total power of wind parks is estimated about 200 MW, generating 590-910 thousands MW electricity per year.

Notwithstanding maritime spatial planning in the beginning of year 2012 there are still no wind farms on the coast of Courland, because the opportunity to implement wind generators in the sea is delayed by absence of legislative framework. Research must be made before commencing the construction of offshore wind power plants, but at the beginning of year 2012 the legislation of Latvia does not allow any research by the state-owned energy company "Augstsprieguma tikli", which was attempted to be delegated to do research on potential wind farm sites by the Ministry of Economy, nor by any other companies.

By the end of the year 2011 there were 37 operational wind farms in Latvia with total power of 31 MW, which all are installed on shores or inland (Table 1): 19 of the wind farms are operating with output power greater than 0.25 MW, 18 are operating with less then 0.25 MW [5]. The first wind generators were installed in Ainazi, other wind generators are located in Sarnate, near Liepaja, in Uzava, in Gluda Jelgava district, Vircava Kandava district, and there output power varied from 1 to 30 MW. There are no wind power plants on the Courland coast of Latvia thus the possibilities of renewable energy on the coast of Courland are not fully utilized. Compared to the power output of its neighboring countries Estonia and Lithuania (Table 1), respectively 184 MW and 179 MW, Latvia with its power of 31MW is very behind.

Looking at the consumed power produced by wind farms, it can be seen that in the year 2011 on average across the European Union 6.3% of the consumed power was produced by wind power plants (Fig.1.).

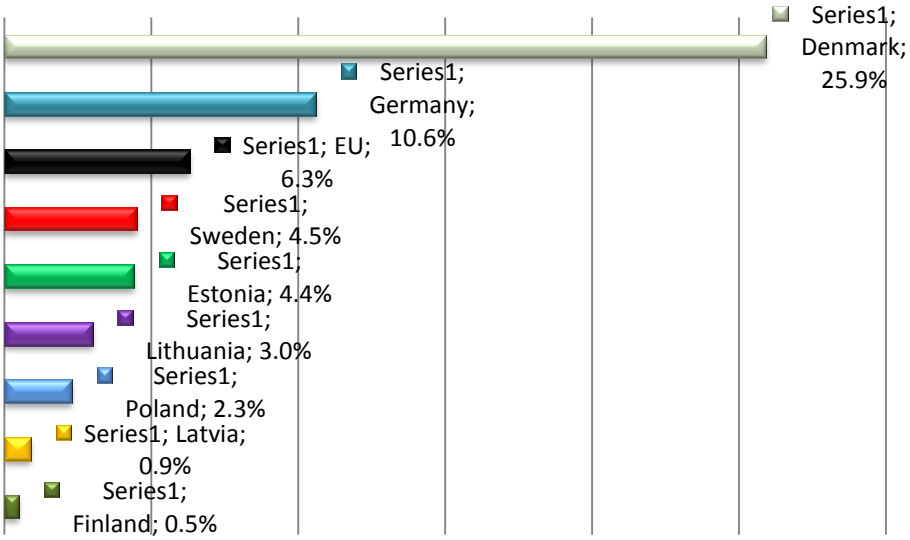

Fig.1. Wind share of total electricity consumption by end of 2011 (%)[7]

Compared to the average in Europe, Denmark (25,9%) and Germany (10,6%) has greater results, (also Spain 15,9%, Portugal 15,6%, Ireland 12%), however , Poland (2,3%), Latvia (0,9%) and Finland (0,5%) has lesser results. The figure of Latvia is not only lower than the average of Europe, but also one of the lowest in the EU, and Latvia is very behind from its neighboring countries Estonia and Lithuania (respectively 4.4% and 3.0%) comparing the ratio of consumed and produced power of wind power plants.

In the year 2010 Latvia produced 48.5% of the consumed power from renewable resources, the most of it produced by hydroelectric power plants in Plavinas, Riga and Kegums (Table 2).

Table 2

Share of electricity generated from RES in Latvian gross electricity consumption (%)[8]

	2005	2006	2007	2008	2009	2010
Share of electricity generated from RES[9]	**48,4**	**37,7**	**36,4**	**41,2**	**49,2**	**48,5**
Large hydro power plants	46,3	35,9	34,3	39,0	46,9	45,9
Small hydro power plants	0,9	0,5	0,9	0,9	0,9	1,0
Combined heat and power plants using RES	0,6	0,6	0,5	0,5	0,6	0,8
Wind power plants	0,7	0,6	0,7	0,8	0,7	0,7

In the year 2009 wind power plants in Latvia produced only 0.7% of consumed power, 0,7% in 2010 and 0,9% in 2011. (Fig.1). If the produced power of wind power plants is compared to the consumed power from 2005 to 2010 and the results of 2011 are taken into account (Fig.1.), it can be deduced that wind power industry in Latvia is developing very slowly.

The matter of wind power plant construction is made difficult by un-coordination, imperfections and ambiguity in political issues concerning maritime wind farm construction and research.

[7] Made by authors based no reference No 7.

[8] Made by authors based no reference No 8.

[9] RES – Renewable Energy Resources.

These include:

1. Absence of competence of responsible institutions and regulatory framework determining who will do the research in potential wind farm sites and when it will be done. The documents of Maritime Development Planning foresee maritime planning however the development of maritime planning, the involved institutions and their responsibilities are not confirmed in the laws and regulations of Latvia [4];
2. Absence of information and research, including human and financial resources, about the best sites for wind power plants;
3. Insufficient solving of conflicts of interest between sea and dry land, for example, wind power plants require a connector site on dry land but these sites have limited development of sea ports;
4. The maritime space of Latvia has a short-term view and absence of evaluation [4], as well as uneven development due to considering the interests of only one party;
5. A technical limitation that is theoretically solved by a project – there are no electricity transmission networks near the potential wind farm sites that could transmit the produced power to a main electricity network. To solve this problem, SJSC „LATVENERGO" has developed an energy infrastructure project „Kurzemes loks" that intends to construct a 330 kV overhead high voltage power line in the western regions of Latvia. The project was developed by the beginning of year 2012 but is not started yet.

The construction and research of wind farms is delayed not only by political matters but also by other conflicting industries:

- Shipping – due to security concerns ship navigation through wind farms can be limited depending on the size of the ship;
- Oil extraction – territories licensed for oil extraction are not available for construction and research of wind farms;
- Tourism is also a dual question. From one side wind turbines could be like an object for tourists (in USA, Denmark etc.), but from other side wind parks have negative impact on the sea landscape concerning nature tourism. According to research of people in vacations they are likely not to see wind parks in the sea;
- Military training – wind farms must not overlap with military training ranges. In 2010 Sea Monitoring System was made by National Armed Forces including six monitoring stations in Jurmalciems, Skede, Uzava, Jaunupites un Mikeltornis. In case of wind park building there should be accurate harmonization measures with National Armed Forces not to disturb Sea Monitoring System;
- Energetic – there are no suitable connection sites and capacity of energy transmission network for transmission of produced power to the main network;
- Intensive fishery places (between Nida and Ovisi till 20m depth). Wind park building may devastate natural spawning ground places, make negative impact of fishery resources in future and also for safety not permit fishers to fish near wind turbines. But from other side, there could be some water organism which would like to create reef on the wind turbine part under water;
- There are blind shells and bombs in the Baltic Sea from the First and Second World War. It is theoretically possible that shells and bombs are also near the Western coats of Latvia. So detailed research of the sea bottom should be done prior wind park building;
- Telecommunication cables – research and ground works are prohibited in areas where safety zones for cables are drawn.

Conclusions

Latvia is one of the leading countries in producing renewable energy in the European Union; however wind energy is not utilized to its full potential.

If compared to other countries of the EU, the amount of wind energy obtainable in Latvia is smaller; however the Courland coast of the Baltic Sea is suitable for obtaining of wind energy. The Maritime Spatial Planning Project BaltSeaPlan intends the construction of wind farms on the western coast of Courland and is considered one of the promoters of wind energy industry development in Latvia, but insufficient political support, including un-coordination of political matters, absence of favorable legislative framework and other conflicting industries, delay the development of wind energy industry of Latvia.

Latvia should make use of this opportunity in development of wind energy industry, advancing it with specific goals and tasks of development to satisfy the demand for electricity in the meantime preserving a healthy ecosystem.

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MONITORING OF ICE CONDITIONS AT SEA USING MICRO CLASS UNMANNED AERIAL VEHICLES

Ilmārs Lešinskis*, Aleksandrs Urbahs Aleksands Pavlovičs***, Vladimirs Petrovs******

**Latvian Maritime Academy, 5B Flotesst, LV-1016, Latvia, E-mail:ilmars.lesinskis@latja.lv*
***Riga Technical University, Kaļķu 1, LV-1658, Rīga, Latvia, E-mail:aleksandrs.urbahs@rtu.lv*
**** Latvian Maritime Academy, 5B Flotesst, LV-1016, Latvia, E-mail:info@latja.lv*
*****Riga Technical University, Kaļķu 1, LV-1658, Rīga, Latvia, E-mail:vladimirs.petrovs@rtu.lv*

Abstract
This title describes an experiment, where the capability and potential of using the micro class Unmanned Aerial Vehicle (UAV) for ice conditions recognisance has been probed practically. The experiment has been conducted with the means of UAV Krauklis, manufactured in Technical University of Riga and equipped with the electromotor, thus considerably minimizing the ecological impact, compared with these UAVs equipped with combustion propulsion. There are seemingly many ways and methods of acquiring the data and information about ice conditions at sea and coastal zone; however, in areas with the dynamic process of ice shifts and movements, there is necessity to have close to real time picture. Precise ice cover information can be of vital importance for ships at sea, especially when such situation has being aggravated. The outcome of experiment is practical proof, that micro-class UAV can be effectively implemented, thou with minor limitations, for local ice conditions reconnaissance and surveillance at sea.
KEY WORDS: *ice at sea, UAV, Gulf of Riga.*

Introduction

The notorious process of Global Warming does not affect much practical ice navigation not only in the Polar Regions, but also in the Baltic Sea. Operators and actors of maritime industry should arrange safe and absolutely reliable maritime traffic in heavy ice conditions, so, the leveraged and layered data and information about ice covers at sea become of extreme importance. The data on ice conditions at sea can be in form of assumed forecast or/and factually collected, real data. Nowadays such blocks of information on ice cover at sea can be originated from different sources: ships on sites, coastal surveillance and weather stations, satellites, and aircraft [1].

Due to modern rapid developments of UAVs worldwide, there is innovative opportunity to deploy them for needs of ice surveillance and reconnaissance. Direct UAV surveillance and visualisation of ice conditions at sea provides the real-time capture of ice situation. Implementation of UAVs for these purposes massively decreases associated risks and functional expenses [2].Key consumer of this information is a ship in marine area, which has to select optimal and best passage, once the ice field is expected to be penetrated.

Operational data or streamlined information about ice condition is specifically important at areas, where ice covers are very dynamic, rapidly changing and unstable. Maritime regions as the areas of "Unstable Ice Conditions" could be defined, where mere existence and forming up of the ice is the variable process, depending not only on seasons but also differentiated from year to year.The Baltic Sea definitely is the region of "Unstable Ice Conditions". The seasonal winter distribution of ice cover at sea is extremely diversified. For instance, there were some years, when Bay of Riga was completely covered by ice; other years are characterised by partial, spotted ice cover throughout the areas, and in some years Baltic Sea surface was ice-less all around the winter season without tangible impact on navigation [3].

In the process of ice conditions surveillance, as the provisional tool of minimizing negative economic impact on the maritime industry, has been implemented micro class UAV from Technical

University of Riga, Transport Institute. The advantages of UAVs are their comparatively low costs, mobility and operational capability to observe much wider water space around the ship, than it is possible from the ship's bridge [1].

The existing system of ice conditions surveillance and forecasting, deployed in Baltic Sea area, is of extremely insufficient performance for the purposes of safe navigation and daily activities of seafarers [1]. Process of formation of ice masses, changes in thickness and structure, as well as ice-shifts, are under influence of various factors. The precise information and accurate data on ice situation at sea is of vital importance for merchant shipping in area of interest as well as for fishermen.

1. UAV *Krauklis* technical data and capabilities

For the purposes of ice conditions surveillance has been used Unmanned Aerial Vehicle system, manufactured at Latvian Technical University. UAV *Krauklis* is the micro-class unmanned aircraft, specifically designed for executing missions as follows: (1) Dynamic environmental monitoring; (2) Detection of accurate positions of designated objects, targets; (3) Meteorological observations [4].

As the micro class aircraft, UAV *Krauklis* is associated with the small dimensions and limited capabilities(Table 1). UAV is being equipped with the High Definition photo camera **Canon Powershot SX 200 IS,** with the associated technical parameters (Table 2). The camera is placed in special for this purpose in-built compartment. Camera provides the technical capabilities of visual surveillance, captures snapshot images and video recording within the mid-perpendicular planes from UAV "middle line" in diapasons: from 90 angle degrees starboard side- lower mid-perpendicular -90 degrees port side (Fig.1).

Table 1

The UAV's *Krauklis* technical parameters

Weight,	1.5 kg
Wing Span	2.1 m
Engine	Electric
Navigation	GPS
Speed	45-90 km h^{-1}
Endurance	1 h dependable by temperature
Altitude Range	10-500m
Payload	1kg

Table 2

Canon Powershot SX 200 IS specifications

Type	1/2.3 CCD
Effective Pixels	12.1 M
Image Processor	DIGIC 4 with iSAPS technology
Focal Length	5.0-60.0 mm
Zoom	Combinedapprox 48x
Image Stabilization	Shift-type
ISO sensitivity	AUTO 80-1600
Shutter speed	15-1/3200
Continuous Shooting	0.8 shoots/sec
Live view	Yes
Movies	(HD) 1280 x 720, 30fps, (L)640 x 480, 30fps, (M)320 x 240, 30fps
Movie Length	Up to 4GB or 29 min. 59 sec (HD) Up to 4GB or 1 hour (L, M)
Weight (body only)	220g
Size	103x61x38mm

Also UAV is equipped with the navigational video camera for the purpose of flight control. The live images from photo camera and video camera are being transmitted to base control station in

the real-time mode. All the images and records are being stored in digital data storage device. The particularly lightweight apparatus can be launched from almost any unfitted location, where no any take-off runway is available.UAV's electromotor dos not emit considerable audio noise or any other environmental pollution [4].

Because of small dimensions, low production costs and relatively simplistic operational procedures of deployment, micro class UAV is well suited tool for surveillance and reckoning within short-to-medium ranges water spaces.

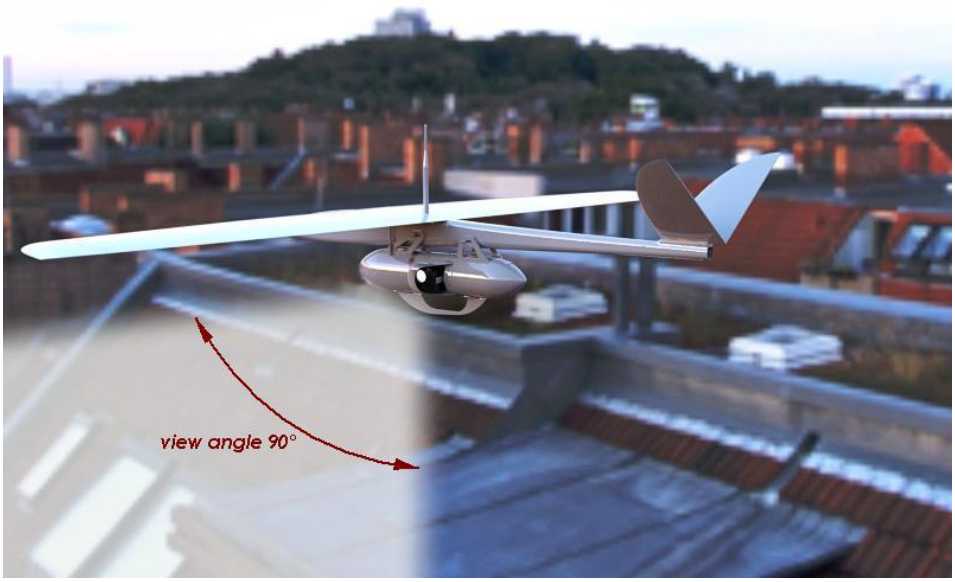

Fig.1. UAV *Krauklis* observation capacity

2. Methods of UAV deployment for ice surveillance at sea

The basic methods of UAV deployment as the means of ice conditions surveillance are as follows:

(1) Perspective surveillance, (2) Detailed surveillance, (3) Pre-planned aerial photo surveying. The methods are being implemented depending on missions, particular situation and location where the UAV is being launched from. All methods are used either by launching UAV from the vessel's deck (preferable) or from ashore with further digital pairing of transmitted operational data with vessel's bridge IT asset. There are none specific requirements for taking off procedure in matter of free ''runway'', there is need to have just 2-5 meters of upper deck for an individual, who has to haul off and throw the propelled aircraft into the air. The process of UAV's after-mission recovery also does not require tremendous technical arrangements. Any ship can be equipped with hand held/pole held easily mountable UAV's so called "arresting gear": fishing net alike simple construction with sufficiently sized cells for soft and safe ''arresting'' of landing UAV on the deck. There is quite ample accumulated technical experience worldwide of operating ''ship born'' UAVs. Moreover, UAV landing on the beach requires just several meters of a terrain free of obstacles, without any additional technical arrangements.

The method of perspective surveillance is being used for fast and accurate data acquisition on ice situation in advanced direction along the ship anticipated course. The method is being used for servicing a single ship or group of ship in a concerted movement, when UAV is being launched from the deck of vessel and all acquired visual data are being digitally delivered and processed on the bridge of ship. This method ensures the ice situation awareness for seafarers. As the practical outcome of Perspective observations (surveillance)is seafarer understands about: (1)Where are the least

consistent ice packs located? (2) Where is the shell ice, lightercompounded ice located? (3) Where are the crevasses accessible for navigation and, ultimately: most optimal course of voyage for getting into the ice-free waters with minimal efforts and related risks?

The basis of this method is deployment of UVA on short notice, as well as to get protracted visual image of ice situation around the ship, compared with this view from bridge. Once this method is used, command and control of UAV is being conducted by means of ‘’direct control”, or control by the method of pre-planned waypoints. In particular situations, when ice-fields have to be crossed within restricted geographical areas, the ‘’direct control ‘’ of UAV is better suited, because it is more simplistic and enables fast camera’s switching from ‘’perspective’’ to ‘’detailed’’ mode of view and observation. The mode of ‘’perspective observation’’ is being executed on the certain altitude of flight, where the water space is being best visually embraced from, thus delivering better quality comprehension about ice conditions in surroundings. Altitude of flight is also constrained by cloud base height and air visibility.

In order to execute the surveillance pattern by method of Perspective surveillance (Fig.2), UAV is being raised up to definite altitude **H,** with further surveillance route in transversal plane to general course **CoG**. The flight is being executed within the range of ‘’direct control’’ from the ship, which is located at point **O.** First surveillance route **dc** delivers the factual visual data and information within defined water zone **ABCD**. In case if acquired data do not provide sufficient information for optimal route selection, then flight is being switch over to automated mode, when UAV proceeds between pre-planned waypoints. The automated mode’s waypoints should be designated considering the transverse ‘’sweep range’’ from initial surveillance track **dc**, in order to prevent surveillance gaps and blank spots. It means that for the sake of reliable data from two adjacent flying surveillance tracks, there should be 20-30% coverage overlap.

Upon the initial visual screening, once preliminary data and information has been acquired about crevasses in ice-fields, ice thickness, ice concentration and availability of ice-free water space, a seafarer comes to a decision on further surveillance: if deemed necessary to get more detailed visual data from certain areas.

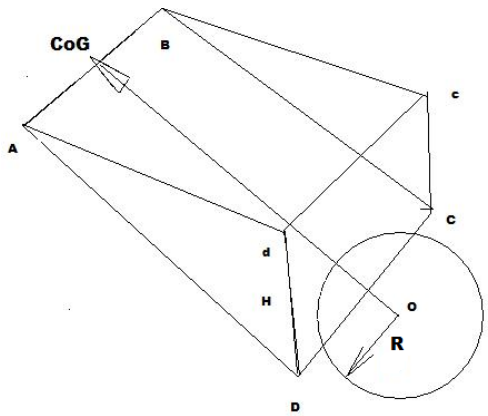

Fig. 2. The method of perspective surveillance

Additional surveillance is being conducted by the method of ‘’Detailed Surveillance’’, when the flight is being executed on the low altitude with the main purpose to rectify ice conditions in surroundings and to eliminate doubts about most optimal ship’s course selection. Detailed Surveillance utilizes such the camera’s generous features like in-zooming of an object and/or observing a particular object from different angles of view.

In the process of Detailed Surveillance ice crevasses and ice-openings are being surveyed, with the aim to clarify their sizing and dimensions.

Additionally, the more detailed data on ice thickness, ultimate ‘’breed of ice’’ and other related ones are being acquired. Trained ice analysts can infer rough magnitudes of ice thickness and type using visible imagery [5].

All these finally extracted data are necessary for seafarer knowledge in order to calculate and plan further ship’s route and to come to a final solution to cross or not to cross the particular ice-field within current ice conditions. All these decisions are of direct economic impact and influence.

In order to process ice recognisance data, besides UAV on ship must be allocated: flight planning and control console, radio link antennas for communication between vessel and UAV.

3. The experiment on UAV *Krauklis* deployment for ice conditions surveillance

The aim of the experiment was practical effort to deploy UAV Krauklis in ice conditions recognisance role, as well as to check up the feasibility of its deployment methods. Secondary purpose of the experiment was to work out practically launching (take off) and landing (recovery) procedures of UAV in beach zone. The launch of UAV from ashore, not from a vessel’s deck at sea, was decided due to desired ‘’clarity of experiment” and commitment to focus on visual/video data processing, instead of ‘’take off” and ‘’landing ‘’ technical arrangements.

The experiment has been conducted within the weather conditions as described in the table (Table 3), and UAV’s technical performance has been limited by relatively strong wind. The general location of the flight was selected *Jaunkemeri* beach (Fig.3). The final outcome of experiment is the practical proof, that UAV *Krauklis* can be effectively used for the purposes of ice-conditions surveillance.

In first Phase of experiment there was used the method of Perspective Surveillance, when aircraft executed a flight in transversal plane of imaginary ship’s general course (Fig. 3). During the first flying Phase there were observed tightened ice-packs, snowdrifts, and there was visually visible ice-free water space in a remote viewing perspective (Fig.4).

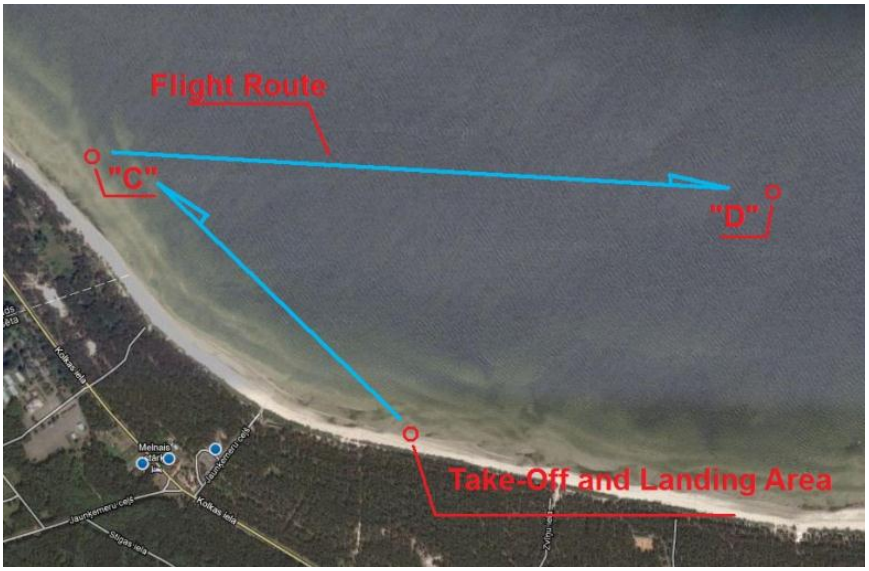

Fig.3 UAV flying location and routes

Second flight Phase has been executed for aim of data rectifying on ice-conditions in accordance with the Detailed Surveillance method’s procedures. Overall ice structure has been estimated more detailed in visual view (Fig.5).

The procedures of UAV landing on the beach were complicated due to slanting gusty wind. Taking in consideration quite limited practical experience of flight operator to work in such the conditions, the final overall results of experiment could be assessed as successful.

Table 3

Weather conditions

visibility	9 km
Clouds Ceiling	1000 – 1500 feets
Winds	N-6 M/s
Temperature	-4.0^{0}C
Pressure	1031.0 mb

4. The analysis of collected observation data

The flight has been executed within 17 minutes in total; in average 6 minutes has been spent for taking-off and landing procedures. Due to extreme negative temperature the battery working power has been decreased considerably, so some 59 % from overall battery's power has been spent out. Flight's average speed was 55 km/h on the 160 meters altitude. Ice congelation of the apparatus has not been observed. Gusts of wind heavily influenced the stability of flight in horizontal plane.

Fig. 4. Perspective surveillance

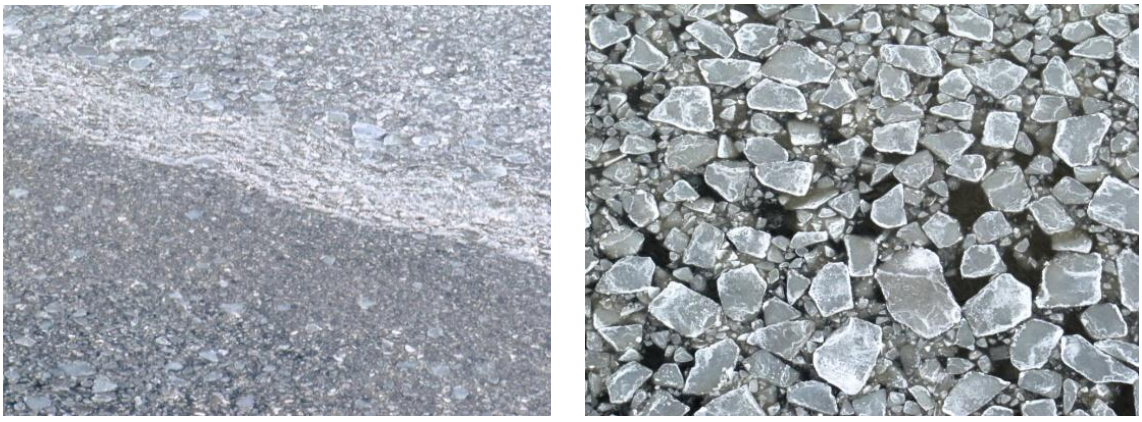

Fig. 5. Method of Detail surveillance with zoom 2x (left) and zoom 5x (right) at H= 155m

Conclusions

1. Micro UAV is well suited tool for surveillance and reckoning within short-to-medium ranges water spaces.
2. UAV equipped with electromotor can be effectively used for ice conditions surveillance.
3. The provisioned surveillance methods ensure the capability to analyse the data on local ice conditions.
4. Technical features of photo camera CanonPowershot SX 200 IS are sufficient for effective aerial video surveillance.

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THE METHOD OF STARTING AIR SYSTEM CALCULATION

Rihards Indriksons*, Janis Kokars, Igors Kurjanovics*****

**Latvian Maritime Academy, Flotes str. 5B, LV-1016, Latvia, E-mail: rihards1940@inbox.lv*
***Latvian Maritime Academy, Flotes str. 5B, LV-1016, Latvia, E-mail: janis.kokars@latja.lv*
****Riga Technical University, Kalku str. 1, LV-1016, Latvia, E-mail: igors.kurjanovics@rtu.lv*

Abstract
This article deals with a method of calculation for diesel engine compressed air starting systems. The method is based on a comparison of the effective work done by the compressed air and the work required to compress air during the compression stroke. Correlations have been found between the approximate time to start the engine and the pressure in the starting air receiver as well as the compressed air consumption. The approximate correlations for calculating the pressure drop in receivers, depending on the receiver volume and the volume of air consumption at engine starting, were given. A six cylinder slow speed engine was used in these calculations as an example.
KEY WORDS: *starting system, efficient work, air receiver.*

Introduction

Over the past 20 years, the design of ship’s main engines has undergone radical changes. Notable changes of cylinder thermodynamic work cycle parameters are observed. An increase of these parameters is associated with the need to increase the relative power and the cylinder indicated power efficiency. Significantly increasing the engine stroke to diameter ratio from 1.7 to 2.2 - 2.5 has increased thermal and mechanical loads.

In the calculation on the basis of LPG tanker's "Kurzeme" main engine MAN B & W 6S50 MC parameters, it is evident that the ratio P_z / P_c, or so-called pressure increase ratio (Lambda), with significant increase in the parameters has been reduced to 1,1 - 1,3 instead of the previous 1,4-1,5. This proves the tendency for the transition to greater R in the diesel cycle.

The compression pressure in cylinder is equal to 98-100 bars and the maximum combustion pressure reaches 130 bars. Such changes in construction and parameters are making a significant impact on the engine starting and reversing processes. These processes are significant for main engines coupled directly to the ship's propeller, despite being of short duration. Although changes in parameters have been made the pressure in starting air vessel remains the same - maximum 30 bars.

Calculations are required to ensure correct starting and reversing in the future as P_z and P_c continue to grow.

Starting duration and rotation speed of crankshaft at the end of starting

The work made by air during one revolution of crankshaft at starting of engine

$$W_1 = W_1^{*} + W_1^{**} ,$$

Where W_1^{*} – the work made by compressed air during the air supply
W_1^{**} – the work made by compressed air after the air supply suspension

$$W_1^{*} = A \cdot p_g \cdot s_2 \; ; \quad W_1^{**} = \frac{p_g \cdot V_2}{n_1 - 1} \left\{ 1 - \left(\frac{V_2}{V_3} \right)^{n_1 - 1} \right\} \qquad (1)$$

where A – the area of cylinder,

p_g – the pressure of compressed air in the system,

s_2 – piston displacement from TDC to the point at which compressed air supply suspended

n_1 – the polytropic index

V_2 – the volume of cylinder when air supply is suspended,

V_3 – the volume of cylinder when exhaust is commenced

The work consumed during the compression W_2 is calculated as follows:

$$W_2 = \frac{p_a \cdot V_4 - p_c \cdot V_c}{n_1 - 1} \qquad (2)$$

Where

p_a – atmospheric pressure, V_4 – the volume of cylinder when exhaust is commenced,

p_c , V_c – the air pressure and the volume of cylinder at TDC

Assuming that the water resistance force to the rotation is proportional to the propeller's angular velocity

$$M_{prop} = k \cdot \omega^2$$

and friction losses taken into account the efficiency at engine starting η , the efficient work W achieved by engine with z cylinders during one revolution of the crankshaft could be approximately determined as follows:

$$W = z\,(\,\eta \cdot W_1 - W_2\,) - 2\pi \cdot k \cdot \omega^2 .$$

According to the theorem of kinetic energy change, crankshaft angular speed of one revolution in the engine at starting to be determined from the relationship:

$$0{,}5\, J_{red} \cdot \omega^2 = W$$

or, taking in account expression:

$$0{,}5\, J_{red} \cdot \omega^2 = z\,(\,\eta \cdot W_1 - W_2\,) - 2\pi \cdot k \cdot \omega^2 .$$

where J_{red} - simplified moment of inertia of the crankshaft with the pistons, connecting rods, flywheels, shaft and propeller after N revolutions:

$$0{,}5\, J_{red} \cdot \omega^2 = N\,[\,z\,(\,\eta \cdot W_1 - W_2\,) - 2\pi \cdot k \cdot \omega^2\,] ,$$

Whence we find:

$$N = \frac{0{,}5\, J_{red} \cdot \omega^2}{z\,(\,\eta \cdot W_1 - W_2\,) - 2\pi \cdot k \cdot \omega^2} \qquad (3)$$

Assuming that the crankshaft moves steadily accelerated at engine starting, starting time t determined from the relationship:

$$t = \frac{4\,\pi \cdot N}{\omega} \qquad (4)$$

The consumption of compressed air and necessary volume of starting air receiver

The consumption of compressed air for one cylinder during one revolution of the crankshaft is slightly less than V_2 . So during N revolutions total air consumption is:

$$Q < N \cdot z \cdot V_2 \ .$$

As the compressed air receivers must run at least n times, the total air consumption will be:

$$Q_{\Sigma} = z \cdot V_2 \cdot \sum_{i=1}^{n} N_i \ ,$$

where N_i – number of revolutions of the crankshaft at i starting time

Based on the Clapeyron equation, the pressure drop Δp_i in starting air receiver at i starting time calculated as follows:

$$\Delta p_i = p_{oi} - p_i = \frac{Q_i}{V_{rec}} \ , \qquad (5)$$

where p_{oi} , p_i – the pressure in starting air receiver at i starting time beginning and the end
Q_i – the consumption of the air at i time starting, V_{rec} – the volume of the starting air receiver.

Example of calculation

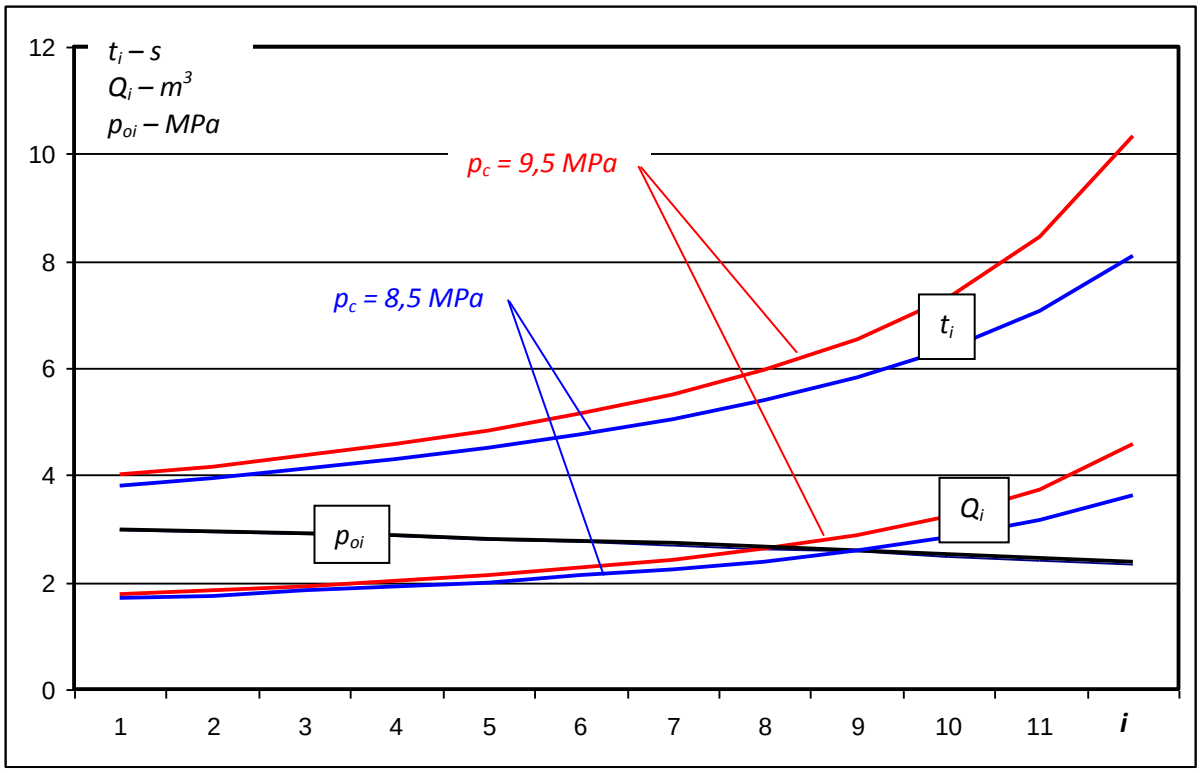

Fig.1. Diagrams of the engine starting duration, air consumption and starting air pressure at i-time starting

By way of example let's look at an L60MC six cylinder engine, produced by the MAN B&W company, with a nominal power of 9880 kW at the rotation speed of 114 RPM ($\omega = 12,0\ s^{-1}$). Cylinder diameter of 600 mm, stroke - 1944 mm, crank length to connecting rod length ratio - 0,5. The simplified moment of inertia of the crankshaft with piston group, a flywheel, the propeller drive shaft and propeller is $125860\ kg{\cdot}m^2$. Resistance moment of the propeller rotation $M_{prop} = 5800 \cdot \omega^2\ (N{\cdot}m)$.

The exhaust commences at the angle of 120 degree of crankshaft rotation $\varphi_3 = 120^o$ in relation to TDC. The exhaust valve closes at the angle of 240 degree of crankshaft rotation $\varphi_3 = 240^o$ in relation to TDC. Compressed air pressure at the first starting time is $p_g = 3\ MPa$. The polytropic index is taken as $n_1 = 1,35$ and mechanical efficiency during engine starting $\eta = 0,8$

Using formulas (1)… (5) calculate starting time duration t_i (till moment when crankshaft achieves 1/3 from nominal RPM i.e. $4\ s^{-1}$, the consumption of air Q_i at i starting time and the pressure in starting air receiver p_{oi} at i time starting beginning at different compression pressures in cylinder p_c (*8,5 MPa* and *9,5 MPa*). Starting air receiver's volume $V_{rec} = 4\ m^3$. The starting air supply suspension is 65 degree of crankshaft rotation angle in relation to TDC

The results of calculations are shown diagrammatically in figure 1.

Conclusions

The paper offers a simplified calculation method of starting and reversing processes.

The key starting and reversing parameters of an engine may be determined, from the cylinder compression pressure and the starting air pressure, without complex calculations. The parameters which may be determined, in this way, are: The engine starting time duration; the number of crankshaft revolutions needed for starting; the air supply suspension angle; the air receiver’s volume for the required minimum 12 starts and the air consumption during starting.

The method can be useful for marine engineers, also for ship designers, for evaluation in designing new or redesigning existing propulsion systems.

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DIFFERENTIAL OPTICAL ABSORPTION SPECTROSCOPY AS A TOOL TO MEASURE EMISSIONS FROM SHIPS IN HARBOUR

Janis Kleperis*,, Līga Grīnberga** and Anatolijs Šarakovskis****

**Department of Housing and Environment of Riga City Council, 49/53 Brivibas str., LV-1010, Riga, Latvia; E-mail: Janis.kleperis@riga.lv*
***Institute of Solid State Physics, University of Latvia, 8 Kengaraga str., LV-1063, Riga, Latvia; E-mail: Anatolijs.sarakovskis@cfi.lu.lv*

Abstract
Differential optical absorption spectroscopy (DOAS) is used to monitor concentrations of air pollutants in Riga Harbour region close to an enterprise involved in the oil transit business from 1999. Light beam (630 m) analyzed in DOAS is separating oil transit company and apartment buildings with hundreds of people. Always when wind is blowing from direction of oil storage tanks and tanker docks which are involved in handling operations, higher SO_2 and hydrocarbon concentrations are registered. Results from monitoring are analysed for a period of 12 years by comparing selected measured pollution values and meteo data.
KEY WORDS: *Differential optical absorption spectroscopy, air pollution monitoring, SO_2 from ships.*

1. Introduction

Three main methods are available to measure air pollution in an open area: passive sampling, active sampling and automatic sampling [1]. Passive sampling refers to diffusion tubes or badges that provide a simple and inexpensive indication of average pollution levels over a period of weeks or months. Plastic tubes or discs open at one end to the atmosphere and with a chemical absorbent at the other is collecting specific gases (depending from the type of absorbent) from environment for defined time period, then analyzed in laboratory with gas chromatograph. The low cost per tube allows sampling at a number of points and is useful in highlighting "hotspots" where more detailed study may be needed. Active sampling involves the collection of samples, by physical or chemical means, for subsequent laboratory analysis. Typically, a known volume of air is pumped through a filter or chemical collector for a known period of time - the collector then subjected to laboratory analysis. Automatic sampling is the most sophisticated method producing high-resolution measurements of a range of pollutants at a single point. The sample is measured on-line and in real-time, typically with 15-minute averages or better, with data being collected from individual monitoring sites by telemetry. Instruments using physical scientific measurement techniques, such as chemiluminescence, UV fluorescence, IR absorption and Differential Optical Absorption Spectroscopy (DOAS), are used. DOAS instrument from OPSIS AB company (Sweden) [2] is used in Riga. Measurements are made in situ and there is no disturbance in the airflow due to pump sampling as with point analyzers. Open-path methods are used for the remote sensing of the atmosphere and provide better estimates of average pollutant concentrations over a given area, besides a single instrument can measure several components, both organic and inorganic [3].

Riga City has DOAS type air quality monitoring station based on differential optical absorption spectroscopy in Riga Harbour region close to an enterprise involved in the oil transit business since 1999. Instead of measuring pollution at a specific location, open-path methods record the average pollutant concentration along the all path length of a light beam (630 m in Riga Harbour) [4]. Monitoring data are analysed for a period of 12 years by comparing selected measured concentrations with meteorological data as well as specific cases with high pollution values are analysed in this article.

2. Principles of Differential Optical Absorption Spectroscopy

DOAS is now one of the most commonly used spectroscopic methods to measure trace gases in the open atmosphere [5]. The basis of spectroscopic measurements of quantitative trace gas concentrations in the atmosphere is Bouguer-Lambert–Beer's law describing the absorption of electromagnetic radiation by matter:

$$I(\lambda) = I_0(\lambda) \cdot \exp(-\sigma(\lambda) \cdot c \cdot L) \tag{1}$$

Here, $I_0(\lambda)$ denotes the initial intensity of a light beam with wavelength λ emitted by source of radiation (high pressure xenon lamp), while $I(\lambda)$ is the radiation intensity of the beam after passing through a gas layer with thickness L, where the absorber is present at a uniform concentration of c. The parameter $\sigma(\lambda)$ is the absorption cross-section at wavelength λ characteristic of any specific molecule (gas). The average trace gas concentration c can be calculated from the measured ratio $I_0(\lambda)/I(\lambda)$ if the light path length L is known:

$$c = \frac{\ln(\frac{I_0(\lambda)}{I(\lambda)})}{\sigma(\lambda) \cdot L} \tag{2}$$

By comparing the intensity of light source with and without the polluting substance in the light path, the integrated amount of the substance can be determined from Lambert-Beer`s law (2) and specific absorption coefficient of this substance. Depending on the absorption spectrum of the species of interest, light at ultraviolet, visible or near infrared wavelengths are used. DOAS is the most widely applied open-path method used for air quality monitoring. The DOAS method is based on the difference in absorption between different wavelengths [5]. It uses advanced computer technology, with software including the spectrographic fingerprint of the pollutants to be determined, to evaluate pollutant concentrations. The advantage of the DOAS method is that it does not use a sample cell and the path length can be increased considerably, to hundreds of meters and even to several kilometers, allowing the determination of much lower concentrations than with conventional instruments. In the DOAS method, the computer rapidly sums the reference spectra while varying the proportions of the different components until a match is obtained. In the DOAS system, a narrow beam of light from a high-pressure Xe lamp is focused onto a receiver up to 1 km away from the source. The light detected by the receiver is transmitted through an optical fiber to a computerized spectrum analyzer. The spectrometer in the analyzer splits the light into narrow wavelength bands using an optical grating. A narrow slit sweeps past the detector at high speed, allowing a large number of instantaneous measurements to be made, building up the entire spectrum. The scan is repeated 100 times each second and the registered spectrum is stored in the computer's memory. The measured spectrum is compared with various spectra calculated by the computer based on different proportions of individual pollutants that may be present in ambient air (reference spectra of individual pollutants are stored in the computer's memory). When the best possible match is obtained, the computer calculates the concentrations of the different gases present in air.

What gases can be measured with DOAS? Usually detectable in sub-ppb levels are so called ***criteria pollutants*** under the current legislation on air pollution [6]: SO_2, NO_2, NO, O_3; selected ***aromatic hydrocarbons***: benzene, toluene, styrene, ethylbenzene, xylenes, cresols, trimethylbenzenes, monochlorbenzene, dichlorbenzene; and typical ***smelling compounds***: NH_3, CS_2, trimethylamine, formaldehyde, acetaldehyde, and phenol. In some cases ***toxic and exotic gases*** must be measured, for example mercury (Hg), phosgene ($COCl_2$), chlorine dioxide (ClO_2), chlorine (Cl_2), sulphur trioxide (SO_3), hydrogen fluoride (HF), hydrogen chloride (HCl), hydrogen cyanide (HCN), methylisocyanate (MIC) etc.

3. Experimental setup

DOAS station in Riga's Harbour area is measuring 6 different gases in air every 5-6 minutes, and the values of 10 minutes are stored in central database [6] connecting equipment’s computer every hour through modem and regular phone. These gases are: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), benzene (C_6H_6), toluene ($C_6H_5CH_3$) and formaldehyde (HCHO). Measurement equipment is situated along Tvaika Street intermediate the residential area with five-floor houses where hundreds of people are living and oil transfer enterprise "Man-Tess Ltd." and "Latvijas Rietumu Terminals Ltd." (Figure 1).

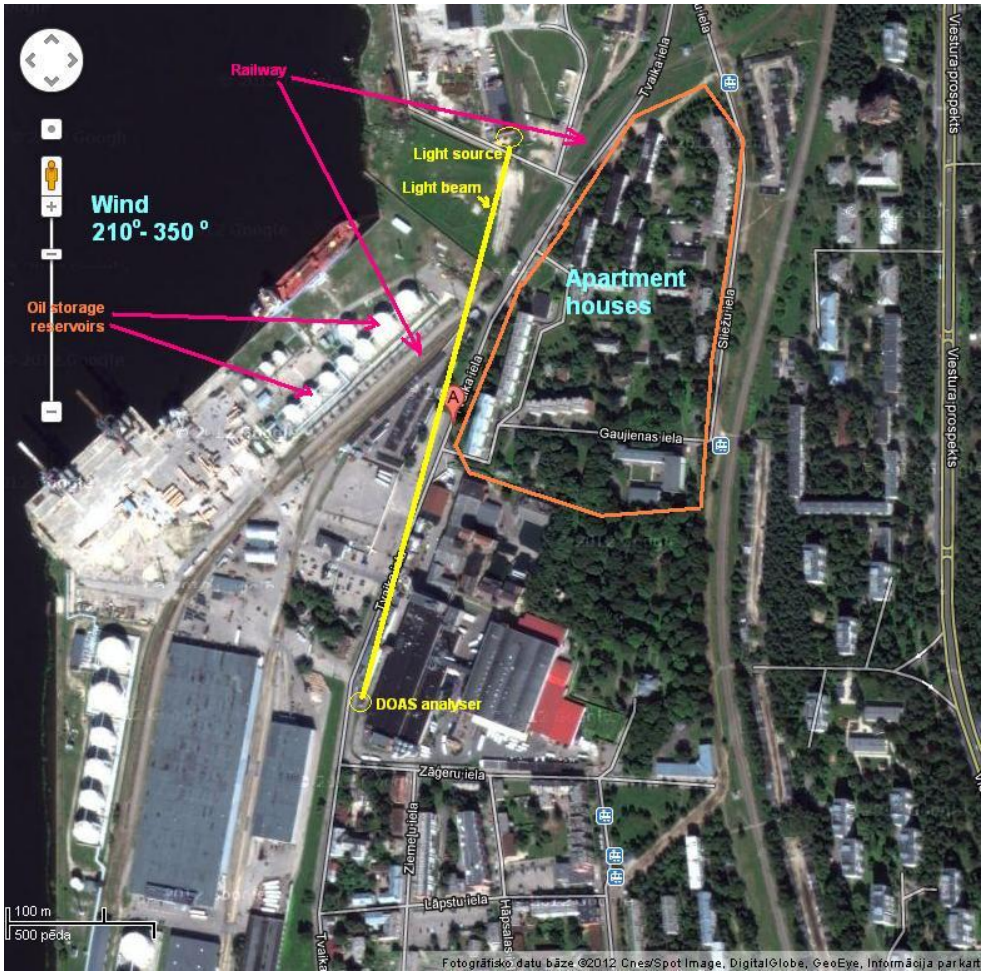

Fig. 1. Scheme for situation of light beam of DOAS air pollution monitoring station at Riga Harbour (wind blowing from southwest, west and northwest is driving the pollution to light beam).

The distance between oil storage tanks, railway platform and first 5-floor apartment house is only 150 m, and in all cases when the wind blows from the west-north (210-350 degrees) and the company transfers oil products from railway tanks to storage or directly in tankers, fumes can reach people. We assume that these emissions enter into the light beam and are registered in the air monitoring station. OPSIS AB (Sweden) equipment AR-500-088 with light emitter ER/RE 150 (larger diameter) is used. Light source (150 W Xe lamp Type B) is situated on the roof of neighbor enterprise "BMGS Ltd" and light beam is focused on the receiver standing on the roof of container with measuring equipment beside J/S company “Aldaris” (Figure 1). Total length of light path is 630 m and the height from ground is 12 m (emitter) and 4 m (receiver). The light from receiver is entering analyzer through optical cable (10 m). Analyzer is upgraded for benzene measurements in 2006, and is

calibrated every year by State limited liability company "Latvian Environment, Geology and Meteorology Centre".

In the landing stages of tankers the company "Latvian West Terminal Ltd." is handling and transferring only oil and liquid pyrolysis products, not chemicals. Total amount of transferred products in period 1999-2011 (the period during which operates air monitoring station) reached maximum in 2002/2003 (1.6 million tons annual) and is decreased to 0.62 million tons in 2011. Petroleum product assortment clearly changed since 2002 when the volatile petroleum products (gasoline, hexane, heptane fraction) were handled at very low amounts. The transport and handling of gasoline was restored from 2006. According to terminal reports in the 2011th the terminal handled diesel (4.3 thousand tons), spirits (180 thousand tons), jet fuel (110 thousand tons), pyrolysis and condensation resins (19.7 thousand tons), solvents and petroleum (total 298.4 thousand tons), absorbents - fuel improvers - 613.7 thousand tons. Although the total volume of oil products handled at the terminal in 2011th is almost the same as last year, however, markedly increased handled light oil products (gasoline, solvents, crude oil), which are volatile and easily felt in the air as the bad smell. To transfer heavy oil fractions, the rail tanks must be heated, and are therefore more additional resource of malodors.

4. Analysis of results

4.1 Concentrations of Benzene C_6H_6

Analysis of monitored benzene concentration in 2011 shows that there were number of high pollution episodes with increased benzene and toluene concentrations in Sarkandaugava region (see Figure 2 with an episode of the 12th August).

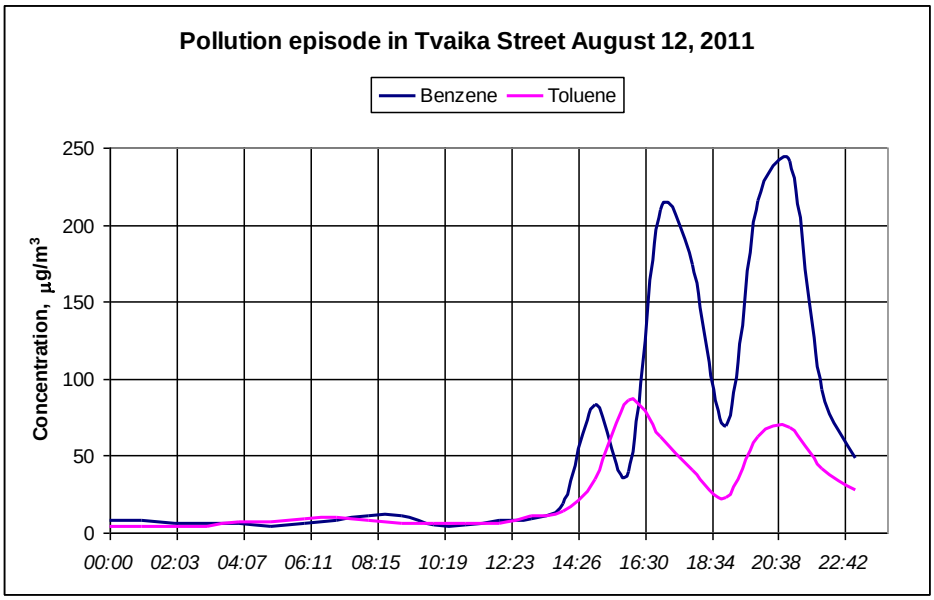

Fig. 2. Observed high concentrations of benzene and toluene in DOAS air pollution monitoring station at Riga Harbour.

It is observed that concentrations of benzene and toluene at the same time are rapidly increasing. It should be noted that there is no growth of sulphur dioxide or nitrogen dioxide pollution at this time, what indicates that probably the source of contamination was leaking from the rail tanks. Weather in this day was hot with wind 4-6 m/s from Northeast. Probably train set with solvents in rail tanks manoeuvre below the light beam of monitoring station.

Annual average benzene concentrations on Tvaika Street at Riga Harbour is decreasing after 2002, when handling of light oil products was stopped, and is increasing from 2006, when their handling returned (Figure 3). After regulations on air pollution in Latvia [6] annual limit value for benzene from 2010 is 5 μg/m^3, and it was again exceeded in 2011 (7.1 μg/m^3). The companies in Riga Harbour is ordering the monitoring of air pollution in their territories from State Ltd LEGMA, and in 2011 benzene concentrations in the territory of "ManTess" was measured 9 months with diffusion sampler technique. Average concentration was only 3.7 μg/m^3, which is about 2 times less than measured with DOAS station. The diffuse sampler method is monitoring air pollution only in one point; nevertheless an open-beam DOAS system captures air pollution from a much wider area.

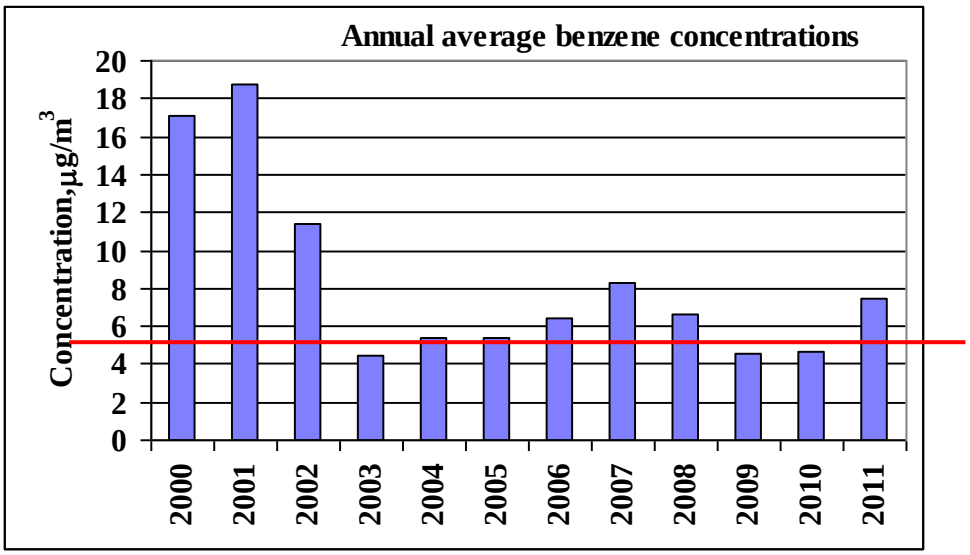

Fig. 3. Annual average benzene concentrations on Tvaika Street at Riga Harbour (red line - annual limit value for benzene).

Therefore it is possible that with DOAS technique are measured benzene emissions from many different sources: rail cars, tankers, handling operations in the terminals, trucks and passenger cars, buses.

4.2 Concentrations of Sulphur Dioxide SO_2

Analyzing SO_2 concentration distribution depending on wind directions (Figure 4), it is noticeable that the higher SO_2 pollution is coming from certain directions. Comparing the position of light beam and surrounding emission sources, it is expected Ltd BMGS is responsible for SO_2 pollution from North, tankers – for pollution from West-Northwest, stacks of Ltd ManTess – for pollution from East.

Sometimes pollution cases are observed in Riga in specific weather conditions (temperature inversion, low wind speed) when simultaneously all 7 urban air monitoring stations are recording the growth of SO_2 concentrations (Figure 5). In the particular case (January 31, 2009, 3:00-5:00 AM) the temperature was -8°C, the wind blew from the North (31 degrees) with speed 3,2 m/s. A possible source of pollution could be a Riga Harbour.

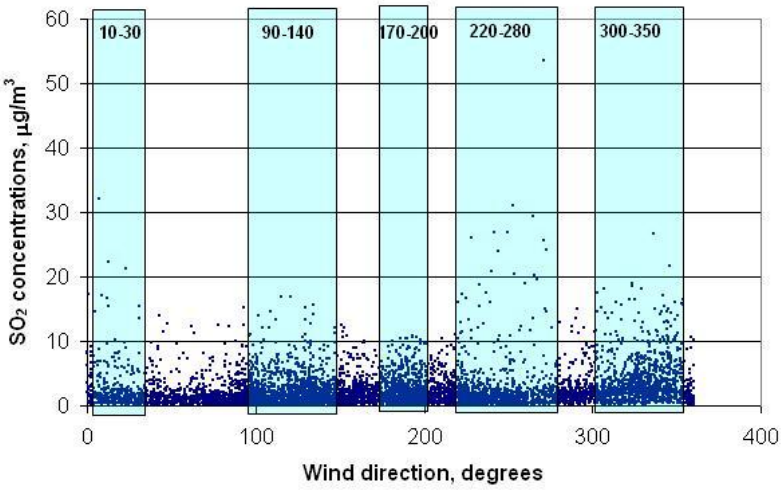

Fig. 4. SO_2 concentrations scatter from wind direction (data from 2009) on Tvaika Street at Riga Harbour.

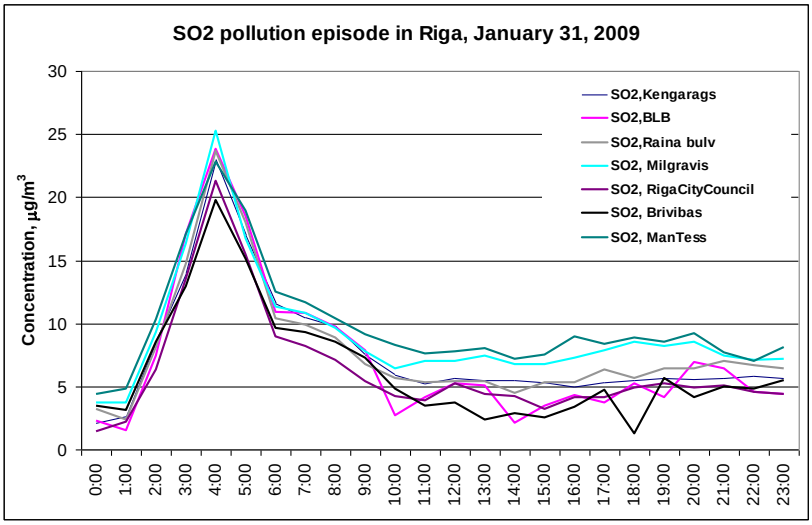

Fig. 5. SO_2 concentrations scatter from wind direction (data from 2009) on Tvaika Street at Riga Harbour.

Conclusions

It is shown that the DOAS method with open light path is suitable for air pollution monitoring at the Riga Harbour. From monitoring data it is possible to track the source of emissions if average hourly concentrations of pollutants are analysed together with the meteorological data. As it is shown, sulphur dioxide sources in Harbour are mostly tankers manoeuvring through the river or standing at docks with powered engines during the handling of oil products. An open-beam DOAS system captures air pollution from a wider area and in case of observed high benzene emissions are from many different sources: rail cars, tankers, handling operations in the terminals, trucks and passenger cars, buses.

Acknowledgments
Riga City is acknowledging data from air monitoring stations.

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APPLICATION OF A PARTIAL DERIVATIVE

Ksenija Maslova, Arturs Smirnovs, Mārtiņš Vanags*, Voldemārs Barkāns**

**Latvijas Zinātņu Akadēmija, Akadēmijas laukums 1, Rīga, LV-1050, Latvija; E-pasts: SF11053@gmail.com*
***Latvijas Jūras Akadēmija, Flotes ielā 5B, Rīga, LV-1016, Latvija; E-pasts: Voldemars.Barkans@inbox.lv*

Annotation
The report covers the application of a partial derivative approximating the curve that is experimentally obtained using the method of least squares.
Key words: *partial derivative, method of least squares.*

Introduction

We continue a series of reports, that cover the various parts of application of Mathematics course that were initiated at the previous Latvian Maritime Academy conferences. The Mathematics course during the bachelor degree programs at technical high education institutions is required to get students acquainted with Mathematics apparatus that is necessary in comprehensive technical courses to deal with practical tasks.

Task

The measurements (Table 1, t and y) were made and the experimental curve 2 (Fig. 1) was obtained, experimenting with the new composition of fuel.

To obtain an empirical formula for the analysis of the physical process, the results of the experiment are approximated using **the method of least squares** [1], [2].

The function for approximation is chosen

$$f(t) = y = a \cdot te^{k \cdot t} \tag{1}$$

The function is converted by taking logarithm of both sides:

$$\ln y = \ln a + \ln t + kt. \tag{2}$$

Designated: Y = ln *y*; X = *t*; b = ln *a* . Obtained:

$$Y = kX + \ln X + b. \tag{3}$$

The difference (bias) δ_i between the experimentally obtained Y_i and theoretically established is designated by:

$$\delta_i = kX_i + \ln X_i + b - Y_i \ . \tag{4}$$

The sum is formed:

$$s = \sum_{i=1}^{n} \delta_i^2 = \sum_{i=1}^{n} \left(kX_i + \ln X_i + b - Y_i\right)^2 , \tag{5}$$

where n – the amount of measurements; $X_i = t_i$ and $Y_i = \ln y_i$ are calculated using the results of measurements.

Parameters a and k in the formula (1) are found, so that the sum of squared deviations is the smallest. Demonstrated that this will be in the case if the partial derivatives are equal to zero:

$$\begin{cases} \dfrac{\partial s}{\partial k} = 2\sum_{i=1}^{n}\left(kX_i + \ln X_i + b - Y_i\right)X_i = 0; \\ \dfrac{\partial s}{\partial b} = 2\sum_{i=1}^{n}\left(kX_i + \ln X_i + b - Y_i\right)1 = 0. \end{cases} \tag{6}$$

The system is transformed:

$$\begin{cases} k\sum_{i=1}^{n} X_i^2 + b\sum_{i=1}^{n} X_i = \sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \ln X_i; \\ k\sum_{i=1}^{n} X_i + b\sum_{i=1}^{n} 1 = \sum_{i=1}^{n} Y_i - \sum \ln X_i. \end{cases} \tag{7}$$

All sumes can be calculated using the results of experiment (Table 1). The two-equation system (8), that can be easily solves usin Gaussian elimination, is obtained.

Table 1

Results of the experiment and sumes for the method of least squares

t[sek} = X	y[V]	Y=ln(y)	X*X	X*Y	lnX	XlnX
0,01	3,6	1,2809	0,0001	0,0128	-4,6052	-0,0461
0,2	31	3,4340	0,04	0,6868	-1,6094	-0,3219
0,4	34	3,5264	0,16	1,4105	-0,9163	-0,3665
0,6	29	3,3673	0,36	2,0204	-0,5108	-0,3065
0,8	26	3,2581	0,64	2,6065	-0,2231	-0,1785
1,0	23	3,13550	1,00	3,1355	0,0000	0,0000
1,2	20	2,9957	1,44	3,5949	0,1823	0,2188
1,4	18	2,8904	1,96	4,0465	0,3365	0,4711
1,6	15	2,7080	2,56	4,3329	0,4700	0,7520
1,8	14	2,6391	3,24	4,7503	0,5878	1,0580
2,0	13	2,5649	4,00	5,1299	0,6931	1,3863
2,2	11	2,3979	4,84	5,2754	0,7885	1,7346
2,4	10	2,3026	5,76	5,5262	0,8755	2,1011
2,6	9,5	2,2513	6,76	5,8534	0,9555	2,4843
2,8	7	1,9459	7,84	5,4485	1,0296	2,8829
3,0	7	1,9459	9,00	5,8377	1,0986	3,2958
3,2	5,5	1,7047	10,24	5,4552	1,1632	3,7221
3,4	5,1	1,6292	11,56	5,53942	1,2238	4,1608
3,6	5,1	1,6292	12,96	5,8653	1,2809	4,6114
3,8	4	1,3863	14,44	5,2679	1,3350	5,0730
4,0	4	1,3863	16,00	5,5452	1,3863	5,5452
Sumes						
42,01	294,8	50,3797	114,8001	87,3412	5,5417	38,2780

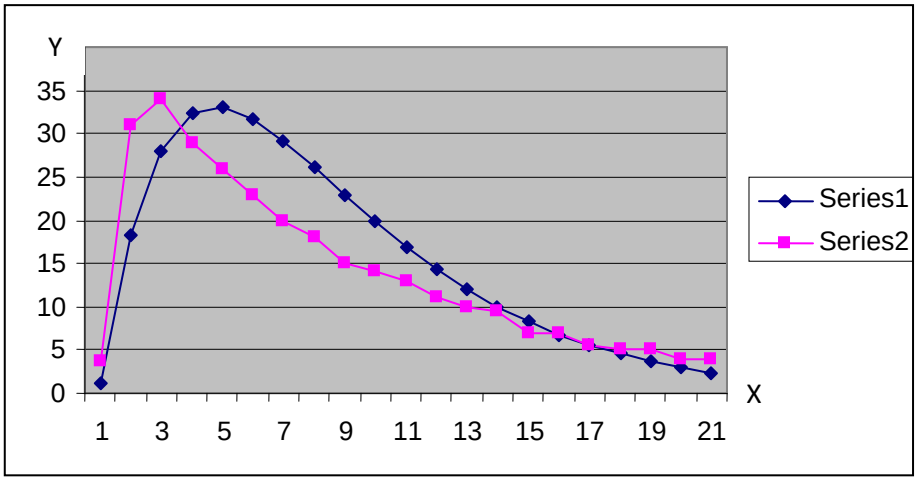

Fig. 1. The graph of tension (Series2) and the empirical curve (Series1)

$$\begin{cases} 114{,}8001 \cdot k + 42{,}01 \cdot b = 49{,}0632; \\ 42{,}01 \cdot k + 21 \cdot b = 44{,}8381. \end{cases} \tag{8}$$

b = 4,788; k = -1,32; a = 118,84 is obtained solving the system (8) and the empirical formula is written:

$$y = 118{,}84 \cdot te^{-1{,}32 \cdot t}. \tag{9}$$

The empirical curve (Fig. 1, Series1) sufficiently corresponds to the experimental curve (Series2).

The selection of the type of function depends on the mathematical method that will be used for further process analysis.

Whereas the process is not periodis, instead of Fourier row Fourier integral is used. **Fourier transformation** is used for the analyse of the results [1]. For the function $f(t) = y = ate^{kt}$ it is:

$$F(j\omega) = \frac{a}{(j\omega - k)^2}. \tag{10}$$

The expression F(jω) is called the spectral density. To draw the **hodograph** of the complex function, the real and the imaginary parts are found in Corteison coordinate system Oxy:

$$\frac{a}{(j\omega - k)^2} = x + jy. \quad \Rightarrow \quad a\frac{k^2 - \omega^2}{(k^2 + \omega^2)^2} + ja\frac{2k\omega}{(k^2 + \omega^2)} = x + jy. \tag{11}$$

And the paramteric equations of hodograph are written:

$$\begin{cases} x = a\dfrac{k^2 - \omega^2}{(k^2 + \omega^2)^2}; \\ y = a\dfrac{2k\omega}{(k^2 + \omega^2)^2}. \end{cases} \tag{12}$$

where ω - parameter.

Excluding the parameter ω, transfer to the polar coordinates: $\begin{cases} x = r\cos\varphi; \\ y = r\sin\varphi, \end{cases}$

calculate:
$$r^2 = x^2 + y^2 = \frac{a^2}{\left(k^2 + \varpi^2\right)^2}; \tag{13}$$

$$1 + \cos\varphi = \frac{2k^2}{a} r. \tag{14}$$

the equation of the **hodograph** in **polar coordinates** is obtained:

$$r = \frac{a}{2k^2}\left(1 + \cos\varphi\right) \tag{15}$$

The **cardioid** is obtained using the results of the experiment:

$$r = 34{,}05\left(1 + \cos\varphi\right). \tag{16}$$

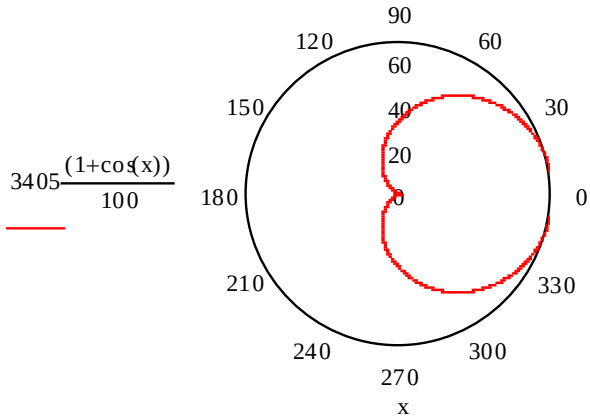

Fig. 2. The hodograph in polar coordinates.

Conclusion

Mathematics apparatus deals with practical tasks. In our case a partial derivative is applied to analyse the physical process after the experiment with the new composition of fuel.

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DIFFERENTIAL EQUATIONS IN GYROSCOPE CALCULATIONS

Miroslavs Mališko, Jevgēnijs Šepeļevs, Jānis Bērziņš*, Voldemārs Barkāns**

**Latvijas Jūras akadēmija, Flotes iela 5B, LV-1016, Latvija, E-pasts: Janis.Berzins@latja.lv*
***Latvijas Jūras akadēmija, Flotes iela 5B, LV-1016, Latvija, E-pasts: Voldemars.Barkans@inbox.lv*

Abstract
In this work are illustrated bachelor programme's differential equations with constant coefficients which are used in gyroscope calculations and their solution.
KEY WORDS: *differential equations with constant coefficients, constant variation method*

Introduction

In technical programs of bachelor studies the course of Math's is provided to get students acquainted with mathematical apparatus which is necessary for studying technical courses of general education. It is also ment for solving assignments of practical nature in speciality and to waken self – contained practical working skills of students. Finally, the course of Math's is included in technical studies to develop logical thinking and ability of students to reach goals according to a plan.

Differential equation of second grade.

Gyrocompass which includes gyroscopes is a navigation aid and is used aboard ships to stabilize ship 's heading. It is possible to have a look at some examples which show that the working principle of gyroscopes is described using system of differential equations. After solving such system it is possible to acquire differential equation with constant coefficients. Such type of differential equations is described in basic course of higher mathematics.

After solving differential system of equations of movement of gyro sphere and gyroscopes [1, IV5, VI2], a non-homogeneous differential equation of second grade with constant coefficients is acquired:

$$\ddot{y} + \omega_\beta^2 y = \omega_\beta^2 \omega_c^2 \cos \omega_c t\,. \tag{1}$$

Coefficients ω_β and ω_c include parameters of the device. Dots are used for marking fluxions by time t. Similar differential equation was also solved in Physics course when examing mathematical model of pendulum.

The result of such equation is stated by sum:

$$y = \bar{y} + y^*, \tag{2}$$

Where $\bar{y}$ is a general solution of appropriate homogenous differential equation.

$$\ddot{y} + \omega_\beta^2 y = 0 \tag{3}$$

y^* is undetermined solution of given non – homogenous differential equation.

Appropriate equation of homogenous differential equation (3) is:

$$\lambda^2 + \omega_\beta^2 = 0 . \tag{4}$$

The appropriate roots of equation (4) are $\lambda_{1,2} = \pm\omega_\beta j$.

The appropriate solution of equation (3) is stated using formula:

$$\bar{y} = C_1 \cos\omega_\beta t + C_2 \sin\omega_\beta t , \tag{5}$$

C_1 *un* C_2 are independent constants of integration. If right side of homogenous differential equation is in special form:

$$f(t) = e^{\alpha t}\left[P_n(t)\cos\beta t + Q_m(t)\sin\beta t\right] \tag{6}$$

and $P_n(t)$ *un* $Q_m(t)$ are polinoms with the highest grade (n and m) then particular solution can be acquired without using integration of non- defined coefficient method [3,4]. It necessary to take into consideration the highest grade of polinoms $k = \max(n,m)$ and concurrence of $\alpha + \beta j$ $j = \sqrt{-1}$ with rot of typical equation λ .

If $\alpha + \beta j \neq \lambda$ then the particular solution of non – homogenous differential equation is written in form (6):

$$y^* = e^{\alpha t}\left[N_k(t)\cos\beta t + M_k(t)\sin\beta t\right]. \tag{7}$$

If $\alpha + \beta j = \lambda$ then then the particular solution of non – homogenous differential equation is written in form :

$$y^* = te^{\alpha t}\left[N_k(t)\cos\beta t + M_k(t)\sin\beta t\right]. \tag{8}$$

Here $N_k(t)$ *un* $M_k(t)$ are polinoms with non – defined with grade k but with non – defined coefficients. Coeficients are stated by replacing y in non – homogeneous differential equation with y^* (solve also all y^* fluxions). It is also required that the identity is accomplished.

In the right side of non - homogenous differential equation (1) one of the polinoms $P_0(t) = \omega_\beta^2\omega_c^2$ highest grade is n = 0 but there is also no second polinom $Q_m(t) \equiv 0$ therefore $k = \max(n,m)$ and $\alpha + \beta j = 0 + \omega_c j \neq 0 + \omega_\beta$.

The particular solving of non – homogenous differential equation (1) y^* is written in form:

$$y^* = e^{0t}\left[a_0 \cos\omega_c t + b_0 \sin\omega_c t\right] = a_0 \cos\omega_c t + b_0 \sin\omega_c t , \tag{9}$$

where is necessary to determine a_0 *un* b_0.

The function (9) must be imported in place of y into equation (1). By comparing coefficients in equal functions two equations are acquired to compare and solve coefficients a_0 *un* b_0. Then the particular solution (9):

$$y^* = \frac{\omega_\beta^2\omega_c^2}{\omega_\beta^2 - \omega_c^2}\cos\omega_c t \tag{10}$$

And the particular solution of (2) of equation (1):

$$y = C_1 \cos \omega_\beta t + C_2 \sin \omega_\beta t + \frac{\omega_\beta^2 \omega_c^2}{\omega_\beta^2 - \omega_c^2} \cos \omega_c t \qquad (11)$$

Now it is allowed to determine undetermined coefficients of integration $C_1 \ un \ C_2$. If $\omega_\beta = \omega_c$ then the equivalence $\alpha + \beta j = \lambda$, t.i., $\omega_\phi j = \omega_c j$ is accomplished.

Accession:

$$y^* = te^{0t}\left[a_0 \cos \omega_c t + b_0 \sin \omega_c t\right] = t\left(a_0 \cos \omega_c t + b_0 \sin \omega_c t\right). \quad (12)$$

Y function in equation (1) is replaced by function (12). Two differential equations are acquired for solving coefficients $a_0 \ un \ b_0$ by comparing coefficients of equal functions. If $\omega_\beta = \omega_c$ then a particular solution (12) is acquired.

$$y^* = \frac{\omega_\beta^3}{2} t \sin \omega_c t \qquad (13)$$

Also the general solution (2) of equation (1) is acquired:

$$y = C_1 \cos \omega_\beta t + C_2 \sin \omega_\beta t + \frac{\omega_\beta^3}{2} t \sin \omega_c t\,. \qquad (14)$$

Now it is allowed to determine undetermined integration constants $C_1 and C_2$.

The constants variation method of Lagrange

The constant variant method is more general than method which was mentioned earlier. It is possible to use it for solving any linear differential equation [3,4] independently from the type of the right side of equation but the method is connected with solution of integrals. The solution of the equation can be left in integral form therefore the solution of differential equation sometimes is called as an integral of equation.

Let us check the equation (1) whose right side is undetermined function f(t).

$$\ddot{y} + \omega_\beta^2 y = f(t). \qquad (15)$$

The solution of appropriate homogenous equation (3) should be stated using formula:

$$\bar{y} = C_1 y_1(t) + C_2 y_2(t) \qquad (16)$$

where $y_1(t) \ un \ y_2(t)$ are undetermined, linearly independent solutions of homogenous equation. Now it is necessary to change (variate) integrating constants so that function (16) could satisfy non – homogenous equation (15), t.s, accept that constants are dependent from t:

$$C_1 = C_1(t) \ un \ C_2 = C_2(t) \qquad (17)$$

The solutions must be written in form:

$$y = C_1(t) y_1(t) + C_2(t) y_2(t). \qquad (18)$$

In order to ensure that function (18) satisfies non – homogenous equation the system[3],[4]: must be sated for solving alternating constants:

$$\begin{cases} \dot{C}_1'(t)y_1(t)+\dot{C}_2(t)y_2(t)=0; \\ \dot{C}_1(t)\dot{y}_1(t)+\dot{C}_2(t)\dot{y}_2(t)=f(t). \end{cases} \tag{19}$$

The homogenous differential equation (3) has particular solutions:

$$y_1(t)=\cos\omega_\beta t; \qquad y_2(t)=\sin\omega_\beta t \tag{20}$$

Functions (20) should be inserted in system (19). The system is acquired:

$$\begin{cases} \dot{C}_1'(t)\cos\omega_\beta t+\dot{C}_2(t)\sin\omega_\beta t=0; \\ -\dot{C}_1(t)\omega_\beta\sin\omega_\beta t+\dot{C}_2(t)\omega_\beta\cos\omega_\beta t=f(t). \end{cases} \tag{21}$$

By solving system (16), acquired:

$$\dot{C}_1(t)=-\frac{1}{\omega_\beta}f(t)\sin\omega_\beta t; \qquad \dot{C}_2(t)=\frac{1}{\omega_\beta}f(t)\cos\omega_\beta t. \tag{22}$$

By integrating calculate:

$$C_1(t)=-\frac{1}{\omega_\beta}\int f(t)\sin\omega_\beta\tau d\tau+C_1^*; \quad C_2(t)=\frac{1}{\omega_\beta}\int f(t)\cos\omega_\beta\tau d\tau+C_2^*. \tag{23}$$

The frontiers of integrals are chosen in accordance with terms in the beginning. The expressions of constants (23) and particular solutions (22) must be inserted in formula (18):

$$y=C_1^*\cos\omega_\beta t+C_2^*\sin\omega_\beta t+\frac{1}{\omega_\beta}\int f(\tau)\sin\omega_\beta(t-\tau)d\tau. \tag{24}$$

The integral:

$$f_1(t)*f_2(t)=\int_0^t f_1(\tau)f_2(t-\tau)d\tau=\int_0^t f_1(t-\tau)f_2(\tau)d\tau \tag{25}$$

is called convolution or composition of function. Linear differential equation with constant coefficients of third grade.

After solving system [1, III50], of differential equations of movement of gyrocompass a third grade differential equation with constant coefficients is acquired which describes the movement of gyrocompass which is dependent from azimuth:

$$\dddot{y}+a_1\ddot{y}+a_2\dot{y}+a_3y=f. \tag{26}$$

Here coefficients a_1, a_2, a_3 and free member f includes parameters of the device. The solution of equation is stated with sum (2) where $\bar{y}$ is general solution of appropriate homogenous differential equation:

$$\dddot{y} + a_1\ddot{y} + a_2\dot{y} + a_3 y = 0 \tag{27}$$

The coefficients of equation are constant therefore it is possible to use characteristic equation for solving equation.

$$\lambda^3 + a_1\lambda^2 + a_2\lambda + a_3 = 0. \tag{28}$$

The parameters of the device are chosen in order to ensure that one rot of equation is real but rest two are complex joint and all 3 rots has negative real parts:

$$\lambda_1 = -m; \quad \lambda_{2,3} = -h \pm qj\,. \tag{29}$$

In such situation the equation (27) describes the process of ceased oscillations. In order to ensure that the real parts of equation (28) are negative in accordance with theorem of Gurvic [5], it is necessary that equations are accomplished sufficiently:

$$a_1 > 0; \quad \begin{vmatrix} a_1 & 1 \\ a_3 & a_2 \end{vmatrix} > 0. \tag{30}$$

The general solution of equation (28) is stated with formula:

$$\bar{y} = C_1 e^{-mt} + e^{-ht}\left(C_2 \cos qt + C_3 \sin qt\right), \tag{31}$$

Where C_1, C_2, C_3 are undetermined constants of integration or

$$\bar{y} = C_1 e^{-mt} + Ae^{-ht}\cos\left(qt - \psi\right), \tag{32}$$

where $A = \sqrt{C_2^2 + C_3^2}$; $tg\,\psi = \dfrac{C_3}{C_2}$.

The particular solutions of (26) of non – homogenous equation (26) is acquired with method of non- defined coefficients:

$$y^* = \frac{f}{a_3}. \tag{33}$$

Using solutions (32) and (33) a general solution must be written (2):

$$y = C_1 e^{-mt} + Ae^{-ht}\cos\left(qt - \psi\right) + \frac{f}{a_3}, \tag{34}$$

Which describes process of ceased oscillations if m>0 and h>0.

Conclusions

In order to understand how the some navigational devices operate and how they are calculated student must be familiar with differential equations. This work shows that if the student will have problems with calculation of differential equations he also will have problems in technical subjects where equations are used.

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USE OF LEARNING MATERIALS IN CONTEXT OF CALCULUS COURSE

Aleksandrs Grachovs*, Ingrida Veilande**

**Latvian MaritimeAcademy, 5B Flotes st, LV-1016, Latvia, E-mail: shapeshftr17@gmail.com*
*** Latvian MaritimeAcademy, 5B Flotes st, LV-1016, Latvia, E-mail: i.veiland@gmail.com*

Abstract
The enquiry about the mastering calculus course between the LMA students is performed. Reasons of relatively low evaluation results of students' final tests are discussed. The necessity and availability of internet materials are investigated.
KEY WORDS: *calculus, study methods, internet resources, free software.*

Introduction

The studying specificity of high schools strongly differs from those learning methods, which are used in Latvian schools. Students are motivated to be more independent. Lack of knowledge in math has a great influence on mastering calculus course in higher education institutions. One of the tasks of this work is to inspect learning methods of Latvian Maritime Academy (LMA) students and define possible deficiency. The other task is to make up modern possibilities of independent work and use of internet materials to broaden and confirm the knowledge range of students.

Enquiry

An enquiry has been made to get a general overview of how students handle calculus related homework. Respectively, the enquiry covered the frequency, length, independence, use of various materials in relation to calculus. The enquiry had covered 74 first course Latvian Maritime Academy (LMA) students, giving a wide range of answers for analyze.

The enquiry showed, that 12% of students do homework every day, whereas 68% of students do it one or several times per week, leaving 20% of students behind, who do homework on rare occasions. Most students (that is 81%) spend less than 25% to 30% of their time for theory, about 15% spend half of their time on it, while only 4% of all students study theory, spending 60% or more of their time on it.

Pointing out the independency of doing homework, the enquiry had shown that 77% of students use internet materials to help their studies, while 23% of them do not use such materials. Also, the enquiry had shown that 59% of students use LMA library materials to help their studies, 26% of them do not, 14% of them use their own books as help resources, leaving as little as 1% of students who use materials from other libraries.

Finally, the enquiry had covered learning methods in relation to mastering course of calculus. Results are following (multiple answers on this question were possible, therefore the overall percentage exceeds 100%: see Fig. 1: Learning methods): 58% of all respondents only do homework tasks, 35% of students do some additional tasks, 39% of them look for similar tasks with explanations, 31% of students repeatedly read their lecture conspectus to get a deeper understanding of the subject, and finally 20% of them make extra notes and use books as teaching aids.

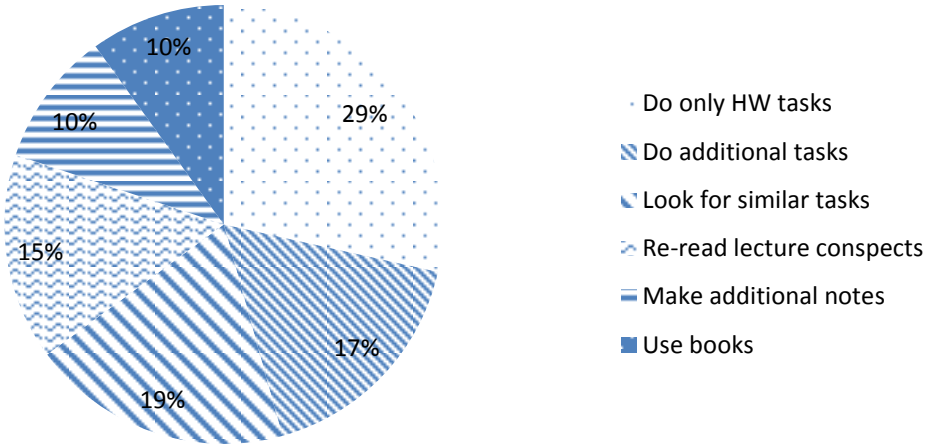

Fig. 1: Learning methods

Difficulties of acquiring calculus course

Students' learning methods and preparatoty work are the factor of their individual scores in the resulting test on calculus. What has been obtained during analysis completely matches the expectations (looking at the winter session results 2012), which are following: insufficient preparation and irrelevant learning methods of students were the reason of relatively low scores on calculus related tasks. As can be seen on Fig. 2: Winter session results, which covers exclusively positive calculus test results of 100 LMA first grade students, 40% of students barely made their ways to the positive score with a mark of 4, 19% of students made a slightly better effort and received a mark of 5, almost as many students (18%) received a mark of 6. As can be seen, this tendency keeps up the percent decrease as the score increases; 13% of students scored 7 in the math session, 6% of them got a mark of 8, which leaves 3% of students who scored 9 and only 1% of students who scored 10, which is the highest score possible.

Furthermore, according to gathered data, 42% of students did not receive a positive mark on their first attempt, whereas 58% (which is slightly over a half) of them, with great effort, but nevertheless, passed the test on their first try.

The above listed data shows that the difficulty of acquiring calculus course actually persists and the situation requires a change (see Fig. 2).

Individual study methods

To improve the knowledge level, it is vital to cultivate learning skills. Any student could create and develop a personal learning method, by making notes, analyzing task solution methods, using handbooks etc. For incitement, two special methods, which can promote this process, are mentioned below.

Mind map

The inventor of mind map is Anthony Buzan. *The mind map* is a kind of diagram that consists of different words, images, coloured lines and other elements, which are drawn around the central key object. The elements of a mind map are grouped according to use and application in a chaotic, yet a graphic vivid manner, which stimulates extensive thinking and analysis. A mind map is similar to a concept map, which is a type of algorythm, used to structurise data.

A. Buzan is the author of several books and an educational consultant suggests various guidelines in order to effectively structurise a mind map [1]. Professor Thomas Teepe develops the mind mapping strategies for math problem solutions that are based on great ideas of G. Polya, A. Engel and other famous mathematicians [2].

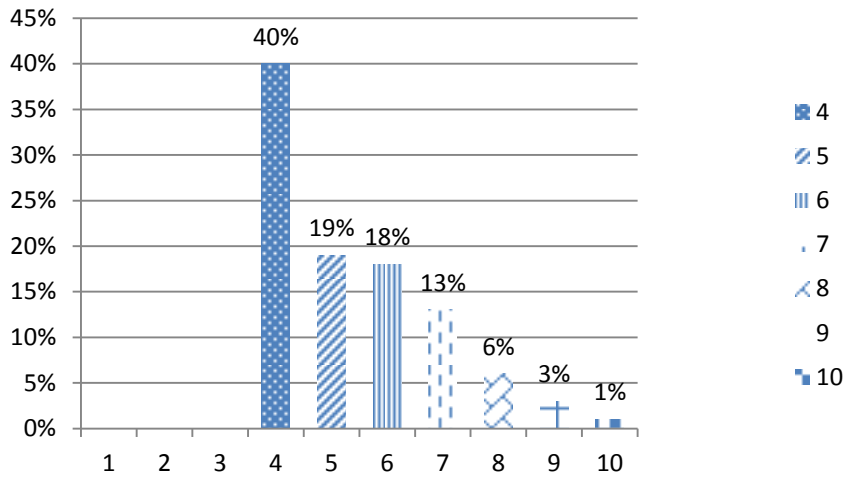

Fig. 2: Winter session results

Critical thinking

Critical thinking (CT) is another method used to ease the process of learning. It studies a topic or a problem with an open mind, meaning that it allows questioning some statements and accepting others. CT allows a deep analysis of the subject that is being learned, in our case that is the subject of calculus. The definition of the subject is given on homepage of Critical Thinking Community [3]:

„Critical thinking is the intellectually disciplined process of actively and skilfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness."

To begin with, one must develop a frame of reference, pointing out what he already knows about the given subject. Then, question what opinions and prejudices you already have about the subject, generalizing what you have red or been told about it already.

Next, estimate available literature and information resource; while doing so note, that you must refer to multiple resources and choose an open-mind approach. In case you find no relevant information, refer to people who may know something about the given subject. You have the right to accept or refuse the resources you might find.

Last but not least, define the terms, during which the planned work amount will have been complete. Method of CT is suitable for mastering calculus course too. For example, professor of Cuesta College USA M.D. Turner shows several methods of CT applications to develop deeper students' comprehension of the given subject [4].

Both approaches can be successfully used while learning calculus; furthermore, such methods are applicable to a wide range of other topics, such as philosophy, economics, physics etc.

Survey of internet resources

Many various websites and internet resources (IR) can be found as help for solving calculus related problems - lecture notes, exercises, software programs, video materials, interactive applets, encyclopaedias etc. The majority of IR is in English. Use of them can stimulate not only comprehension of calculus, but also can expand language skills.

Students can use different interactive software to complete their homework and learn calculus topics. Such useful software as *GeoGebra*, *C.a.R.*, *Geonext* [5, 6, 7] etc. has free access and is applicable for geometrical calculations, constructions of shapes and solids. Additionally to well known commercial software as *Maple*, *MathCad*, *Matlab*, *Mathematica* that are popular at many universities, colleges, high schools, there are also many freeware computer programs available. *SAGE* [8] includes computer algebra and two or three dimensional plotting of objects; *SMath Studio* [9] is free mathematical program with "paper"-like interface and numerous computing features and is like the *MathCad* design. That gives the possibility to calculate integrals or derivatives symbolically or numerically. Matrix calculations are available too. The construction of functions' graphs is simple and well designed. The following software is created to solve different problems of linear algebra, vector algebra and for other precalculus topics: Linear *Algebra*, *CMAT – Matrix Calculator* [10, 11]. *Wolfram Alpha* is an interactive website [12] that allows free form information entry with further information interpretation to match possible operations developed by Wolfram Research group. In relation to current topic, *Wolfram Alpha* offers solutions with steps for calculus tasks, such as derivatives and integrals, as well as solutions for other topics, even ones that are not related to mathematics. *Wolfram Demonstration Project* [13] gives the opportunity to investigate a lot of visual examples of mathematical problems. The demonstrations run in *Mathematica 6* or in *Wolfram CDF Player* is a free modified version of *Wolfram's Mathematica*.

Free Math Help [14] is a website that includes lessons, a discussion forum, solution examples of math problems with detailed explanations and an interactive applet to solve the user's given problems. The website *Math Serfer* (in Russian) [15] solves calculus tasks online. The specificity of this website is to show the solution of problems step by step. To do this, one must firstly select the type of task, and then insert the task data, after doing so you will get the task solution on the screen.

Khan Academy [16] is an educational website, created in 2006 by Salman Khan, an American educator. This website offers high quality education on any topic free of cost, including mathematics, history, medicine, physics etc. Respectively, it offers video lectures uploaded to a domain called *Youtube*, where these videos are also available. Along with lectures, the website offers practice tasks. The website contains over 3000 video lectures and receives daily positive feedback from users of all ages, since it has no limitations and has proven itself as an easy and effective learning aid for people all over the world.

Many mathematical manuals, encyclopedias, books, lecture notes are located in the internet. Wide online library is on the Moscow Center of Continuous Math Education website [17]. There it is possible to read books online – V.M.Tihomirov "Differential Calculus", A.J.Hinchin "8 Lessons on Calculus", G.Polya, G.Sege "Problems and Theorems of Calculus" and many other excellent books. One can find lecture notes with numerous examples of how to implement calculus to real life problems, for example, the lecture notes of Paul Dawkins [18], professor of Lamar University. Correctly explained calculus topics can be found in the book "Introduction to Real Analysis" by W.F.Trench.

Conclusions

The enquiry was the turning point of this work, which showed a necessity in learning methods improvement. Clearly, material that is obtained by students during lectures is insufficient to get a good understanding of the subject of calculus and become fluent. Inadequate student activity relating to this topic, as well as lack of new material learning skills has resulted in such results, as the ones listed above.

Students have to pay a lot more attention to studies, master various effective individual learning methods and make use of materials accessible by internet and programs, by these fulfilling learning skills, which are useful for learning along life.

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SHIP SHORE POWER CONNECTION SOLUTIONS IN RIGA FREEPORT

Jānis Brūnavs, Gundis Lauža, Andris Unbedahts

**Latvijas Jūras akadēmija, Flotes 5B, LV-1016, Latvija, E-pasts: Janis.Brunavs@latja.lv*
***Latvijas Jūras akadēmija, Flotes 5B, LV-1016, Latvija, E-pasts: Gundis.Lauza@latja.lv*
***Latvijas Jūras akadēmija, Flotes 5B, LV-1016, Latvija, E-pasts: Andris.Unbedahts@latja.lv*

Abstract
Technical solution of ship shore electrical power supply in the Baltic and Northern sea ports and their technical parameters are analyzed. The results of the analysis are proposals for power supply in the Riga Freeport.

Introduction

The Baltic Sea is one of the busiest shipping areas in the world, freight volume and the number of ships entering the Baltic, and in particular the port of Riga continues to grow. Considering the intensity of the traffic in the port new technologies shall be carried out to reduce emissions from ships and pollution level in the port area. This is specifically important in Riga Passenger port where docking area are located in the immediate vicinity of the Riga old town and residential area.
The following documents concerns Emission levels in EU ports :
1. EU Directive 2005/33/EC - change to fuel oil sulphur controls for ships at berth in EU ports which specifies the maximum allowable sulphur content of the fuel oil used " at berth" will be not over 0.10 % by mass (m/m). It covers use for main and auxiliary machinery and boilers and is applicable for ships berthing more then for 2 h in the port.
2. European Community has adopted a Recommendation 2006/339/EC "Promotion of shore-side electricity for the use by ships at berth in Community ports" (Published on 12.05.2006 in the EU Official Journal No.125/42) on May 8, 2006.
3. The EU Directive 2003/96/EC allows a tax reduction for the use of shore-side electricity. Other ways are also considered to encourage ports to invest in shore-side electricity infrastructure and to ensure its use.

Based on EU documents more and more EU ports start to be equipped with necessary infrastructure for such a connection getting the necessary funding from the EU structural funds. In October 2011 Port of Rotterdam launched a pilot project implementation, resulting in 120 shore side connecting the points for vessels.

Leading ship classification societies, including Lloyds Register (LR), Germanisher Lloyds, Bureau Veritas (BV), Det Norske Veritas (DNV) and others has issued new sections in their Class Rules (or as tentative rules), governing the safety, protection and technical aspects of shore-side connection.

Different terminology are used by authors in technical articles e.g. OPS - On shore Power Supply (LR), CI - Cold Ironing , APS - Alternative Power Supply,SPS - Shore Power Supply ,SPC - Shore Power Connection.

1. Ship shore power connection characteristics

On shore Power Supply (OPS) fulfill the functions of the ship's diesel generators, while she is at the berth, that is to provide electricity to all the necessary facilities, cargo handling equipment, lighting, heat, etc.

Reasons for the use of OPS:

- Reduce vessel's fuel consumption;
- To provide possibility to carry out engine maintenance , overhauling and inspections during the vessel at the port
- Reduce air pollution , CO2 emissions and noise level.

Building the ship shore power supply, it is essential to evaluate the technical characteristics of the system. The most important of these are the ship and shore power frequency, voltage and power.

Port of Stockholm

Shore power for large vessels was equipped in 1985. Connection place 440 V is at Stadsgarden terminal for ships operating to the Åland Islands ms VIKING CINDERELLA and ms BIRGER JARL. With 9 cables, which are alongside the berth, the supply power of 2.5 MW is provided. Accession process takes about 5 minutes.

Stockholm Freeport in 2006 established shire-side connection 690 V / 50 Hz for Tallink ferries ms' Victoria 1 " and " Romantika "with 12 cables and connectors, as shown in Fig.1. Connection / disconnection and takes no more than 5 minutes [5].

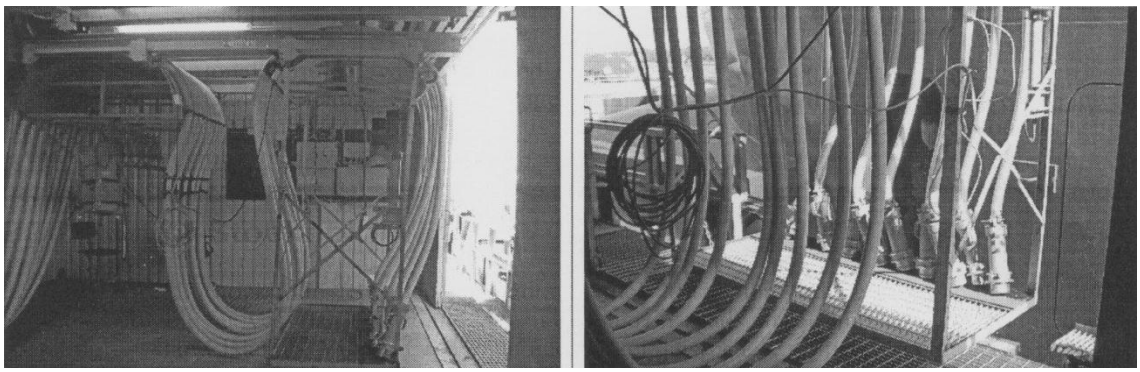

Fig.1. Connecion cables at docs ready to connect ms „ Viking Cindarella” [8].

Port of Piteo (Sweden)

MS Balticborg and MS Bothniaborg use 6 kV high-voltage grid with power cable and a separate command / control cable.

Port of Kemi and port of Oulu (Finland)

Since 2006 Stora Enso terminal of port of Kemi and port of Oulu use Ro-Ro ships with 6.6 kV connection, similar to the design of the port Gothenburg.

Port Gothenburg

Shore-side connection has been operating since 1989. Stena Line Ro-Ro passenger ferries Stena Scandinavica and Stena Germanic serving Kiel-Gothenburg line use 400V connection. The connection at the port of Gothenburg operates since January, 2000. It was originally established as a high voltage connection system for Ro-Ro ships in cooperation with Stora Enso and ABB. Transformer 10 kV / 6.6 kV 1250 kVA is located on the quay (Fig. 2). Equipment, automatic control and connection sockets are located in 9-foot container. Connection is realized through a single cable [8].

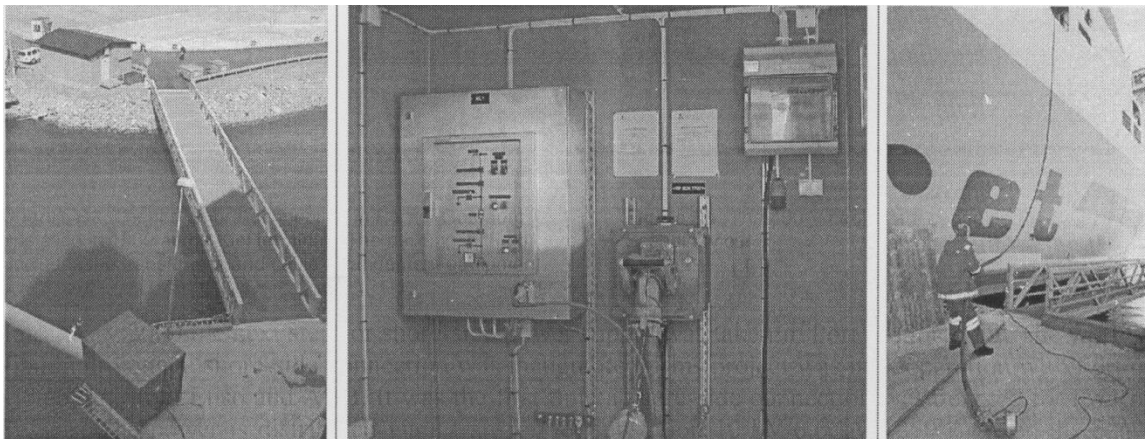

Fig.2. Connection site at port of Gothenburg
Left - hardware and close-up of the container connection place.
Middle - interior view of the connection container.
Right image – connected ship [8].

Port of Helsingborg (Sweden)

Scandlines ferries use connection of 400 V / 50 Hz, 2 x 250 A for vessel night stay in port that gives a limited access to the vessel's equipment and machinery. Sundbussarna ferries also use 400 V/50 Hz, 2 x 125A connection, but HH-Ferries use 440V/50 Hz connection.

2.Connection parameter selection

2.1. Ship mains frequency

Most of the commercial fleet (around 80%) is known to work with the network frequency of 60Hz. However, a different picture emerges when examining the passenger ferries and cruise ships, which carry passengers in the Baltic Sea region. For example, Shipping Company Tallink ferries are using 50Hz frequency networks.

Also, most of the nearby ferry shipping companies such as Scandlines, works with 50Hz frequency, although a number of TT-Line ships operates with a net frequency of 60 Hz. It should be noted that most of the regional ports (Stockholm, Gothenburg, Lübeck, Zeebrugge, Helsingborg, Kotka, Oulu, etc.) with the exception of a few ones (e.g. Antwerp, Rotterdam) provide shore power connections offering a 50Hz alternating current frequency only [5.6].

Some ports beside the shore power supply with 50Hz frequency are planning to offer also the connection of the 60Hz (Gothenburg, Trelleborg, Tallinn, etc.). The U.S. major passenger Ports (Los Angeles, Seattle, Long Beach, Pittsburg, Juneau, etc.) offers connection with 60Hz frequency only.

2.2. Ship supply voltage

The differences between ship power system voltages are considerably higher. Most medium and small ferries has net voltage 400V , however, some passenger ferries has 440V system (TT-Line) and some also 690V [2]. It should be noted that both of Riga to Stockholm Tallink ferries Romantika and Festival has a 690V system. There are also ships with a higher voltage network. Usually they are vessels with electric propulsion. For these vessels use of 6.6 kV or 6.3 kV are common. Some Baltic and North Sea region ports offer a high-voltage connection of 6.6 kV power supply, for example, Gothenburg, Antwerp, Oulu, etc. High-voltage power supply voltages of vessels may vary, so ports offer different high-voltage standard connections, e.g., Lübeck and Piteå 6 (6.3) kV, but Gothenburg also 10kV. The U.S. major passenger ports, serving primarily large cruise ships, Seattle, Los Angeles,

Juneau, Long Beach actually standardized shore power supply voltages, offering a 6.6 kV high-voltage 60 Hz connection, but some terminals (Seattle, Juneau) also 11kV connection [7].

It should noted that sometimes a high-voltage shore power connection are used for ships with low-voltage power grid. In this case, high voltage makes it possible to reduce the number of bulky parallel cables, which is important for high power transmission. This solution requires a high voltage transformer, deployed at the ship.

2.3. Ship-shore power supply connections

The connection capacity is an important factor in assessing the connection costs. It is determined by both the existing power facilities, and the potential amount of reconstruction and investment in new power lines, cables, transformers deployment. The vessel required connection capacity depends on the type of ship, size and other parameters.

In assessing the potential of the Freeport of Riga, let us restrict it to passenger ferries and cruise ships.

A study of ferries employed at Baltic and North Sea trade reveals that the maximum power, while at pier, is in the range of 1400kW to 3600kW. For Tallink ferry Romantika maximum required power in summer is around 1600kW and does not exceed 2400kW in winter.

Estimation of the power consumption for a cruise ship is considerably more complicated. There are some surveys, such as done for the cruise ships arriving the port of San Francisco [1]. This survey, done for 40 vessels, shows that the average power consumption at the port can range from 1500kW to 10000kW. Since about 95% of cruise ships standing at pier have average power consumption of less than 7000kW, this value can also be accepted as the average cruise ship's power consumption. However, for the port of Riga, this capacity may be overstated. Wider research on necessary power for cruise and passenger vessels use to berth at Baltic Sea ports are necessary.

Fig. 3. Tallink ferry is connected to the shore at Stockholm harbor.

Shore power delivery technology is best suited for ships arriving in port on a regular basis and for this fleet the shore power supply will provide a major environmental impact.

Technical safety plays an important role in choosing technology to use for a shore power connection. When creating / designing the shore connection systems it is necessary to investigate and

evaluate the safety aspects and connection / disconnection procedures. Safety for the personnel involved should be assessed in terms of transition processes in the vessel power system as well as considering the ability of the staff to perform the necessary operations in extreme cases of emergency (fire, flooding) also in case of necessity to use the mooring winches , anchor gear, etc.).

For example MS "Romantika" onboard power plant constitutes of 3 diesel generators Wartsila 6R32L with a nominal capacity of 2400 kW (3 generators with Sn = 2950kVA). In winter and summer, the engine load is in the range of 70 - 80%. The ship at Riga port is standing for 6 hours and consumes 1.0 – 1.2 t MDO with the S content of 0.1%.

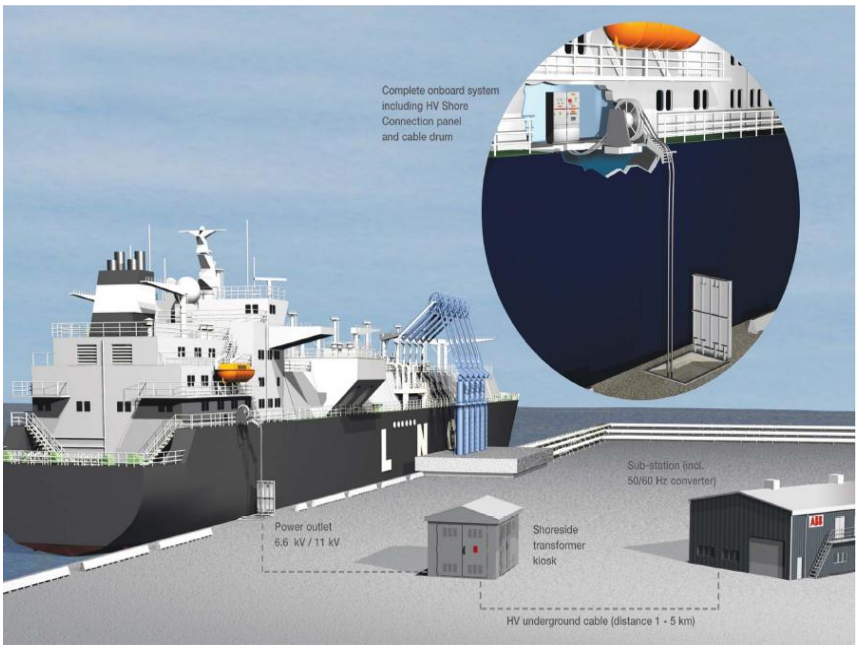

Fig.4. Shore power connection visualization of the LNG vessel [4.7]

Conclusions and proposals for set-up of ship shore-side electricity in Riga Freeport

1. It is important to involve in the shore-side electricity project potential shipping lines, environment protection organizations, shore power connection technology / solution providers, electrical power companies and terminal operators.

2. It would be prudent to provide shore power module / cable runs from the port in emerging areas such as the Krievu sala already in their design stage.

3. Passenger port

To provide ferries Romantika and Festival with the connection of 690V/50Hz voltage, analogous to how they are provided at the port of Stockholm. It is possible that without substantial additional costs a high voltage connection 6.6 kV as well as the connection to 380V mains is also established.

Necessary shore power capacity estimation:

Assuming that at Riga Passenger Port at the same time could berthed up to 4 Romance (Tallink) size ships (length 200 m, 2500 passengers). Power consumption for one vessel varies from 1600kW (summer load in case if there is no need for air conditioning) to 2200kW in winter.

At least 3 ships from them will get shore power supply at the same time.

So the total capacity of the shore network to be estimated up to 5-6 MW (assuming simultaneity factor of 0.8).

4. Design / research works to be done:

4.1. Due to European Union directives 205/33/EC (from January 2010) the introduction of the shore power supply may become economically profitable for ship owners / operators. It is necessary to

make the onboard electricity generation cost estimates to get comparative figures and base to convince ship owners / operators and terminal operators to invest in shore power supply technologies,

4.2. A detailed study throughout the different areas/terminals the port of Riga to be done to assess the possible technical solutions for the shore supply and to forecast their costs. On the basis of such a study should be outlined optimal shore power connection locations (also available power / frequency/ voltage) .

4.3. Analysis of the experience of other ports, e.g., Klaipeda, Tallinn, Stockholm, Gothenburg, Lübeck, Kotka, etc., including the U.S. West Coast ports and this knowledge transfer to select optimal solutions for the port of Riga.

4.4. Study of 60Hz shore power system reasonability for the port of Riga to be performed.

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LATVIAN NAVAL FORCE FLOTILLA SECURITY QUESTION

Kaspars Pollaks

Latvian National Defense Academy, Ezermalas street 8, LV-1014, Riga, Latvia
Latvian Maritime Academy, 5B Flotes st, LV-1016, Latvia, E-mail: info@latja.lv

Abstract
Up growing terrorism threats in Europe and participation of Latvian Armed Forces in several international military operations and the significant role of the port of Riga in the NATO Northern distribution Network define the Republic of Latvia as potential terrorist attack target. High effectiveness of unconventional warfare methods as use of combat divers and the access of unauthorized persons to military objects restriction need determines the demand of well organized and prepared security system for Latvian warships and Naval bases.
KEY WORDS: *Navy, terrorism, maritime security.*

Introduction

Modern security situation has absolutely changed hundreds of years old military strategy, tactics, thinking and methods for the conduct of war principles. Today great battles on sea, land and in the air are the history. The greatest military challenge today is war with terrorism and the general method of achieving military aims is using the surgical strike without involving big amount of military resources.

Participation of the Republic of Latvia in military operations in Afghanistan and Iraq, membership in NATO and up growing terrorism threats in the Baltic region points to the need to define Latvia as a potential terrorist attack target. For this reason Latvian Naval Force Flotilla personnel must be prepared and equipped in such a way to be able to face the challenge of nonconventional warfare methods and weapons.

One of general objectives today for ensuring effective use of Naval forces in the combat or emergency situations is providing secure trimming of Latvian Naval Force Flotilla warships in the Latvian Naval bases and in the previously unprepared places as non military harbors. Different methods of naval base security problem solutions are practiced today.

Within this paper the insight into the security problems in the existing Latvian Naval Bases in Riga and Liepaja will be given. Possible technical solutions of the problem and the examples of the experience of other countries will be described.

1. Topicality

Despite the increasing terrorist activities in the world, the level of terrorism in Latvia remains low. Nevertheless, the Latvian Security Police has announced that the increasing of terrorist activities in Latvia and neighbouring Baltic countries in future is still topical. Global terrorism tendency analysis in 2010 and several prevented terrorists attacks in Denmark and Sweden demonstrated the increasing terrorism level in North Europe countries [1].

Lithuanian citizen connection with Russian Radical Islamic organizations and commitments to participate in terrorist attack organization is Chechnya demonstrates the up growing terrorism threats in Baltic countries [2]. Active involvement in international war with terrorism and participation in several international military operations, NATO membership, as well as the role of the Port of Riga in the NATO Northern Distribution Network dictates the necessity for Latvia to assess all possible threats and identify itself as a potential target for terrorists' attacks.

In modern warfare the general aim of the modern professionally trained Navy is to destroy enemy's vessels engaging trivial naval resources in naval battle or destroy enemy's vessels before they leave the harbour. The great battles of ironclad vessels of the World War I and II are the history. The modern navy battle is carried out by use of long distance weapons with no high risk for homeland ships and sailors. One of long distance weapons and war conduct methods is a use of specially trained saboteurs able to cause high damage for enemy's vessels and personnel engaging trivial forces and resources. The effectiveness of underwater military saboteurs called frogman was proved by Italian and German navies in the Second World War. A very important aspect should be noticed that terrorists for the achievement of their objectives could use wide availability of equipment and combat diver tactics due to the fact that training is cheap and easy acquired [3].

As a significant example of the effective use of underwater saboteurs in modern military operations is a case of Israel Navy operation "Escort" hold on 7 September 1963. Well-trained Israelite Navy divers destroyed standing Egypt Navy missile boats in harbour. They were able to cause serious danger for Israelite Army troops who were ready to land on Egypt coast [3]. This operation demonstrates effectiveness of well-organised pinnacle attack that influenced the run of the whole military operation.

Along the combat force protection needs, protection and unauthorised visitors limits to naval bases and warships must be considered. Noticing so-called *human factor*, unauthorised entrance of curious divers, swimmers and water craft drivers into the naval harbour aquvatorium, first of all, may cause dangers for their lives. Second, the NATO member military base is stated as the restricted area.

Despite the fact that Latvian citizens trust to National Armed Forces and their high level of readiness [4], provocations still are considered and should not be excluded in perspective. The Latvian society keeps double viewpoints regarding participation of the Latvian National Armed Forces in international missions, i.e., Afghanistan. A few unsuccessful search and rescue operations caused dissatisfaction and claim to the Latvian Navy. One of these accidents happened on 3 December 2009 the day of the shipwreck of fishing vessel *Beverina*. Due to bad weather condition and unclear *Beverina* actions, Latvian Navy warship A-53 *Virsaitis* was unable to help the fishing vessel. Thus, *Beverina* sank near the Port of Liepāja, in Latvia. This tragedy shocked all Liepaja and Latvia and unknown persons under cover of night using boat got to the *Virsaitis*, which was moored in the Port of Liepaja and painted, on its hull – THE DEATH OF BEVERINA, YOUR FAULT [5]. This incident actualised this security problem in the Latvian Navy.

2. Protection methods

Analysing the underwater security assets and technologies, they must be divided into two parts. The first part is harbour and port security assets and equipment for whole port and big water aquvatorium protection. The second side of the problem is protection of alone standing ships, for example, alone standing ship in unprotected port. A lot of countries and companies have tried to find different possible and effective solutions for harbour, port and vessel security. To give the insight into realized solutions of this question, a few methods used in USA and the Russian Federation will be described

Organizing protection against fast speedboats loaded with explosives is as equally important as organizing the protection against underwater diversions or sabotage threats. One of the methods used by almost all world navies for fighting small fast boats with bad intentions is use of night watch on the ship armed with automatic weapons. The example of USA Navies bad experience with USS Cole that was attacked by terrorist speedboats in the Port of Aden in 2000 proves that this method is not always efficient enough. Due to the bad weather conditions, difficult visibility and other factors, sometimes it is impossible to detect the attack in time or destroy attacking speedboat before it has reached the ship.

The method used by US Navy to bound standing warships from attacking speedboats or other water going crafts and make potential attacking boat stop and become good target in the sufficient and safe distance is using floating security barriers by Wave Dispersion Technologies, Inc. It is very important to mention that this kind of barriers could be used not just for combat and power protection

but it is possible to use it for simple limitation of some special water territory with limited access like navy base for non military water crafts which are trying to enter base of curiosity or with the goal to damage military inventory as it is described above [6].

Security floating barriers are made in such a way to guarantee the durability of barrier after the strike of more than one speedboat. Barrier consists of a lot of individual modules which are made from high density polyethylene. Separate modules are connected with each other to achieve the necessary length of barrier. For higher counter diver protection floating barrier can be equipped with underwater net to prevent divers intruding in to the secured territory and barbed wire entanglements over the barrier floating part [6].

One of the weapons used by US Navy and Coast Guard for protection of vessels and port facilities and fighting enemy’s swimmers and divers is Anti – Swimmer Grenade. It is possible to set the detonation depth of the grenade according to the depth of water basin and the depth of detected diver [7].

Fig. 1: Security floating barriers on the duty of US Coast Guard [6]

One of the armament units used by Russian Navy for coastal installation and warship protection from underwater diversion threats is small sized remote controlled counter diversion grenade launcher complex DP-65. Complex consists of ten-barreled 55 millimeter grenade launcher for launching rocket-propelled grenades, control panel, power supply, mechanism for vertical and horizontal guidance and fittings. For destroying targets high explosive grenades RG-55M are used, but for illumination of detected target complex is fitted with reactive signal grenades GRS-55. The system provides a single and salvo firing on the distances from 50 – 500 meters [8].

Fig. 2: Complex DP -65 and Grachonok class anti-terror boat [9][10].

System can be operated ether manually or using sonar "Anapa ME" which provides automatic detection of targets, aiming the complex at the potential target and escorting of the target till the destruction [9].

The general advantage of this system is application possibilities both on the alone standing warships of almost any size in the unprotected or not specially prepared ports and harbors or alone standing ships in the open water territory and in the navy bases or other coastal infrastructure units for protection of moored ships and coastal installations. This makes complex universal combat tool against underwater diversion forces or even single small surface targets like speedboats [9].

A little bit different solution of this question used by the Russian Navy is maintenance of special anti-terror boat. Project „Grachonok" ship is specially equipped vessel for patrolling and fighting underwater diversion forces in the waters of navy basing sites and in the approaches to them. Vessel is equipped with previously described complex DP-65, sonar Anapa ME, maritime heavy 14, 5 mm machine gun and other necessary equipment. The use of this kind of vessels allows organizing and making counter diversion protection mobile for achieving the faster and more efficient response capability [10].

3. Naval Force Flotilla defense capability improvement

No doubt, the Latvian Navy must follow technological progress and apply new inventions to solve security problems. One of the challenges is organisation of effective protection of naval bases in Ports of Riga and Liepaja in order to avoid diversion threats from the water by divers or fast speedboats. The second challenge Latvian Navy faces today is development and implementation of protection system for alone standing warships in unsecured harbours in Ventspils, Pavilosta, Mērsrags often used by warships of the Latvian Navy, or in open sea. The third issue regards to limited access to warships and naval bases. Such access should be strictly assessed by the respective security authorities and controlled. Taking into account that the Liepāja Naval Base is not recognised as a secure base for warships trimming, the Port of Riga could be considered as the best solution of the current problem, however, it should not be intended in long-term perspective. Meanwhile, the Liepāja Naval Base should be reconstructed and secured in accordance with the NATO standards [11].

Now the biggest Latvian Naval Base is considered to be the Port of Liepaja. The most important advantage of the Liepaja Naval Base is its direct access to the Baltic Sea, as well as, the fact that the Port of Liepaja is ice free port. It means the Latvian Navy readiness for action from time perspective is effective throughout a year. Nevertheless, the existing Naval Base in the Port of Liepaja is inappropriate for successful and secure trimming of warships. The main reason of this is the fact that Liepaja Naval Base is not isolated from other part of the territory of the Port of Liepaja.

Naval Base in the Port of Riga is considered as more appropriate for military use than the Base in Liepaja. The general advantage is a partial isolation from other part of the port of Riga and possibility to isolate the water territory of base completely from the access of unauthorized persons. For this mean the floating buoy barrage is used. Using this method it is possible to prevent free access of unauthorized watercrafts in the territory of base, but it is not a considerable obstacle for possible attackers [11].

The security system of the water basin of Latvian naval bases must be composed of three security elements. The initial solution of the security problem of naval bases must guarantee the limited access to the water territory of bases for unauthorized persons and water crafts. The second part of the first security level is establishment of such security equipment that prevents the attack on moored warships using fast speedboats carrying explosives. The solution of this problem could be the deployment of floating barriers similar to existing floating buoys barriers but with the possibility to stop the attacking fast speedboats, e.g., floating security barriers by Wave Dispersion Technologies. Installation of such base lighting system that provides a good observation of the base surrounding territory and dazzles the driver of attacking water craft or combat swimmer is very important. Taking into account that Riga Naval base is located in the river Bullupe, it is very important to limit the access to the water basin of the base from the opposite riverside. One of the solutions is to enclose the whole water of base not only with the floating security barriers mentioned before.

The second problem is prevention of underwater threats caused by divers' attacks. One of the most popular solutions of this problem used by a number of World Navies is usage of underwater nets compared with floating security barriers to prevent the infiltration of intruders into the underwater part of the base. To avoid damage of warships response capabilities stationed in the Riga Naval base, it is important to install opening gates in the floating security system to allow warships move in and out of the base.

For successful diver protection installation of diver detection system is necessary. Currently the concept of different diver protection systems available on market is more or less similar. One of the most popular is Underwater Surveillance and Protection System offered by Kongsberg. The general principle of the system is constant monitoring of underwater area using diver detection sonar. After the detection of potential attacker, system informs the command centre about possible attack [12]. To ensure the high level of underwater security the best solution is installing of two diver detection units in the Naval Base in Riga. Thus, it could ensure complete sonar coverage of the underwater area of the Base.

Te third part of the naval base security system is implementing of force protection element. The solution of this problem could be divided into two parts. First part is the installation of such equipment and weapons that can be used for destroying attacking boats, combat swimmers or detected diver. Force protection element must provide the possibility to affect the invader without destroying it to prevent the attack using killing power against for example wandered into fisherman.

The first part of force protection element can be realized by watch personnel armament with heavy rifleman weapons to fight attacking water crafts like M2 heavy machine gun or other automatic weapons. The widely used hostile swimmer combating weapon what could be used by Latvian Naval Force Flotilla is anti diver grenades like US Navies used anti swimmer grenade.

The protection of alone standing warships in unprotected harbors, ports and open sea is equally important as naval base protection. The organizing of effective defense against explosives carrying attacking small watercraft in the open sea or standing at anchor in the port raid is possible by appliance of well organized lookout and continuous maintenance of response readiness by all kinds of weapons. The organization of armed night watch on the ships exterior decks in the hostile waters and ports is necessary. View of the fact that being out of the well secured naval base warship is not able to use base stationary diver detection system any warship must have capability of organizing diver detection wherever located by other methods. The one of the solutions is use of the DSIT Technologies Point Shield Portable Diver Detection Sonar. Despite the small size this is full-fledged diver detection sonar which bigger version of DSIT Technologies Aqua Shield Diver Detection Sonar which is used for port and harbor protection from underwater attack threats [13].

Conclusions

The Republic of Latvia as the member state of NATO and the participant of international military operations must be defined as potential terrorist attack target. The up growing terrorism level in the Europe and Baltic countries increases terrorist attack possibility in Latvia. Latvian Naval Force Flotilla must follow technological progress and apply new inventions to solve security problems. Liepāja Naval Base is not recognised as a secure base for warships trimming, but it should be reconstructed and secured in accordance with the NATO standards. The security system of the water basin of Latvian Naval bases must be composed of three security elements – surface security element, underwater security element and force protection element. The protection of alone standing warships in unprotected harbors, ports and open sea is equally important as naval base protection

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THE DEVELOPMENT OF DIFFERENT TYPES OF NAVAL SHIPS FOR SPECIAL OPERATIONS SUPPORT

Raimonds Rozenfelds

NAF Training and Doctrine Command, Riga, Ezermalas street 8, LV-1014, Republic of Latvia. E-mail: rozenfelds@inbox.lv

Abstract

In this article author analyze the development of the fast naval ships and craft for special operations in the last years. The development of the special operations naval craft and equipment in near future will be analyzed. The article includes 3 chapters. In the first chapter author analyze the special operations and connection of them to the marine transport and navies. In the second chapter author analyze the development of multipurpose amphibious ships and other multipurpose support ships for special operation support. Third chapter talks about special operations littoral waters naval craft building, modernization and technology development in different world navies. The different special operations naval craft development projects and plans in world navies will be analyzed. There are the summary and references in the end of article.

KEY WORDS: special operations, world navies, ships and naval craft development.

Introduction

In this article author will analyze the development of the different type of naval ships, what can be used for special operation force (in text - SOF) support. Author will analyze tendencies of different support ship type's development and their role in special operation support in present and near future. The role and tasks of special operations in the navies will be described. The conclusions about this topic will be given in the summary.

1. The special operation tasks in the navies

In this chapter author will describe and analyze the special operation tasks and their connection to navy. The Republic of Latvia became the NATO member state in 1st April 2004, that's mean that we need to fulfill requirements and common guidelines of NATO. The NATO approved the unclassified common publication AJP-3.5 „NATO Special Operation Doctrine" in 27th January 2009. This doctrine defines and describes the special operation and defines the tasks of those operations in air, sea and land. According to this doctrine during the special operations the NATO member states SOF or other units specially trained and equipped for special operation tasks do the following tasks connected to navies:

1. Threat evaluation;
2. Target evaluation;
3. Recovery operations;
4. Hostage release operations;
5. Ships, naval vessels and costal infrastructure defense;
6. The ships forced search operations [1].

In this doctrine the naval special operations is defined as one of the types of special operations.

The significance of special operations and naval special operations in last year's continues to grow. The main reason for that is the problem of piracy in different parts of the world like Somalia, Brazil, Strait of Malacca near Singapore in South-East Asia and other.

2. The development of multipurpose amphibious ships and other multipurpose ships for special operation support

In the near future the SOF equipment will develop. The main development will be towards SOF personal security, intelligence, observation, different lethal and non-lethal weapons systems development and/or modernization, operations effectiveness, ports and special operations infrastructure and vessels security. The detection equipment will be developed for reason to detect enemy SOF, pirates and other threats. The rescue equipment will be developed. The multipurpose amphibious ships and other support ships are the excellent platform to help SOF do their tasks in the different parts of the world.

The different doctrines developed in recent past and present time have articulated the need of maritime forces that are mobile, flexible and versatile, able to react and/or redeploy quickly, capable of operating in crisis, conflict or humanitarian relief scenarios and able to sustain operations at reach for extended periods. These tasks are very close to tasks, what SOF do. So, the demands and requirements of SOF playing important role, when different types of multipurpose amphibious ships (MAS) and other support and battle ships are projected, developed, constructed and modernized.

Several navies in recent years developed requirements for MAS designs combining the multiple attributes of a multi-spot aviation capability; protected load/offload and berthing for watercraft; excellent command, control and communications (C3); organic medical/primary care facilities; possibility to support different operations and special operations and a large internal volume for the transport of personal and material. Given budgetary pressures, shipbuilders have sought to leverage mercantile standards and shipbuilding practices wherever practical to create what are essentially "hybrid" warships. The result is a new generation of affordable, European designed landing helicopter dock (LHD) vessels designed to be the centerpiece of a national or coalition task group. They are the multipurpose ships of the modern navy [2].

The advantages of hybrid ships are possibility to quickly install and change the equipment for different tasks. Because of these constructions one ship can perform different tasks, what can help reduce the number of ships in the navy, reduce the number of different ship types. The disadvantage is necessity to have special equipment for mission modules change, that make this ships more dependable from ports infrastructure. The exploitation costs are higher, because the construction of those ships is more complicate.

In this chapter author will analyze the several main types of MAS what are under development at present time and will be used in future for different special operations support in world seas and oceans and other tasks.

The different MAS types are used and will be used for SOF logistical, medical, information and intelligence support. The aviation groups, located on these ships can make air strike support, intelligence, material supply. The aircraft can be used for insertion and evacuation of SOF troops. The MAS is used and will be used for SOF support when they operate far away from their main home bases, making anti piracy and other special operations.

The 1st MAS type is "Mistral" class (France) command and projection ships of French navy. The first two of this class is in service for French navy from 2006, the third will follow in the end of 2012, 4th is planned. This MAS have been conceived to meet the French navy requirement for new capital platforms for undertaking crisis management and force projection missions, intended to enable force projection onto a lightly defended coast by air and sea, sustain force elements ashore and provide operational command and control, support for special operations [2].

The prime contractor for "Mistral" class of MAS ships is Shipbuilder Company DCNS (France), the main subcontractors is STX France Company and Stocznia Remontowa Gdansk Company. The "Mistral" class MAS displaces 21,500 tons fully loaded and 199 meter in length. Its design is characterized by a six-spot, 5,200 m2 flight desk, served by 2 elevators from a 1,800 m2

hangar below with capacity for a mix of 12-16 helicopters (NH90, AS532 Cougar, As 665 Tiger and SA342 Gazelle). The forward helicopter spot is strengthened to take a heavy rotorcraft of MV-22 or Sikorsky CH-53 class. The ship have the military lift capacity of 450 troops- rising to 750 in short term overload conditions-and a 2,650 m2 vehicle desk for 60 armored vehicles and 13 Leclerk main battle tanks (MBT) or 1,200 tons of cargo (a side ramp provides direct vehicular access from the dock-side). The stern well dock can accommodate 4 landing craft utility vessels, 2 landing catamarans and 2 landing craft air cushion hovercraft. This MAS class also holds the hospital with 69 beds and additional modular l\field hospital units may be embarked for humanitarian missions. Other modular facilities can be embarked according to missions. The ship has large staff planning facility, extensive communication set and combat management system to manage real time situation awareness and self-defense. The ship has all electric power and propulsion architecture. Four Wartsila diesel generators provide total of 20.8 MW for propulsion and services, 2 MERMIND 7 MW pod propulsors, in combination with a bow thruster and dynamic positioning system, offer exceptional maneuverability (design being able to turn around its own length). The maximum speed is 19 kt, with a range of 11, 000 n miles at a 15 kt cruise speed and its endurance is 45 days [2].

The 2nd MAS type is “Juan Carlos I” class (Spain) command and projection ships of Spanish navy. The single ship is in service for Spain navy from September 2010. These MAS have been conceived to meet the Spain navy requirement for undertaking crisis management and force projection missions, conducting expeditionary operations at extended range and endurance, provide operational command and control, support for special operations, air assault, amphibious operations, tactical sealift and humanitarian relief missions. The vessel is primary intended to support amphibious power projection and army lift but additionally lends itself to sea-control missions with a larger fixed-wing air group embarked, it also offers utility for non-combat and evacuation operations [2].

The prime contractor for “Juan Carlos I” class of MAS ships is shipbuilding company “Navantia” (Spain). This class ship design is arranged around 3 payload desks comprising the flight desk, a hangar and upper garage deck and a dock and lower garage deck. Cargo handling is enabled through a combination of lifts, cranes and access doors. The lifts comprise two 27-ton aircraft elevators linking the flight desk and hangar desk, a 5-ton ammunition lift bringing munitions up to the flight desk from a deep magazine, a 20-ton cargo lift operating between the upper and lower garage desks and a 2-ton provision lift linking the upper garage with a deep store. The well dock can accommodate 4 LCM-1E or LCM-8 landing craft plus 4 rigid inflatable boats. Alternatively, 2 LCM craft and single landing craft air cushion could be fitted inside. The lower garage desk stretchered to take vehicles like MBT is 1,400 m2. This area can be increased by a further 975 m2 if the dock is used as a garage, allowing for the embarkation of up to 46 MBT. Above, the upper garage space offers 2,046 m2 to accommodate lighter vehicles such as trucks and soft skinned vehicles. The adjacent hangar can hold up to 12 medium helicopters and a maximum of 7 McDonnell Douglas AV-8B Harrier II aircraft. The light vehicle garage can be used as additional hangar space when the MAS are operating with enlarged air group in the aircraft carrier role. In this case, up to 30 NH90-size helicopters or 20 Harrier II STOVL aircraft could be hangared. The flight desk itself is 202.3 meter in length and 32 meter wide, providing for the spotting of 4 CH-47 Chinook or 6 medium (Sikorsky Sea King or NH90) helicopters. A 12-degree ski-jump is fitted on the bow to improve the payload/radius performance of embarked STVOL aircraft. The embarked payloads can be tailored according to the exact nature of the mission. Turning to the humanitarian mission the internal cargo arrangement allows for the embarkation of multiple payloads like sanitation, medicine, stores, space for evacuated non-combatants and other. This class MAS is designed to support military force up to 1,200. The flag staff can be 103, a landing force 903, a beach recognition group of 23 and air wing of 172. The permanent ship complement number is 243. The operation complex have the operational and planning spaces, information center, join intelligence center, and combat management and communication systems. A medical complex combines a general sickbay with the fully equipped hospital area. The latter include 2 operating theatres, a triage area, an X-ray room, sterilization area, laboratory, an isolation room and intensive care ward/post-operative room (up to 8 beds). This MAS also adopts an all-electric power and propulsion architecture. The maximum speed is 19.5 kt when fully laden (27,079 tons). Endurance is 9,000 n miles at 15 kt. [2].

The different multipurpose logistic support vessels will be used for special operation support. The example can be the France ships builder DCNS proposed BRAVE multipurpose support ship project for French navy. Measuring 195 m in length, the new ship has a crew of 100 and will carry up to 60 troops or other passengers together with fuel, fresh water, ammunition, vehicles and other equipment, a naval force command team, a modular hospital and containers (for storage or special missions). There are 2 helicopter spots and launch and recovery facilities for autonomous underwater vehicles. Options for self-defense include remotely controlled weapon stations, a twin launcher for short range surface to air missiles and mounts for heavy machine guns. The vessel could be equipted with a combat management system. Maximum speed is 19 kt and range is 10, 000 n miles at 18 kt. [3]. Other types of multipurpose logistic support vessels is similar and designed to perform similar tasks, so author used description of this ship project as example.

Analyzing the literature about MAS and related ships development author made conclusion that other world navies, like Russia, Australia, Turkey and other, what want to build the MAS type ships for their tasks partner with leading MAS projects to develop and build these ships in future.

3. The development of different littoral combat ships for special operation support

The different world navies develop the ships and vessels, what is smaller, faster and more cost efficient that MAS ships. Mainly this ships and vessels is designed to operate in littoral waters, performing coast guard, special operation support and other different tasks close to coats and/or riverine waters.

In this chapter author will describe and analyze different types of that ships and vessels, what can support the naval and other special operations and is under development in present time and will serve in worlds navies in near future for naval and other special operations support and other tasks. This ships and vessels will be developed multifunctional, modular to perform different tasks and rapidly change performed roles.

The 1st example is Sweden’s Combatboat 90 (CB90) fast craft, what continues this development. The many navies take that type of vessels in their inventory and use them for special operation and other tasks. This vessel can carry 18 troops with equipment close to coast in shallow waters. The equipment for special operation support on land and water can be installed. The vessel can be armed with 120 mm Patria mortar systems, Lockheed Martin AGM 114 Hellfire missiles and other modular systems and armament according to performed SOF tasks. The speed of vessels can be 40 kt close to coast in swallow waters [4].

Because of the successful construction and development, this craft can be used in any shallow waters and flat beaches areas. Recently this craft undergo trials with Brazilian navy for use in Jungle Rivers, Amazon area. The craft is used in Mexican navy for SOF support in different swallow waters like rivers, beaches, etc. Because of this craft swallow water action capabilities the craft can be used for anti piracy operations in swallow waters close to coasts, beaches.

The 2nd example is Mark V (USA) special operation craft class (price 3.7 million $), what is in USA NAVY inventory from 1999. The next modernized upgraded and developed version is Mark V.1., what was made in 2008 and continues development. In this model the construction is made from composite materials instead aluminum with reduce weight to 57 tons, endurance is increased of 50% compare with Mark V. The length of that vessel is 24 meters, maximum speed is 50 kt and range is 431 n miles, settling 1.2 meter is the same, that Mark V, that allows operations in swallow waters close to coasts, what can be useful in anti piracy and other SOF operations close to coasts. The armament and special operation mission equipment is modular and quickly changeable [4].

The 3rd example is company “Zodiac” (USA) rigid inflatable fast boats (RIB) with possibility to install ballistic panels for protection from 7.62 mm ammunition hits. These companies “Armor Holding” panels can be installed in 40 seconds time. The other different equipment mission modules for SOF needs and performed tasks can be installed [5].

The 4th example is M80 “Stilletto” (USA) special operation craft, what is under trials in USA NAVY. The length of this craft is 27 metres, speed 50 kt, range 500 n miles. It can take 60 tons of cargo and have settling of 0,8 metres, that allows to operate this craft in costal swallow waters. This

craft can perform different special operation tasks, antipiracy operations and support for special operations. The approximate price of that craft is 6 million USD, but with additional equipment the price can reach 10 million USD. The craft have “Stealth” design and reduced detection possibilities with different infrared and other detection devices [5].

The 5th example is “Skrunda” class (Latvia) multifunctional patrol ship of Latvian navy. The ships construction is modular with possibility to install different mission containers for different missions, including special operation tasks. This is the first SWATH class ship in the world made for naval military needs. The SWATH ships is the new class of ships, that begun to develop from year 1999. The two MAN units on Skrunda are Type 2842 high speed diesels, each of 809kW at 2,100 rpm driving two Servogear controllable pitch propellers over Servogear reduction gearboxes. Trial speed was 21.4 knots using this redundant propulsion system but service speed is put at 20 knots with an operational radius of 1,000 nautical miles at 12 knots. The engines on “Skrunda “are also in the lower hulls, leaving more space for a crew of eight in the superstructure while even further personnel can be housed, if required, in a spacious wardroom [6].

The 6th example is the “Protector” (Israel) unmanned surface vehicle (USV), what was developed by the Israeli company “Rafael Advanced Defense Systems” in response to emerging terrorist threats against maritime assets. Based on a 9 meter (30-foot) rigid-hulled inflatable boat, the “Protector” is stealthy, fast and highly maneuverable. The vessel's low profile upper structure is sealed and aerodynamic, and its modular platform design allows it to be reconfigured to meet changing mission requirements, such as force protection, anti-terror, surveillance and reconnaissance, mine and electronic warfare. The hull is a deep V-shaped planning hull, with the inflatable section providing stability and endurance. A single diesel engine drives water jets, allowing speeds of 50 knots (92.6 km/h; 57.5 mph). The “Protector” offers enhanced surveillance, identification and interception capabilities. It is equipped with a Mini-Typhoon stabilized weapon system, a TOPLITE electro-optic surveillance and targeting system with day and night targeting capabilities through the use of forward looking infrared, charge-coupled devices and laser rangefinders, as well as a public address system. The Protector is remotely controlled and can be operated with guidance from a commander and operator located ashore or aboard a manned vessel. This allows it to provide the first line of defense, inspecting vessels of interest while personnel and capital assets are held at a safe distance. The 7,62 mm and 12,7 mm machine guns can be installed [7].

At the present moment “Protector” craft is used for Israel and Singapore navies for port and port infrastructure protection. The different USA institutions, like Coast Guard, Navy and special operation command (SOCOM) make trials to use this craft for their needs. By author’s opinion, this craft concept can be implemented in European Union (EU) ports, but trials are necessary, because climate differences, port location differences and legislation differences in different EU countries and ports locations. After the successful trials craft can be used for port surveillance and threat detection. The use of weapons is possible according with national and EU common legislation norms.

Conclusions

In this article author described and analyzed the role of special operations in world navies and SOF performed tasks. To support SOF tasks the world navies modernize and develop different types of support ships of different classes and sizes.

Author described and analyzed the development of MAS ships, different multipurpose logistic support vessels and ships and vessels, what are designed to operate in littoral waters, close to coasts and riverine waters. Author makes following conclusions:

Different MAS classes’ ships can deliver different capabilities from single platform like helicopter assault ship, amphibious platform, hospital ship, joint command platform, training ship and special operation support. MAS is planned to be flexible, versatile, modular and highly cost effective to sustain operations in high operation tempo. The multipurpose logistic support vessels differ from MAS, because they can`t perform amphibious assault operations to unprepared environment.

The different manned and unmanned littoral combat ships and vessels develop to perform special operation tasks in swallow waters close to coasts and riverine waters. This types of ships and

vessels is the choice of small countries navies, what can`t afford to have large military ships. The world's leading navies use this class ships and vessels to perform different special operation tasks, what larger ships can`t do. This ships and vessels is also planned to be flexible, versatile, modular and highly cost effective.

Different ships and vessels development programs in different world navies run to made warships that will be modular, affordable and multirole. The antisubmarine, air defense, counter terror (piracy) and different special operation and other general purpose and military variants are developed. Fuel reduction measures are taken. The work also continues on ships and vessels weapon system modernization and development.

The previous constructed ships and vessels of different classes are modernized to perform the tasks, what are important for modern navies. One of those tasks is special operation support. The different equipment, designed to protect ships and vessels from terrorist attacks are installed and developed. The different "stealth" and other technologies that help perform the covert operations are developed.

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INTERNATIONAL WORDS IN MARITIME ENGLISH

Marita Sausā

Latvian Maritime Academy, 5B Flotes St., LV – 1016, Latvia, E-mail: marita.sausa@latja.lv

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

KEYWORDS: *International words, borrowing, intercomprehension.*

1. International words in Europe

European internationalisms originate primarily from Latin and Greek. Many non-European words have also become international, often by way of one or more European languages.

International words are generated by new inventions, scientific and technological advances and are spread by speakers of one language living in geographical regions where other languages are spoken.

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

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

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

Engineer is one who contrives, designs, or invents; an author, designer.

The word *engineer* is derived from the Latin root *ingenium*, meaning “cleverness” [1]

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

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

These words constitute international scientific vocabulary i.e. a vocabulary of scientific and technical words, terms, formulae, and symbols that are almost universally understood by scientists and similarly used in at least two languages.

2. Conditions for Borrowing

The mere contact of two languages does not necessarily guarantee that one will borrow from the other. Speakers must have motives for the borrowing. People usually emulate those whom they admire, not only in speech patterns but also in all other respects.[2] Upper class Englishmen, in the

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

The spread of Christianity into England in the 7th century carried many Latin words into Old English as cultural loanwords: *abbot, pope, cap, sock*, etc.

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

In the course of history English has come in close contact with many languages, mainly Latin, French and Old Norse (or Scandinavian). However, in spite of Latin, Celtic and Scandinavian influence, the general character and vocabulary of Old English in the middle of the eleventh century was essentially that what it had been five centuries before, but in 1066 came the Norman conquest, an event which had more influence on the English language that any other from outside.

3. The Effect of Borrowing on the English Language

If we base our conclusions on the study of the forms recorded in dictionaries, it is very easy to overestimate the effect of foreign words. The actual number of native words is extremely small compared with the number of foreign borrowings recorded. On the other hand, if we examine spoken English in familiar conversation, we find the proportion reversed. It has been estimated that less than fifty words, all of them native words, suffice for more than half our needs [3]. The proportion of native words to foreign words will naturally vary with the subject matter and any article on scientific knowledge would naturally contain a high percentage of borrowings.

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

When in two languages we find no trace of the exchange of loanwords one way of the other, we are safe to conclude that these two nations have had nothing to do with each other. But if they have been in contact, the number of loan words will inform us of their reciprocal relations, the influence they have had on each other and in what domains of human activity each has been superior to the other. The study of language proves the fact that when one nation produces something that its neighbours think worthy of imitation they will take over not only the thing, but also the name. Loan words are nearly always technical words belonging to one special branch of knowledge or industry, and may be grouped so as to show what each nation has learnt from the other [4].

4. The Influence of Latin on English

Latin has since the earliest period of the history of English been one of the principal donor languages in the expansion of the English vocabulary. A great many of the lexical items which can ultimately be traced back to Latin have entered the English language indirectly via French and various other Romance languages, which together with Latin probably contributed almost two thirds of the word stock of present day English. All through the Middle Ages Latin played an important role as an official written language in England. A substantial part of Latin and Greek loans which have survived to the present day were first introduced as particular terms in science e.g. *theory (Gr), praxis (Gr), system (Gr), method (Gr), atmosphere (Gr),radius (L), formula (L), calculus (L), notion (L), concept(L), satellite(L), exist(L),* etc. Sometimes quite a number of English words come from just one Latin root. For example, the Latin word *vocare, vocatus vocare* - to call; *vocatus* – called - has produced a whole range of words in English vocabulary e.g. *provoke, provocative, evoke, evocative,*

convoke, convocation, vocation, avocation, voice, vocal, revoke, revocation, revocable, irrevocable, convocator, advocate, advocate, advocation, provocation, etc.

5. Prefixes and suffixes of foreign origin

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

Prefixes of foreign origin came into the English language ready made, due to syntagmatic loans from other languages: when a number of analysable foreign words of the same structure had been introduced into the language, the pattern could be extended to new formations. [5]

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

A basic knowledge of suffixes can increase vocabulary for the student of English. An understanding of just one common ending can have a significant effect on student performance in reading and writing e.g. Latin *–fy* to make or to become. The older English verbs in *–fy* are adoptions of Fr. Verbs in *–fier*, which are either adapted from Latin verbs or formed on the analogy of verbs. [1]

To *magnify* is to make bigger. To *reify* is to make into a king. To *fortify* is to make stronger.

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

6. The Role of Intercomprehension

The big problem of comprehension and intercomprehension involves recognizing language both grammatically and semantically. The process of *understanding* involves understanding the situation as well, and this relates the understanding of language to understanding the world.

The vocabulary of the sciences and other specialized studies consists of words or other linguistic forms current in several Romance languages and differing from Latin in being adapted to the structure of the individual languages in which they appear.

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

Table 1

English	*French*	*Italian*	*Spanish*	*Portuguese*
boom	**la bôme**	**il boma**	**la botavara**	
bows	**l'avant (m)**	**la prua**	**la proa**	**a proa**
bridge	**la passerelle**	**il ponte**	**el puente**	**a ponte**
cabin	**la cabine**	**la cabina**	**el camarote**	**a cabine**
captain	**le capitaine**	**il capitano**	**el capitan**	**o capitão**
compass	**le boussole**	**la bussola**	**la brújula**	**a bússola**
crew	**l'équipage (m)**	**l'equipaggio**	**la tripulación**	**a tripulação**
deck	**le pont**	**il ponte**	**la cubierta**	**o convés**
flag	**le pavillon**	**la bandiera**	**el pabellón**	**a bandeira**
funnel	**la cheminée**	**il fumaiolo**	**la chimenea**	**o funil**
headsail / jib	**la voile d'avant**	**la vela di prua**	**el foque**	**a vela de proa**
hold	**la cale**	**la stiva**	**la cala**	**a cala**
hull	**la coque**	**lo scafo**	**el casco**	**o casco**
keel	**la quille**	**la chiglia**	**la quilla**	**a quilha**
life boat	**le canot de sauvetage**	**la lancia di salvataggio**	**el bote salvavides**	**o bote salvavidas**
lighthouse	**le phare**	**il faro**	**el faro**	**o farol**
mainsail	**la grand-voile**	**la vela di maestra**	**la vela mayor**	**a vela principal**
mast	**le mât**	**l'albero**	**el mástil**	**o mastro**
oar	**la rame**	**il remo**	**el remo**	**o remo**
porthole	**le hublot**	**l'oblo**	**el ojo de buey**	**o olho de boi**
propeller	**l'hélice**	**l'elica**	**la hélica**	**a hélice**
bow	**l'avant**	**la prua**	**la proa**	**a proa**
purser	**le commissaire**	**il commissario**	**el contador**	**o comissário**
quarterdeck	**le pont arrière**	**il casseretto**	**el alcázar**	
radar	**le radar**	**il radar**	**el radar**	**o radar**
rudder	**le gouvernail**	**il timone**	**el timón**	**o timão**
sail	**la voile**	**la vela**	**la vela**	**a vela**
seaman	**le marin**	**il marinaio**	**el marino**	**o marinheiro**

seasickness	**le mal de mer**	**il mal di mare**	**el mareo**	**o enjôo de mar**
ship	**le bateau**	**il bastimento**	**el barco**	**o barco**
stern	**l'arrière**	**la poppa**	**la popa**	**a popa**
tiller	**la barre**	**la barra**	**la caña del timón**	**o leme**
tug	**le remorqueur**	**il rimorchiatore**	**el remolcador**	**o reboque**

Conclusions

Language can control or influence actions and attitudes. This controlling aspect of communication is important in maritime communications to make meanings clear and unambiguous in order to promote vessel safety. Intercomprehension based on the understanding of words in several Romance languages contributes to effective maritime communications. Relevant language structures in related languages express different kinds of social function in all manner of situations both ashore and afloat.

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UTILIZATION OF ACCOUSTIC EMISSION AS A SHIP`S DAMAGE PREVENTION METHOD

Andris Unbedahts*, Leonid Vindergauz**

**Transport Claims Consultants Network cvba, Keizerstraat 66, B-2000, Antwerpen,*
E-mail: andris.unbedahts@tccn.be
***Transport Claims Consultants Network cvba, Keizerstraat 66, B-2000, Antwerpen,*
E-mail: leonid.vindergauz@tccn.be

Abstract
Worldwide Maritime Statistics show that about 80% of marine incidents are caused by ¨the human factor¨. However, the remaining 20% still severely impact the economic performance of shipping companies. Ships` hull and engine defects caused by metal fatigue or poor construction quality are usually very expensive to repair. Additionally to the direct costs there are also indirect ones, such as forced lay-up, environmental impact etc. In certain cases, these costs can lead a shipping company to bankruptcy. Therefore hidden defect detection in at its starting point is very important. One of the most perspective methods to do so is the Acoustic Emission method.
KEY WORDS: *Acoustic Emission, damage, vessel*

Introduction

The Acoustic Emission (AE) technique (with sensitivity ranging from 20 kHz to 1 MHz) has a 40 year history of use for machinery condition monitoring. It has gained an even further widespread throughout the industry in the last decade. The particular strength of AE is its ability to directly detect the processes associated with wear and degradation of the materials at their early stage (including friction, impacts, crushing, cracking etc.). This is achieved by detecting and reading the surface component of stress waves that these processes invariably generate. These stress waves spread all over the hull`s and machines` surfaces, which means that sensor positioning is not critical and allows certain freedom in placing same in more convenient spots. Obviously, this is very important for application on board of a ship.

Main advantages of the AE technology are as follows:

- High sensitivity;
- Early and rapid detection of defects, flaws, cracks etc.;
- Real time monitoring;
- Relatively low cost;
- Reduces the ship`s downtime needed for inspection, since there is no need for scanning the entire structural surface.

1. AE technology

When we talk about a vessel's hull & machinery (H&M) condition monitoring, we mean monitoring the vessel's hull`s and machineries` ability to continue performing their intended functions in an efficient manner. Sometimes it is hard to use direct measuring methods, therefore indirect measurement techniques have to be applied. Currently there are a range of technologies allowing indirect Condition Monitoring (CM), but we believe AE can become one of the best, due to the following:

- time saving and efficient;
- instantly alerting of a presence of a fault in H&M;
- analysis of the trend of the damage can be used to forecast the critical time.

Measurements can be taken also with a portable AE based CM instrument. Today this instrument has its own standard - ISO 22096 (Condition monitoring and diagnostics of machines – Acoustic Emission) and is specifically listed in the CM standard ISO 18436 (Condition monitoring and diagnostics of machines – Requirements for qualification and assessment of personnel) as one of the four main CM techniques, together with Infra-Red Thermography, Lubrication Management & Analysis and Vibration Analysis.

Furthermore, AE based technology can be used to forecast such important metal defects as:

- Crack propagation
- Fatigue
- Corrosion, Stress corrosion

Types of monitoring:
- Continuous monitoring (preferable)
- Periodical testing

Currently the following types exist:
- Traditional acoustic emission
- Source-function and waveform analysis

1. Typical AE system setup. The AE sensors are generally very sensitive piezoelectric devices. As the traditional AE technique only uses AE features, the actual waveforms are not critical to this method
2. In recent years, due to the improvement of transducer technology, wide-band, high-sensitivity sensors have been developed to capture the whole waveform.

As already relayed above, one of the biggest advantage of the EA system is the flexibility of the sensors allocation on the hull and machinery elements, which can be placed in convenient spots. Fig. 1 shows an example of the allocation of the sensors on a ship’s hull for monitoring the integrity of same.

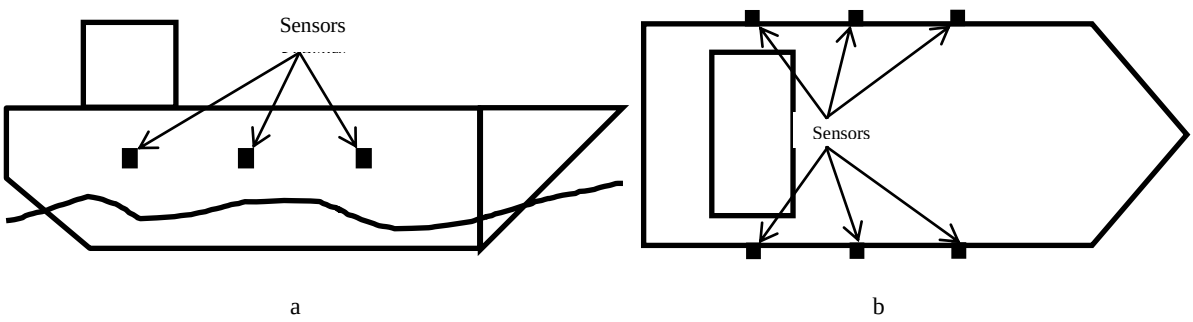

Fig. 1. Allocation of AE sensors on ship’s hull:
a – side view; b – top view

Fig. 2 provides an example of how the readings of AE sensors are received, visualized and can eventually be interpreted. The “spike” draws interpreter`s attention and allows for certain conclusions.

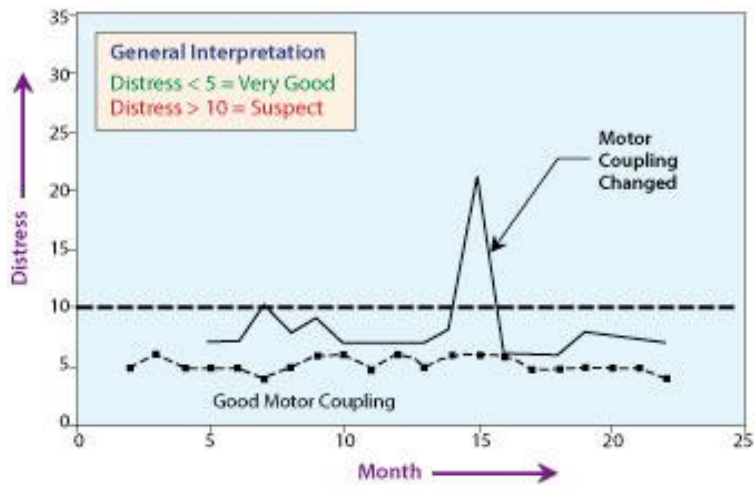

Fig. 2. Example of AE readings

2. AE application

Having relayed the theoretical concept of the AE system, we would like to further provide a number of real-life cases as examples of situations where the application of the AE technologies for damage detection would have prevented significant ship`s damage and consequential financial loss. However, for commercial privacy reasons we cannot disclose any names or provide any facts serving to identify the vessels and the parties involved. Furthermore, some minor details, not related to the actual topic of the paper, were changed for the same reason.

As a first example we would like to take a 4000TEU middle size containership, loaded up to about a half of her capacity with full containers, which suffered a sudden and unexpected crack in the crankshaft, resulting in heavy damage to the main bearing, and the breakdown of the engine. As in many similar cases, the problem was identified by noticing a rise of the temperature. While this served as a good alarm to prevent any further damage, it was actually a result of a damage which had already happened and, quite logically could not be prevented anymore. The main engine was immediately stopped in order to limit the damage, but AE would have allowed for an earlier warning, perhaps allowing preventing the breakdown at all.

As a result of the incident, the vessel has to be towed to the nearest port of refuge, where the full containers had to be transhipped on other vessels for further on-carriage to the corresponding consignees, arriving with significant delays. The vessel itself was put in lay-up for lengthy and costly repairs – replacement of the crankshaft and the bearing - thus bringing her out of service for a period for about half a year. Due to obvious reasons, we cannot disclose the exact figures, but we can advise that the repairs alone will cost over two and half a million Euros. In addition, one has to take into account the extra logistical costs for the transhipment and on-carriage operations, compensations for cargo consignees for late deliveries, vessel being out of service for an extensive period of time, surveyors and supervision costs and so on. The overall costs involved can easily be estimated to reach an astonishing amount of three and a half million Euros.

Currently the exact reason for the breakdown was still not yet certainly identified, but is suspected to be related to the bending forces affecting the crankshaft, originating from the cargo loading and distribution on-board throughout many years of the vessel`s operations. Which means that if the AE system would have been applied, it would allow identifying the problem a lot earlier and preventing the breakdown by applying the necessary preventive measures/amendments in due time - ranging from revision of cargo distribution patterns and up to replacement of the crankshaft. Needless to say, if applied in correct time these measures would have brought the overall costs down quite significantly. Furthermore, it would allow for similar measures to be applied to the vessel`s sisterships, which are now feared to soon start encountering similar problems.

a b

Fig.3. Damages suffered by the vessel
a – main bearing; b – crankshaft

Another example would be a rather large fishing trawler suffering damage to her gearbox while operating off African coast. The damage was identified when the crew heard a severe rattle coming out of the gearbox and seen lubrication oil gushing from it. As in the previous case – the damage was noted already too late to be prevented and the gearbox seized it’s functioning, depriving the vessel from her propulsion. Eventually, the vessel had to be towed a significant distance to the nearest port of refuge, where the necessary adequate repair facilities were available.

Upon investigation, it became obvious that some teeth of main gearwheel of the reduction gear and those of the secondary gearwheels were broken off. Although it was initially suspected that a foreign object got in between the gearwheels and has caused the damage, it later transpired that the accident was actually caused by the misalignment of the gearwheels, which gradually lead to grinding of the teeth and eventually to the mentioned incident and a major breakdown.

The costs involved are again quite impressive. The repairs alone would have taken 3-4 month and would have cost in between 200,000 and 350,000 Euro. In addition to that towage expenses, 3-4 month being out of service, surveyor and supervision costs and so on have to be added. All in all, the owners of the vessel were facing about a half a million to a million Euros expenses in relation to this incident.

If the AE damage detection system would have been applied on this vessel, the damage could have been identified at a lot earlier stage and consequently easily prevented by simply fixing the alignment of the gearwheels. This, of course, would require the owners to go through certain expenses, but in comparison to the consequences of the incident – they can be considered neglectable.

Third and final example is of a small elderly general cargo coaster, loaded with a consignment of grain in bulk. This vessel, due to her age, lack of proper hull maintenance and unfavourable weather conditions, has suffered from multiple cracks in her hull and heavy ingress of water. Initially the damage was noted by an extraordinary change in the vessel`s angle of list and was later confirmed in a most obvious way – by actually seeing the water gushing in through fresh openings in the hull. The vessel had to urgently proceed to the nearest port of refuge, hoping for her equipment to be sufficient to pump out the entering water and to remain afloat, which she eventually managed to do.

We believe this example to be interesting not only regarding the vessel’s structural damage, but also from her P&I point of view. The ingress of salt water has penetrated into the holds and damaged the cargo beyond the point at which it still could have been accepted by the consignee. The latter has arrested the vessel and presented the owners with a cargo claim for several hundreds of thousands of euros. Apart from the cargo claim the owners were also facing the costs of repairs needed to bring the vessel back into service, which, judging the overall condition of her wasted hull and her age might have made the vessel a constructive total loss.

Application of AE would have given a clear sign that the vessel`s hull is far from a perfect condition and that a laden sea voyage is highly not recommended, due to excessive risk. Should the

owners have wished to keep the vessel in service – the system would have indicated which hull areas are requiring immediate repairs and would have certainly alarmed the owners not to accept cargo, thus avoiding an eventual cargo claim.

Conclusions

The most important contribution of AE to industry is that AE can provide early warnings of severe and sudden failures, the most dangerous characteristic of which is that they usually happen without a warning or with very insignificant warnings. AE can be efficiently used to detect the accumulation of microdamage inside components, especially during service, and allow for these failures to be identified and, possibly, prevented.

The use of AE will become more prevalent because it can provide unique insights into damage processes. However, the AE technology is not fully developed yet and still needs some improvements, such as noise reduction, reliability, and reducing some problems with waveform analyses. These needed improvements represent areas of future endeavor in AE science and technology. There is also a great need for further research.

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APPLICATION OF DIFFERENTIAL CALCULUS

Jevgenija Kovalova, Voldemārs Barkāns

Latvian Maritime academy, Flotes iela 5B, Riga, LV-1016, Latvja;Voldemars.Barkans@inbox.lv

Abstract

The aim of the mathematics course of bachelor's degree programme:

- *to solve practical tasks;*
- *to develop independent learning skills;*
- *to develop logical thinking;*
- *to develop ability to achieve goals;*
- *to build a mathematical model of the problem and solve it.*

Introduction

Every subject contains information necessary to become a knowledgeable and functional member of our society. As we become more technologically dependent, technical reasoning is needed for survival.

Bachelor degree programs in technical mathematics course designed to familiarize students with the mathematical methods, as well to solve practical tasks in the specialty, students develop independent work skills, develop logical thinking, the ability to reach a planned target.

One of the most important and most difficult tasks is to learn the skills to express mathematical language. Differential equations play a prominent role in engineering, physics, economics, and other disciplines, which in fact are used to solve these equations. Some illustrative examples will be shown in this project.

Problem 1. Parabolic mirror. Establish, what should be the shape of the searchlight mirror in order for a pointed source of light to be reflected as a beam of parallel rays.

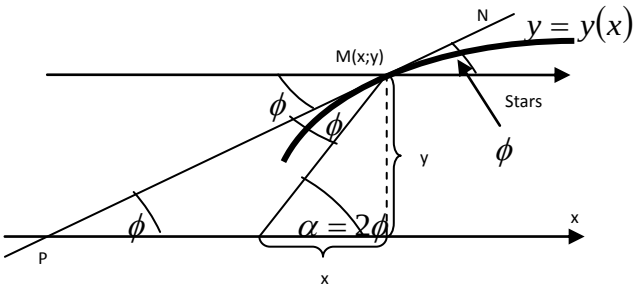

Fig. 1 Parabolic mirror

Solution. Due to its symmetry, mirror has a shape of rotation surface. We will see that the mirror has a shape of rotation paraboloid.

Let's assume that initial point of coordinates is the same as source of light, but the Ox axis direction of abscises is the same as direction of beam of rays.

We look at assumed section line of surface y = y(x) in the plane XOY (Fig.1) and freely choose a point on this line M(x;y). At the point M we mark a tangent PM for the line y = y(x). Angles PMO and KMO are identical, as angles of falling ray OM and reflected ray. Angle MPO is angle of curve tangent PM direction: $k = tg\phi = y'(x)$. All three of these angles are equal (Fig.1) and $\alpha = 2\phi$.

Therefore

$$tg\alpha = tg2\phi = \frac{2tg\phi}{1-tg^2\phi} = \frac{2y'}{1-y'^2} \tag{1}$$

or (Fig. 1)

$$tg\alpha = \frac{y}{x}. \tag{2}$$

We arrive at first order homogenous (nonlinear) differential equation:

$$\frac{2y'}{1-y'^2} = \frac{y}{x} \quad \Rightarrow 2xy' = y\left(1-y'^2\right) \tag{3}$$

From the equation (3) we get:

$$y' = \frac{-x \pm \sqrt{x^2+y^2}}{y} \tag{4}$$

and introduce new unknown function:

$$u = \frac{y}{x}; \qquad \Rightarrow y = ux; \qquad y' = u'x + u \text{, where } u' = \frac{du}{dx} \tag{5}$$

After introduction of new variables in the equation (4), we separate variable and integrate:

$$\int \frac{udu}{\sqrt{1+u^2}\left(-\sqrt{1+u^2} \pm 1\right)} = \int \frac{dx}{x} + \ln C \tag{6}$$

For the integral at the left side of equation we make substation of integration variable:

$$1+u^2 = t^2; \qquad \Rightarrow 2udu = 2tdt \tag{7}$$

and by integration we arrive at:

$$-\ln\left|-t \pm 1\right| = \ln x + \ln C. \tag{8}$$

Applying formulas (5) and (7), from (8) we get:

$$\sqrt{1+\left(\frac{y}{x}\right)^2} \pm 1 = \frac{C}{x}. \tag{9}$$

After removing square root and making changes in constant C, we arrive at parabolic equation:

$$y^2 = 2Cx + C^2. \tag{10}$$

When parabola (10) rotates around Ox axis a surface is created, which is called a rotation paraboloid.

Problem 2. Radioactivity. The disintegration speed of radium is proportional to quantity of substance Q. We know that after time of t_1 only half of the initial quantity Q_0 is left. Calculate amount of radioactive radium left after time of $t = \frac{t_1}{10}$.

Solution. The speed of radium disintegration $\frac{dQ}{dt}$ is proportional to amount of substance **Q**. Therefore we can write an equation:

$$\frac{dQ}{dt} = -kQ, \tag{11}$$

where k is proportionality coefficient.

After separation of variable and integration, we get:

$$\frac{dQ}{Q} = -kt; \qquad \Rightarrow \qquad \ln Q = -kt + \ln C; \qquad \Rightarrow \qquad Q = Ce^{-kt} \tag{12}$$

If t = 0, then $Q = Q_0$, from (12) we arrive at $C = Q_0$. Therefore:

$$Q = Q_0 e^{-kt}. \tag{13}$$

If $t = t_1$, then $Q = 0{,}5Q_0$, from (13) we get $0{,}5Q_0 = Q_0 e^{-kt_1}$ and calculate $k = -\frac{\ln 2}{t_1}$.

From (13) it follows:

$$Q = Q_0 e^{-\frac{t}{t_1}\ln 2} = Q_0 \cdot 2^{-\frac{t}{t_1}}. \tag{14}$$

If $t = \frac{t_1}{10}$, then from the formula (14) we get $Q = Q_0 e^{-0{,}1} \cong 0{,}9Q_0$.

Problem 3. Sinking body. Body is slowly sinking in the water. Calculate draught s, depending on the time t, if at the starting point t = 0 is s = 0 and v = 0.

Solution. Sinking speed **v** and acceleration **a** are mutually related by the formula:

$$\mathbf{a = g - kv}, \tag{15}$$

where **k** and **g** are constants.

Since the speed is derivation of road by the time $v = \frac{ds}{dt}$, but the speed – derivation of speed by the time $a = \frac{dv}{dt} = \frac{d^2 s}{dt^2}$, by applying relation (15) we arrive at equation:

$$\frac{d^2 s}{dt^2} + k\frac{ds}{dt} = g. \tag{16}$$

Differential equation (16) is a linear non-homogenous differential equation with constant coefficients. So the solution can be expressed as a sum of respective homogenous differential equation's

$$\frac{d^2 s}{dt^2} + k\frac{ds}{dt} = 0. \tag{17}$$

general solution

$$\bar{s} = C_1 + C_2 e^{-kt} \tag{18}$$

and of a particular solution of a given non-homogenous equation

$$s^{\bullet} = \frac{g}{k} t \tag{19}$$

which is:

$$s = \bar{s} + s^{\bullet} = C_1 + C_2 e^{-kt} + \frac{g}{k} t\,. \tag{20}$$

In order to calculate integration constants $C_1 \quad un \quad C_2$, we find a time dependant speed:

$$v = \frac{ds}{dt} = -kC_2 e^{-kt} + \frac{g}{k}\,. \tag{21}$$

If t = 0, s = 0, v = 0, then from (20) and (21) we get:

$$C_2 = -C_1 = \frac{g}{k^2}\,. \tag{22}$$

These constants are placed in the formula (20) and the result is written:

$$s = \frac{g}{k^2}\left(e^{-kt} - 1\right) + \frac{g}{k} t\,. \tag{23}$$

Conclusions

Differential equations are mathematically studied from several different perspectives. Differential equations can be used for many purposes, but ultimately they are simply a way of describing rates of change of variables in an equation relative to each other. Many real world events can be modeled with differential equations, this mathematical method brings you the opportunity to enter and experience a unique, global learning environment.

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THE GLOBAL WARMING IMPACT ON TEMPERATURE AND WATER LEVEL CHANGES IN LATVIA

Viesturs Bērziņš*, Aleksandrs Pavlovičs, Ilmārs Lešinskis**

**BIOR Fishery Department, Marine laboratory,8 Daugavgrīvas str., Riga, Latvia*
E-mail:Viesturs.Berzins@bior.gov.lv
*** Latvian Maritime Academy, 5B Flotes str., LV-1016, Latvia, E-mail: info@latja.lv*
**** Riga Technical University, Kaļķu-1, LV-1658, Latvia, E-mail: Ilmars.Lesinskis@latja.lv*

Abstract
The title analyses fluctuations and changes of some hydrometeorology parameters of Latvian coastal area in relation with the global warming, covering the time period of last centuries: water temperature changes in Bay of Riga, air temperature changes in the City of Riga, as well as the alterations of the water level in Venstpils and Daugava river basin. The findings reveal, that last centuries dynamic of the air temperature fluctuations is being expressed as the cyclic process, however, there is not considerable temperature growth monitored. The average tempo of water level growth in the area is considerably less than as compared with the records from last Glacial Era's final phase. The global warming process is being continuing after the end of last Glacial Era up to now, and there is no solid ground for assumption, that this process has been facilitated nowadays.
KEY WORDS: *temperature, levels of water, globalwarming*

Introduction

So called "global warming" trends, the process which is being continuously discussed and described during last decades, is directly associated with the common tendencies of water and air temperature growth, as well as augmentations in the levels of water and other different climatic phenomenon and processes. Hereinafter some hydrometeorology parameters of Latvian coastal area are being analysedin direct relation with the warming; namely,temperature changes in Bay of Riga, air temperature changes in the City of Riga and in vicinity, as well as water levels alterations in the Ventspils and Daugavgriva (Daugava river basin).

Data provided from Fishery Department's Marine laboratory (BIOR) has been used for dynamic of water temperature changes in the Bay of Riga (before 1991 – Baltic Fishing Industry Research Institute, BaltNIIRH, 1991-2004 – Latvian Fishing Research Institute, LZPI, 2004-2010 – Latvian Fish Resource Agency, LZRA). Average water temperaturein the Bay of Riga is being calculated using the observations, which are equalized in adherence to average seasonal calendar datum and in pro-rata to layers volumes [1].

Air temperaturedata series for the City of Riga are erratic due to changing methods of observations in the Riga and vicinity, as well as there are some time-gaps in observations. Since 1795 up to 1960 observations were conducted in the University of Riga-with the omissions at time periods from 1814 till 1823. In some time periods observations have been conducted in Jelgava, Spilve, Daugavgriva,suburbs of St. Petersburg and these observations have been rendered to related data from Riga, using transient coefficients [2]. At time period from 1960 to 1973, observations have been conducted in Riga Observatory; from 1973 to 1991 at Riga Airport [3]. The period 1992- 2009 is covered by dynamic observation data from Website FOBOS, weather station at Riga Airport, http://www.gismeteo.ru/catalog/latvia/; further observations after 2009 have been extracted from Webiste WINDGURU, from location in Riga (Kisezers DA), Web: http://www.windguru.cz/.

Observations on the water levels alterations in Ventspils and Daugava river basinare retrieved from the publications of Latvian Hydrometeorology Administration [4].

This research implements calculations and parameters-related average indicators and values in the profile of perennial dynamic. The changes of the parameters per 100 years have been calculated; for instance, temperature changes ºC/100 years, or water level changes cm/100 years.

1. Temperature

The analysis of water and air temperature data for time period from 1963 to 2011 delivers impression, that Global Warming process is ultimately in force, because average air temperature has grown up by 4.1 ºC/100 years, and, accordingly, water temperatureby 2.3 ºC/100 year. The correlation factor between these two parameters is 0.8, meaning tight mutual alignment of data (Fig.1).

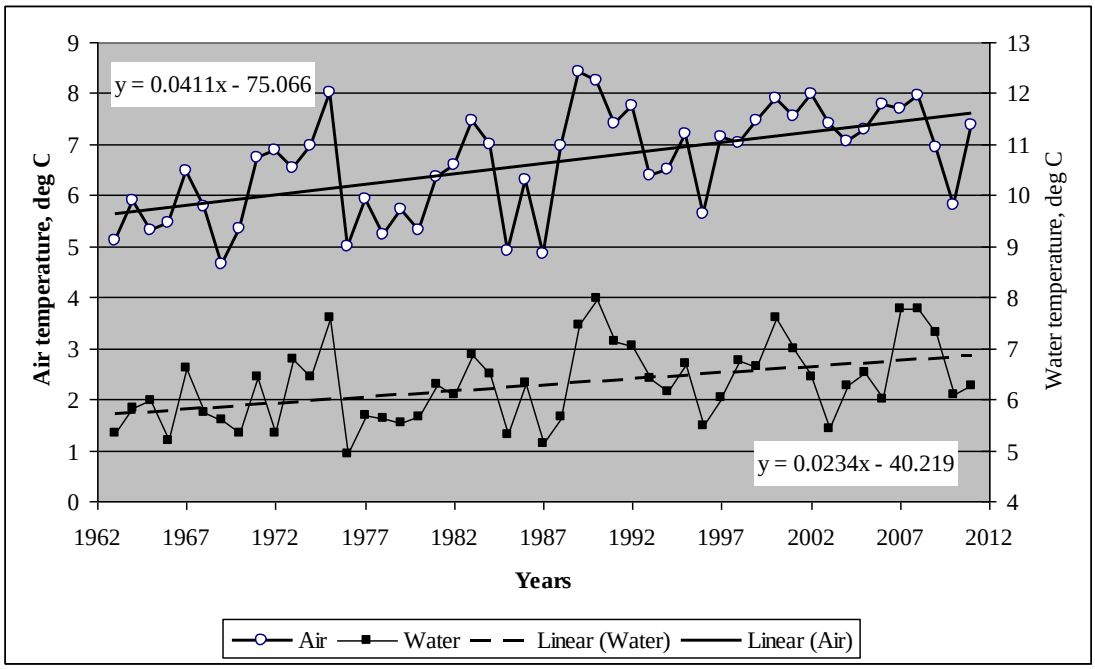

Fig.1. Annual average air temperature measurements in Riga and water temperature in Bay of Riga at time period 1963-2011

However, analysis of the data for longer time period provides the dynamic of considerably less air temperature growth. Average growth for several previous centuries is just 0.31 ^{o}C/100 years, and, when calculation time span is being widened up, the trends of temperature growth considerably decrease accordingly (Fig.2, Table 1).

The above mentioned data quite clearly demonstrate, that concept and assumption about the existence of Global Warming as a reality phenomenon is strongly doubtful, at least within the region of the Baltic Sea. The processing of these data leads to an assumption, that there are short term and long term natural cycles of climatic changes, and yet, we are not quite capable to figure them out. There are some written literary approvals on that, for instance, the book by O. Aboltins about the natural processes at time period after the glacial era and global warming, as well as other written materials. So, for instance, book of Aboltins describes the trends of temperature changes upon the end of last glacial era, when there were at least three particular periods of time with much high average air temperature compared with nowadays. These periods of higher temperatures occurred nearly 2000 years before, 4000 years before, and 6500 years before. It means that there is no solid ground for stipulations, that intensive temperatures growth is being observed only within the period of last centuries [5, 6].

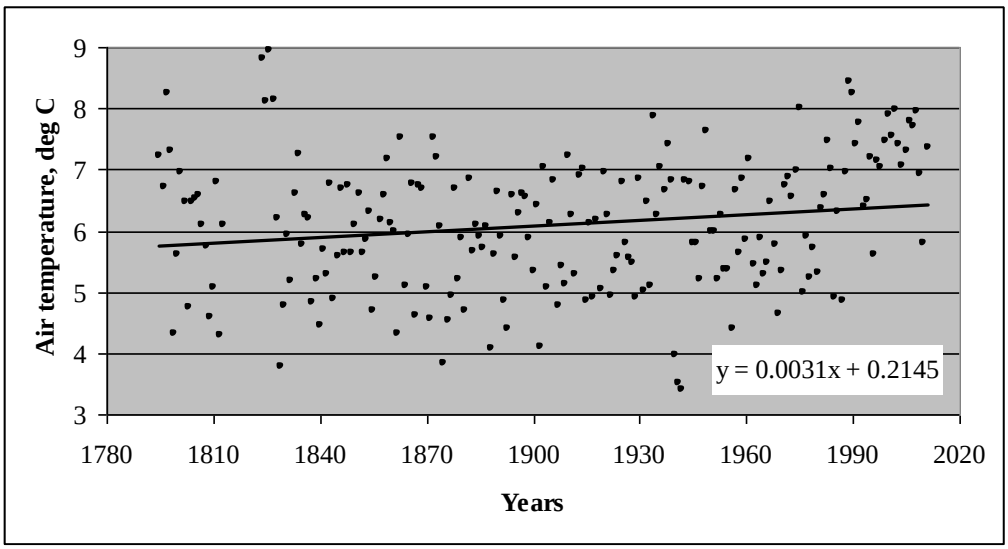

Fig. 2 Average air temperature changes in Riga at time period from 1795 to 2011

Table 1

The general tendency of air temperature changes in Riga, at value of ^{o}C/100 years for different periods

Time period years	1795-2011	1840-2011	1900-2011	1960-2011
Tendency of air temperature changes, ^{o}C/100 years	0.31	0.69	1.37	3.73

2. Levels of water

Levels of water are being influenced by astronomical conditions, fresh water balance, uneven atmospheric pressure, and wind /water density mutual rates. Water level changes in Baltic Sea are being under direct impact from endogenous fresh water flow fluctuations, changes of atmospheric pressure and winds; there are some direct relations of such changes with melting of ice cover and Earth crust's vertical shifts. This title covers annual average changes of the levels of water in Ventspils and Daugavgriva at time period from 1873 to 1968. Both locations are characterized by clear tendency of water level growth – in the Daugavariver the level of water has grown by 20.5 cm per 100 years, in Ventspils water level has grown by 4.4 cm/100 years (Fig. 5).

The interest sparking finding is that the average speed (rate) of water level growth in both locations is quite different. This difference could be explained by Earth crust's lithospheric vertical shifts in Baltic region. There are no significant vertical lithospheric shifts in Daugavgriva, but average vertical lithospheric movement rate in Ventspils is about 0.6-1.0 mm/year, providing 6-10 cm/100 years [7]. The assumption is that water level fluctuations in Daugavgriva are in direct relation with the trends of Ocean water level, in turn, Ventspils indicators are under impact from Earth crust's lithospheric vertical shifts.

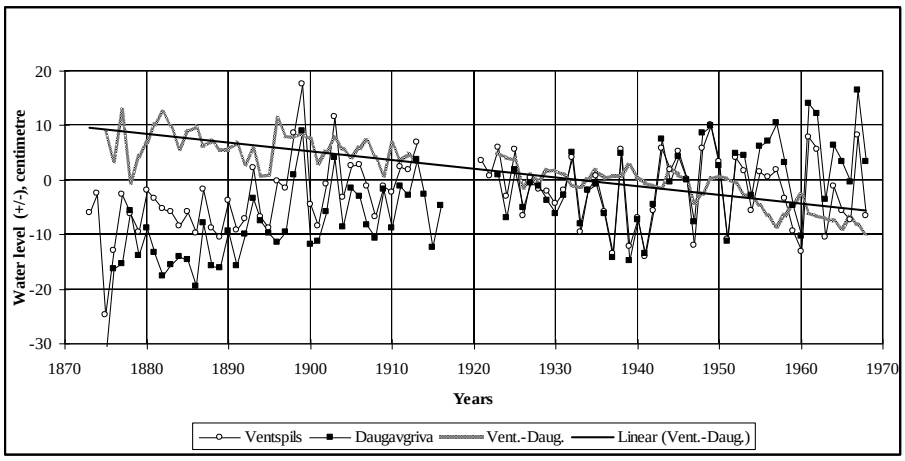

Fig. 3 Changes of the level of water in Ventspils and Daugavgriva (river basin) at time period of last centuries

At times of Glacial era (~12000 years before), the oceanic water levelwas approximately 60 meters lower than nowadays, and average water level growth rate until now is 50 cm/100 years [8]. Making the comparison of water level growth rate at time period of last centuries and after the last Glacial era, we can assume, that current growth rate is at least three times less than latter. It means, that general ice melting rate is considerably decreased and there is no ground for a statement, that last centuries are associated with the intensive water level growth.

Conclusions

Upon the analysing of air temperature and water level changes in Latvian coastal area, in a context with other associated researches, we can conclude as follows:

- The analysis of air temperature data in different profiles leads to the conclusion, that nature has short term, middle term and long term climatic conditions cyclic variations;
- The rate of water levels raise at time period of several previous centuries is three times less than this rate at period after the final stage of last Glacial era;
- The process of global warming has started after the final stage of Glacial era and is progressing up to nowadays, and there is no ground for statement, that the process has being facilitated.

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DETERMINATION OF APPROPRIATE TORSIONAL VIBRATION DAMPERS FOR A SHIP PROPULSION PLANT

Fatih Cüneyd Korkmaz*, Fuat Alarçin

**Yıldız Technical University, Barbaros Bulvarı Besiktas ,Istanbul, E-mail: fkorkmaz@yildiz.edu.tr*
***Yıldız Technical University, Barbaros Bulvarı Besiktas ,Istanbul, E-mail: alarcin@yildiz.edu.tr*

Abstract
Unstable working performance of main engine and some other external disturbances are the main reasons for vibration of propulsion plant of a ship. The most efficient encountered vibration is torsional vibration by reason of unsteady power loads and inertia forces on the ship main engine-shaft system. Crankshaft balancing weight as a passive system and torsional damping element as an active system are used in order to prevent this type of vibration. In this study angular motion of the main engine-shaft and propeller plant was modeled using Lagrange Method and damping elements were added to the composed model to decrease the torsional vibration effect. Different damping values were tried to find appropriate torsional amplitude and velocity for the model. As shown in simulation results, torsional vibration values of propeller-shaft system being up to ABS standards were obtained.
KEY WORDS: *Ship main engine propulsion systems, vibration analysis, Lagrange equation*

Introduction

Vibratory forces generated in ship propulsion systems by some internal sources such as; main engine, shaft, propeller, gearbox and by some external sources such as wave, current and imbalanced ship loads are often unavoidable. These forces have influence on axial, radial and torsional vibrations. However their effect on propulsion system can be minimized or reduced by different isolation methods. One of these methods the use of springs and damping elements for isolation between main engine and its foundations.

Rao [1] modeled the power transmission system with spring and damping element as four-degrees of freedom system. Damping elements of the system were positioned between main engine and gearbox to reduce torsional vibration, and between thrust bearing and propeller to reduce lateral vibration. The springs were placed in between main engine, gearbox, bearings, propeller and foundations. Radial forces and propeller thrust forces were thought of as moving forces on main engine and propeller respectively. The equations of model were solved theoretically and then calculated values of torsional vibration were compared to practically measured values. Some of the calculated and measured values of frequencies are very close, while there are differences between them for some cases, which is recognized as suitable for ISO vibration standards.

Shu et al.[2] expressed torsional and axial vibrations of the engine crankshaft with Rayleigh differential method. The engine crankshaft was modeled as a mass spring system to obtain easily natural frequency of torsional and axial vibrations. Calculated results were compared with measured results and it is recognized that torsional vibration has an enormous effect on axial vibration that causes noise and vibration in engine.

Grzadziela [3] carried out a study by using Matlab-Simulink, in which a propeller shaft system has four-degrees of freedom. In this study, the rotation torque of the main engine, fixed blade propeller torque, axial force and the shaft line bearings hydrodynamics effects have been taken into consideration. Model was established by using the Finite Element Method, the propeller shaft speed ranges in different frequency values were determined according to different forms of support. Simulation results showed a maximum 10% error with the measured values converges.

Hara et al.[4] established a main engine propeller shaft system with building block approach and analyzed the torsional, axial and lateral vibrations. The three dimensional solid model of the

crankshaft was analyzed by using the FEM and the equivalent beam model was constructed. Propeller was modeled as a rotor, the properties like weight, inertia and polar moment of inertia were entered to the equations and the additional mass of water was also taken into account. Bearings and rigidity of the body were considered as a spring in the model established. Vibration dampers placed in different positions were analyzed. Then results of the model were compared with measured results. Because main engine shaft system has many elements having damping effect, it can be concluded that predictions of these approaches for the model need to be accurate.

Zhang et al.[5] investigated the influence of angular and axial forces acting on propeller by modeling propeller and crankshaft. Frequency changes in torsional vibrations have been observed between the propeller and 1st order crankshaft journal, and between 5 th and 6 th order piston crank journals. For axial vibrations, on the other hand, changes in frequency values are expressed almost the same. Considering of coupled vibrations a nonlinear behavior effect was observed. They determined that large amount of errors would be experienced, when the propeller crankshaft analysis was assumed to be linear.

MacPherson et al. [6] investigated methods to calculate the additional water mass of a propeller for vibration analysis. In this paper the effect of added mass on the torsional and axial vibrations of the propeller was examined. In order to calculate the added water mass of Weldsma BS-VII series of propellers a new formula and a new prediction was performed. The authors indicated that this prediction method would be beneficial for vibration analyses of propulsion systems because the reliability of the method have increased by the contribution of damping effect.

In this study main engine, shaft and propeller system was modeled by Lagrange Method and the model was solved by using Matlab-Simulink. Analysis of torsional vibration was put emphasis because it causes hazardous vibration. The aim of this paper is to apply an appropriate torsional damper with using different coefficient.

1. Torsional Vibrations Modeling of Main Engine and Propulsion Plant

Kinetic, potential and damping energy were considered and described in form of Lagrange Equations [7];

$$\frac{d}{dt}\frac{\partial T}{\partial \dot{q}_i} - \frac{\partial T}{\partial q_i} + \frac{\partial U}{\partial q_i} + \frac{\partial D}{\partial \dot{q}_i} = Q_i \tag{1}$$

where

T: Total Kinetic Energy,
U: Total Potential Energy,
D: Total Damping Energy,
Q_i: Generalized forces (i=1,2,3,…,n),
q_i: Generalized coordinates (i=1,2,3,…,n),

General formulation is represented the dynamic behavior of the mechanical systems in matrix form is expressed as follows.

$$[\mathrm{M}]\{\ddot{x}\} + [C]\{\dot{x}\} + [\mathrm{K}]\{\mathrm{x}\} = \{F_x\} \tag{2}$$

where

[M], [D] and [K] indicate mass, damping effect and spring matrix respectively. F_x express as a vibration disturbance effect and {x} represent displacement. As stated Fig. 1 is single degree of freedom. Motions of shaft propeller model are implemented by Lagrange method.

Ships are enforced by many different dynamic and hydrodynamic forces. These forces are occurred due to inside of the ships and also external loads. Large diesel reciprocating main engines leads to an important force at low frequency. Ship propeller blade rate cause pressure fluctuations and these changes cause vibration at the form of ship. If these internal and external shocks and harmonics frequencies of the force encounter natural frequencies of the structure, a resonant condition will occur.

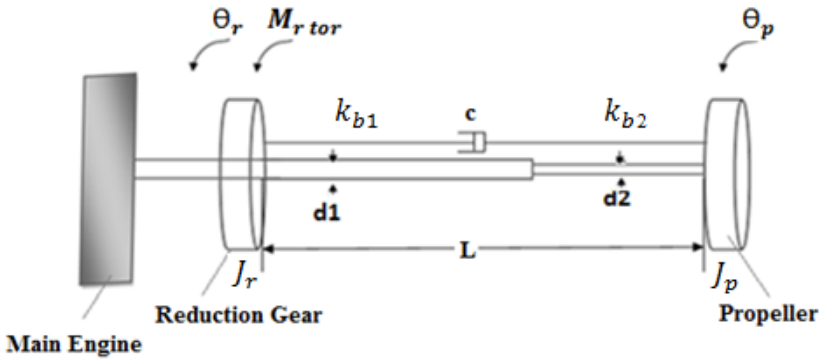

Fig. 1. Main engine and shaft simplified model

The simplified shaft system consists of the main engine, shaft and propeller.

$$\begin{gathered} \mathrm{T} = \frac{1}{2} J_r \dot{\theta_r}^2 + \frac{1}{2} J_p \dot{\theta_p}^2 \\ \mathrm{U} = \frac{1}{2} k_{b1} (\theta_r)^2 + \frac{1}{2} k_b (\theta_r - \theta_p)^2 \\ D = \frac{1}{2}\, c(\dot{\theta_r} - \dot{\theta_p})^2 \end{gathered} \tag{3}$$

where

J_r= reduction gear inertia J_p=propeller gear inertia
C= damping coefficient k_{b1}= stiffness factor
k_{b2}=stiffness factor $M_{r\,tor}$= reduction gear torque
θ_r= reduction gear angular displacement L= distance from propeller to reduction gear
θ_p=reduction gear angular displacement
In the Lagrange equation method to derive to dynamic equations of this system:
where in prospect of $\theta_r > \theta_p$

$$J_r . \ddot{\theta_r} + c * (\dot{\theta_r} - \dot{\theta_p}) + k_{b1}\Theta_r + k_b(\theta_r - \theta_p) = M_{r\,tor}$$

$$J_p . \ddot{\theta_p} - c * (\dot{\theta_r} - \dot{\theta_p}) - k_b(\theta_r - \theta_p) = 0 \tag{4}$$

$$\begin{bmatrix} J_r & 0 \\ 0 & J_p \end{bmatrix} \begin{bmatrix} \ddot{\theta_r} \\ \ddot{\theta_p} \end{bmatrix} + \begin{bmatrix} c & -c \\ -c & c \end{bmatrix} \begin{bmatrix} \dot{\theta_r} \\ \dot{\theta_p} \end{bmatrix} + \begin{bmatrix} k_b + k_{b1} & -k_b \\ -k_b & k_b \end{bmatrix} \begin{bmatrix} \theta_r \\ \theta_p \end{bmatrix} = \begin{bmatrix} M_{r\,tor} \\ 0 \end{bmatrix}$$

Natural frequencies can be determined in case of vibration without forces.

Let

$$\theta = \theta \sin(\omega_n t)$$

Thus, from

$$\begin{bmatrix} k_{b1} + k_b - J_r . \omega_n{}^2 & -k_b \\ -k_b & k_b - J_p . \omega_n{}^2 \end{bmatrix} \begin{bmatrix} \theta_r \\ \theta_p \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \tag{5}$$

Here $\theta_r = \theta_p = 0$ is a solution. However, this solution means, motion of the system equal to zero that acceptance. Here is the solution make the desired solution is not equal to zero uniformly;

according to the linear algebra determination of the design matrix on the left column must be equal to zero.

$$\det|\Delta|=0$$

$$(-J_r.\omega_n{}^2 + k_b + k_{b1}).\left(k_b - J_p.\omega_n{}^2\right) - k_b{}^2 = 0$$

$$-J_r.\omega_n{}^2.k_b + J_r.J_p.\omega_n{}^4 + k_b{}^2 - J_p.\omega_n{}^2.k_b + k_b.k_{b1} - J_p.\omega_n{}^2.k_{b1} - k_b{}^2 = 0$$

setting

$$\omega_n{}^2 = \lambda$$

The complete solution can be written as;

$$J_r.J_p.\lambda^2 + \lambda\left(-J_r k_b - J_p k_b - J_p k_{b1}\right) + k_b.k_{b1} = 0$$

$$\lambda_1 = 103.8258 \text{ and } \lambda_1 = 1.2375$$

Thus, the natural frequencies were determined as 10.189 rad/s for reduction gear and 1.112 rad/s for propeller.

2. Torsional Vibration Response of Calculation and Analysis

In this study, fishing boat has been taken a base which particulates are length 20 m, width 5.7 m, depth 2285m and MAN 8L 32/40 is considered as a main engine. The considered ship and propulsion system is shown in Figure 2.

Torsional vibrations occupy because inertia forces (due to resistance elements formed in the rotary shafts) try to block angular displacement of two points at rotating shafts. Torsional vibration is not distinctive as bending vibration at bearings and should be control in depth. Without any signs, torsional vibrations give rise to very dangerous consequences (Maurice [8]).

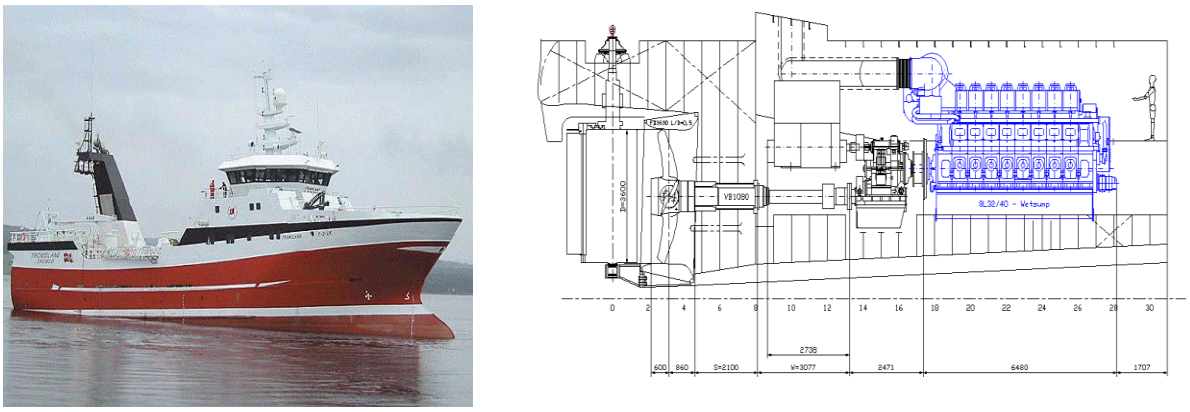

Fig. 2. Base on ships and main engine, propulsion systems (MAN [9])

The main engine that considered consists of 8 cylinder diesel engine. It is assumed that the engine is operated at the constant speed of 750 rpm. The specific parameters about this engine are all given in table 1 for calculating the torsional vibration.

Table 1

Main engine particulars

MAN 8 L 32/40	
Piston Stroke	40 cm
Cylinder bore	32 cm
Number of cylinders	8
Power	4000 KW
Speed	750 rpm

The torsional angles have obtained by running the matlab programs. Ship main engine, shaft and propeller system was analyzed with undamped and different torsional damped coefficient. Displacement amplitudes are shown in figure 3 and figure 4. Torsional speed of change values indicated in Fig. 5 and Fig. 6.

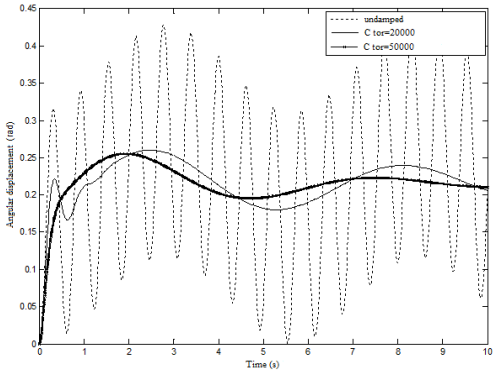

Fig. 3 Torsional angular displacement at shaft

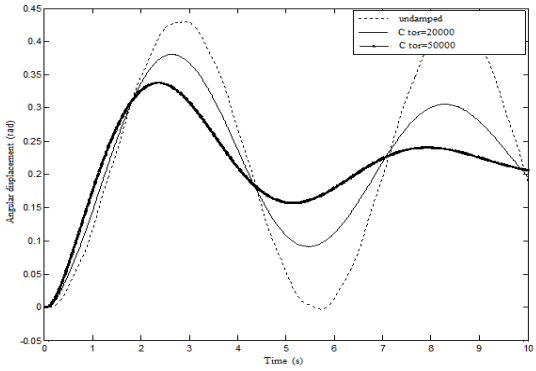

Fig. 4 Propeller torsional angular displacement

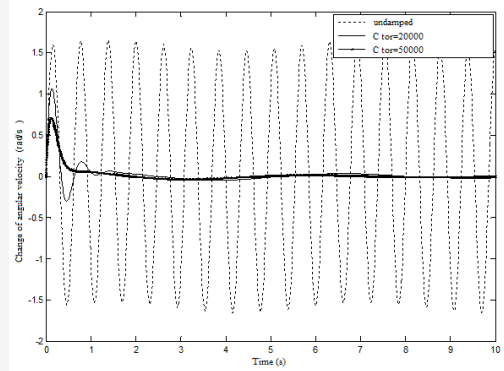

Fig. 5 Torsional angular speed change at shaft

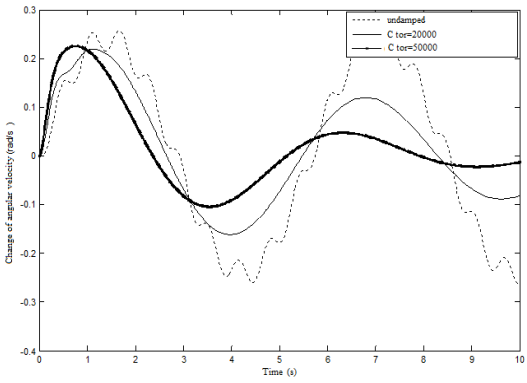

Fig. 6 Variation speed of the propeller torsional angular velocity

Amplitude of shaft torsional angular occurred as a unstable position in the undamped condition, unstable condition has been seen just for first two second than amplitude continue to decreased with effecting from torsional damper coefficient value at $2 \text{ x } 10^4\ Nm\ s^2$. Other simulation have proceeded with $5 \text{ x } 10^4\ Nm\ s^2$ coefficient and understand that the amplitude with using this damper has determine better damping coefficient because amplitude have settled at reference line at the end of the first ten second.

Propeller amplitude is behaved continuously as a sinusoidal without damping coefficient. Propeller angular displacement decrease from 0.43 rad to 0.37 rad when the $2 \text{ x } 10^4\ Nm\ s^2$ damping coefficient effected, in case of damping coefficient implemented to system as a $5 \text{ x } 10^4\ Nm\ s^2$, the amplitude rate decreases to 0.32 rad in ten seconds.

The comparison of different damping action is presented in table 2, which shows velocities and angular displacement of engine propeller.

Table 2

Damping rotation of the engine- propeller model

Torsional Damping rate $\% \, c_b = 2 \, x \, 10^4 Nm \frac{s}{rad}$	Torsional Damping rate $\% \, c_b = 5 \, x \, 10^4 Nm \frac{s}{rad}$
% 87	% 93

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MARITIME EDUCATION RESOURCE: LIBRARY SERVICE EVALUATION

Vidmante Mockute, Ricardas Mova, Rima Mickiene, Inga Bartusevičienė, Genute Kalvaitiene

Lithuanian Maritime Academy, I. Kanto str. 7, Klaipeda LT-92123, Lithuania, E-mail: v.mockute@lmc.lt

Abstract
Modern academic library service depend on understanding and evaluating the unique competence of libraries in this constantly changing educational, economic, health infrastructure and info structure. The unique purpose of Lithuanian maritime Academy library is to collect maritime sector information fund, to spread maritime culture, to strengthen maritime traditions, to encourage students during their maritime spirit development and to motivate people to get involved in maritime lifestyle more actively. LMA library work has been evaluated by students by the following criteria: working hours, provided services, desired services.
KEY WORDS: *maritime academic library, library services.*

Introduction

In Lithuania there are deep librarianship traditions. Even so, can the library become a creative laboratory for a modern student and researcher, where he could quickly obtain all the needed information from all over the world to write a scientific paper, think, communicate with colleagues and so on? Modern academic libraries play an important role in the study process by increasing the skills of students and researchers as well as stepping up the work. How must the library change to properly respond to the challenges of nowadays?

Object of research – the services of Lithuanian Maritime Academy library.

The unique purpose of Lithuanian Maritime Academy (LMA) library is to collect maritime sector information fund, to spread maritime culture, to strengthen maritime traditions, to encourage students during their maritime spirit development and to motivate people to get involved in maritime lifestyle more actively.

Purpose of research– to evaluate the services of Lithuanian Maritime Academy library.

Objectives of research:

1. To describe the purpose of a modern academic library.
2. To analyze the LMA library fund.
3. To evaluate services and working hours provided by the LMA library and reading room.

Methods – analysis of scientific literature, analysis of documents, survey.

The survey list was created by I.Bartuseviciene, G.Kalvaitiene, and was conducted in November-December of 2011. Survey data analysis was provided by 2nd course 10-V-14 group students A. Gintauskas, A. Juščius, D. Kairys, V. Mockutė, K. Stonkutė, V. Vailionytė, lecturer R.Mickienė. The criteria in which library work was evaluated by students: working hours, provided services, desired services. The students were also asked for suggestions how the library should be improved.

1. The meaning of libraries in education and study process

Pattern of cultural heritage, gathered in libraries, has an important meaning to education, science, culture and national economy [2]. Their most important task – information, i. e. to provide needed information to think of or make decisions.

It is important to understand and evaluate the unique competence of libraries in this constantly changing educational, economic, health infrastructure and info-structure.

Library status requires it to collect and store the written heritage. Also library has to adapt to the needs of its users and keep up with changing environment. Libraries that will not keep up with the needs of changing environment will eventually lose their power and be put at the periphery of the knowledge flows [1].

Today scientific and academic library is understood as an institution that collects and protects the scientific literature and other special (heritage, electronic) documents, serves readers, scientists, researchers and students. The essential function of these libraries should be educational, scientific information, communication and research [1]. Scientific library must become into a scientific laboratory where the scientist would have top notch working conditions, quickly delivered required literature to provide him with work-friendly environment. Modern library cannot be imagined without an information technology and an internet access. Readers could also save a lot of time if the technical possibilities would allow them to explore catalogues, lists of books that must be returned right from their home or workplace. All this could be done with his personal computer. It would also be a good thing if a librarian could introduce a reader with requirements for writing a scientific paper.

Other important task of a scientific library is educational. The workers of a library should constantly be organizing courses for users to provide them with knowledge about newest technology and how to use it. Only with this knowledge a scientist or a researcher can work more effectively and use information more rationally. Modern student often uses an electronic textbook which can be copied and money can be saved. Library staff must educate users to find, register and take the needed information themselves. If this kind of tuition is not needed, the staff that often has a university education, could organize exhibitions, classes and various projects.

It is very important for a student to be able to use a computer and access internet in a library, to have space to do collective work and feel free to ask any questions about needed information. There are libraries where people can drink a cup of coffee, eat a sandwich or have a snack while reading. This permission does no harm to the library but rather creates a cosy atmosphere for a visitor.

One more accent – the library cannot work until 5 p.m., it must work until late evening or through the night. The audio and video material should also be available in the library.

To sum up the evolution of academic libraries, it can be determinate that modern academic library should be hybrid-use, because teachers, scientists, students' academic activity starts with a search of required information, analysis of the literature and ends with one or another academic or scientific writing, printing, trimming and binding. These services should be provided in the library.

2. Analysis of Lithuanian Maritime Academy library fund

Library and reading room of LMA – the place where students can find required information for their studies. Library staff advise on issues with information retrieval (electronic catalogue of academic libraries – ALEPH, abroad electronic databases: EBSCO, Emerald etc.) at any convenient time for students. Information is given about services provided at the library by phone or verbally. Readers are consulted about the bibliographic description of documents, forming references. Librarians also revise the bibliographic data of documents in the catalogues of LMA.

The library ensures supplement of needed information and documentation to all study programs of LMA. Library service consumer segment is made of full-time and part- time students, various courses participants, qualifying specialists, lectors and also Klaipėda university students and lectors. Anyone interested can become a library user, because the funds collected not only the professional literature needed for studies in Lithuanian, Russian, English and other languages, but also some historical content. Specifically supplied information fund assures effectiveness of the library (Fig. 1.).

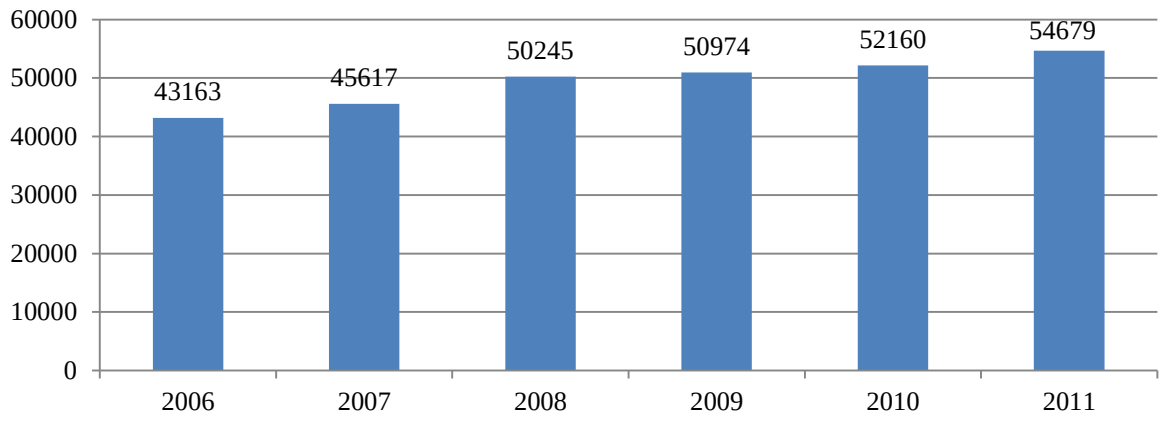

Fig. 1. LMA library fund 2006-2011 [3].

Heads of academicals departments, lectors are actively involved in the process of filling the fund of library by carefully analyzing, studying, discussing and selecting the most competent information for specific study programs. The fund is also constantly filled with literature published by the Lithuanian Maritime Academy lectors (fig. 2.).

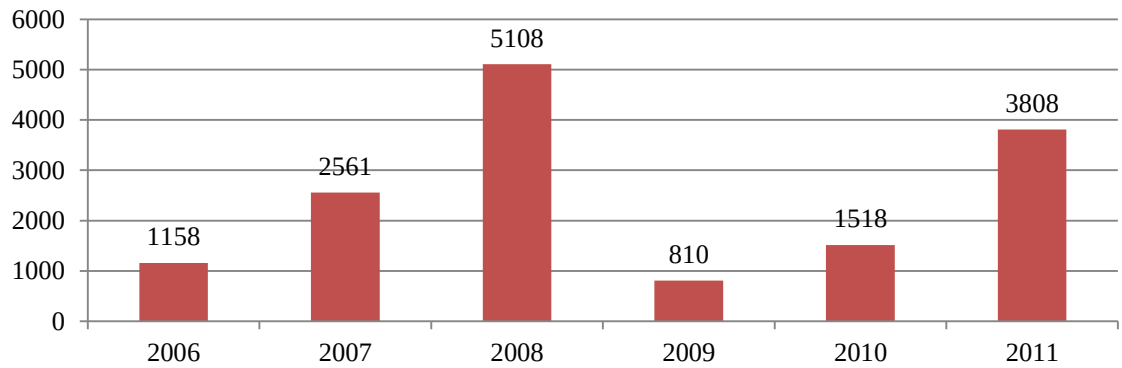

Fig. 2. LMA library fund supplement 2006-2011 [3].

The library fund is funded by various international projects and own resources, i. e. in 2011 LMA spent 3.5 times more financial recourses than in 2010 and purchased 3808 copies of 272 titles. A variety of publication is satisfying, because in every period of 5 years academy purchases in average 216 different title publications. This trend is not forgotten this year either, in the first quarter of 2012 LMA purchased 1153 copies of professional literature in Lithuanian and English, dedicated to maritime specialists.

The number of library users constantly changes and it is mostly affected by the LMA students: in 2007 there were 2% more readers than in 2006 however in 2008 there was a 14% decrease in readers number and in 2009 the readers number again got up to the level of 2007 and is constantly rising. In 2011 the library had most registered readers in its history – 1754.

In order to making maritime studies more international it is essential to increase the fund of literature written in English, because at the time of research English literature had a part of only 9% of all fund. Otherwise this could be explained by the fact that most of the English literature is provided in electronic form. The documents of the International Maritime Organization are available online and to increase savings and international literature often electronic publications are purchased.

3. Lithuanian Maritime Academy library working hours evaluation by the students

The survey was taken between 1st – 3rd year students of all study programs in order to evaluate the activity of library and 319 students took part in this survey (fig. 3.).

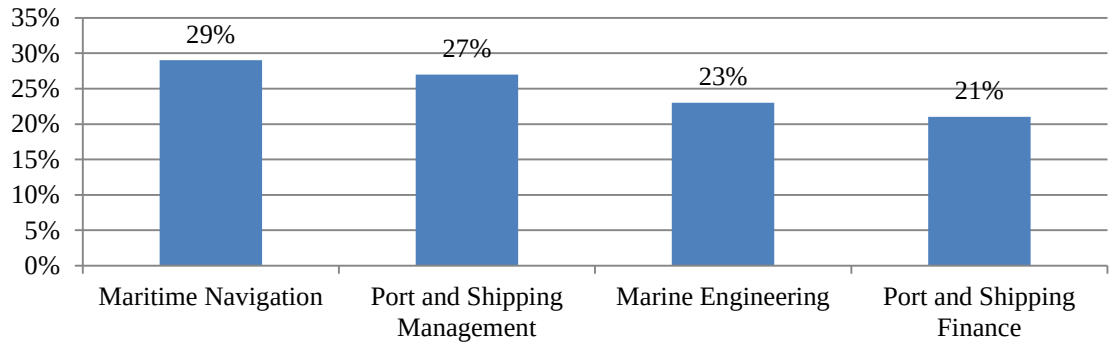

Fig. 3 Spread of the respondents between study programs

Working hours of the library is important to students so they suggested the most convenient library visiting time: 49% of students told that the library should be opened from Monday to Thursday, so it is assumed that present working hours are comfortable, 28% of students wish for library to extend staffs working hours by one hour, until 6 p.m. and 9% of students would visit library until 7 p.m. in the evening, 4% of students suggested other time, convenient to their interests (fig. 4.).

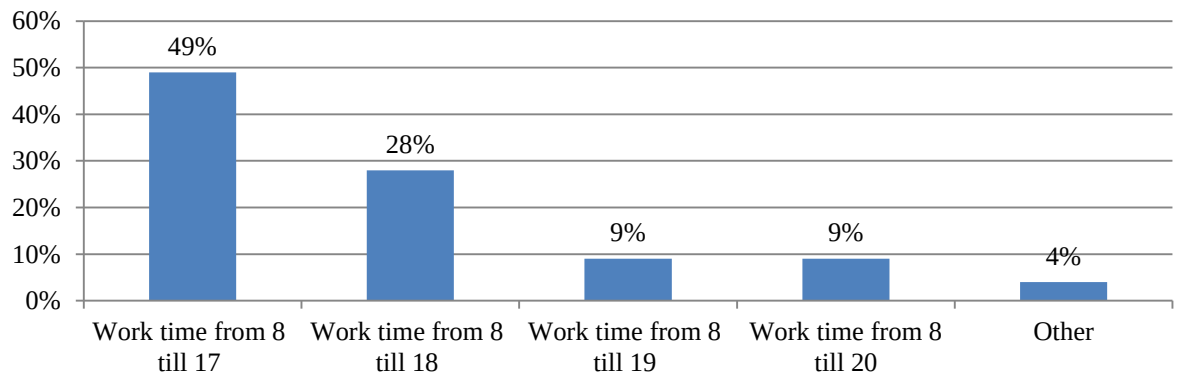

Fig. 4 Evaluation of most convenient library visiting time from Monday to Thursday

More than a half of respondents (55%) told that library should also work on Fridays until 4 p.m. About one third of students (28%) said that library on Fridays should work as long as it does from Monday to Thursday and the same amount of students would like the library to work on Saturdays. Therefore the majority of students are satisfied with present working hours of the library, one third would like it to work also on Friday as it does other days and one third would be happy if they could visit the library on Saturdays.

4. Student evaluation of the services provided by Lithuanian Maritime Academy library

Library of LMA provides various services to its readers but not every service is being used equally (Fig. 5).

Services provided by the library can be sorted by the amount of use (Fig. 5):

1. Most of the respondents use their own laptops (74%), Wi-Fi (73%) and spend their free time (72%).
2. Slightly less respondents use book give-away, document copying and consulting services.
3. Less than 40% of respondents use computer desktops and related services.

It should be noted that consultations provided by the librarians are valued and needed in search of textbooks, e-books, science papers as well as the answering questions about database search. Service in a state of improvement – preparation for classes. This can be explained by the lack of area in the library. Likely there problems will be solved as soon as the new library development plan will be accomplished.

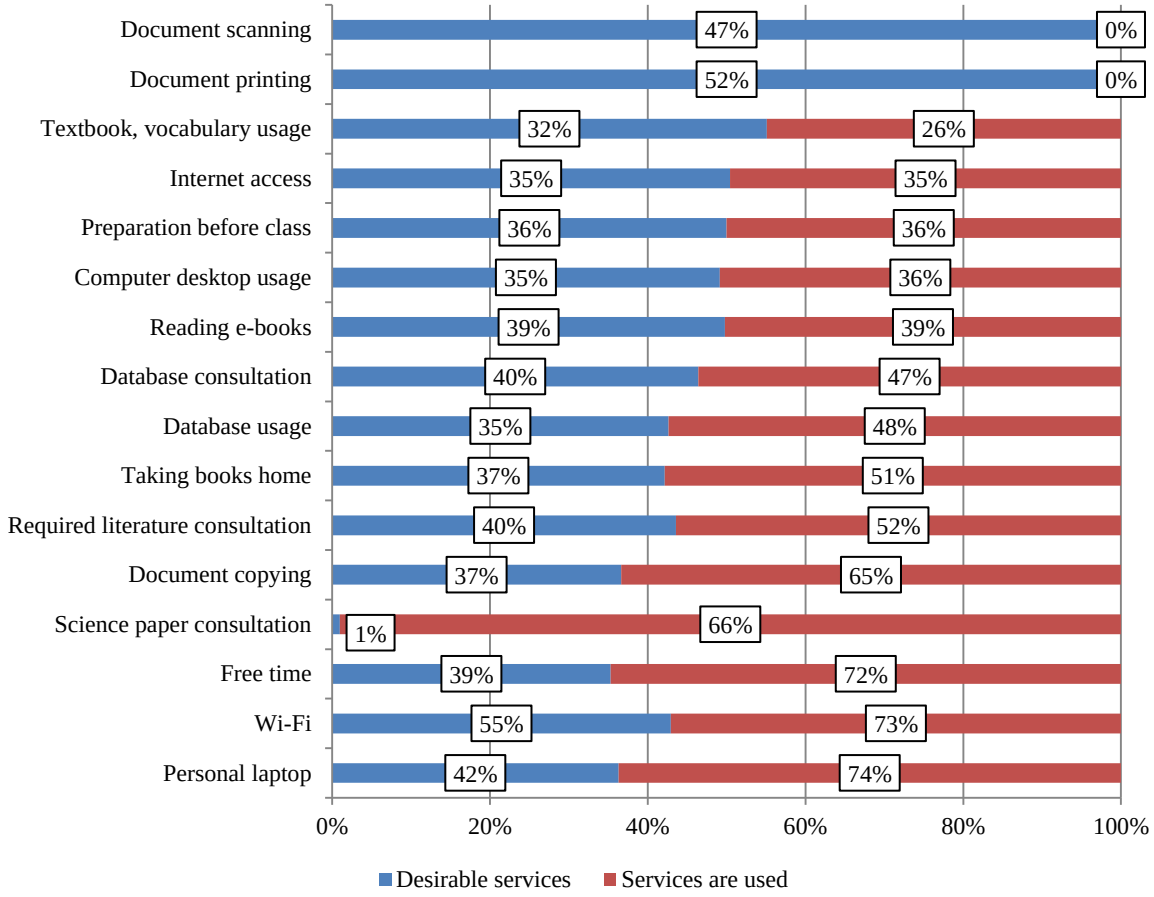

Fig. 5 The supply and the need of services provided at the LMA library

Desired services by the respondents (Fig. 5)

1. Mostly desirable service – document scanning and printing (from internet, USB-drive etc.). This service is not yet provided in library and students have to use it somewhere else.
2. 32% of respondents often use their own laptops at the library so they would like a permanent Wi-Fi connection.

The library has no separate spaces for work and rest therefore sometimes it causes dissatisfaction of visitors gathered for different purposes.

At the time of survey respondents were asked how library can be improved. All suggestions can be sorted to some main groups:

- To provide the possibility to print written papers.
- To supply fund with more information written in Lithuanian and be able to take more books away.
- To provide service of using the external memory devices at the library.
- To keep order of discipline and silence.
- To provide more resting space.
- To provide possibility to make tea or coffee.

Conclusions

1. Modern library must provide informational, educational, consulting and other services to students, lectors and other users. Library cannot be imagined without informational technologies, scientific literature, databases, internet access. Search for required information, analysis of literature, writing of the paper, printing, designing and binding are the most important phases for a student or a lector while writing a science paper so all these services should be provided right at the library.
2. The library fund is collected by various international projects and LMA own resources. A variety of publication is satisfying, because in every period of 5 years academy purchases in average 216 different title publications. In order to making maritime studies more international it is essential to increase the fund of literature written in English. For the formation of library funds are responsible heads of academic departments, lectors, students. According to library fund structure and providing infoservice activities, LMA library meets main options of modern academic library.
3. For the comfort of LMA students the library visiting time should be from Monday to Saturday 8 a.m. to 6 p.m., it is also desired to extend visiting time until 8 p.m. during workdays. Services provided at the library are not used equally. Services to be able to work with own laptops ant be able to connect to Wi-Fi are desirable. It is important that students spend their free time at the library and this trend promises library will be distributed into working and resting areas when the development plan will be accomplished. It is essential to determine publications needed for specific study programs and supply the library fund by this information to motivate people to use provided services more actively. It is also needed to establish an office center in the library for students to be able to scan, print, bind, copy documents from internet and various external memory devices. More resting places are desired with the ability to make a cup of coffee or tea to make the atmosphere cosier.

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IMPACT OF THE DECREASE OF COSTS OF A LINER SHIPPING COMPANY ON THE FINANCIAL RESULTS OF THE COMPANY

Jurate Zukauskaite, Regimantas Lukosevicius

Lithuanian Maritime Academy, I. Kanto str. 7, Klaipeda LT-92123, Lithuania, E-mail: j.zukauskaite@lmc.lt

Abstract
Presently maritime transport serves up to 80% of global market and 90% of European international transportations market. Costs of a maritime transport company can be defined as ship charterer`s costs. The cost price of a charter for clients consists of maritime transport costs, brokerage costs and the profit of a ship owner. Current ship costs is special by the fact that it is approximately calculated when making annual budget and later on distributed taking into consideration ship maintenance/exploitation plan. It is important for the companies to optimize costs under market economics conditions in order to maintain competitiveness in market.
KEY WORDS: *liner shipping, costs, profit, decrease of costs.*

Introduction

Liner Shipping – is one of the types of shipping based on certain elements that distinguish it from other forms of shipping. Distinctive features of liner shipping are: coordinated schedule of ship calls between concrete ports; priority for the ship services at the port; stable (conditionally) tariffs; contracts between shipping line operator and port terminals where the liner ships are served. The costs of maritime transport company and the companies operating on shore differ.

Object of research – AB DFDS SEAWAYS activity costs.

AB DFDS SEAWAYS is a sea ferry company which up to 2011 operated as AB (JSC) „LISCO BALTIC SERVICE", when in 2006 JSC „Lietuvos jūrų laivininkystė" was reorganized. The main activity of AB DFDS SEAWAYS is transportation of passengers by ferries and ship chartering.

The company hires its ships on the following lines: Klaipėda – Kiel, Klaipėda – Karlshamn, Klaipėda – Sassnitz, Dunkerque – Dover, Amsterdam – Newcastle, Esbjerg – Harwich, and Copenhagen - Oslo. It also fulfils the functions of ship agent for its own and „DFDS Tor Line" lines from Lithuania to Germany, Sweden, Denmark and Russia (Kaliningrad region).

AB DFDS SEAWAYS group ships transport cargo in ro-pax lines network of the southern Baltic region. The activities cover the transportation of passengers and cargo between Scandinavian and West European countries as well as the Baltic States and Russia. Tor Botnia and Tor Finlandia execute cargo transportations in the North Sea.

Goal of research – is to ground the impact of chartering and wages costs on the profit of liner shipping company.

Tasks of research:

1. Classify the costs of a liner shipping company.
2. Distinguish the costs making the greatest impact on the profit of a liner shipping company.

Methods of research – analysis of scientific literature, content analysis of company activities documents, analysis of conditional indices, correlation, regression.

1. Costs structure of a liner shipping company

Distribution of ship costs gives possibility to more precisely assess the impact of costs on the profit of a liner shipping company [4]. Liner shipping costs groups are: ship costs, sailing cost, capital costs of a ship owner, cargo handling costs.

Current ship costs are calculated as total annual costs when costs is calculated for one exploitation day and the current costs of sailing is calculated evaluating the duration of a sailing and the costs for one exploitation day:

- Costs for the maintenance of a crew: wages, overtime/ bonuses, payment for vacation, social costs, professional training, transportation of a crew to a ship, medical services, hiring costs, food products and etc.
- Insurance: contributions to P&I clubs.
- Deck technical equipment: buying of maps/charts, auxiliary navigation means, mooring ropes, paint, flags, and deck and superstructure regulation devices.
- Technical supply for engine-room: chemical materials, welding equipments, electric apparatuses and equipment, instruments, spare parts.
- General supply: cartridges, supply for devices and etc.
- Spare parts: for deck mechanisms and equipments, for main engine, for auxiliary mechanisms, for electricity systems and rescue equipment.
- Servicing and survey: survey of fire-extinguishers and rescue boats.
- Repairs: deck equipments and machine costs.
- Costs for ensuring of safety and protection: preparation of documents, survey, checking, certification.
- Administrative costs: communications and postal costs, visits of the representatives of the company to a ship, improvement of computer systems.

Exceptional peculiarity of sailing costs is that the costs is planned for each concrete sailing as it depends on sailing conditions. Sailing costs consists of:

- Fuel costs. They make the biggest part of sailing costs. Fuel costs are predetermined by 2 main factors: fuel price and fuel consumption. The owner of a ship cannot control the price of fuel but he can decrease the consumption of fuel. Consumption of fuel depends on speed of a ship.
- Port dues – port administration, customs and other bodies collect sums of money from ships and cargo owners for the compensation of construction costs, maintenance of port infrastructure and superstructure. Lighthouse, port, tonnage or ship, navigation, quay, dock, canal, river locks and cargo dues are attributed to the main dues.
- Payment for ship agents` services. The ship covers costs for ship agent services. Those services are rendered by maritime agent who is on contract relations with the owner of a ship.
- Payment for sailing along canals. Calculating the dues for sailing the biggest attention is paid to the size of a ship, besides, the tariffs for fully loaded ships and ships with ballast significantly differ.

Ship costs at a port are connected with cargo handling at a port. The quantity of cargo and the rate of cargo tariff make great impact on cargo handling costs. Not only cargo handling costs are included into the tariff but also cargo storage for the foreseen period. Cargo tariff rate depends on the type of cargo, cargo handling technologies and cargo handling standard. The *Cargo handling costs* are:

- Ship costs at a port,
- Cargo handling costs at a port.

Capital costs of a ship owner are first of all connected with the acquisition of a ship:

- ship purchasing costs;
- ship maintenance costs.

Capital ship costs depend on the value of a ship and the way of acquisition. When a ship was purchased using commercial bank credit, capital costs depends on the amount of a loan, loan conditions, type and term of loan repayment, interest payment and type of currency. During ship exploitation period capital costs are covered via amortization instalment system.

2. Ways of costs decrease of liner shipping companies

Costs of AB DFDS SEAWAYS consist of:

- ships costs;
- chartering costs;
- personnel costs;
- costs on selling, administration and other activities.

It is proposed to decrease costs in liner shipping using the following ways [3]:

- by decreasing exploitation costs (fuel, lubricants, repairs);
- by decreasing costs connected with the crew of a ship;
- by decreasing the tariffs of services rendered at the port;
- by decreasing port dues.

Ship exploitation/maintenance costs can be decreased by using new ships with modern engines using less fuel than the old ones. In a lot of countries it is proposed to use new ecological ships by applying different privileges.

Before buying or hiring a ship for a concrete line exploitation costs are to be determined precisely. Quite a lot of them are to be followed by the crew, nevertheless, the resolute decrease of a number of crew members may have negative consequences: small crew cannot ensure suitable fastening of cargo (in Ro-Ro ships), therefore they are to hire the workers from the terminal or special fastening companies and they are paid more for the same job than the members of a crew. The biggest problem is that small crew of a ship cannot ensure necessary navigational duty and it increases the probability of ship accidents and insurance companies increase insurance for such ships. It is especially important to suitable assess the necessary number of crew members for each shipping line, in order to:

- ensure navigation safety;
- execute additional works more efficiently using minimal costs.

The tariffs of port services make the greater part of liner ship costs at a port, therefore the negotiations between the operator of a line and port terminal are especially important. Having negotiated on more favourable tariffs for port services, it is possible to increase the economic efficiency of a line. In order to make the agreement successful, it is important to assess the possibilities of port terminal and shipping line.

Port dues make a significant part of liner ship costs. Port dues in a lot of ports are oriented to progressive discounts: the more times a ship calls the port, the less port dues it pays, therefore, at the beginning of work of a shipping line it is important to plan its work as precisely as possible (fig. 1).

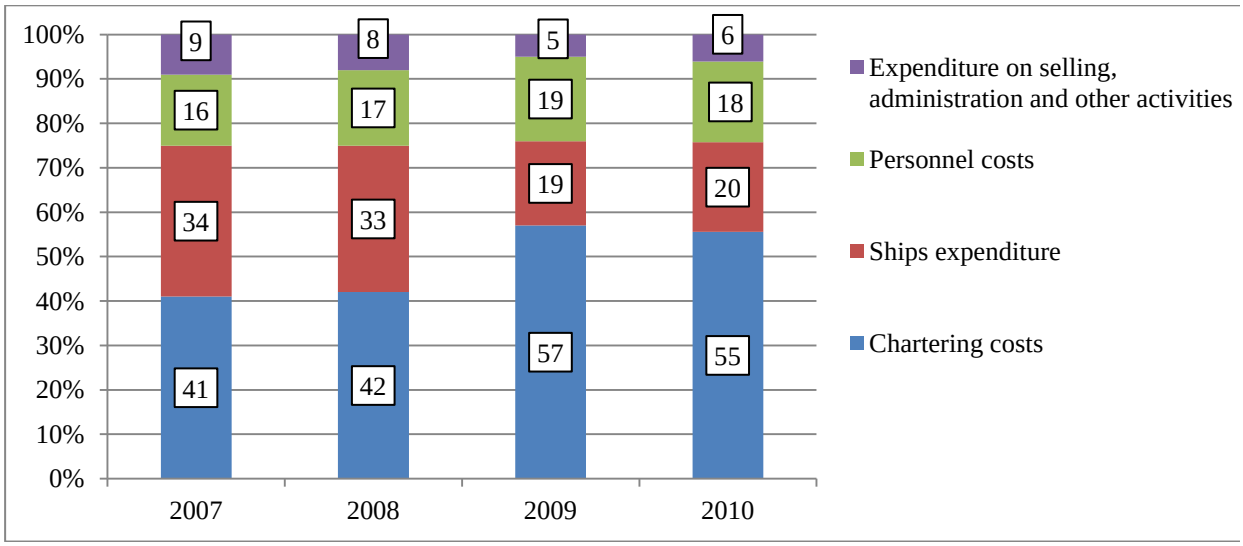


Fig. 1. AB DFDS SEAWAYS structure of costs

Chartering costs make the biggest part under analyses period (fig. 2). The smallest value of chartering costs in 2007 reached 41% i. e. 68,22 mln. Lt, and the biggest value of chartering costs was in 2009, when it made 57% i. e. 114,71 mln. Lt of total costs.

The increase of chartering costs can be grounded by the fact that AB DFDS SEAWAYS transferred ship`s costs to the main office of company in Denmark and main income got from hiring of ships. Increasing chartering costs was one of the main reasons that predetermined the decrease of ship`s costs.

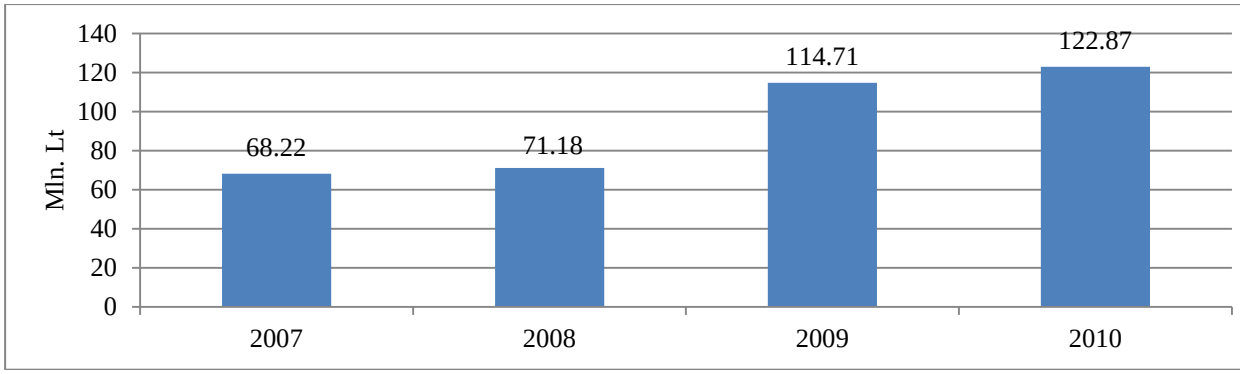


Fig. 2 AB DFDS SEAWAYS chartering costs

The increase of costs for human resources was predetermined by increasing wages comparing to basic year 2010, it increased by 41% and reached 21,51 mln. Lt. The tendency of increasing is peculiar to chartering costs. In 2008 the increase of chartering costs was only slight and it reached 4%. But when ship`s costs was transferred to the main office of company in Denmark, chartering costs significantly increased (in 2009 – 68%, and in 2010 – 80%). As the main activity of AB DFDS SEAWAYS became ship hiring, the growth of chartering costs is a natural process.

Ship exploitation and repairs make the biggest part of ship`s costs (fig. 3).

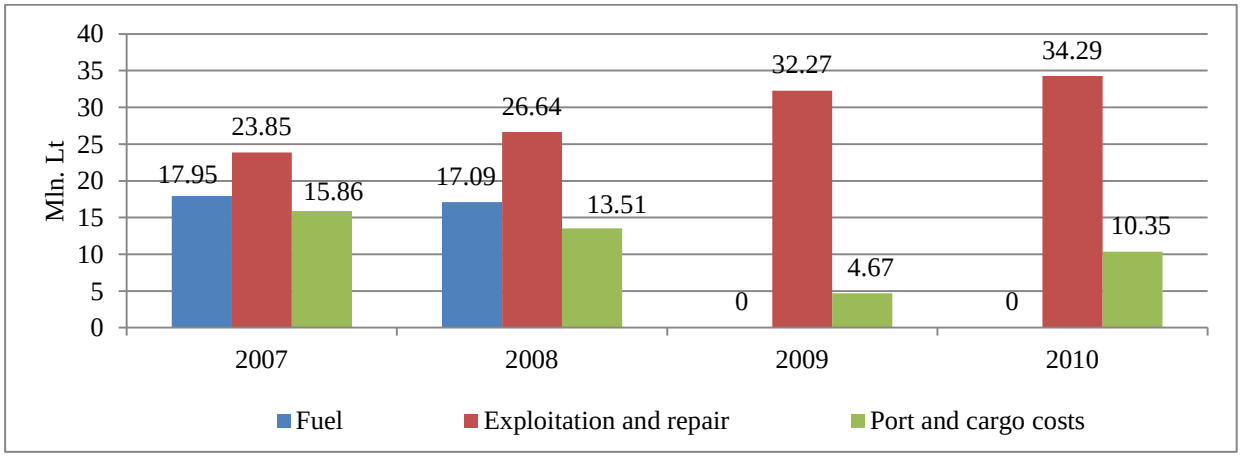
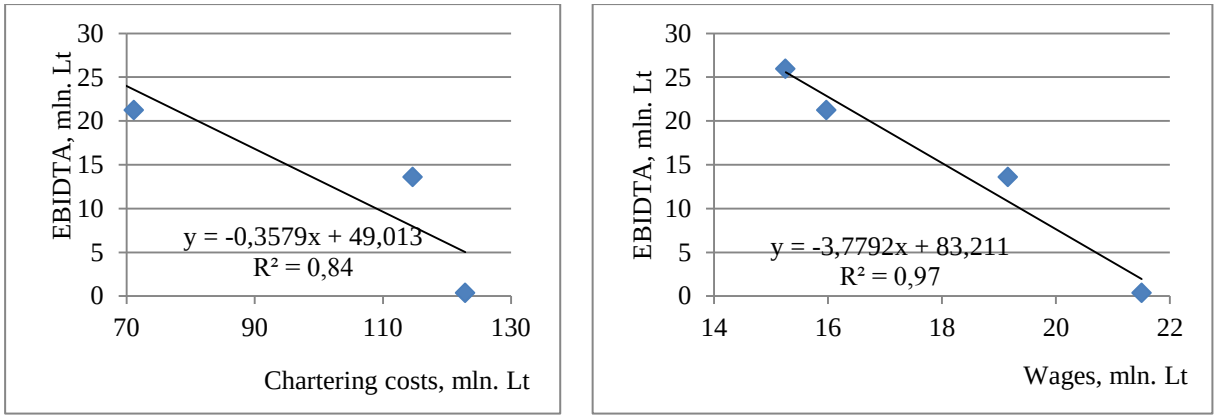


Fig. 3 AB DFDS SEAWAYS ships costs

In 2007 exploitation and repair costs reached 23,85 mln. Lt. In 2008 exploitation and repair costs increased by 12%, and in 2009 – 35%, in 2010 – 44% and reached 34,29 mln. Lt (fig. 3). Annual increase of exploitation and repair costs was predetermined by bigger exploitation costs. But AB DFDS SEAWAYS tries to cover increasing exploitation and repair costs by bigger income. Port and cargo costs in 2008-2009 decreased due to smaller cargo transportation flows during economic downturn, but in 2010 the costs significantly increased up to 10,35 mln. Lt. It was predetermined by the growing cargo transportation flows. Tendency of decreasing of fuel costs was peculiar in 2007-

2009. In 2009 they decreased to 0. As AB DFDS SEAWAYS transferred ship`s costs to Danish people, there is no fuel costs in the financial statement of patronizing company.

EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization) is called a profit before interest, taxes, depreciation and amortization. EBITDA is widely used as it reflects the activities of a company clearer without the inclusion of costs as they „do not take part" in the main activities. In order to determine the dependence of EBITDA on costs, correlation and regression analysis was made. Investigation of chartering costs and wages was executed.



a) b)

Fig. 4 The impact of costs on EBITDA
a) The impact of chartering costs on EBITDA; b) The impact of wages on EBITDA

EBITDA relation with chartering costs linear dependence is y = -0,3579x + 49,013. EBIDTA 84% (R^2=0,84) relay on chartering costs. Having decreased chartering costs by 1 mln. Lt, EBITDA increases by 0,36 mln. Lt. If it were possible to decrease chartering costs by 10%, EBITDA would reach 9,53 mln. That prove relation chartering costs and EBIDTA (fig. 4. a). Increasing of cost decrease EBITDA (correlation coefficient r=-0,9). To balance impact of chartering cost it's necessary to optimize chartering costs. EBITDA 97% related to the wages costs (fig. 4. b), correlation coefficient r=-0,98. Lithuanian wage policy is to increase minimal wage about 25%, that increase total shipping costs, and EBIDTA will decrease more intensive. Having decreased wages costs by 2 mln. Lt, EBITDA increases by 7,4 mln. Lt.

Conclusions

The costs of liner shipping companies consists of current ship`s costs, sailing costs, costs connected with cargo and capital costs of a ship owner. The decisions of a ship owner determine the decrease of costs.

The impact on the formation of EBITDA of chartering costs is 84%. Lt. Optimisation of chartering costs during several years might stabilise losses made by the accident of LISCO GLORIA. The impact on the formation of EBITDA of wages is 97%. To minimize impact of wages increasing for EBIDTA its necessary to improving efficiency of human recourses of company. Therefore, AB DFDS SEAWAYS would be made to increase the tariffs for services.

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MECHANICS OF CONTACT INTERACTION OF PARTS IN FRICTION COMPONENT WITH REGARD TO THE RHEOLOGICAL PROPERTIES OF CONTACT

Aleksandrs Urbahs*, Gints Rijkuris **

**Riga Technical University, 1 Kalku str., LV-1658, Latvia, aleksandrs.urbahs@rtu.lv*
***Latvian Maritime Academy, 5B Flotes str., LV-1016, Latvja, gints_rijkuris@inbox.lv*

Abstract
Main problem described in this paper is that well-known theoretical approaches to calculate the actual contact area do not take into account the effect of time of loading and temperature of the contacting surfaces of solids. In modern tribology [1, 2] wide range of phenomena caused by interaction of the contacting surfaces of solids under normal load, offset, deformation of the material surface and the gas-liquid environment between the two contacting surfaces. Contact interaction in friction pairs largely determines their frictional characteristics, durability, and is therefore an important object of tribology. By term of contact is understood the interaction of solid surfaces under the influence of external forces considering their deviation from the ideal form, as well as participation in the deformation of the environment (gas and lubricants presence in the area of contact and indirect temperature). Main characteristics of the standard geometry of the rough surfaces are also examined in this paper.

Introduction

Macroscopic deviations from the ideal forms are lack of roundness, lack of flatness, corrugateness, etc. The scale these irregularities usually have is measured in the range of $10^{-3} \div 10^{-4}$ m. Macroscopic asperity brings the microscopic irregularities which is measured at $10^{-5} \div 10^{-7}$ scale. In turn, microscopic asperities are measured in order of molecular dimensions.

When determining the characteristics of the frictional interaction of rough surfaces and the area of their contact altitudinal and longitudinal properties of the irregularities, the radius of curvature of protrusions and depressions, the laws of their distribution and regulation are used.

Another most significant aspect of the contacting of the surfaces is the molecular mechanics of contact. The surface energy of solids is so great that it causes the active interaction of the solid with components of gases, liquids and parts of solids, forms adsorption and chemisorption layer on the surfaces, adhesion force to resist motion, setting, deformation, heat and other processes.

1. Geometry of rough surface

In a random arrangement of the asperities on the surfaces of contacting solids, actual area of contact which is known by the geometry of contacting surfaces limits bringing closer these contact surfaces under the influence of external load. Fig. 1 shows the main characteristics of the standard geometry of the rough surfaces: roughness with a maximum profile height of R_{max}, the maximum corrugation height Rw_{max} and macrodeviation from horizontal base plane with height characteristic δ .

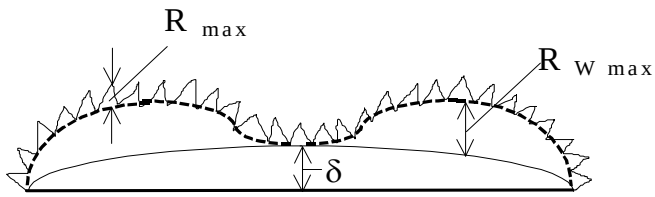

Fig.1 Main characteristics of the rough surface geometry

Well-known theoretical approaches to calculate the actual contact area [1, 2] do not take into account the effect of time of loading and temperature of the contacting surfaces of solids. However, all materials to a greater or lesser extent have the viscoelasticity and viscoplasticity, i.e. elastic and plastic deformation does not affect immediately after loading, but progress after some time.

2. Rheologic properties of contact

The rate of increase of deformation increases with raise of temperature. Such behavior of materials, leading to a change in the actual contact area depending on the temperature and time, is described by means of rheological models. *Rheology* - a set of deformation study methods for studying the deformation and flow of media having a viscosity and plasticity. In Fig. 2a, b, c are shown the most often used models describing the rheology of materials

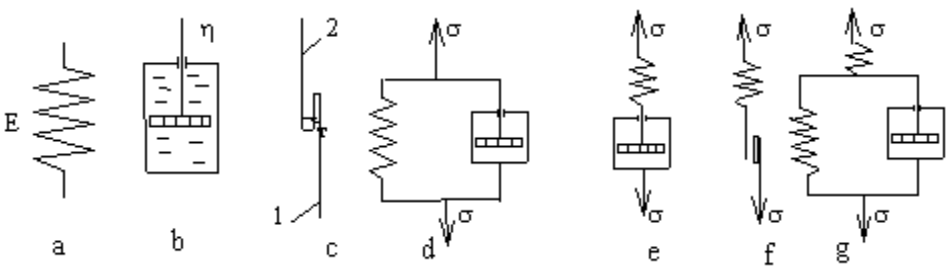

Fig. 2 Rheological model for the interaction of solids

The first model (see Fig. 2a) describes the ideal elasticity (Hooke's body):

$$\sigma = \varepsilon E. \tag{1}$$

The second model (see Fig. 2b) reflects the viscous flow (Newton's body). For it applies Newton's formula:

$$\sigma = \eta \frac{d\varepsilon}{dt} = \eta \dot{\varepsilon}., \tag{2}$$

here $d\varepsilon$ - relative offset deformation.

The third model (Fig. 2, c) describes the plastic deformation (Saint-Venant's body):

$$\sigma = \sigma_T \text{sign } \dot{\varepsilon}, \tag{3}$$

where the "sign" stands for variable gradual function. If $\sigma > \sigma_T$, then the elements 1 and 2 (see Fig. 2c) are one unit. $\varepsilon = 0$, if $\sigma > \sigma_T$ – elements slide relative to each other. The body is indefinitely plastically deformed if $\varepsilon \to \infty$.. This is followed by a combination of the first three models (see Fig. 2, d, e, f), reflecting at first approximation, the properties of actual solids.

The first of them (see Fig. 2, d) is a model of Kelvin - Voight, considering that the total load is perceived as by the Hooke's so by Newton's body:

$$\sigma = \sigma_E + \sigma_\eta = E \cdot \varepsilon + \eta\dot{\varepsilon}. \tag{4}$$

Assuming σ = const and integrating, we obtain the law of deformation progress in time:

$$\varepsilon = \left(\frac{\sigma}{E}\right) \left[1 - \exp\left(-\frac{E}{\eta}\right) t\right] . \tag{5}$$

If at some moment of time τ the body would be unloaded (σ = 0), then integrating equation (4), we obtain a law of reducing the deformation in time:

$$\varepsilon = \varepsilon_\tau \exp\left[\left(-\frac{E}{\eta}\right)(t-\tau)\right]. \tag{6}$$

By equation $\frac{E}{\eta} = t_o$ we get so called relaxation time.

For the Maxwell model (see Fig. 2, e) applying the load, first instantaneously the Hooke's body is deformed, after the Newton's body begins to act. Because the bodies are connected in series, they have the same loads. The rate of deformation of the system consists of the rate of deformation of two bodies:

$$\dot{\varepsilon} = \dot{\varepsilon} \cdot E + \dot{\varepsilon} \cdot \eta = \frac{\dot{\sigma}}{E} + \frac{\sigma}{\eta} \tag{7}$$

If we assume that ε = const, integrating, we obtain a law to reduce load in time:

$$\sigma = \sigma_o \exp\left[-\left(\frac{E}{\eta}\right)t\right], \tag{8}$$

where σ_o the load at the initial moment of time. Both models (see Fig. 2, d, e) characterize the behavior of viscoelastic bodies.

Prandtl model (see Fig. 2, f), characterizes the behavior of viscoplastic bodies.

For this model
$$\begin{cases} \sigma = E_T \text{ if } -\varepsilon_T < \varepsilon < \varepsilon_T ; \\ \sigma = -\sigma_T \text{ sign } \dot{\varepsilon} \text{ if } -\varepsilon_T \geq \varepsilon \geq \varepsilon_T , \end{cases} \tag{9}$$

here ε - elastic deformation, when $\sigma = \sigma_T$, where σ_T - flowability boundary. While $\sigma < \sigma_T$ only the Hook's body is deformed. As soon as $\sigma \geq \sigma_T$, the deformation increases indefinitely due to slippage of the Saint-Venant's body at a constant deformation of the elastic element. Fig. 3 shows the rheological curves for Kelvin - Voigt, Maxwell and Prandtl models.

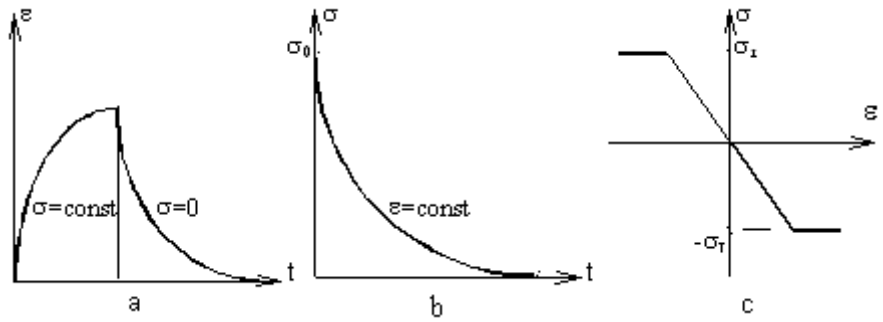

Fig. 3 Rheological curves for different models

The effect of temperature and time on actual area of contact most perceptibly appears during plastic contact. The growth of the actual area of contact with raise of temperature is mainly due to the raise of plasticity that has an exponential dependence. Time dependence of the actual area of contact at a constant load (for metals) is satisfactorily described by the equation:

$$\Delta A_{rt} = N(t_2^m - t_1^m) / HB \cdot t_{HB}^m, \tag{10}$$

where ΔA_{rt} - change of the actual area of contact during the time interval $t_2^m - t_1^m$; N – the time of ball tip load determining Brinell hardness, m - rheological constant of the material.

Assessment of contact deformations, considering the microgeometry of the surfaces and the heterogeneity of the mechanical properties of surface layers, surface films, and the stress distribution in the surface layers is necessary for the calculation of nodes with minimal friction and high wear resistance.

During the capillary adhesion condensation of water vapors leads to the formation of thin liquid films on solid surfaces. In this case, the force of capillary adhesion Pa on a single micro protrusion is defined by the formula [2]:

$$P_a = 4\pi R_\tau (1+\delta), \tag{11}$$

where δ - thickness of the liquid film.

Contact characteristics in the presence of a liquid film depends on the shape of the stamp, the bilateral attraction of two molecular roughness, the energy dissipation in the loop "converging-removal" roughness (Fig. 4), etc. a b

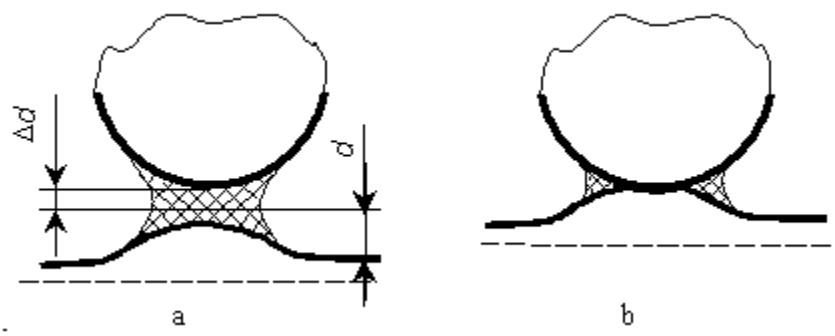

Fig. 4 The scheme of the convergence of the contacting surfaces
a – initial position; b – end position and deformation of the protrusion.

In case of "dry" surfaces contact, it is found that the adhesive interaction increases. As shown in Fig. 4, with a decrease of liquid in the meniscus adhesion component in friction bearings increases.

Form of protrusive roughness is important during contact, which can be examined using simple models (Fig. 5).

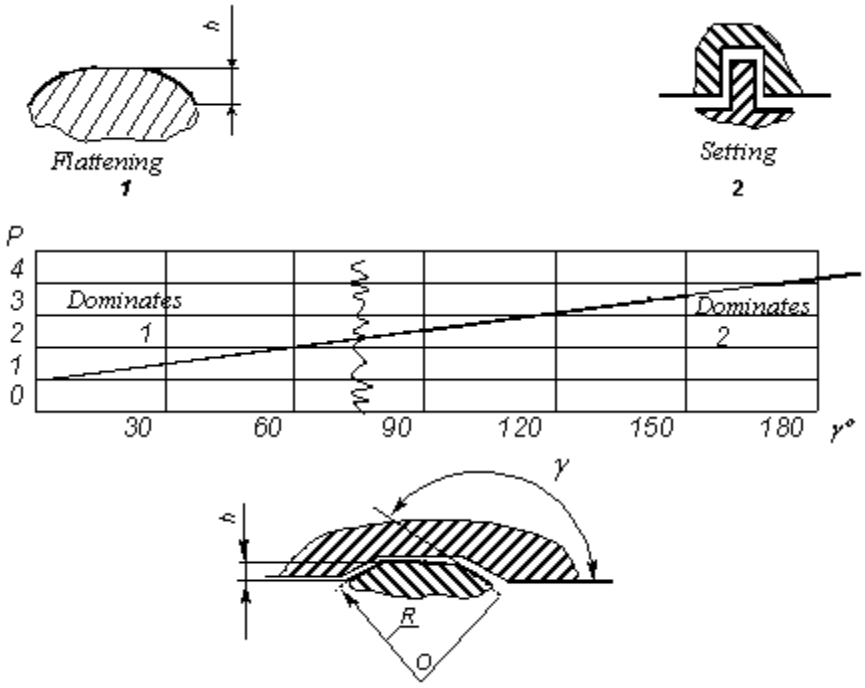

Fig. 5 The effect of the form of asperity on contact interaction in two areas:
1 – flattening; 2 – setting in the function of the angle γ:
h– height of asperity; γ - angle between asperity slope and friction surface;
R – conventional radius of asperity

As seen in Fig. 5 (for example, carbon steel) at $\gamma < 180^o$ setting is dominated, at $\gamma < 80^o$ – flattening, and the loads are related as follows:

$$\frac{h}{R} \approx K\left(\frac{\sigma_T}{E}\right), \tag{12}$$

where E – modulus of elasticity; σ_T – flowability boundary, K has following values:

if $\sigma_{max} = \sigma_T$ K = 2,4;

if $\sigma_{сред} = \sigma_T$ K = 5,4.

It should be noted that during friction and contact the state of the material properties of the surface layer changes due to wear-in. The micro-and macrogeometry of contact, height, shape, pitch of asperities are changed due to the wear-in and deformation of surfaces. In addition, the structure of the surface layer of material changes - defects in the crystal structure: the point (vacancies), line (dislocation type) appears; boundaries are developed, coagulation defects of various origins, formation and dissolution of carbides, diffusion, phase transformation (formation of new phases), etc. that leads to the recrystallization, amorphization and the formation of secondary structures (most often - the films of oxides) and adsorbed films.

The rate of formation of these films is determined by the adsorption:

$$\vartheta_n \approx \chi \frac{U_o}{kT}, \tag{13}$$

where

U_o - the energy of activation of sorption process;

k - Boltzmann constant ;

T - temperature;

χ - constant.

Conclusions

An important place in the knowledge of the contact process belongs to the interaction between the surfaces, gases and moisture. The size of the gas molecules is equal to $10^{-9}\ldots10^{-8}$m, the average density is equal to $3{\sim}10^{-19}$ мол/см3, the velocity $U \approx 4\cdot10^{4}$ cm/sec., indicating a significant kinetic energy of gas particles interaction with surfaces.

In conclusion, one more important process from the scientific and practical point of view should be noted - the electrochemical interaction of surfaces separated by a layer of grease (which creates the conditions of the electric condenser). According to the laws of electrochemical kinetics the anode is dissolved and the dissolved metal ions are deposited on the cathode.

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