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Turbine propulsion education at Maritime University of Szczecin

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Key words: turbine, education, simulator, training

Abstract
The analysis of students' education at the Engineering Department of the Maritime University of Szczecin has been presented in this paper with reference to steam and gas turbine propulsion used in marine industry. Changes in syllabuses have been taken into consideration due to the changes of studies organization at the University and requirements for marine crew education. Laboratory base used for practical training has been presented too.

Introduction

A ship is a complex and fully automatic technical object used in extremely changeable conditions of operation and surroundings. In operation, it is the adequately trained crew that decide about the safety of sailing, mainly navigational and engineering officers. Introduction of more and more advanced testing and measuring systems for control and steering causes less workload for performing routine duties, repeated activities for machine, device and systems operation – particularly for ER crews.

Information sent to ECR gives the possibility to asses machinery and ER devices working parameters and their technical condition as well. In case of critical value of working parameters an alarm in "on" and the information about its reason is sent to engineers' cabin or widely available places such as the messroom, the TV room or the bridge.

All that requires more prerequisites of knowledge and skills for marine engineers. There are more perfect methods of education, taking into account technical development of machinery, marine devices, engine room systems, automation systems, computer technologies and rules for natural environment protection.

Problems of marine staff training are regulated by International Convention on Standards of Training Certification and Watchkeeping for Seafarers (STCW) where the knowledge and skills required by crews of sea-going vessels are included. The content of the STCW convention is determined during meetings of IMO (International Maritime Organisation) representatives from membership countries. After the ratification, membership countries – Poland too – are obliged to use it as standard training for marine crews.

Education plans for propulsion turbines according to STCW:

- there are different forms of developing professional career – starting with courses and up to academic studies;
- assessment of professional qualifications is based on the testing of knowledge and skills used by a particular rank;
- it determines training requirements for crews on specialized vessels (with turbine propulsion);
- it determines requirements for teaching staff for subjects covered by the convention;
- it introduces competence norms and responsibility levels:
  a) support level (refers to ordinary crew members, for the ER it refers to motormen who perform duties under control of the person from operational or managing level);
  b) operational level (refers to watch engineering officers performing independent activities and duties who are responsible for ER operation);

c) management level (refers to chief engineers and second engineer officers responsible for direct control of duties performed by ER crew);

– it introduces requirements for teaching equipment, including laboratories and simulators necessary for the training.

The m/a requirements are a challenge for marine academies in order to provide a proper level of training, following STCW training standards and current domestic education prerequisites.

Training process at marine academies is under control of Polish Accreditation Committee, some committees designated by Polish marine administration and EMSA (European Maritime Safety Agency) and it means getting a certificate for crews training on the proper level.

Our University has obtained the training certificate for marine crews on the highest level of management. Thanks to that our graduates are given engineering officers diplomas recognized all over the world. Moreover, the Engineering Department has obtained a certificate for ER training with propulsion different than piston Diesel engine. The notion means the use of steam and gas turbines as propulsion.

Completed training of the m/a scope permits the graduates to work on ships using turbines. That was the reason to present the analysis of changes in plans and types of training for turbine propulsion which have taken place in 40 years' time. The list of subjects with teaching hours and types of training for turbine propulsion has been presented in table 1.

The number of hours and the type of classes were changing according to STCW requirements and the status of the school. Maritime College was established in 1971, academic rights were granted in 1974 and then ME (master of engineering) studies started. Classes were introduced as an additional type of lessons. Turbine training was covered by navy department. After it had ceased, new faculty "Turbine propulsion" was opened where students were trained in gas turbines too. It should be noticed that apart from the diploma faculty, the certificate for turbo / steam ER training was granted to the Engineering Department not earlier than in 2012. During lectures students are acquainted with the theoretical knowledge about basic operation of turbines, their building, construction materials, operation and diagnostic testing procedure, starting procedure, control and shut down, working with the power receivers.

Practical skills for turbine operation and devices and systems for their service are taught during laboratories and with the use of simulators.

Laboratory classes

Laboratory classes were introduced to the syllabus in 1971. Building of the workstations for turbine propulsion training requires the installation of many machines and devices such as: steam boilers, turbines gears, power receivers, condensers, pumps, water tanks, automatic systems and security systems. That demands considerable financial outlays and in turn high expenditure on operation and upkeep of the workstations in operational condition. The m/a factors were the reasons of not building the workstations at Maritime University of Szczecin. There are only cross-sections of the steam turbine and gas turbines and their construction elements. Laboratory classes were organized in the power plant "Dolna Odra", heat and power station Szczecin and in the factory "Zamech" in Elbląg. In the

Table 1. List of subjects with teaching hours and types of training for turbine propulsion performed at the Engineering Department of Maritime University of Szczecin [1]

Subject	Year of introduction	Semester	Number of hours				
			Lectures	Classes	Labortories	Simulator	Summed up/Altogether
Steam turbines	1971	6 7	32 57	– –	– –	– –	89
Steam turbines	1974	8 10	22 16	11 16	– 16	– –	81
Thermal rotor machines Gas turbines (navy)	1983	9 5	32 65	32 –	16 –	16 –	96 65
Thermal rotor machines Gas turbines (navy)	1989	7 5	32 65	– –	– –	16 –	48 65
Faculty: Turbine propulsion Main steam boilers Steam and gas turbine operation Turbo steam marine operation Devices and systems for marine turbines	2006	 7 8 8 8	 15 45 15 15	 – – – 	 – – – –	 5 – 15 –	110

eighties laboratory classes were performed in the turbo machine laboratory of Ingenieur Hochshule für Seefahrt (IHS) in Warnemünde, due to cooperation with that high school. The simplified schema of a turbo machine workstation from HIS has been presented in figure 1 [2].

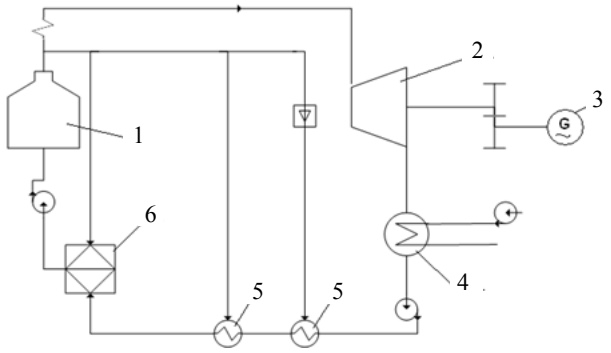

Fig. 1. Schema of a turbo machine laboratory workstation [2]; 1 – steam boiler, 2 – turbine, 3 – generator, 4 – condenser, 5 – water preheater, 6 – deaerating heater

The classes were performed for 2 days. Students were obliged to do the following, under the supervision of both HIS and Maritime University employees:

- prepare the fuel system for operation;
- start the steam boiler;
- prepare the turbine for operation, (clearance measurement, manual turbine rotation, direction of steam at the labyrinth sealing, valve and control-measuring apparatus checking, opening of the water outlets);
- preparation of the condenser for operation (creation of vacuum, starting the cooling, checking the water level);
- preparation of the steam, condensation and feed water systems for operation;
- preparation of the heat exchangers for operation;
- preparation of the deaerating heater for operation;
- starting the turbine (heating, gradual loading with power);
- parameters measurement at different loads;
- checking of the blocking operation;
- shut down of the turbine and other devices [1].

Having finished the classes students wrote a report containing the description of the performed activities, measurement tables, calculation of the turbine power and the efficiency of the boiler, turbine and circulation and conclusions.

The extended system of the turbo / steam ER made possible teaching the operation of steam turbines and boilers, devices and systems contained in the steam / turbo ER to students.

Nowadays in the current training syllabus, there are no laboratory classes with the use of real objects. The practical training function has been taken over by the classes with the use of marine ER simulators.

Classes performed with the use of marine ER simulators

A marine ER simulator, based on many mathematical models of processes taking part in the ER allows the trainee to follow their dynamics in the real or accelerated time. It gives a chance to know the structure of each system, machine or device in the ER, with the proper way of their operation and diagnosing. All the operations done by the trainee are registered and performed under the supervision of the instructor and the malfunction made are widely discussed [3].

Having realized the important role of simulators in the training process, Maritime University bought the first one in the year 1980. It was replaced with the new generation device in the year 1991 and in the year 1999 a simulator PPT 2000 was bought which consisted of two parts: operational and graphic ones. The operational part contains 2 simulators of conventional ERs. In the graphic part, 6 simulators of the ERs with different propulsion systems are installed.

Steam ER simulator

There is a steam simulator SP25 equipped with the steam turbine as the main propulsion in the graphic part, simulate on a VLCC (very large crude carrier) where classes on turbine propulsion operation are held.

Basic data of the modelled devices:

- Deadweight of the vessel: 280 000 t;
- Speed of the vessel: 15 knots;
- Rotational speed of the propeller: 70 rpm;
- Power on the shaft: 25 158 kW.

The system consists of:

- the propulsion machinery – consists of a cross compound, double reduction geared turbine, driving a single, fixed pitch propeller;
- the boiler plants – the main and the auxiliary;
- the steam plant – consists of a five stage, regenerative steam cycle;
- the main vacuum condenser;
- the LP turbine extractions (Fig. 2);
- the HP turbine extractions (Fig. 2);
- the turbo generator – is sufficient for electric power generation at normal cruising conditions;
- three turbine driven cargo pumps (Fig. 3).

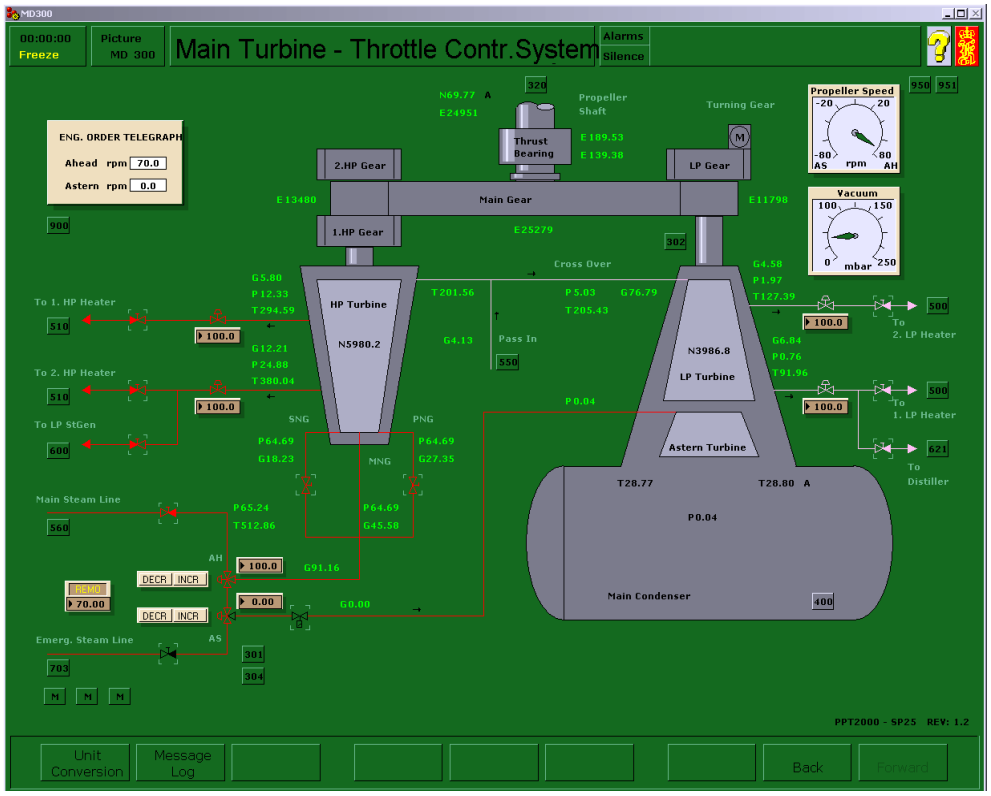

Fig. 2. Simulator screenshot showing the throttle control system [4]

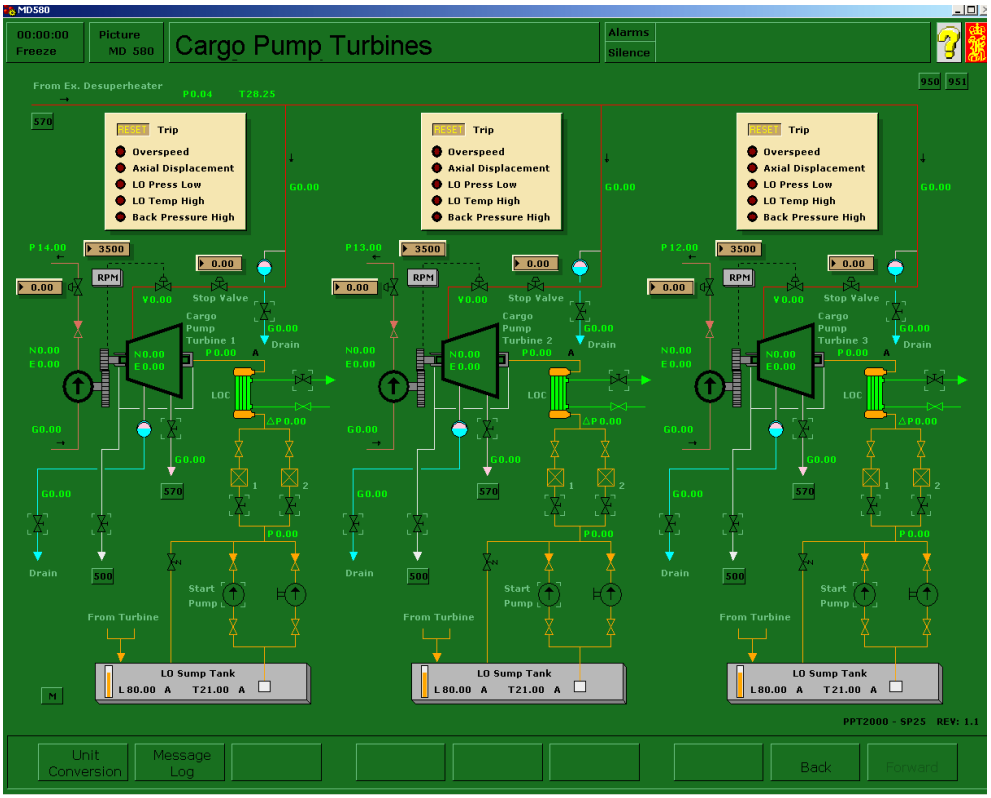

Fig. 3. Simulator screenshot showing the cargo pump turbines [4]

Trainings are based on earlier prepared scenarios allowing to adopt the level of the training to the requirements and knowledge of the simulator trainees. The system also gives the instructor a chance to interfere in the exercise via remote control panel, which permits to supervise and introduce malfunction or damage on line.

Simulator of the ER equipped with gas turbine

In the graphic part, there is also a simulator GT-22 with main turbine propulsion equipped with two gas turbine General Electric LM2500 of the power 19 700 kW each and the rotational speed of 3 600 rpm.

Each of these units can be connected to either an electric load or a water brake via reduction gears, as shown in figure 4. Hence the load can be changed with:

– operation at constant speed when using the electric load;

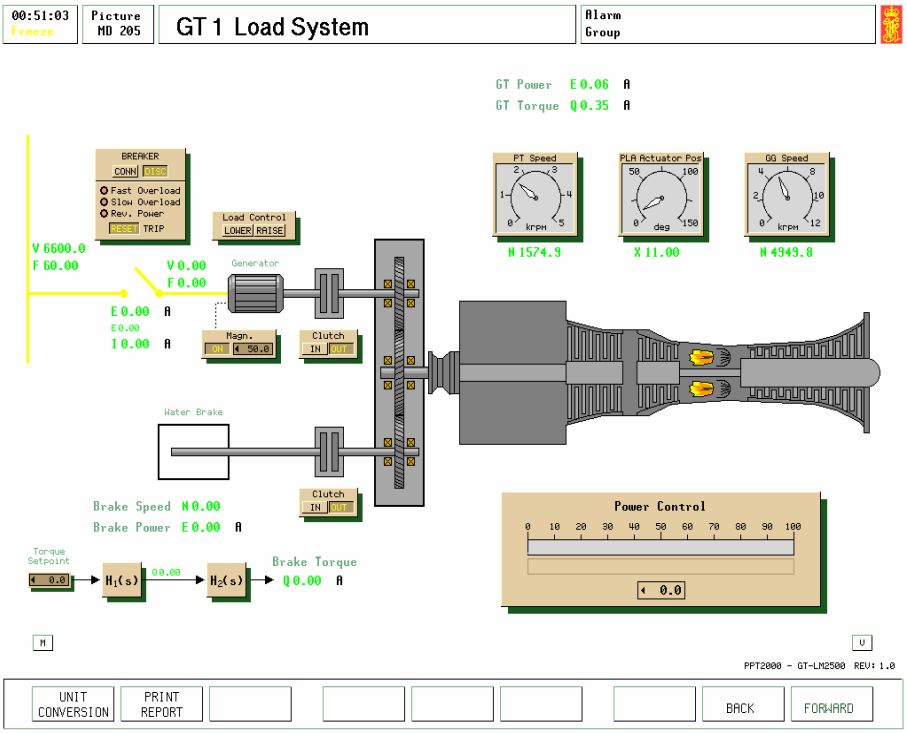

Fig. 4. Simulator screenshot showing the load system [4]

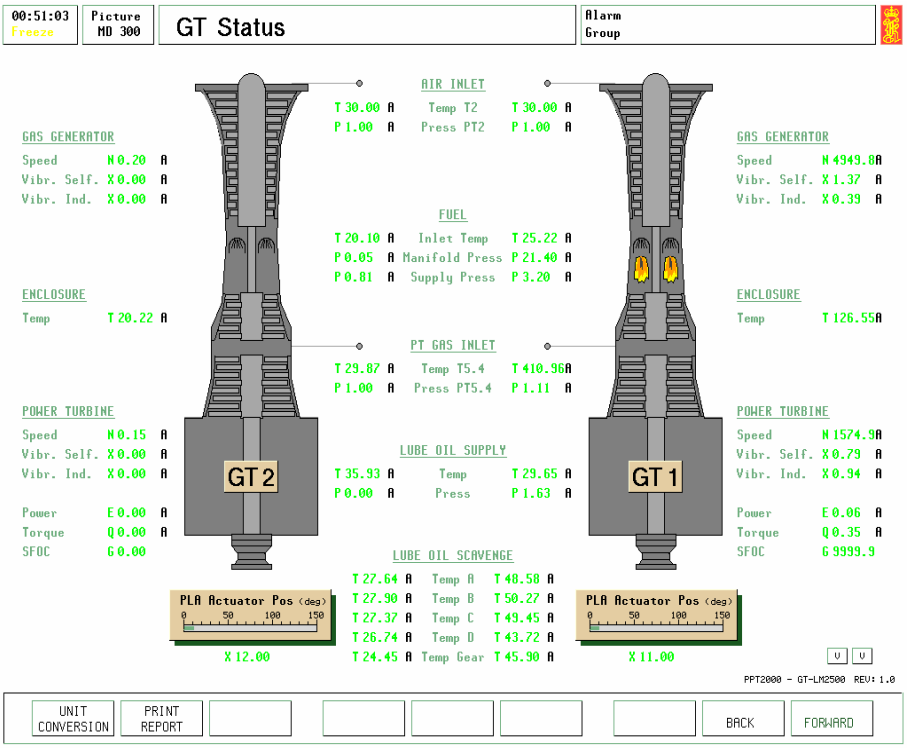

Fig. 5. Simulator screenshot showing the GT sensing systems [4]

– operation using the water brake at either the propeller law;
– power as a function of both speed and torque.

Sensors are used to control and monitor the turbine unit whilst running (Fig. 5).

Engine monitored parameters include:

– compressor inlet total pressure;
– power turbine speed;
– compressor discharge static pressure;
– power turbine inlet temperature;
– gas generator speed;
– gas generator and power turbine vibrations;
– power turbine inlet total pressure.

The reason to appreciate the use of a simulator for laboratory classes is its potential – hard to deny because of the didactic goal. It means the simulation of the real, correct running of the machinery and ER systems in the changeable conditions of the ship operation. The second, unique advantage of the simulator is the possibility of malfunction introduction to their regular running, as long as to bring about a serious damage.

On real objects such experiments as axial displacement of turbine rotor cannot be demonstrated due to enormous costs or safety reasons.

There is a possibility to introduce various malfunction or interferences in the operation of the ER on the owned simulator. That exclusive feature of the simulator allows the trainee student get to know different kinds of damage and breakdowns in the ER. By means of learning about the reasons of the malfunction which led to the particular faulty situation in the ER, the trainee gains the important knowledge how to act on a real object in order to minimize the risk of disorder at work.

In order to get the positive mark, students are required to pass the consecutive blocks in a few steps because of the classes being divided according to subjects and timing (into 2 hour or 4 hour blocks). Having completed the task, student's simulation is recorded and malfunction or alarms found during the training are discussed by the instructor.

To get the final positive score, students must obtain positive results of all particular steps and carry out the simulation from the syllabus correctly, in due time, giving the explanation of the performance.

Conclusions

It may be stated that the change of syllabuses and the number of teaching hours for turbine propulsion training subjects and auxiliary systems have allowed to work out a new model of effective training for students. The aspect of classes on real time simulators are of particular importance because they provide:

– getting to know the steam-water system;
– getting to know starting procedures of oil fired boiler, utilizing turbo-generator, loading pump turbines, gas turbines;
– getting to know preparation procedures for the operation of the steam-water system.

Software simulators with turbine propulsion make the training process for ER crews easier and faster as a result of learning by one's mistakes, without the cost of damaging or destruction of a real device. That plays an important role in the process of acquiring proper maintenance skills for a future

ER operator [5].

At the moment it is hard to determine, to what extend the number of breakdowns will be decreased in the ERs on ships if they are operated by crews trained on simulators. Yet there is a complete agreement for an opinion expressed by classification institutions and insurance companies representatives, that experienced in service / operation crews of well equipped simulators will reduce the breakdowns number of about 50% in comparison to the ones that could happen if the training were done in a traditional way.

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Challenges in teaching and learning physics for first year students

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Key words: curriculum reform, compensatory course, multimedia technology

Abstract
The authors analyze the methods of effective teaching of physics in the context of an increasingly weak preparation of students from the high school. They draw attention to the opportunities that in this field can offer new multimedia technologies, especially computers, applied to various forms of physical classes. The analysis is based on many years of experience in working with students of different specialties and in different countries.

Introduction

Curriculum reform in schools caused that on the technical universities increasingly are accepted graduates of the high school whose education of the physics comes to an end with the 30-hour course realized in the first year. The ambitious and optimistic intentions of the authors of the reform were that the 30 hours was to be treated as a multi-stage closure, a comprehensive course curriculum (middle school + high school). It is difficult to definitively determine the effect on the level of knowledge of physics that is made by a two-year break in the teaching of the subject (the second and third year of high school), but all tests carried out at the beginning of the first year of studies, show clearly that the level of knowledge of the physics students who have completed the so-called basic program is embarrassingly low.

This creates a serious problem, because the physics course, provided for first-year students whose aim was to prepare the theoretical understanding of the material necessary for the program realized in professional subjects, has to practically start from the zero level. In order to keep the academic standards under these conditions it would require substantial widening of the number hours foreseen for the subject in the curriculum. It is of course impossible for several reasons, although many universities for the sake of the student introduce a mandatory compensatory course, thus taking upon himself the task of the secondary school in this field.

But not everyone is aware of the fact that the compensatory course should not be kept in the form of a standard lecture. The specificity of teaching in high school and university is significantly different [1], and not every university teacher is able to cope with this challenge. On the other hand, the primary physics is based on the experiment, and not all universities have laboratories equipped to present the experience of the high school, which of course significantly reduces the form of conducted classes. You can also have doubts about the efficiency of two physics courses at different levels conducted simultaneously.

However, when the compensatory course [2] is carried out, taking into account all the considerations above, that is, in small groups with the experiments demonstrations its effects are very significant.

An example of this is compensatory course for first year students in the Mechatronics carried out in the Maritime University of Szczecin in the scope of program for ordered specialties. Participants of this course not only attained good results with the same physics, but in contrast to students not covered by the course did not have any problems with

the other objects that required a thorough knowledge of the laws of physics. Unfortunately, the compensatory course in such comfortable conditions was carried out only once in the academic year 2010/2011. The following year, the program has been finished and the same course took much less effective formula: many groups and optional classes in the late afternoon hours.

Because now it is difficult to rely on another program as in the case of Mechatronics so we need to find new forms of activity that will allow to increase the effectiveness of education in the range of hours included in the studies program, while maintaining the academic standards to the maximum possible extent. This applies to all forms of classes included in the program of physics, lectures and especially such important laboratory classes. Particularly wide possibilities creates the optimal use in the teaching of modern multimedia techniques.

Characteristics of multimedia system

The use of multimedia technology makes sense wherever information is communicated. The advantage of multimedia over traditional media, such as a classical computer, printed materials or a movie, lies in the integration of different media in the using of interaction techniques [3]. Application of interaction means that the computer responds to input from the man, giving him the opportunity to choose what, when, where, how often, and in what order he wants to see and hear. Thus, only a computer provides the ability to connect a variety of media to interactive transmission of information, thus creating a completely new way of communicating and solving problems.

Multimedia technology also carries risks for teaching, because the computer integrating other media, and thus replaces it. This may be perceived by some teachers as an impoverishment of the forms and means of expression used by the teacher. It is known, however, that the computer is no substitute for direct contact between the teacher and students. Important here is an experience, that allows the teachers using the multimedia presentation find the right relation between what shows the presentation and what he has to say.

Modeling and simulation in the teaching of physics

Modeling is based on a mathematical description of a natural phenomenon and then obtaining new information about it. The purpose of modeling is to facilitate thinking about a particular phenomenon, and what is most important aspect it is to build a relation between the known laws governing phenomena and the same model. A model can contain one or more complex systems of equations. After creating the model it should be checked experimentally by comparing the data obtained in two ways, namely by the data generated by the model and the actual results of the experiment. Thanks to this method, students can check their hypotheses based on the results of modeling. The advantage of the modeling is the ability to edit the model and its changes, which allows you to study how the system due to changes made in the model. A completely different character have simulations, which show the selected physical phenomenon or a specific experience. Simulations are virtual experiments, in which you can change some parameters and observe the effect of those changes. Might want to use simulation experiments that are difficult, dangerous, too expensive, or impossible to achieve in school. They facilitate the introduction of difficult concepts.

The appearance of modern data processing (computer) and the availability of information on the Internet caused a revolution in the methods of their practical use [4]. Computerization and informatisation invaded every aspect of life, including education, which the school could not ignore. IT education is seen as a new item, the purpose of which is to show the capabilities of modern computing resources and their use in solving multiple problems and as a means of supporting teaching, in order to improve its efficiency. A student solving a problem, usually has a certain amount of knowledge, but it is often insufficient to resolve it. The gaps in his knowledge student complements, reaching out to other sources, primarily to the computer. The computer not only provides the missing knowledge, but also it can help identify the hypothesis and its verification, making it a center of teaching about unattainable by other means possibilities. Computer education is a tool that can organize the process of learning – as a tool to support existing educational program. Use a computer in teaching gives a number of advantages, most important of which seems to be quite rapid development of learning outcomes. Working with a computer requires from the learner keeping the principles of collection, processing and presentation of information, which gives rise to logical thinking, precision of expression and right formulation of the problems.

The value of the computer as a means of teaching is huge, because more than 80% of information reaches the human through the eye channel. In addition, the computer can present processes or

phenomena that are impossible to observe in a natural environment, because normally these processes are too fast or too slow. Research performed on the effectiveness of teaching using a computer showed that the learning process is increased by 40% and the rate of learning is faster by 60%.

Some will no doubt complain that this technique of "active learning" forces the lecturer to cover less material. It is indeed true that the lecturer talks about less material with this approach; the challenge to the lecturer is to choose between the material that is worthy of discussion during the lecture and the easier material that the students can learn adequately on their own from the textbook. Thus this technique does not require that any material be deleted from the course syllabus. Employing "active learning" in the lecture keeps students engaged in the lecture. More importantly, as shown in several studies conducted in this area it yields substantially better student performance on exams than does conventional instruction.

Teaching physics in Polish schools is a theoretical dimension. It's true obvious to most teachers of this subject. Another truth is that it should not be, because an experiment is the essence of classical physics. Nothing else, but that experience should be the starting point of the theory or illustration and ignore it, not only should, but actually must not! Physics is for students considered to be one of the most difficult subjects, and the reasons for this assessment are quite obvious. This subject requires a thorough understanding very difficult problems and the efficient use of mathematics. The fact that there are elements of mathematics included in a separate field of knowledge, which has its own characteristics, causes an additional problem. Physical model operates not only in the numbers. Mathematics is treated as a tool, but the numbers, patterns relate to realistic, not abstract phenomena. Each number in mathematics, in the physical formula has the character of a unit: kg, meters, Jouls, Newtons. Efficient conversion of units makes students extra great difficulties. If you also take into account the fact that some physical values are scalars, and other vectors for which there is quite a different algebra you come to the only right conclusion: physics can not be taught theoretically, physics you need to see in her practical terms. A sensible way to teach the subject in schools requires mathematical foundations, then the understanding of phenomena and presentations of theoretical problems in the form of tasks, equations and calculations. Many physics faculty come away from teaching introductory physics deeply dismayed with how little the majority of their students have learned. Even worse, the growing importance of technological literacy in the workplace makes it increasingly important for us to provide value to more of our students. Introductory courses are often designed for the prospective professional with many topics treated superficially to provide a context for later study, and with an emphasis on mathematical manipulations and structures. These mathematical structures may later serve as a framework for building a strong and well-organized understanding of the subject in which concepts and knowledge structure are tightly woven into the mathematics.

Physics can not be learned by heart. It is impossible to teach physic in such a way to make student become familiar with the typical tasks which will be solved, without a fundamental concept of the essence of phenomena. A characteristic feature of modern education systems is to look for more and more attractive and effective methods and forms of work with the student. This property applies to all stages and levels of education. Among the various trends and tendencies of modernization of education systems, concepts which call for better use in the educational process of teaching (aids), and especially the media (video, television, computer with appropriate software), used in combination with conventional measures, occupy a special place.

Didactic means in the teaching- learning process play an important role making the thought processes easier, assisting in the performance of students exercises and obtaining their practical abilities. The choice of measures in the learning process is dependent on many factors. One of the most important is transferred content and the recipient. The content transmitted through educational measures should not include ready-made solutions, but only indicate the multiplicity and variety of news categories that affect the solution to the problem.

New form of Lecture

The lecture is one of the most ancient of teaching methods. In the teaching of physics, it is typically used to demonstrate physical phenomena, to present derivations; and to show examples of how to solve problems. The first of these uses of the lecture is an important one, and is often neglected by instructors who feel compelled to "cover more material" or who regard the demonstrations as a distraction [5]. My own experience is that good lecture demonstrations are absolutely indispensable as tools for helping students to relate physical concepts to the real world. Good lecture demonstrations also have the strength of being memorable.

By contrast, the use of lecture time to present derivations is typically ineffective. A derivation presented on the blackboard is less useful to the student than the same derivation presented in the textbook, where it can be traced through repeatedly at the student's leisure. On the other hand the level of commitment of present students sometimes authorizes instructors tend to present derivations in lecture because they doubt that their students read the book.

Numerous instructors, myself included, have found that lectures become more useful when students are forced to become active participants in the lecture [4]. In my own classes, I speak briefly about each new topic then I define all of the new concepts typical for analyzed problem trying to take advantage of all the knowledge of students resulting from their everyday experience. Contrary to established ideas, the first years students do not begin their physics course in a state of nearly perfect tabula rasa. Even taking into account the shortcomings and drawbacks of the education system I mentioned earlier, students arrive in their first physics course with a set of physical theories that they have tested and refined over years of repeated experimentation. Students have spent over a dozen years exploring mechanical phenomena by walking, running, catching footballs, and riding in accelerating vehicles. Therefore, the appeal to the typical situation in the mechanics course makes the presented theory and equations assume more realistic dimensions. Another important element of an active lecture is the use of the students to perform certain simple transformations. This allows you to maintain concentration among students, no one knows when he can be asked to the blackboard, on the other hand to stimulate the rate of the lecture.

You can decisively improve the efficiency of the lecture if you join a short film, or a demonstration that shows up most intriguing experience related to the realities that are known and understood by the student, and show some phenomena in a slightly different aspect. Analysis of the experience always leads to an interesting discussion, which skillfully stimulated by the teacher helps students to develop interest and inspiring them to deepen their knowledge.

Multimedia in laboratory

The main role, in this modified by necessity curriculum, have to play laboratory classes. Unfortunately, the economic criteria force the universities to increase the number of students in groups, so that the teacher often has to deal with a group of a dozen or so. Because the programs of the technical studies are constructed, so that the physics laboratories are among the first if not the first classes of this type which the first-year student faces, one should think carefully about a set of laboratory exercises that should be carried out at this stage of study. Full of electronics, the laboratory sets, in this situation, are quite impractical because students are not able to follow a sequence of events occurring in them and to understand very substance of the measurement. On the other hand, entrusting the specialized and therefore expensive equipment to totally unprepared students dramatically increases the probability of its destruction. In this situation much better suited are simple exercises, where students making relatively simple measurements can observe the phenomenon directly.

With a little help of teacher the students are able to make such measurements relatively quickly [6]. This allows to supplement the performed experiments with appropriate computer simulations. Since these computer simulations are generally available on the internet, you can supplement them practically every experience. This form of experimental activities is particularly important in the case of classes with electricity [7]. While with the mechanics, we can always call upon the experience of everyday life and so-called common sense, whereas in relation to electricity, such parallels might be completely unreliable. Emphatic in this regard is test, carried out among American students and relating to a simple circuit.

The first electrical circuit consists of a battery connected to two identical light bulbs A and B in series. In the second, the battery is connected to a single bulb C which is identical to bulbs A and B. McDermott and Shaffer [8] asked students in introductory physics courses to compare the brightnesses of bulbs A and B in first circuit and to compare these with the brightness of bulb C in second circuit. The results of this investigation were incredibly disappointing. The correct answer, that bulbs A and B in first circuit are equally bright and that bulb C in second circuit is brighter still, was given by only about 10% of the students. The same question asked students of the first year of Maritime University in Szczecin has made an even bigger problem, only less than 5% of students answered it correctly.

The most remarkable result of this simple test is that the types of student errors made on this question are unrelated to, and unaffected by, conventional instruction. One common student error is the belief that in first circuit, bulb A will be brighter than bulb B because bulb A "'uses up' the current

first." Another common error is that the brightness of each bulb will be the same in either circuit because the battery provides a constant current in all cases. Neither of these incorrect ideas are learned from an introductory course, but neither are they discredited in a standard introductory course.

Investigations of this sort show that it is not enough to merely teach students the right way to think about physics. Rather, the challenges to the instructor are to identify possible student misconceptions, to confront these misconceptions head-on, and to help students to unlearn these misconceptions at the same time that they are learning correct physics. Failure to do this will invariably leave students with their erroneous "common sense" ideas intact. Therefore, an important element of the comprehensive preparation of students in the field of electricity seems to lead in preparing a number of laboratory sets oriented not at traditional measurements, but at the demonstrations that students can do themselves. The typical experiments involving this scope of physics must include:

- the magnetic field due the conductor with current;
- inducing of alternating currents;
- Lenz rule checking;
- the phenomenon of self-induction;
- electrodynamics force.

The purpose of these exercises is to perform simple experiments by students and draw the correct conclusions. The same exercise we can then show in the form of a short film or a computer simulation paying attention to the key elements. A significant advantage of classes in the formula is the possibility of making a substantial part of computer simulations outside the laboratory, in the student's individual work.

Conclusions

Physics curriculum reform in schools has caused that the vast majority of students going to technical college has huge shortcomings in this subject. Due to competition in the labor market and the requirements imposed by the technological advances on the future engineers, universities can not afford to reduce drastically the level of teaching in the basic subject which is the physics. On the other hand, the economic criteria decide on a limited number of hours devoted in the curriculum to this course.

All this makes that the teachers are facing tremendously difficult task, as in the intact and usually a small number of education hours to achieve satisfactory results starting from a much lower level than earlier academic programs could predict. One of the possibilities to achieve success in these conditions, it is a significant modification to the teaching methods of physics with the optimal use of multimedia techniques. Great opportunities in this field provide the present computer programs that allow to perform a difficult, or even impossible experiments in virtual reality.

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Abstract

The paper presents key legal instruments governing the issues of the protection of the marine environment with respect to the management of ship-generated waste and cargo residues in European Union seaports. In view of the observed development of maritime transport, it is particularly important to organise the reception of wastes and cargo residues in seaports, in line with the principle of sustainable development. As a result of the harmonisation of the relevant legal regulations, Member States of the European Union and port and harbour authorities have taken a number of measures over the last few years to arrive at optimum solutions in this respect. The main objective of the paper is to analyse the existing system of environmental fees, the calculation criteria for such fees, and the techniques used in selected European Union seaports to submit ships' waste notifications. The research is aimed, inter alia, at determining which of the solutions that are now used in Rotterdam, Antwerp and Klaipeda could possibly be optimal for the ports in Szczecin and Świnoujście.

Introduction

The changes observed in the global economy are directly reflected in the magnitude, type structure and directions of transport. Activities involving intensive development of transport have led to the utilisation of more complex sources of energy, which affects the ecosystems. The negative environmental impact of transport is caused by a number of factors, including, for example, the type of means of transport, the geographical range, as well as the duration of the transport service. Due to the continuing development of the transport infrastructure, we are facing an escalation of activities causing harm to the environment. This situation forces the European Union to look for sustainable transport solutions. In accordance with the guidance provided in the White Paper, the priority for the European Union is to develop a competitive and resource efficient transport system, with the key role played by less polluting transport modes (rail and waterway). The objectives of sustainable development are met through the development of an environmentally focused mix of transport modes. One of the main objectives of the common policy of the European Union is to support the sustainable economic growth in marine sectors, while ensuring the highest standards of environmental protection. It is particularly important for the Community to support the development of the "blue economy", with a major role played by marine transport (shipping and ports). Shipping is one of the most environmentally friendly ways to move large quantities of cargo on long routes. According to the Blue Belt concept, the activities of European Union Member States should focus on the optimum utilisation of the potential arising from the common access to marine waters. Along with the increasing demand for marine transport within the European Union, increased numbers of ships handled by seaports should be expected. A higher number of calls means that seaports will have to address a range of new logistical challenges involving the optimisation of the receipt and further disposal of wastes and cargo residues generated by ships. The need to ensure the adequate number of reception facilities in seaports and to establish relevant administrative procedures to accommodate the increased vessel

traffic was pointed out, for example, in the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

The problems of the management of ship--generated waste and cargo residues in the light of the law

Issues of the management of ship-generated waste and cargo residues[1] have been incorporated in a number of legal instruments in the field of the protection of the marine environment, the most important of them being international conventions, local agreements and EU directives. The most important international regulations governing the management of ship-generated waste and cargo residues include: the Marpol 73/78 Convention, the Helsinki Convention which covers the Baltic Sea region, and Directive 2000/59/EC.

The International Convention for the prevention of pollution from ships (MARPOL 73/78) contains, inter alia, the most important legal and technical standards for the design of ships, equipment ensuring ecological safety, technical equipment requirements for all types of vessels (oil separators, sewage treatment systems, pollution measuring equipment etc.), as well as guidance on discharges of pollution into marine waters. The MARPOL 73/78 Convention in force includes the general part and six adopted annexes, with two further annexes (VII and VIII) in the pipeline, intended to cover the issues of polluted ballast water and bulk cargoes carried as solids in bulk [2]. The Convention is particularly important for the national legislation, as the countries – parties to the Convention are required to consider its requirements when drawing up legal instruments covering the issues of the protection of the marine environment.

The Convention on the Protection of the Marine Environment of the Baltic Sea Area, known as the Helsinki Convention, is an international document governing the issues of the protection of marine waters against pollution from marine vessels, of particular importance to the countries of the Baltic Sea area. In accordance with its provisions, Baltic coastal states undertook to take a range of measures to support the protection of the marine environment. In its content, the Convention significantly extends and strengthens the requirements of MARPOL 73/78 with respect to the "Baltic Sea Area" [3]. With respect to the organisation of the reception of ship-generated wastes in seaports, the contracting parties are obliged, inter alia, to develop and apply uniform requirements for the provision of reception facilities for ship-generated wastes, with particular regards to passenger ships. Detailed guidance covering the above topics is provided in the *Baltic Strategy for Port Reception Facilities for Ship-generated Wastes and Associated Issues*. The document contains requirements for handling ship-generated waste, the arrangements for waste reception, as well as administrative guidance. In accordance with its provisions, the reception of waste from ships in seaports in the Baltic Sea Area should follow the no-special-fee principle. Before departure, each ship must deliver the waste carried on board, in accordance with the notification submitted beforehand. A penalty system is applicable to infringements of the principles of protection of the marine environment. Port operators are obliged, inter alia, to develop and implement port waste management plans for ship-generated wastes, and to equip their ports with special reception facilities [4].

The most important legal instrument governing the arrangements for the reception and management of ship-generated waste in seaports of the European Union is Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues. Under that Directive, Member States are obliged to arrange the reception of ship-generated waste and cargo residues in accordance with certain administrative procedures. The Directive imposes a range of waste management obligations, both on ports and on ships. These measures are aimed at, inter alia, reducing the illegal discharges of pollution generated during the service of ships into marine waters. The Directive allowed the Member States a high degree of freedom with respect to the use of the most suitable

[1] **Ship-generated waste** – "shall mean all waste, which are generated during the service of a ship and fall under the scope of Annexes I, IV, V and VI to the Marpol Convention and cargo-associated waste other than cargo residues as defined in the Guidelines for the implementation of Annex V to Marpol 73/78 – until the delivery to port reception facilities" – according to Article 3.4 of the Act of 12 September 2002, Journal of Laws of 2002, No 166, item 1361, as amended, on port reception facilities for ship-generated waste and cargo residues.
Cargo residues – in accordance with Article 3(5) of the aforesaid Act, these are defined as "the remnants of any cargo material on board in cargo holds or tanks which remain after unloading procedures and cleaning operations are completed and shall include loading/unloading excesses and spillage" [1].

tools to introduce its provisions into national law. Building on the Directive, each Member State has developed appropriate national legal instruments that are fully consistent with international regulations on the protection of the marine environment. Member States are obliged, inter alia, to ensure the suitable technical facilities necessary to receive ship-generated waste and cargo residues in their ports, and to ensure the administrative supervision for those facilities. Port reception facilities should handle all types of ships on an ongoing basis. The Directive does not impose any particular requirements on seaports as regards the organisation of the system of environmental fees, their calculation criteria, techniques used to submit waste notifications and the operators providing the service. In 2007, the sewage requirements of the Directive were extended, and sewage was added to the group of waste delivered to port reception facilities [5].

Arrangement of the reception of ship--generated waste and cargo residues in the light of the applicable regulations

Due to the harmonisation of the legal regulations governing waste management in the seaports of the European Union, it has been and it still is particularly important that each Member State develops its own financial and organisation mechanisms in this area. To implement optimum solutions, it is necessary to ensure the clear understanding and continuous monitoring of the pollution generated by particular types of vessels, which normally use port services. Pollution from ships, in accordance with the categorisation of MARPOL 1973/78, is divided into: oil, noxious substances, sewage, garbage, air pollution and ballast waters. International regulations allow (in keeping with certain procedures) the discharge of specified groups of pollutants into marine waters [6]. It should be stressed that wastes generated by marine vessels are particularly dangerous to the marine environment, as they contain high quantities of noxious substances, of which oily waste are the most dangerous to ecosystems. In view of the above, the optimisation of measures relating to the arrangement of the reception and further disposal of waste at sea ports should begin directly "at source". It is particularly important to use the best available technologies directly on board, to develop integrated systemic measures, to raise the environmental awareness of crews and to ensure the ongoing control of the procedures relating to the reception and further disposal of wastes in seaports on the basis of the applicable international and national regulations [7].

European Union promotes the use of state-of-the-art environmental solutions on ships, which will enable the efficient and environmentally sound handling of vessels in seaports. In accordance with the Community concept of "green ports", ships using environmentally friendly technologies will be dealt with more quickly and pay reduced harbour dues. Seaports are particularly significant hubs for transport activities in the European Union. Their operations play a major role in the protection of the marine environment. Pursuant to applicable regulations, European Union seaports are obliged to arrange the reception of ship-generated waste through, inter alia, providing the suitable technical facilities for such services. Ships, on the other hand, are obliged, inter alia, to submit notifications to seaports concerning waste and cargo residues carried on board during their journeys. On the basis of the notification submitted by the ship, the port is obliged to arrange the reception of waste. Feedback sent to ships contains detailed guidance, including information on the reception possibilities for particular groups of waste and cargo residues and the location of reception facilities. In a situation where the port is unable to receive the waste, the information is forwarded to the next port of call. Such an organisation of activities makes it possible to control the streams of wastes and cargo residues within European Union seaports.

Due to the ever-rising costs of waste management, the marine industry is obliged to develop optimum recycling technology solutions, both on board and in ports. An appropriate information flow between seaports and vessels is necessary to develop the best organisational solutions, in ecological, economic and technical terms. The proper arrangement of the reception of waste and cargo residues in seaports ensures the control over ship movements and compliance with the appropriate marine environment standards. For the sake of environmental protection, fees for waste and cargo residues delivered by ships should be optimum. The use of excessive rates for the services provided by seaports may be directly reflected in increased illegal discharges by ships, since it is particularly important to create such economic and legal tools owing to which illegal discharges of pollutants, which are dangerous to the marine environment, will be no longer profitable for ships. Shipowners should be encouraged to use devices and installations on their ships that will minimise the quantities of waste and cargo residues on board [8]. There are no regulations that would specify detailed criteria or guidance with respect to the design of systems of environmental fees. Directive 2000/59/EC requires

European ports to shift the costs involved in the operation of port reception facilities to ships, in accordance with the "polluter pays" principle adopted by the Community. The fee for the use of reception facilities should be paid by the party using the facilities. In accordance with HELCOM recommendations, ports of the Baltic Sea should use the no-special-fee principle when designing their fee systems.

Analysis of the process of the reception of waste and cargo residues in selected ports of the European Union

The analysis covered organisational and economic solutions for the arrangement of the reception of ship-generated waste and cargo residues developed on the basis of applicable regulations and used in selected ports of the European Union. The study was aimed at identifying how the experience of selected ports of the European Union could influence the optimisation of activities carried out in this area in the ports of Szczecin and Świnoujście. The findings of the study are provided in tables 1 to 4.

Summary and Conclusions

Considering the ongoing changes in marine transport, it has become necessary for the international community to take appropriate legal and economic measures focusing on the protection of the marine environment. In order to ensure the competitive but still sustainable development of marine transport, a number of environmental measures must be taken by seaports, which represent a particularly significant link in the marine transport chain. In view of the envisaged increase of cargo carried by sea within the European Union, the problem of proper management of ship-generated waste and cargo residues can be expected to aggravate. The strengthening of legislation in this area has led European Union Member States to look for optimum system solutions for waste management in ports.

The analysis carried out has shown that EU ports use very diverse economic solutions for the reception of waste and cargo residues from ships, which may indicate that an optimum model for the calculation of the environmental fee has not yet been found.

Table 1. Arrangements for the reception of waste and cargo residues in the ports of Szczecin and Świnoujście (own work on the basis of [9, 10])

Organisational and economic solutions	Advantages	Disadvantages	Comments
Charges – The fee for the reception of a limited quantity of waste is included in the tonnage dues, calculated on gross tonnage of vessels. The tonnage due is charged for ship handling in the port. – Limits are allocated on the basis of the location of the last port where waste was delivered. An additional fee is charged when the limit is exceeded. – Cargo residues are received according to tariffs applied by companies providing such services. **Waste notification** – Since April 2013, ship's waste notification must be submitted using an electronic form, which is integrated with PHICS (Polish Harbours Information & Control System). **Calculation criteria** – The limit on the quantity of waste delivered to port reception facilities depends on the location of the last port where the ship delivered waste. – An additional fee is charged for delivered waste exceeding the limit. – A special fee is charged for waste delivered under conditions other than those required by ZMPSiŚ SA. **In addition**: – There is a sewage treatment plant in the Port of Szczecin. – A harmonised ship-generated waste management system is in place at the ports of Szczecin and Świnoujście.	– Guaranteed delivery by a ship of a certain quantity of waste to port reception facilities. – The environmental fee calculation approach used by Zarząd Morskich Portów Szczecin i Świnoujście SA strongly reflects the *no-special-fee* concept, promoted by the Baltic Strategy. – Waste reception is in line with the "polluter pays" and "user pays" principles. – Ships' waste notification must be submitted to ports using an electronic form, which is integrated with the control and information system. Integration with PHICS should guarantee the effective control of ships with respect to delivered waste.	– The ports do not use preferential rates (exemptions) for ships equipped with modern, environmentally sound installations. – Arrangements with respect to the reception of wastes and cargo residues have been imposed by the legislator. – Polish ports are not free to set the fees for waste reception and management on their own. The tonnage dues are fixed by law. – Waste reception (within a certain limit) is included in tonnage dues, which have not been increased along with the introduction of the statutory obligation to collect ship-generated waste. – In the period from 2006 to 2010, only in 2010 the revenues from special and additional fees exceeded the costs of provision of reception facilities.	– Until April 2013, waste notification was only submitted in a traditional format (attached to PHICS as a PDF file). – Pursuant to the Regulation of the Minister of Transport, Construction and Maritime Economy of 17 January 2013 on the submission of notifications of waste on board ships (Journal of Laws of 11 January 2013, item 77), an electronic port notification format integrated with PHICS was introduced. – In practice, ships very often restrict the delivery to the specified quantitative limit.

Table 2. Arrangements for the reception of waste and cargo residues in the port of Antwerp (own work on the basis of [9])

Organisational and economic solutions	Advantages	Disadvantages	Comments
Charges – Each ship calling at the port is obliged to pay an environmental fee. – The fee is made up of two components (fixed and variable fee). The fixed fee is EUR 20, and the variable fee is EUR 45 (as at 2012), multiplied by the applicable factor, depending on gross tonnage and vessel type (according to *Lloyd's Register of Shipping* classification). The level of payments is subject to revision and depends, inter alia, on the costs of reception arrangements and further handling in the port. – Cargo residues are received according to tariffs applied by companies providing such services. **Waste notification** – Submitted by electronic means, using a special electronic form. **Calculation criteria** – The level of fees depends on vessel type and gross tonnage (applicable factors are set for particular vessel types). **In addition**: – It is possible to apply for a refund for certain waste groups delivered to port reception facilities (EUR 30 per m³ for oily waste, EUR 15 per m³ for garbage – as at 2012). – Ships using environmentally friendly technologies (e.g. propelled by environmentally friendly fuel) can apply for a reduction of the environmental fee.	– The system of environmental fees takes into consideration, among other things: the duration of the voyage, the type of fuel used, the number of crew members and the speed of the vessel. – The fee is calculated on the basis of certain vessel classification criteria (on a scale from 1 to 6). – The fee includes a fixed component and a variable component, which is subject to refunds. – The level of the environmental fee is subject to revision and is set in consultation with port authorities (adjusted to the current conditions). The level of the fee depends, inter alia, on the size and type of the vessel (factor values have been estimated on the basis of the port's statistics). – Preferential rates apply to ships using environmentally sound solutions. – Vessels may apply for refunds for the delivery of oily waste and garbage (the level of the refund is revised on a regular basis).	– Vessels applying for the refund are subject to a special administrative procedure.	– The existing organisational and economic solutions have been developed on the basis of a large number of variables. – The fees are subject to review. – The refund system is intended to encourage ships to deliver certain groups of waste to port reception facilities, which is beneficial to the marine environment. – Environmentally friendly solutions are promoted. – If the system was adjusted to the situation of ZMPSiS SA, it is very likely that the solution used to calculate the environmental fee would be economically beneficial.

Table 3. Arrangements for the reception of waste and cargo residues in the port of Rotterdam (own work on the basis of [9])

Organisational and economic solutions	Advantages	Disadvantages	Comments
Charges – An environmental fee is charged, made up of two components. The system of fees is based on indirect and direct financing. – Each ship calling at the port (with the exception of ships that are exempted pursuant to separate regulations) is obliged to pay an environmental fee before the call. – The port authority charges an additional administration fee for ship handling with respect to the reception of ship-generated waste, at the rate of EUR 15 (as at 2012). – Cargo residues are received according to tariffs applied by companies providing such services. **Waste notification** – Can be submitted using a traditional form or by electronic means. **Calculation criteria** – The level of the environmental fee is dependent upon main engine capacity – MEC. – The limit for the reception of domestic waste is based on the number of crew members. – Higher rates are charged for vessels delivering unsorted waste. **In addition:** – A harmonised ship-generated waste management system is in place in the Rotterdam-Rijnmond Port Region. – It is possible to apply for a refund for the delivery of certain waste groups (Annex I and V to MARPOL 73/78).	– The indirect fee covers the delivery of a certain limited quantity of waste (oily waste and garbage) to port reception facilities. – Ships must pay for the reception of waste, but may apply for reimbursements for certain waste groups. – The level of the environmental fee is dependent upon main engine capacity (MEC). – Ships using environmentally friendly technologies can apply for exemptions from fees for the reception of wastes covered by Annex I to MARPOL 73/78. – The fees are subject to review. – Environmentally friendly solutions are promoted.	– A limited group of waste is collected for the indirect fee. – The environmental fee obligation also applies to seagoing vessels which leave the port and return 4 hours later (unless it concerns a tide-bound ship which visits the Calandkanaal from the Nieuwe Waterweg or vice versa via the offshore separation buoy).	– The possibilities of adjustment to the Polish conditions are limited. Main engine capacity information is not collected. – The use of reimbursements for certain groups of waste is beneficial to the marine environment.

Table 4. Arrangements for the reception of waste and cargo residues in the port of Klaipeda (own work on the basis of [9])

Organisational and economic solutions	Advantages	Disadvantages	Comments
Charges – An environmental fee of 0.25 litas per GT unit is charged if a vessel stays at the port up to 10 days inclusive. The rate applicable from the 11th day for each following day is 0.025 litas per GT unit. – Cargo residues are received according to tariffs of companies providing such services. **Waste notification** – A form submitted to the port operator by the ship owner. – Calculation criteria. – The environmental fee is charged on the basis of the vessel's gross tonnage (GT). **In addition:** – There is a sludge treatment plant in the port. – Oily waste is collected by special boats, operating 24/7.	– A high environmental fee. This solution is economically beneficial for the port. – For the environmental fee, a ship may deliver any type of waste arising from the normal operation of the ship to port reception facilities.	– A high environmental fee. The solution is unfavourable to ships. – It is not possible to submit waste delivery notifications using an electronic form. – No preferential rates are used for ships equipped with innovative installations.	– If the system was adjusted to the situation of ZMPSiS SA, it is very likely that the solution used to calculate the environmental fee would be economically beneficial.

The system of fees should be reasonable, as it is directly reflected in the condition of the marine environment. The international regulations in force do not provide any specific economic guidance for seaports. Therefore, the criteria used by particular ports to calculate the environmental fee are very often based on the experience of their authors. With respect to the organisational solutions used by ports, the main focus was on the techniques used to submit waste notifications to seaports. Efficient submission of notifications from ships helps to optimise the operations of particular units in charge of waste and cargo residue management in ports. The study shows that the port in Klaipeda is the only port where EDI technology is currently not used for that purpose. It should be emphasised that pursuant to the most recent regulations, the ports of Szczecin and Świnoujście introduced the obligation to submit notifications of the wastes and cargo residues on board using an electronic form integrated with the PHICS control system as late as in April 2013.

On the basis of the solutions used in the ports under study, the process of reception of ship-generated waste in the ports of Szczecin and Świnoujście could become an optimum system provided that:

– the level of the environmental fee charged to ships would cover all costs relating to the maintenance of port reception facilities;
– it would not hamper the competitiveness of ports;
– the level of the fee would encourage ships to deliver all groups of waste to port reception facilities;
– the fees would be calculated according to criteria which would consider the types and sizes of ships;
– the level of fees would incorporate preferential rates (or even exemptions) for ships equipped with modern, environmentally sound installations.

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Unintended "biological cargo" of ships entering the River Odra estuary: assemblages of organisms in ballast tanks

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Key words: ballast tank water, ballast tank sediment, alien species, River Odra estuary, Szczecin harbour

Abstract

Water and sediment in ships' ballast tanks provide habitats for various organisms, and thus facilitate alien species introductions. Ballast tank water and sediment of 19 ships docked in the GRYFIA Szczecin Ship Repair Yard (Szczecin, Poland) located in an area connected with the River Odra estuary (Southern Baltic), were sampled in 2009–2011 to find out if the ships could be vectors of species introductions to the estuary, already known for the presence of non-indigenous taxa. This study showed the ballast water of the ships examined to house rotifers, copepods, cladocerans, and bivalve and cirriped larvae – common constituents of zooplankton assemblages in coastal waters. The ballast tank sediment supported meiobenthic foraminiferans, nematodes, harpacticoid copepods, turbellarians, bivalves, polychaetes, and chironomid and cirriped larvae. It is not possible at this stage to judge what meiofaunal taxa constitute an alien component in the estuary biota. Macrobenthos in the ships' ballast tank sediment examined was represented mainly by nereid polychaetes. Although the unintended "biological cargo" examined proved quite diverse and abundant, it contained few identified alien taxa. It does not seem likely than any of them could pose a threat of a biological invasion in the River Odra estuary. However, numerous species remained unidentified, and therefore assessment of the risk of alien species introduction and invasion contains a large measure of uncertainty. On the other hand, the risk as such remains, since the density of ballast water-borne organisms in all ships exceeded the allowed limits.

Introduction

Ballast tank water and sediment of sea-going ships may provide habitats for a number of pelagic and benthic organisms, thereby facilitating their dispersal and introductions into novel areas [1, 2]. An important role in this respect is played also by biofouling [3], which is of a particular importance for the spread of epibenthic, in most cases Ponto-Caspian, species in inland waterways of the central and western Europe [4, 5]. The River Odra estuary (ROE; Fig. 1) is an area of both marine and inland shipping; therefore, the estuary's harbours, primarily Szczecin, Police, and Świnoujście, can act as gateways for species' introductions [6].

ROE consists of three major parts. The Pomeranian Bay, a brackish (salinity about 6–7 psu) Baltic embayment, constitutes the northernmost component. The Bay receives inflows of, usually, oligohaline (about 1 psu) to fresh water from the Szczecin Lagoon, the middle ROE component which intercepts the River Odra water and is periodically affected by seawater incursions from the Bay. The southernmost part of ROE is formed by the downstream reaches of the Odra and the adjacent Lake Dąbie, the salinity there seldom exceeding 0.4 psu [7, 8, 9].

Out of 50+ alien species ever reported from ROE and adjacent waters, about 30 are known to have been introduced into the Baltic Sea, and/or to have spread there, in connection with ships' traffic (cf. Baltic Sea Alien Species Database http://www.corpi.ku.lt/nemo/mainnemo.html and Alien Species in Poland http://www.iop.krakow.pl/ias/

Default.aspx). Most of those species represent macrobenthos, and could have been brought in by ships operating in inland waters. The presence of as few as 10 alien species known now from ROE can be related to introductions via ballast tanks of the usually sea-going ships [6].

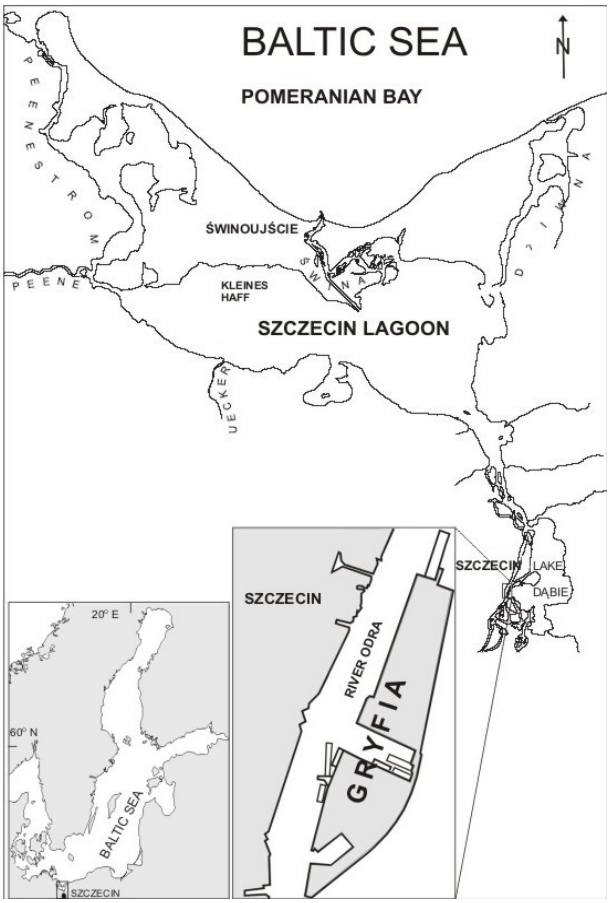

Fig. 1. GRYFIA Ship Repair Yard' location against the background of the River Odra estuary

Introductions of non-indigenous organisms with ships' ballast water and the resultant biological invasions are widely regarded as a considerable threat to the integrity of aquatic (including marine) ecosystems. This threat has been recognised both in scientific literature [1, 10] and in the management practice of the International Maritime Organization (IMO), the latter calling for efficient methods of alien species control [11, 12]. The control measures imply the need to identify potential invaders [13].

In 2009–2011, ballast tank water and sediment biota of a total of 19 ships docked in the GRYFIA Ship Repair Yard, located in the Szczecin harbour (Fig. 1) were examined. This paper is aimed at presenting preliminary data on ballast tank assemblages and at assessing whether the unintended "biological cargo" poses any threat of introducing alien species into ROE.

Materials and methods

The ships whose ballast tank water and sediment were examined included vessels of 1682–38 056 DWT; they were bulk, general cargo, dry cargo and RO-RO carriers, tankers, reefers, a car carrier, and a passenger vessel (Tab. 1). The ships were last ballasted from 1 to 19 days prior to deballasting (and/or sampling) in Szczecin (Tab. 1). Obviously, the ballast tank sediment residence time was longer than that of the water, as usually not all the sediment is removed along with the ballast water during its discharge. Therefore, the sediment residence time in the tanks was impossible to assess.

Upon arrival to the shipyard and prior to docking, some of the ballast water was discharged directly to the shipyard basin adjacent to the docking quay. The remaining water was discharged once the ship was placed in a dry dock. The ballast tank water was then sampled (Fig. 2), and its salinity and pH measured. Whenever possible, at least a 1000 dm^3 sample of water discharged from the ballast tank was collected. In two instances, ballast tanks were not opened after docking, so the ballast water was sampled when pumped to the engine room. The water was filtered through 50 µm (diagonal dimension) mesh size plankton net. The material retained on the net was fixed in 70% ethyl alcohol and examined for the zooplankton.

Fig. 2. Sampling of ballast water on the dry dock

Table 1. Characteristics of ships surveyed, including ballasting history (n.a. – data not available; e – estimated)

Ship No.	Ship type	DWT	Ballasted at (last port of call*)	Last ballasted on	Date of dry-docking / sampling	Amount of ballast released in Szczecin [t]	Days in tank
1	Fall pipe vessel	11546	Norway	18.11.2009	28.11.2009 / 01.12.2009	4000	10
2	General cargo	4234	Wismar, Germany	28.11.2009	30.11.2009 / 02.12.2009	1560	2
3	Reefer	6129	Maloy, Norway (St. Petersburg, Russia*)	22.11.2009	01.12.2009 / 03.12.2009	340	9
4	Passenger/Ro-ro	4655	Rostock, Germany	07.12.2009	09.12.2009 / 11.12.2009	1397	2
5	Ro-ro cargo	4450	Immingham, UK	07.12.2009	15.12.2009	1207	**8**
6	Multiporpose / General cargo	4800	Söråker, Sweden	14.12.2009	17.12.2009	1560	**3**
7	General cargo	11990	Rotterdam, the Netherlands* + Marin + North Sea + Baltic Sea	28.04.2010	10.05.2010 / –	2871	12
8	Tanker	14910	Antwerp, Belgium	03.05.2010	19.05.2010 / 27.05.2010	5497	16
9	Bulk carrier	38056	Rotterdam, the Netherlands	25.07.2010	27.07.2010 / 28.07.2010	5100	**3**
10	Bulk carrier	28115	Lübeck, Germany	12.01.2011	17.01.2011	9572	**5**
11	Bulk carrier – self unloader	18964	Rostock, Germany	08.01.2011	16.01.2011 / –	7203	8
12	Reefer[1]	6333	St. Petersburg, Russia	04.02.2011	07.02.2011 / 22.02.2011	258	**18**
13	Tanker	36993	Sines, Portugal	14.02.2011	21.02.2011	12513	**7**
14	Dry cargo	3495	Szczecin, Poland (Halsvik, Norway*)	20.02.2011	26.02.2011 / –	672	6
15	Dry cargo	3120	Åhus, Sweden	23.02.2011	28.02.2011 / 01.03.2011	930	5
16	Chemical tanker	9494	Antwerp, Belgium	26.02.2011	03.03.2011	3988	**6**
17	General cargo[2]	1682	Tilbury, UK	03.04.2011	07.04.2011	300	**4**
18	Bulk carrier	26264	Liverpool, UK	01.04.2011	20.04.2011 / 15.04.2011	7250	19
19	General cargo	1800	Rhine and Meuse delta (Dordrecht) the Netherlands	? 17.04.2011	29.04.2011	540	**<12**
20	Reefer	7763	St. Petersburg, Russia	23.04.2011	02.05.2011 / 17.05.2011	800	9
21	General cargo	6260	Świnoujście, Poland	21.06.2011	22.06.2011	2438	**1**
22	Car carrier	3347	Ust' Luga, Russia* + Grimsby + Malmö	30.07.2011	01.08.2011 / 02.08.2011	1390	**2**

[1)] 1106 l of water sampled (pumped) in engine room, [2)] 42 l of water sampled (pumped) in engine room

Once the ballast tank was emptied of water, the sediment accumulated on the tank bottom was collected (Fig. 3) for the study of meio- (5 samples of 50 cm^3 sediment each, collected with 2.73 cm i.d. plastic liners) and macrobenthos (5 samples of 1 dm^3 sediment each, collected into plastic jars of appropriate size). The sediment samples were sieved on 0.500 mm (macrofauna) and 0.063 mm (meiofauna) mesh size sieves. The sieving residue was preserved in 10% buffered formalin, and the meiofauna samples were stained with Rose Bengal for the ease of examination. The fish were collected from the bottom of the dry dock during or shortly after the discharge of ship's ballast water.

Fig. 3. Sampling of sediment in a ballast tank

Results

Water

The ballast tank water salinity ranged from 0.3 to 35.2 psu; based on the Venice system [14], the water was classified as ranging from fresh (2 ships) to oligo- (6) to meso- (9) to polyhaline (3) to seawater (euhaline) (1) (Tab. 2). Most of the water discharged was meso- to polyhaline (Fig. 4).

The ballast tank zooplankton was found to consist of taxa regarded as members of holo-, mero-,

and tychoplankton (Tab. 3), the latter consisting of organisms (e.g. harpacticoid copepods) which were transferred to the water accidentally, most probably by disturbance of the tank water sediment. The holoplankton was represented by 4 higher taxa (Rotifera, Copepoda, Cladocera, Mysida), whereas the meroplankton consisted of larval forms of polychaetes, cirripeds, decapods, bivalves, and gastropods. Most holoplanktic taxa showed a fairly high frequency of occurrence (5.3 – 63%; Table 3), copepods being the most common among them (63%). The meroplankton occurred at a frequency of 5.3 – 31%, bivalve larvae being the most common organisms (Tab. 3).

Table 2. Characteristics of ballast water and sediments form the ships studied

Ship No.	Water			Sediments	
	pH	PSU	Classification acc. to Venice System*	Sediment type	Organic matter content (%)
1	7.3	2.5	O	fine sand	12.9
2	9.1	16.6–21.8	M	silt/clay	10.5
3	7.2–7.9	1.2	O	–	–
4	–	0.9	O	very fine sand	35.2
5	7.5	2.4–2.8	O	fine sand	13.5
6	7.8	6.7	M	–	–
7	–	–	–	very fine sand	15.4
8	7.5	13.7	M	fine sand	9.2
9	8.2	24.3–25.3	P	silt/clay	10.6
10	7.8–7.9	10.8–11.0	M	–	–
11	–	–	–	very fine sand	31.0
12	8.6	0.3	F	–	–
13	7.2–7.5	33.0–35.2	E	–	–
14	–	–	–	medium sand	3.2
15	8.1	9.3	M	–	–
16	8.3	2.8	O	very fine sand	24.0
17	8.6–8.7	16.4–18.3	M/P	very fine sand	54.5
18	8.4	29.0	P	silt/clay	54.2
19	7.8	0.4	F	very fine sand	31.5
20	8.3	8.9	M	medium sand	10.3
21	8.4	4.1	O	very fine sand	8.6
22	8.7	11.5	M	very fine sand	19.0

* code describing Venice System classification: F – freshwater; O – oligohaline; M – mesohaline; P – polyhaline; E – euhaline (marine).

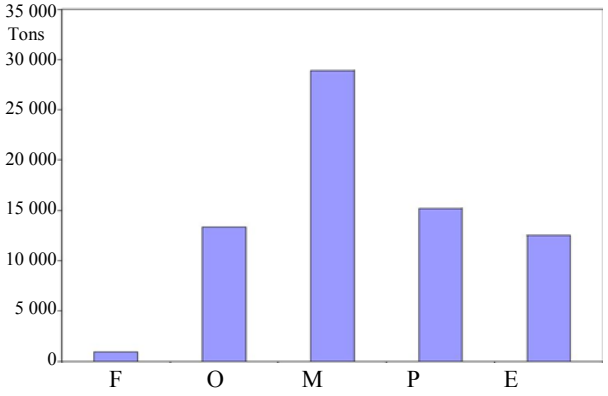

Fig. 4. Amount of ballast water [t] released from ships studied in Szczecin (n = 21) grouped in salinity classes according to Venice system (see Table 2 for explanation of symbols)

Table 3. Occurrence of major taxa in ballast tank water and sediment of ships surveyed

Habitat / taxon	Frequency (%)	No. of identifiable lower taxa	No. of alien taxa
Ballast water (n = 19)			
Rhizaria	15.8	unknown	unknown
Rotifera	15.8	13	0
Polychaeta	5.3	unknown	unknown
Copepoda	63.2	26	4
Cladocera	26.3	10	0
Cirripedia	26.3	unknown	unknown
Mysida	5.3	1	0
Decapoda	5.3	unknown	unknown
Bivalvia	31.6	unknown	unknown
Gastropoda	5.3	unknown	unknown
Actinopterygii	5.3	6	1
Ballast sediments (n = 17)			
Rhizaria	76.5	unknown	unknown
Turbellaria	35.3	unknown	unknown
Rotifera	23.5	unknown	unknown
Nematoda	100.0	13	3
Gastrotricha	17.6	unknown	unknown
Kinorhyncha	5.9	unknown	unknown
Oligochaeta	11.8	unknown	unknown
Polychaeta	23.5	2	1
Copepoda	88.2	9	2
Cladocera	5.9	unknown	unknown
Ostracoda	29.4	unknown	unknown
Cirripedia	11.8	2	1
Isopoda	5.9	unknown	unknown
Insecta	17.6	2	0
Halacaroidea	5.9	unknown	unknown
Tardigrada	11.8	unknown	unknown
Bivalvia	35.3	1	1

Not all the planktic taxa could be identified to lower taxonomic levels (genera and species). Overall, the number of ballast water-borne taxa identi-

fied to a lower taxonomic level ranged from 0 to 21 per ship (Fig. 5). Those taxa that could be identified further included rotifers (13 species and genera), adult and sub-adult copepods (26 species and genera), cladocerans (10), and mysids (1) (Tab. 3). Most of the identifiable species and genera represented taxa common in coastal and/or estuarine waters of the Baltic Sea, and the non-indigenous species were few only. These included the copepods *Saphirella* cf. *indica* and *Oncaea* spp. which occurred at a very low frequency (2 and 1 ships, respectively). However, none of the meroplankters could be identified to the genus / species level, and hence the non-indigenous species incidence could not be determined. On the other hand, the decapod crab zoeae present in the ballast tank water can be regarded as non-indigenous in the Baltic Sea and its adjacent coastal water bodies (including ROE). Among the 3 tychoplanktic taxa identified to lower level (3 genera of harpacticoid copepods), 1 (the harpacticoid genus *Dactylopsia*) had not been reported earlier from the Baltic Sea and its adjacent water bodies (including ROE).

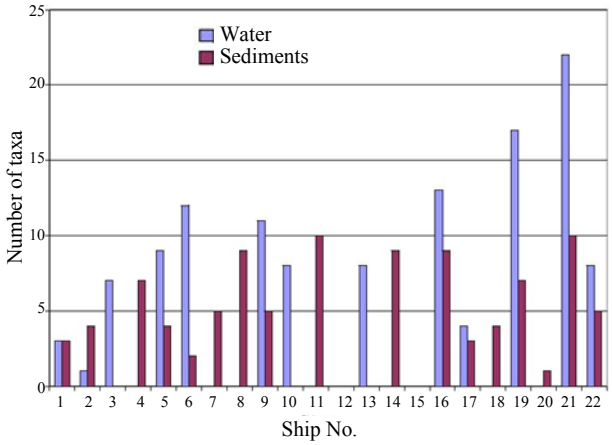

Fig. 5. Number of identified taxa found in ballast water (n = 13 ships) and sediments (n = 17 ships) from ballast tanks of ships sampled in GRYFIA Szczecin Ship Repair Yard in 2009–2011

The ballast water of two ships did not yield any organisms; the total densities of animals found in the quantitative ballast water samples collected from the 10 ships were found to range from 62 to about 643,400 ind./m^3 (Fig. 6). Copepods were the most abundant zooplanktic component. The non-indigenous taxa *Saphirella* cf. *indica* and *Onceaea* spp. occurred at densities of 2–300 and 13 ind./m^3, respectively.

The ballast water discharged by a ship arriving to ROE from Antwerp was found to carry 6 freshwater fish species. Nearly a half of the 60+ individuals retrieved from the ballast water were made up by the ruffe (*Gymnocephalus cernuus*), a species common in ROE. On the other hand, the sample revealed also the bullhead (*Cottus perifretum*), a riverine species [15] that does not inhabit the Odra.

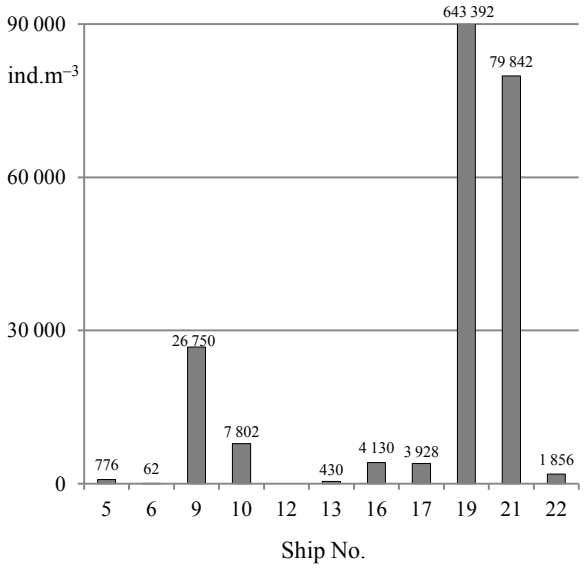

Fig. 6. Total abundance of organisms in m^3 (> 50 microns in minimal dimension), found in water released form ballast tanks upon dry-docking (except ship No. 12 and 17)

Sediment

The ballast tank sediments of most ships were classified as very fine to medium sand; two ships only carried silt / clay in their tanks (Tab. 2). Consequently, the sediment-dwelling fauna, summarised in table 3, is typical of fine sediment habitats. Organisms found in the sediment consisted of the meiobenthos and the macrofauna. Among the benthic meiofauna (organisms smaller than 0.5 mm), the ballast tank sediment supported a total of 8 major taxa (meiobenthic foraminifers, nematodes, harpacticoid copepods, turbellarians, bivalves, polychaetes, and chironomid and cirriped larvae). Only the nematodes and harpacticoid copepods could be identified to lower taxonomic levels (genus). Among the first, the genera *Deontolaimus*, *Rhabditis*, and *Southerniella* had not been reported from the area before, whereas among harpacticoids, 2 taxa (*Asellopsis intermedia* and *Paralaophonte* sp.) proved to be unreported before. Identification of other meiobenthic taxa to lower taxonomic level was not possible, hence the incidence of non-indigenous taxa remains unknown. It may be contended, however, that the foraminifers present in the sediment can be regarded as non-indigenous for ROE, since they were represented by calcareous taxa absent from the coastal Baltic waters and the Odra estuary [16].

The number of sediment-occurring taxa identified to a lower level ranged from 0 to 29 per ship (Fig. 5).

Meiobenthic organisms occurred in the sediment at average abundances of 14 to $107.8 \cdot 10^3$ ind./dm^3 sediment. They were dominated by nematodes (up to 100% of the total meiobenthos in a ship's sediment) and foraminifers (up to 89%).

The macrobenthic organisms were found to inhabit the ballast tank sediment of 6 ships. The macrofauna, wherever present, consisted mainly of annelids: unidentified oligochaetes and the nereid polychaetes *Alitta succinea* and *Hediste diversicolor*. While the first occurs in the western part of the Baltic Sea, the other is a polychaete common in the sandy bottoms of the Baltic Sea proper. The annelids were accompanied by large nematodes. The macrobenthos occurred at average abundances of 0.3 to 7.6 ind./dm^3 sediment.

Discussion

The ballast tank water in the ships surveyed were found to support quite diverse assemblages of organisms (altogether 11 major taxa and at least 57 lower level ones; cf. Tab. 3). For comparison, other studies revealed from 9 major and 12 lower taxa [17] to 25 major taxa [18] in the ballast tank water. In their summary of 25 years (until 2000) of European research on the life in ballast tanks, Gollasch et al. [19] reported up to 18 major taxa and 135 identifiable lower taxa (data from 131 ships). When the comparison is restricted to faunistic lists from the ballast tank water of ships surveyed in Baltic ports, it is only Walk and Modrzejewska [20, 21] who provided relevant data; they found 15 major taxa and 34 lower-level ones in ballasted ships in the Polish Baltic ports of Gdańsk and Gdynia. In their interesting study, Olenin et al. [22] examined en-route the faunistic composition of the ballast water plankton of ships travelling from the Baltic Sea to European ports on the open Atlantic coast and recorded the presence of 9 major zooplanktic taxa and at least 27 species.

Although the taxonomic richness of the ballast tank water assemblage in the present study was comparable to data reported elsewhere, the number of non-indigenous taxa was very low. There were only two non-indigenous copepods, *Saphirella* cf. *indica* and *Oncaea* spp. While both are known to be marine copepods [23, 24], *Saphirella* sp. has been reported (even as a zooplankton dominant) from estuarine waters of the North American Atlantic coast [25]. In view of ecological requirements of both taxa, their chances of tolerating reduced salinity typical of ROE (particularly in its upper reaches where the GRYFIA shipyard is located) are rather slim. Besides, both occurred at few ships only, although in one of them copepodites of *Saphirella* sp. occurred at a considerable density. Although Gollasch and Leppäkoski [26] quoting Carlton [1], contend that the probability of colonisation of brackish recipient areas by organisms from a marine donor region is high, the two copepods do not seem, at present, to be posing a threat of invasion in ROE or the Baltic Sea in general. The differences in environmental conditions between the donor (fully marine regions and North American estuaries) and receiver (ROE) areas should make it impossible for those taxa to survive in the latter [18]. On the other hand, the overall densities of the ballast tank water fauna proved, for all the ships examined, higher (or even substantially so) than the highest acceptable levels (i.e. not more than 10 viable organisms, greater than or equal to 50 micrometres in minimum dimension, per cubic metre) as given in Regulation D-2 of the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediment of 2004 [11], which is noteworthy in itself.

The ballast tank sediment assemblages, in this study comprising 17 major meiobenthhic taxa (with 13 nematode and 8 harpacticoid copepod genera) and 6 macrobenthic ones, were generally less diverse, compared to other studies. The number of higher taxa (meiobenthos and macrofauna combined) reported by other authors amounted to 18 [27], with 89 species and genera; Gollasch et al. 2002, with 139 species and genera, those studies involved a much higher number of ships. In the Baltic Sea, the only published study dealing with ballast tank sediment concerned the meiobenthos [28] examined in a single ship, also docked in the GRYFIA shipyard. The analysis revealed the presence of 7 major meiofaunal taxa, the number of nematode genera being 11. It is not possible at this stage to judge which meiofaunal taxa constitute an alien component in the ROE biota. Although 3 of the 13 nematode genera and 1 harpacticoid copepod identified have not been reported from the meiobenthos of ROE and southern Baltic coastal waters before, the poor general knowledge on the taxonomic diversity of the Baltic meiobenthos cf. [29] precludes any conclusion as to the non-indigenous status, and invasion potential, of any of these genera and the species they represent.

Of the two polychaete species found in the ballast tank sediment, *H. diversicolor* is common in the sandy bottoms of the Baltic Sea, including the northern part of ROE. *A. succinea* is typical of the western part of the Baltic, and has been reported from the north-western part of ROE [30]. The habitat preference of the two nereids is convergent with

that of the invasive spionid polychaete *Marenzelleria neglecta* [30], one of two alien species (known in ROE since 1986) whose appearance in ROE can be attributed to the ship-mediated introduction.

All but one fish species, including the most abundant ruffe (*Gymnocephalus cernuus*), found in the ballast tank, are common in ROE. The bullhead (*Cottus perifretum*) has not been reported from the River Odra so far.

Szczecin is a freshwater harbour, so the highest risk of alien species introduction should be connected with ballast water originating from freshwater or oligohaline port located within short distance (requiring short time voyage) [26]. The risk assessment for ballast water mediated species introductions based on voyage pattern analysis of ships calling at Polish harbours (except Gdynia) in 2007–2009, carried out by Jóźwiak [31], showed that Szczecin was among the recipient ports with the highest, or extreme, risk (12% in Szczecin) of alien species introductions. This risk category included also Antwerp and Rotterdam, the ports of call from which some of the ships surveyed in this study arrived.

Conclusions

Although the unintended "biological cargo" of ballast tank water and sediment carried by the ships surveyed proved quite diverse and abundant, it comprised few identified alien taxa. It does not seem likely at present that any of them could pose a threat of a biological invasion in the River Odra estuary. However, numerous species had to remain unidentified, and therefore the assessment of the risk of alien species introduction and invasion involves a large measure of uncertainty. On the other hand, the risk as such remains, since the density of ballast water-borne organisms in all ships exceeded the allowed limits.

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Theme cruises, as a trend in marine tourism

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Abstract

For several years, marine tourism market has been experiencing a renaissance and is one of the fastest growing segment of the tourist economy. Strong competition on the marine carriers market forced them to seek out innovative products, and in the wake of that, their specialization, as well. At the same time, there has been a tendency to change a model of resting from passive lying in the Sun on aboard of the ships for an active participation in theme and profiled marine voyages. That caters to various customers' needs and preferences. Owners of cruise vessels outdo each other in inventing the original theme offers for specific groups defined within: religious faiths, musical tastes, sport hobbies, health needs, or sexual orientation and many others. In both, polish and foreign literature, there is a noticeable lack, when it comes to a scientific approach to this phenomenon. In this light, it seems reasonable to take this topic of the research. The main aim of this article is an estimation of tenders in terms of theme cruises offered by marine carriers and making their generic classification. The research was realized using a method of desk research, a critical and comparative analysis of available literature, offers of marine tourist carriers, and also other scientific reports. Moreover, the author shows a list of criteria that could be implemented in the statistical researches of demand on theme cruises.

Introduction

For several years, a tendency to specialization of offers on the marine tourism market has been observed. The Cruise Line International Association CLIA says that "the cruise product is incredibly diversified with literally a cruise vacation for everyone. Over the past 10 years, the industry has responded to extensive market and consumer research that has guided the addition of new destinations, new ship design concepts, new on-board / on-shore activities, new themes and new cruise lengths to reflect the changing vacation patterns of today's market" [1].

The stereotype, that a marine cruise travel is only designed for rich tourists, mainly from Germany, Great Britain and the United States, has passed. "Many tourism authors have noted that contemporary tourists are much more experienced than those of earlier decades, particularly in terms of international travel. Such experienced visitors have greater access to information technology, are more demanding of products, and are more likely to seek educational components in their tourism experiences (Cleverdon, 1993; Poon, 1992; Urry, 1990)" [2].

Now every tourist, with a variety of preferences and interests, and also of various ages, is able to find an attractive offer. Owners of cruise ships, ferry lines, whether the owners of yachts and sailing boats come out to meet the growing demand, which is presented by various group of interests and prepare innovative products addressed only to a narrow group of arrivals, as for example: cruises for fans of country music, poker cruises, cruises for lovers of ancient art, cruises for wine connoisseurs, cruises for singles, seniors, nudists, and many others.

Among the most important factors, that contributed to specialization of the products offered in marine tourism, it is a need to mention:

- growing popularity of marine cruises among various groups of tourists;
- changing shopping behavior of people travelling by sea from passive to active;
- competitive struggle for a client among marine carriers;

- desire to maintain a demand for marine cruises by carriers;
- extending the tourist season in regions with strong seasonality by offering theme cruises, but not to the "sunny" destinations;
- fashion for belonging to the various formal and informal groups of interest, that organize a number of meetings, seminars, or expeditions;
- development of information systems (Internet, Mobiles) and social networking (Facebook, Twitter, Youtube, Blogger etc.), make opportunities to organize joint expeditions, including marine cruises, by various groups of interest.

The main aim of research is the evaluation of tenders in terms of theme cruises proposed by marine carriers in the world and making their generic classification. There were also indicated two other sub-goals: the first goal – What factors affect the specialization of offers on the marine tourism market? and *the second goal* – What are the criteria for classification of the forms of theme marine cruises? In addition, it has also been indicated the following research issues: the first – What are the characteristics of theme marine cruises? *and the second* – Which marine carriers propose a variety of offers of theme marine cruises? The researches were conducted using a method of desk research, a critical analysis of the available literature and comparative analysis. In order to illustrate some phenomena, a few available scientific reports of marine travel market have been used, as well.

Nowadays, tourists look for offers that are innovative, unique, interesting and fascinating, and most importantly cater to their needs, expectations, interests and dreams. Tourists are not satisfied with a standard sightseeing in a famous destination on the cruise route. They want something more, what will give them chances for personal development or vocational trainings, allow them to develop their skills, broaden knowledge, exchange of experience, and will provide them with new and an unforgettable experience. They want to break away from everyday life and move in a completely different world, era, neighborhood, or reality, etc. It is just possible during theme marine cruises. In addition, in the world for several years, there is a need for different communities to make new formal and informal groups of interest, that will be happy to organize joint meetings, including marine cruises. Marine carriers compete in inventing exciting deals for tourists with different interests. Analysis carried out showed that the range of offers is very wide. In fact, it can be concluded, that today almost every tourist is able to find an offer on the market, which is adapted to his/her expectations.

The criteria for classification of theme marine cruises

In the literature, only a few authors deal with a phenomenon of specialization of marine tourism. Any undertaken trials in this sphere are rather random and quite chaotic. For example J. Miotke-Dzięgiel said that marine tourism is also "specialist cruises associated with excursions to little-known, however interesting, areas or sea ports" [3]. Specialized cruises in marine toruism were also described by W. Gaworecki, who mentioned among others: "medical cruises: a relatively new type of cruise, with significant growth opportunities as a form connecting two tourist destinations, the holiday and medical treatment at sea and also school cruises: combination of education system with an interesting form of marine tours" [4]. In turn, R.K. Dowling said that "popular theme cruises have included a focus on dance, music, food, wine and health and well-being. More specialized offering have included nude cruises, gay and lesbian cruises and motorcycle crusies" [5].

Originally, tourists travelled by the purposes of leisure or religion, but now tourist became more demanding and expect diversity from the organizers of the marine tourism in order to satisfy their needs. In some regions of the world, special forms of maritime tourism have developed, due to the cultural, geographical, economic or social separation of these areas. The excellent example it is "*aboriginal marine tourism*" in Australia, "Aboriginal marine and coastal tourism focuses on fishing, traditional use of marine resources and viewing of marine life" [6]. In turn, for example in Western Canada there are organized marine excursions "focus on viewing marine wildlife and coastal scenery, along with a traditional salmon barbeque" [7].

Theme Marine cruises can be divided into, on one hand, due to the interest, needs and personality characteristics of tourists (Fig. 1), and, on the other hand, due to the period of travel planning and related events and festivals held throughout the calendar year (Fig. 2).

"The offering by organizers of marine tourism various theme offers spreading across the different periods of the year, allows to minimize the negative economic impact of seasonality and affects positively on profitability of enterprises (…) in Northern Europe the tourist season on marine travels takes about four months, from June to September. In turn, the tourist season in the Mediterranean Sea Region is much longer and starts in April and ends in November. (…) the organizers of the holiday at sea prepare lots of tourist packages for other seasons of the year" (Fig. 2) [8].

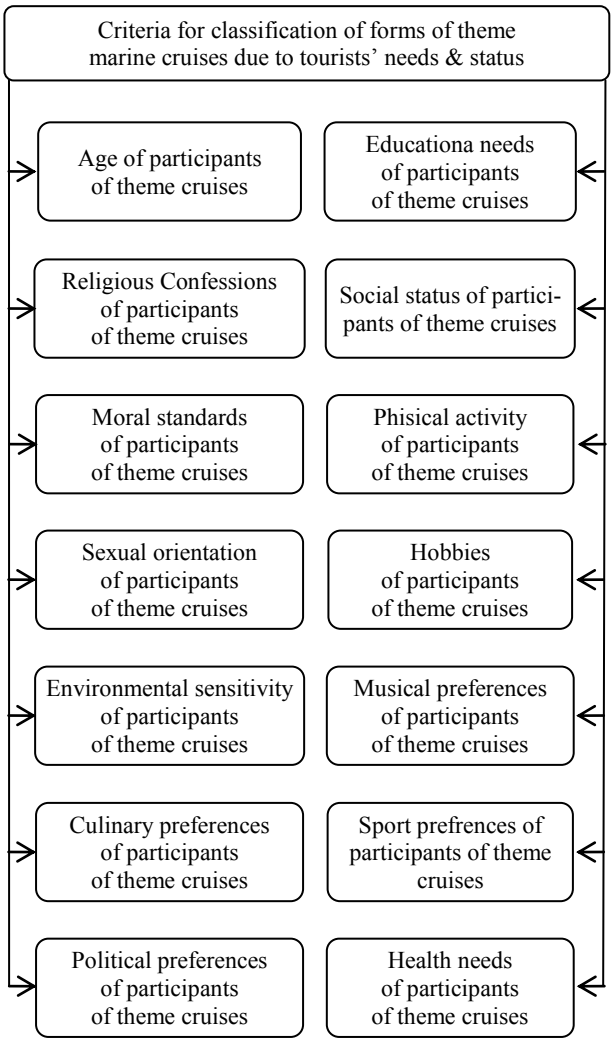

Fig. 1. Criteria for classification of forms of theme marine cruises [own study]

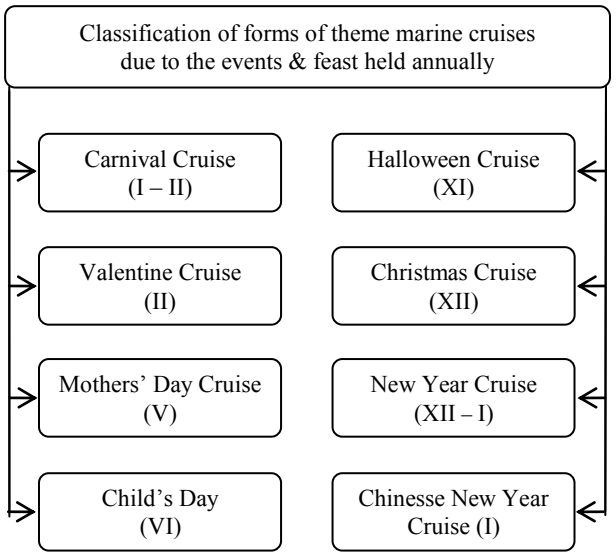

Fig. 2. Criteria for classification of forms of theme marine cruises due to the events & feast in a year [own study]

Theme cruises create conditions for development of tourists' interests, gaining new skills and knowledge about culture, art and history of visited destinations, or communing with unspoiled nature. They are a platform for exchanging of knowledge and experience of people with similar interests. Theme cruises are perfectly planned and organized. Organizers of theme marine cruises care about details of proposed products, as tourists with special interests are extremely sensitive to the quality and standard of services offered. Recognized experts in a thematic area and outstanding personalities of the world of science, politics, film, theater, music or sport usually participate in the theme cruises. While cruises, there are held thematic: lectures, trainings, demonstrations, tastings, competitions, festivals, fairs, conferences and seminars with the participation of experts in field of a guiding thought of a theme cruise. In addition, theme cruises are also combined in the tourist packages including visiting places which are thematically compatible to the themes of cruises.

The offers of marine carriers within the field of theme cruises

In the hereby work, an analysis of offers proposed by dozens of marine carriers, operating in all regions of concentration of marine tourism, was conducted. Eighty-eight percent of the world's supply of cruise ship bed – places is controlled by three large groups: Carnival Corporation & Plc,[1] Royal Caribbean Ltd., and Star Cruises Group. In other words, supply is characterized by the existence of what is very close to an oligopoly. These three multi-brand groups encompass all market segments and operate very modern fleets (average age: 11,4 years)" [9]. These three companies set the directions and trends in the development of marine tourism. The cruise vessels of these three corporations operate in all regions of the world and there are offered a variety of theme cruises on each unit.

"The main cruising grounds are North and Central America (57% market share), Europe (24%) and the rest of the world (16%)" [5]. "In every region of maritime tourism concentration in the world (i.e.: in the Caribbean Sea, in Australia and Oceania, or for example, in the Mediterranean Sea Region and the Baltic Sea Region), tourist offers of all above forms can be found. Next to the traditional cruises by cruise ships or ferries, for tourists with

[1] Cruise Lines in the group: Carnival Cruise Lines, Holland America Line, Princess Cruises and Seabourn in North America; P&O Cruises (UK), and Cunard in the United Kingdom; AIDA Cruises in Germany; Costa Cruises in Southern Europe; Iberocruceros in Spain; and P&O Cruises (Australia) in Australia.

special interests, or less wealthy, who want to relive adventure at sea, some maritime transport companies offer special cruises by fishing vessels or cargo vessels, when a traveler has an ability to participate in fishing on the seas or to operate a vessel. Of course, the quality of the services, offered during these forms of a qualified marine tourism, differ from the standard of services on typical tourist ships. However, a tourist, who chooses such a form of a maritime travel, is prepared for inconveniences in advance" [8].

It must be pointed out that "annually in the world, there are organized 30 thousands cruises to about 2 thousand tourist destinations" [10]. The European Commission reports that "more than 400 million passengers visit the European seaports each year" [11]. The greatest concentration of the theme cruises is in the Caribbean Sea Region and the Mediterranean Sea Region, Theme cruises are especially offered by: Royal Caribbean Cruise Line, Celebrity Cruises, Cristal Cruises, American Cruise Line, Holland Cruise Line, Fred Olsen and P & O Australia and Compagnie du Ponant.

While the dominant market, as far as ferry travels are concerned, there is the Baltic Sea Region. "Here are among the others: Stena Line, Silija Line, Viking Line, DFDS Seaways, Unity Line, PŻB Polferries and others. While the percentage of passenger services on the cruise vessels in the BSR, is at just 3% of the total passenger traffic in the 27 countries of the European Union" [12].

Table 1. Growth by Length of Cruise (Total passengers carried) [1]

Duration of a cruise	Passengers (000's)		% Growth
	1990	2010	
2–5 Days	1,434	4,030	181.0
6–8 Days	1,966	7,895	301.6
9–17 Days	358	2,662	643.6
18+ Days	16	231	1343.8
TOTAL	3,774	14,819	292.7

Theme cruises on cruise vessels usually last from 6 to 8 days, what is in the line with the worldwide trend (Tab. 1) [1]. In turn, ferry cruises, as a general rule, last less than 2 to 5 days, due to the fact that ferry ships, in principle, cruise on shorter routes than cruise vessels. Due to the Cruise Line International Association reports "from 1980–2010, over 191 million passengers have taken a cruise (2+ days). 67% of the total passengers have been generated in the past 10 years. 39% of total passengers have been generated in the past five years alone" [1].

The analysis of theme cruises, proposed by the marine carriers, allowed to make a segmentation of this market and extraction of defined groups of products, aimed at customers with certain characteristics, beliefs and interests. The social status and personality profiles of travelers (Fig. 1) are basic criteria of classification of theme cruises. According to this criterion extracted: the age of travelers, their religious beliefs, social status, family and sexual orientation. In principle, in each of these categories one can find various offers of theme cruises. Cruises for families with children are the most popular forms of theme cruises. For the guests there are prepared packages containing taking care about children, animation time with qualified staff, attractive games, fun and artistic and music competitions for the youngest, film screenings in 3D and many others (Tab. 2). Cruises for families with children also have a guiding thought and so, for example, under the slogan: Barbie, Pipi, Harry Potter, Shrek, Madagascar, Kung Fu Panda and other DreamWorks Animation films. For example Royal Caribbean Cruise Line offers more than 260 different tourist destinations for fmily with childern in Europe, in the Caribbean Region and in Alaska. In addition to the Royal Caribbean Cruise Line, a wide range of offers for families with children propose among the others: Norwegian Cruise Line, Royal Caribbean Intenational, Compagnie du Ponant, MSC Cruises, Princess Cruises, Carnival Cruise Lines, Carival Australia, P & O Cruises and Disney Cruise Lines, but also ferry carriers such as: Stena Line or PŻB Polferries.

So far, the pensioners have been the largest group of tourists travelling by sea. As it was already mentioned above, this situation has been changing in recent years. However, persons aged 65 and more are still an important group of travelers, who expect a special treatment on aboard. Therefore, special offers have been prepared for them, such as: dietary menu, music from the past, dance, physical therapy, and for the richer – more exclusive cruises. The offers for groups of travelers are prepared by: CUNARD, Celebrity Cruises, Seaborn Cruises, Princess Cruises, Royal Caribbean Cruise Lines and also a ferry carrier – Stena Line.

Lately, a growing demand for pilgrimage cruises has been seen. These are the journeys to holy places. The motives of participation in religious tourism are various, for example: pilgrimage, sightseeing of sacral monuments and praying in sanctuaries of professing religion, and also learning about other religions and sightseeing of their sanctuaries and sacral monuments. The Mediterranean Sea Region is the center of pilgrimage cruises, thanks to

the rich cultural and historical heritage of Italy, Greece, Croatia and Spain. These types of cruises are organized by: Windstar, Louis Cruises, Pullmantur Cruises, and also Fred Olsen Cruise Lines. Moreover, hundreds of cruises are prepared for the lesbian, gay, bisexual and transgender community. This is not a large group of tourists, but so important, that the owners of cruise lines prepare extra offers for them, especially: Celebrity Cruises, Katarina Line, Carnival Cruise Lines, Celebrity Cruises, or Wind Star Cruises.

In spite of the above mentioned cruises, it is observed a trend for participation in cruises for the health and beauty (Tab. 3). It is possible to formulate a conclusion that, it is seen a boom for improving of the beauty by cosmetic services and plastic surgery in societies of developed and developing countries. Due to that, a full range of travel services offering a variety of treatments in this respect has developed. In principle, on an every cruise vessel and some ferry ships, there are beauty salons and centers of Spa & Wellness, but only some of the cruise lines promote these services as the separate theme cruises.

The fashion for a good look, caring for mental and physical condition, there are main factors which had influence upon emergence of theme cruises including Spa & Wellness and body modeling. The following cruise lines have rich offers in these fields: Royal Caribbean Cruise Line, Cristal Cruises, America Cruise Line and also PŻB Polferries. On the other hand, there are also cruises

Table 2. Offers of theme cruises for tourists with various social status & moral standard (own study on the basis of [13–23])

Selected offers of theme cruises	The name of an offer	The name of a marine vessel	The name of a marine carrier
Social status of participants			
Family Cruises	Dora's Dance Party	Norwegian Jewel	Norwegian Cruise Line
	Legoland i Kopenhaga	Vision, Spirit	Stena Line
	Fisher Price® Play Groups & The Dreamworks Experience	Allure of the Seas	Royal Caribbean Intenational
	Disney Family Cruise Vacations	Disney Dream	Disney Cruise Lines
	Family fun on P&O Cruises	Oceania, Ventura	P & O Cruises
Sexual orientation of participants			
Cruises for Lesbians, Gays, Bisexuals and Transgenders	7-Night Alaska Cruise	Oosterdam	Holland America Line
	10-Night Venice to Rome Cruise	Silhouette	Celebrity Cruises
	Croatia Gay Cruise Split Departure	Adriatic Queen	Katarina Line
	Croatia Gay Cruise Dubrovnik Departure	M/S Dalmatia	Katarina Line
	LA to Mexico All-Gay Cruise	Carnival Miracle	Carnival Cruise Lines
Age of participants			
Seniors' Cruises	Seniors' Cruise	Vision, Spirit	Stena Line
	„New England & Canada"	Seaborn Pride	Seaborn
	„Hawaii" Roundtrip Los Angeles	Island Princes	Princess Cruises
	"Golden Age of Ocean Liners!"	Queen Mary 2	CUNARD
	Easter Mediterranean" Roundtrip Rome	Galaxy	Celebrity Cruses
Religious Confessions of participants			
Piligrim Cruises	Religious – Footsteps of Faith	Wind Spirit	Windstar
	Piligrims & Paella Cruise	Braemar	Fred Olsen Cruise Lines
	"Paul's Pilgrimage of Faith"	M/V Zenith	Pullmantur Cruises
	7-day Pilgrimage Voyages cruise	Orient Queen	Louis Cruises

Table 3. The offers of cruises for health proposed by marine carriers (own study on the basis of [13–23])

Selected offers of theme cruises	The name of an offer	The name of a marine vessel	The name of a marine carrier
SPA & Wellness Cruises	Low-Carb Cruise	Carnival Magic	Carnival Cruise Lines
	Minf, Body & Soul Cruise	American Star	American Cruise Line
	Mind, Body & Spirit	Symphony, Serenity	Cristal Cruises
	Cruise into New Era	Carnival Dream	Carnival Cruise Lines
	Cruise for health and beauty	M/V Baltivia	PŻB S.A.
Fitness Cruises	Fitness and Running Cruise	Allure of the Seas	Royal Caribbean Cruise Line
Cruises for Diabetes	Cruises for Diabetes	Liberty of the seas	Royal Caribbean Cruise Line

for people with serious diseases, such as: rheumatism, obesity, diabetes and others. Some interesting offers for these people, Royal Caribbean Cruise Line proposes.

Educational cruises also became more and more popular. Initially, there were mostly marine cruises related to dancing courses and now, one can find all sorts of educational offerings at sea (Tab. 4). The offers include: dance courses, culinary trainings, workshops in arrangement of the gardens, handicraft and painting workshops, or for example, diving and scuba diving courses and even fishing courses.

While cruises, there are organized various activities such as: trainings, demonstrations, workshops, competitions and exhibitions. The participants of educational cruises can broaden their knowledge, gain skills and qualifications in different fields. The following cruise lines have a wide offer in this field: Royal Caribbean Crusie Lines, Fred Olsen Cruise Lines and Holland America Lines.

However, the analysis of offers available on the market showed that the greatest number of theme cruises are proposed for people who are lovers of cuisine and wines. In principle, all major players in the market of marine passenger services offer theme cruises relating to various cuisines and wines. At the top of the list of cruise lines are: Celebrity Cruises, Cristal Cruises, Royal Caribbean Cruise Lines, czy Fred Olsen, oraz P & O Australia, Compagnie du Ponant i Holland American Line (Tab. 5). Last years show an increase in popularity of national cuisines among the public. On TV, there are produced a lot of culinary programmes with celebrities, organized travels to the most remote corners of the world in order to search and explore new flavors, spices and recipes for meals. In bookstores, there are numerous books with recipes, and all because, it is the fashion to meet new tastes and enjoy various meals, and what is the most important, lots of travelers also wants to know the secrets of preparation of dishes under the guidance of master chefs.

In the meantime of the culinary cruises, there are organized shows of food preparation, wine tastings, culinary competitions, but also trainings and workshops for amateurs or professionals. The widest range of culinary cruises have: Cristal Cruises, Fred Olsen Crusie lines, Oceania Crusies and Celebrity

Table 4. The offers of educational cruises proposed by marine carriers (own study on the basis of [13–23])

Selected offers of theme cruises	The name of an offer	The name of a marine vessel	The name of a marine carrier
Dance crusies	Let's Dance Vacations	Royal Princess	Royal Caribbean Cruise Line
	Dancing with Stars at Sea	Oosterdam	Holland America Line
	Portugal & Spain	Black Watch	Fred Olsen Cruise Lines
Handicraft Cruises	Handicraft Cruises	Royal Caribbean	Royal Caribbean Cruise Line
Culinary Cruises	Culinary arts Voyages	Silver Spirit	Silversea Cruises
Garden Cruises	Gardens & Floral	Crystal Symphony	Cristal Cruises

Table 5. The offers of culinary cruises proposed by marine carriers (own study on the basis of [13–23])

The name of an offer	The name of a marine vessel	The name of a marine carrier
Cruises for lovers of wine and liquors		
Food and Wine, Polynesian Parade	Crystal Symphony	Cristal Cruises
Food and Wine, Bordeaux & Rioja Cruise	Braemar	Fred Olsen Cruise Lines
Mediterranean Grandeur – Wine	Nautica	Oceania Cruises
Immersive Europe Wine Cruises	Celebrity Infinity	Celebrity cruises
Food and Wine, Malaga – Marseille	L-Austral	Compagnie du Ponant
Food and Wine, Great Barrier Reef & Islands	Orion	Orion Expedition Cruises
Wine, dine & Music cruise	Brillance of the Seas	Royal Caribbean Cruise Lines
Beer Festival	M/V Baltivia	PŻB S.A.
Cruises for lovers of national and regional cuisines		
Food – Veniece	Celebrity Equinox	Celebrity Cruises
Mosaic Masterpiece	Riviera	Oceania Cruises
Tastes of Summer	M/F Scandinavia	PŻB S.A.
Crystal Wine & Food Festival	Crystal Symphony	Cristal Cruises
Flavors of Europe	Silversea	Silversea Cruises
California Beer Festival at Sea	Celebrity Solstice	Celebrity Crusies
Culinary arts Voyages	Silver Spirit, Silver Shadow	Silversea Cruises

Cruises. Obviously, on every cruise vessel, there are facilities and opportunities to organize these types of theme cruises, because there are from a few to dozens of restaurants of different world cuisines, but unfortunately, not all cruise lines have culinary cruises in their tourist packages.

Cruise lines take care about people who have various hobbies, such as: motorcycling, photography, literature, art and theatre, and prepare special tourist packages for them, as well. The main objectives of people involved in this type of cruise are: meeting people with similar interests, developing of new contacts, exchanging of knowledge and experience, but also learning and experience of new things related to the subject of interest. The most diverse range of offers of this kind have prepared Fred Olsen Cruise Lines. It is a full range of theme cruises addressed to lovers of art, photography, cinema, theatre, arts, culture and literature (Tab. 6). In addition, theme cruises of this type are sold by: Cristal Cruises, Compagnie du Ponant or American Cruise Lines and the others.

Table 6. Theme Cruises for people with various interests proposed by marine carriers (own study on the basis of [13–23])

The name of an offer	The name of a marine vessel	The name of a marine carrier
Cruises for fans of Autos and Motorcycle		
Kingstands Up Motorcycle Cruise	Explorer of the Seas	Royal Caribbean International
Sweden on a motorcycle	Stena Vision, Stena Spirit	Stena Line
Esprit du Grand Prix	Crystal Serenity	Cristal Cruises
Cruises for fans of internet		
Social Media Cruise	Norwegian Jewel	Norwegian Cruise Line
Cruises for lovers of art		
Art. – Scandinavian Capitals	Boudicca	Fred Olsen Cruise Lines
Emerging Artists	Crystal Symphony	Cristal Cruises
Cruises for lovers of photography		
Photografy	Crystal Symphony	Cristal Cruises
Pilgrims & Paella	Black Watch	Fred Olsen Cruise Lines
Islands, Highlands & Irelands	Balmoral	Fred Olsen Cruise Lines
Kangerlussuaq	Le Boreal	Compagnie du Ponant
Colonal Charm	Crystal Symphony	Cristal Cruises
Cruises for lovers of movies and theatre		
Film and Theater cruise	Crystal Symphony	Cristal Cruises
Movies – Casablanca & The Algarve	Braemar	Fred Olsen Cruise Lines
Commedy Short Break	Pacific Jewel	P & O Australia
Theatre – city of the Tsars	Seven sea Voyager	Regent Seven Seas
Hollywood	M/F Scandinavia, M/F Wawel	PŻB S.A.
Cruises for lovers of culture and history		
Barcelona, Mallorca & Gibrartar – Maritime History	Boudicca	Fred Olsen Cruise Lines
American Civil War Theme Cruise	Queen of the Mississipi	American Cruise Lines
Celtic Culture: Lisbon - Reykjavik	Le Soleal	Compagnie du Ponant
China Golden Week Japan & Korea	Voyager of the Seas	Royal Caribbean Cruise Lines
Clippers & Klwis – Maritime History	Crystal Symphony	Crystal Cruises
Cruises for lovers of literature		
Agatha Christie	Balmoral	Fred Olsen Cruise Lines

Table 7. The offers of music cruises proposed by marine carriers (own study on the basis of [13–23])

Selected offers of theme cruises	The name of an offer	The name of a marine vessel	The name of a marine carrier
Russian music Cruises	Russian Reverie	Crystal Serenity	Crystal Cruises
Irish music Cruises	Celtic Thunder	Carnival Victory	Carnival cruise Lines
Classical music Cruises	Alabama & Friends at Sea	Norwegian Pearl	Norwegian Cruise Line
Country music Cruises	Country Cruising	Norwegian Pearl	Norwegian Cruise Line
Rock music Cruises	Concerts at Sea Rock'n Roll Cruise	Crown Princess	Princess Cruises
Jazz Cruises	The annual Smooth Jazz Cruise	Westerdam	Holland America Line
Disco Cruises	Disco Stars Live	Vision, Spirit	Stena Line
Ancient music Cruises	Echos of Anciet Civilizations	Crystal Serenicty	Crystal Cruises

In spite of cruises mentioned above, music cruises are also very interesting proposals for music lovers. Everyone can find something interesting for her/himself (Tab. 7). While music has always accompanied tourists on cruise vessels during the banquets, galas, in dance clubs and discos. But recently, special theme cruises dedicated to one type of music introduced to the tourist offers e.g.: cruises with classic music, country music, jazz, rock, soul or irish music, gothic, russian etc.

Music cruises are a huge attraction for travelers especially then when are combined with shows and concerts of the music stars. These events are also accompanied by meetings with personalities in the world of music, as well as there are organized caraoke competitions or "The chance of success", and music festivals. It's hard to say who is a market leader within the theme cruises dedicated to music, because almost every major cruise lines have music cruises in their regular offerings.

Cruise vessels are fully adapted and equipped with facilities and equipment for a variety of sports and recreation. On aboard, one can find: swimming pools, tennis courts, golf courts, climbing walls, running paths, fitness clubs, body building etc. Moreover, for guests there are organized: bridge, poker and chess tournaments and the others. At the same time, while visiting stops of cruise vessels in tourists destinations, the leisure activities on aboard are combined thematically with the tourist packages on land. Therefore, in the case of eg. Golf Cruises (Tab. 8) cruise vessels call at ports, from where tourists are picked up on golf courses, but in the case of Diving Cruises, underwater excursions on coral reefs are organized. Cristal Cruises is an undisputed leader in organization of golf cruises. Sport-related cruises one can also find in the offer of: Windstar, Lioyd Cruises, Compagnie du Ponant, StarLauro Cruises, Holland America Cruise Line, Oceania Cruises and obviously, Royal Caribbean Cruise Line. Taking into the consideration the fact that, in the last decade, it is observed a change in a model of holiday among societies from passive to active. It can be concluded, that a segment of marine theme cruises has a good chance for development.

A huge advantage of the sea cruise vessels is the fact that they may wrap to the most remote and unspoiled places on the Earth, where other means of communication are not able to reach. Cruise lines prepare unique cruises to pristine corners of the Earth (Tab. 9), that are very popular among tourists. Cruise programmes are very exciting from admiring and photographing icebergs, glacial landscape, volcanoes, geysers, fjords, through watching wildlife (birds, penguins, whales, polar bears, turtles etc.) and enjoying the polar nights, as well as exploring rarely-visited local tribes, participation in the traditional ceremonies and manufacturing of unique handicrafts. Expedition cruises take tourists to the most unique destinations on Earth, and gives an opportunity to experience the rich diversity of ancient and primitive cultures. "It is important to outline that, in contrast to the mass market and the Caribbean as the leadning cruise region, the adventure cruise sector is dominated by the Meditarranean. It comprises one third of adventure cruise market capacity by region of operation. The Meditarranean offers a high level of historical and cultural heritage and a wide diversity of scenery to

Table 8. The offers of sport cruises proposed by marine carriers (own study on the basis of [13–23])

Selected offers of theme cruises	The name of an offer	The name of a marine vessel	The name of a marine carrier
Golf Cruises	Canary Island Classic	Serenity	Cristal Cruises
Diving Cruises	Diving – Fort de France	Le Ponant	Compagnie du Ponant
Baseball Cruises	Baseball Great Cruises	MSC Cruises	StarLauro Cruises
Running Cruises	Running Cruise	Westerdam	Holland America Cruise Line
Bridge Cruises	Bridge – Ultimate Panama Canal	Regatta	Oceania Cruises
Poker Cruises	Ante Up Poker Cruises	Freedom of the Seas	Royal Caribbean Cruise Line

Table 9. The offers of expedition cruises proposed by marine carriers (own study on the basis of [13–23])

The name of an offer	The name of a marine vessel	The name of a marine carrier
The Antarctic Peninsula and the Weddell Sea	MS Expedition	G Adventures
Whale watching – Rurutu & Society Islands	Paul Gauguin	Paul Gauguin Cruises
Glaciers of Norway	Braemar	Fred Olsen Cruises
Sea Adventure – Temples & Safaris	Crystal Serenity	Crystal Cruises
Bird watching – South Georgia and Antarctic Penisula	Sea Spirit	Quark Expeditions
Solar Eclipse and Nothern Lights Spectaular	Marco Polo	Cruise and Maritime Voyages
Mystery cruise- A Hebridean Surprise	Hebridean Princess	Hebridean Island Cruises

Table 10. The offers of event cruises proposed by marine carriers (own study on the basis of [13–23])

The name of an offer	The name of a marine vessel	The name of a marine carrier
Chinese New Year Spice of SE Asia	Mariner of the Seas	Royal Caribbean Cruise Line
Chrismas in July Short Break	Pacific Pearl	P & O Australia
Andrew's Day Cruise	M/V Baltivia, M/F Scandinavia	PŻB S.A.
Children's day	Polonia	Unity Line
Andrew's Day Cruise	Polonia	Unity Line
Santa Claus Cruise	M/V Baltivia, M/F Scandinavia	PŻB S.A.
Mothers Day Cruise	Pacific Jewel	P & O Australia

Table 11. The offers of other theme cruises proposed by marine carriers (own study on the basis of [13–23])

Selected offers of theme cruises	The name of an offer	The name of a marine vessel	The name of a marine carrier
Political Crusies	National Review Cruise	Eurodam	Holland America CL
Horror Cruises	The horror Cruise	Glory	Carnival Cruise Line
Veterans' Cruises	Cruise for a Cause U.S.Veterans	Caribbean Princess	Princess Cruises
Entertainment Cruises	Party Cruise	Azura	P & O Australia
Magic Cruises	Magic – Tropical Trade Winds	Serenicty	Crystal Cruises
Shopping Cruises	Shopping–Honfleur & Guernsey	Balmoral	Fred Olsen Cruises Lines

cruise tourism. This, together with pleasant climate makes the area very attractive with a number of very popular destination ports" [24].

Cruiser vessels and expedition ships range from luxurious and amenity-rich to those with poor facilities for travelers. While expeditions there are lectures onboard on various topics like: glaciology, marine biology, anthropology, ornithology etc. The leaders in organizing of expeditions to natural environments are: G Adventures, Paul Gauguin Cruises and Fred Olsen Cruises (Tab. 9).

On the tourist market, there are numerous cruises, which are organized annually for the reason of the celebration of various events, religious feasts and national events in accordance with the calendar. Due to the calendar each year, the marine carriers prepare a full range of theme cruises, such as.: New Year Cruises, Carnaval Cruises, Easter Cruises, Cruises on the Children's day, Mother's Day, St. Andrew's Day, or Halloween Cruises and Christmas Cruises (Tab. 10). The researches proved that every cruise line has an offer in this field, but the leaders are: Royal Caribbean Cruise Line, P & O Australia, and also ferry companies such as: Stena Line and Unity Line.

Finally, there are a great number of other theme cruises, which are difficult to clasify to the above described groups of cruises, but they are a response to reported tourists' needs. They can be devided into cruises for special groups like: politicians or war veterans, but on the other hand due to the topic of a cruise, e.g.: magic cruises, horror cruises, entertainment cruises, shopping cruises etc. (Tab. 11).

Summing up, one can say that the variety and quality of the theme cruises available on the market is really impressive. In fact, every tourist with various interests can surely find a product, which can satisfy his/her expectations, both as far as duration of stay, its topic, quality and a price are concerned.

Leading corporations of the cruise lines regularly follow the trends in buying behavior of the potential clients and react quickly on the needs and preferences. Most cruise vessels are equipped with facilities and amenities, which allow to organize different theme cruises. Nevertheless, not all cruise lines decide to take advantage of the potentials and promote the theme cruises, but only inform their clients about the possibilities of using all the facilities and events available of aboard. Such attitude to the marketing of tourist products may cause, that potential clients will not take into consideration of their offers, but only those, which are adopted to his/her needs and preferences. It must be underlined, that people who are very active at work, they also look for an active way of spending time during holiday. They are not interested in a passive way of spending time in the random destinations, but they consciously choose the products and services, that meet their expectations of the personal development. In an era of the competitive fight about a client, customizing services to customer expectations is the key to success.

Conclusions

Specialization in marine tourism is a necessary phenomenon, due to the fact, that it changes, as the reports of the United Nation World Travel Organization and Cruise Lines International Organizations proved, a profile of tourist travelling by sea has

been changing. The analysis carried out in this article allowed to draw the following conclusions:

– on the marine tourism market, there is seen a tendency to specialization, which is manifested by implementation of the profiled tourists offers in the form of theme cruises by marine carriers;
– all leading cruise lines in the world have marine theme cruises among their regular offerings;
– segmentation of the marine tourism market allowed to extract cruises due to the interests, needs, and personality characteristics of tourists, but on the other hand, in accordance with the period of a year, when a marine voyage is organized and related events and festivals are held during the calendar year;
– it is necessary to conduct market studies of the marine tourism, taking into account the issues regarding theme cruises.

Thanks to research made in the hereby article, it is possible to indicate the characteristic features of theme cruises. A theme cruise means: the participation of people with similar interests or personality profile, a wide range of goods and services related thematically with the idea of the cruise, a high standard and quality of the services, a low level of seasonality and a travel lasting from 2 to 8 days.

A phenomenon of marine theme cruises should become the subject of scientific researches, because, so far, there is a great lack in statistical data regarding the participation of tourists in marine theme cruises. Existing data and research reports provide information mainly on the number of people participating in sea voyages, demographic characteristics and consumers' behavior. Therefore, it seems reasonable to undertake further study of this segment of the tourist market.

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The method of processing of rapidly changing data for the inventory of flood effects purposes

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Key words: GIS, orthophotomap, flood, open source

Abstract
This article presents the method of inventory of flood in the real-time GIS system. The method includes: obtaining data, sending data to the server of data base, their analysis in GIS environment and presentation of results. For this purpose the Open Source type of applications were used. The last stage of the presented method is the cartographic development of the hybrid map (orthophotomap with thematic overlays). The authors gave the boundary conditions of these types of studies taking into consideration the data obtained from various sensors of high resolution image systems. The presented method in a complex way describes the development of fast-changing data from the moment of existence of the change, through their acquisition, analysis, to the cartographic development of the map of flood changes.

Introduction

Geodetic development (information) of the after-flood areas is the first element on the way to undertaking repair action. Fast undertaking of actions is conditioned by obtaining the set of current data, their sending to the server, processing (analysis) and presentation. These data are characterised by high dynamics and should be obtained in the continuous system and in the real time or the one close to it. For the development of these type of data – fast-changing – the proper equipment-programme-application architecture is also necessary.

The solution of the above formulated task, together with its limitations, requires the answers to the following questions:

1. What characterises rapidly changing data?
2. In what way data should be acquired and processed?
3. What hardware and application solutions should be used to provide rapid acquisition and processing of data?
4. How should the acquired information be distributed?

Fig. 1. Flood damages

Modelling rapidly changing data – current solutions

In this publication the rapidly changing data stand for the information, which are difficult to be acquired with traditional methods used in the systems of spatial information, such as e.g. aerial and satellite imaging, or the field geodetic measure-

ments. This is caused both by the high variability of field situation, and the imperfection of the existing measurement methods, which prevent measurements with the sufficiently high frequency (allowing the properly detailed reflection of the phenomenon). The flood and damage being its result can certainly be included to the rapidly changing phenomena. Rapid flooding, and what follows the flooding of large areas should be monitored and transmitted to emergency command centres, so to minimise the loss of life and destruction.

Acquisition of dynamic data (fast-changing) in real time, is partially possible thanks to the remotely sensed data, which can be used to the analysis of areas difficult to reach, in situations of natural disasters, military threats, or floods [1]. The usage of these data is dependent on their resolution, mostly temporal and spatial. The full modelling of the crisis situation (flood) often requires the performance of field measurements (inventory), and both techniques of measurements may supplement each other. Field measurements should be in a short time sent to data bases, processed and published, and the way of cartographic presentation and scale of cartographic development adapted to the operational situation, and not to rigors posed to traditional topographic maps. Additionally, the equipment-programme configuration should enable a free access to solutions within data modelling, what is allowed by the solutions of the Open Source type (free).

At present there is no single universal solution taking into consideration all of the above factors. Therefore, in this publication, the authors have taken the tasks of planning and constructing such system based on the method of acquisition and development of fast-changing data.

Method of the inventory of flood effects

Method of the inventory of flood effects was developed in accordance with the scheme presented in figure 2.

The method shown in figure 2 consists of the system of acquisition, transmission and processing of vector and raster data (matrix) in one integrated application environment O-GIS (described in the further part of the article). The acquisition of image and matrix data should take place in a relatively short time, so that they can be used already at the stage of preparation to the inventory measurements (field). In case this turns out to be impossible, data of both types (image, field – vector) are acquired in parallel, in order to supply the data base. In the data base there are also used data acquired from WMS

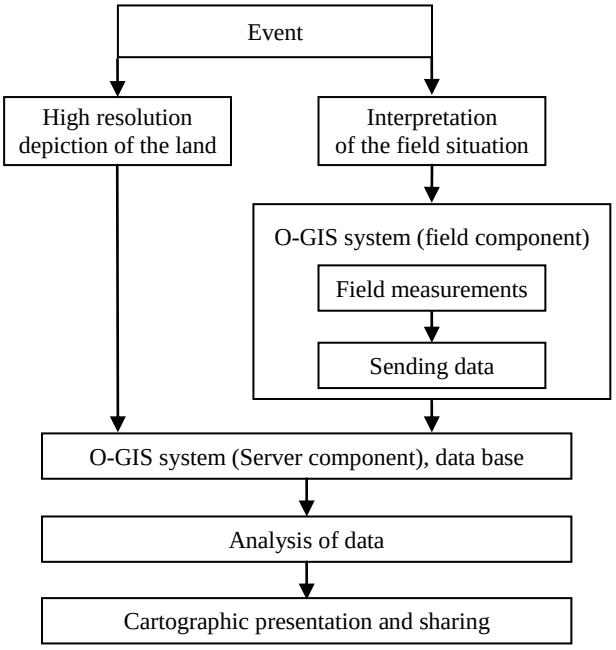

Fig. 2. The method of inventory of flood effects in GIS system of the real time

and WFS servers, in order to complement the base with data from before the flood (on which there will be placed data with the current scope of coastline and losses caused by it). Data acquired this way are processed and analysed. The result of the analysis of the data is the special cartographic development – hybrid map. The hybrid map is worked out based on the acquired imaging, numeric models of the land, as well as fast-changing data obtained in the O-GIS system. The visualisation of the results takes place based on the orthophotomap or topographic map (large scale), depending on the availability of materials. Boundary conditions in terms of the scale of the study – resolution were given in the further part of the study.

OGIS system

O-GIS system (www.ogis.pl) is an example of a solution enabling the processing of fast-changing data. These data are collected in the vector notation enriched with attributes. The solution consists of the server containing data bases (accumulating raster and vector data) and networks of mobile devices, which are connected with the server by using wireless transmission links (Wi-Fi, GPRS, etc.). This connection enables the service providers supporting the mobile devices (computers of the *UMPC or tablet* type) the download from the server the right in terms of details and scope the set of spatial data and the visualisation of them on displays (generated maps). The equipment of mobile devices with the system of fast acquisition of data

Fig. 3. Measurement devices used in the system

enables the navigation and update of data on a base of data obtained from the server. In the solution for obtaining data the navigation GPS receiver and the binoculars laser rangefinder with the digital compass – device TruPulse 360B by Laser Technology were used. It enables a remote ground measurement with the scope to 1000 m with the frequency of one measurement per 5 seconds. The performed tests showed that for the typical distances from the measured detail (50–300 m) the accuracy of the set is from 5 to 12 metres (for the determination of coordinates).

A very important functional feature of the system is the modifier's ability (adding, editing or removing) by operators in the field, of both information about the spatial shape of objects, as well as their descriptive parameters. After editing, data are sent to the server updating the central data base (this may happen automatically or under the supervision of the system's administrator). Thanks to that, on the server there is the latest version of data base, which may be sent to the remaining mobile devices. The project is crowned by the module of storing previous versions and the predicting of the location of objects. The system based on previously obtained data is able to inform the user about the history and the predicted future of the object. It is worth noting that the O-GIS system was built entirely only on the software based on Open Source licenses. Therefore, its software is totally free and publically available.

Practical capabilities of the system within the scope of inventory of fast-changing data were tested by obtaining data with the scope of the progressive, hypothetical flood (Fig. 6). The measurement was performed every hour, on the distance of 800 m (time of one measurement equalled about 15 min). The obtained objects were automatically sent to the server, where they fed the central data base.

Prediction module

During testing there was made the four times measurement of the shoreline, wherein each next shape of this line was the next version of the previous object (except the first acquisition of geometry). After downloading the information about the object they are sent to the server (prediction is treated as the service performed by the server). The solution of this problem in this way results from the fact that the service collects all versions of ob-

Fig. 4. Architecture of the O-GIS system

jects (the client doesn't have to have all latest data). After receiving the request, the server retrieves all versions of objects with the indicated ID, and then it analyses it. As a result of the analysis there are selected two most recent locations of objects (prediction of the location takes place based on two most recent locations of the object). As a result, to the client computer there is sent a response containing elements:

- the amount of all versions of the object;
- speed of the object's movement;
- azimuth (direction) of the object's movement;
- shape (geometry) of the last (latest) version of the object.

After receiving the response (the whole operation of sending data to the server, data processing and receiving the response lasts a few seconds) in the settings panel of predictions there appears information about the amount of the object's versions, its speed and direction of the movement. Therefore, all necessary information have been acquired, the programme may proceed to predict the object location in the future.

On the basis of the speed and direction of the movement of the object, the system determines the point, in which there will be the object of the future (this point is the geometrical middle of the object). The shape representing the expected position in the future has the geometry of the last acquired version of the object. Prediction in the O-GIS system has the linear character. Due to the character of the

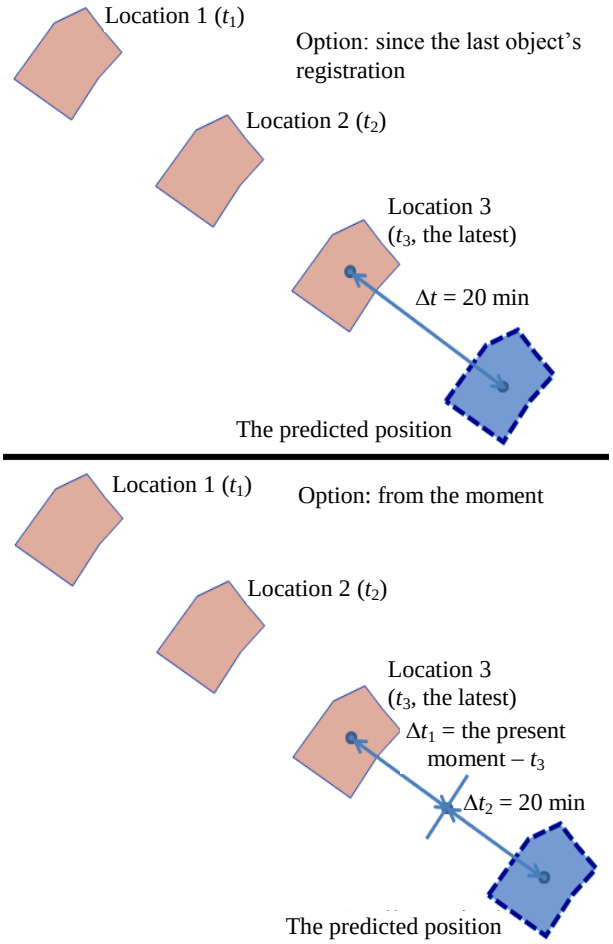

Fig. 5. Linear prediction, location of the object acquired from the server

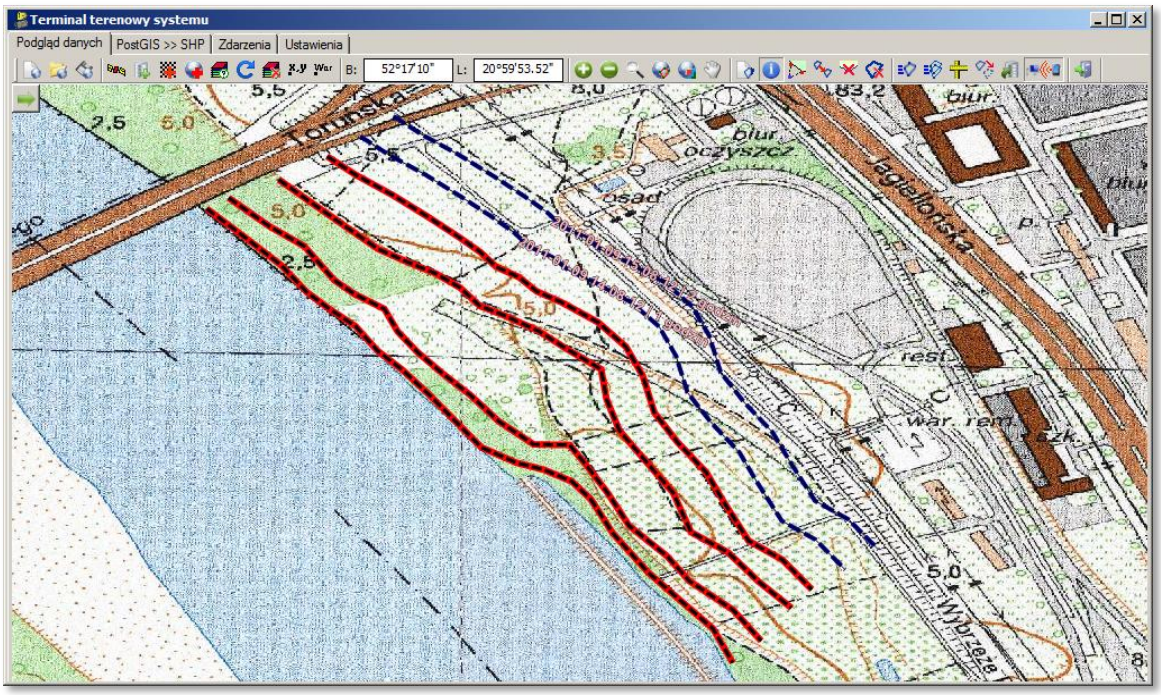

Fig. 6. The result of next stages of flood progress (red line), prediction of the location of the shoreline after one hour and 2 hours from the moment of performing the last measurement

system, built based on the open application solutions (free), of the Open Source type, it is possible to implement the module counted according to the equation of non-linear regression. The currently accepted solution is exemplary and it does not exhaust the possibilities of the system within the predictions of the objects' location.

Calculating the predicted location of objects is possible thanks to the usage of mechanisms of versioning the location of the shoreline, and the vector data acquired in the time close to the real one may be presented on any base (topographic map or orthophotomap).

Cartographic study (hybrid map)

The final stage of the proposed method is the determination of the scale of cartographic study (scale range). In order to determine the cartographic area of flood (difficult to reach) it is suggested to prepare cartographic studies in scales determined in accordance with the empirical factor *d* presented in table 1, according to the relation:

$$S_{\max} = \frac{1}{d \cdot R \cdot 1000} \tag{1}$$

where:

$S_{\max}$ – maximal scale;
d – empirical factor – minimal number of pixels in the millimetre of the cartographic study (according to table 1);
R – spatial image resolution expressed in [m].

Calculated from the equation (1) the scale is the maximal scale, and the optimal scale is approximately half the size. Moreover, in case of the final study in the form of the raster file, the authors recommend its creation in the resolution of 250–300 dpi.

Authors as a result of their own research stated that the accuracy of objects' location on orthophotomap, in case of cartographic studies for operational goals (e.g. images of areas covered by flood) should not be smaller than 15 m. While there must be preserved the remaining metric values: uniform scale, length measurements, surface and angles in the borders (negligibly exceeded) of the mistakes of the measurements of the same magnitudes, like in the case of aerial images with similar dimensions of a pixel. The assumed mistake of the objects' location is possible to be achieved (should not be exceeded) with the help of the presented O-GIS system.

Table 1. Empirical factor *d* – minimal number of pixels in the millimetre of the cartographic study

Type of imaging (sensor)/ spatial resolution [m]	Empirical factor *d*	Maximal scale	Optimal scale (safe)	Minimal scale
Ikonos/1	1.8	1:1800	1:3500	1:7500 – 1:10 000
Quick Bird/0.6	1.5	1:1000	1:2000	1:7500 – 1:10 000
Word View-2/0.5	1.5	1:800	1:1750	1:7500 – 1:10 000
Quick Bird/2.4	1.2	1:3000	1:5000	1:7500 – 1:10 000

Moreover, an error on the 10–15 m level does not influence the use of the map while moving in the area. While there must be preserved the remaining metric values: uniform scale, length measurement, surface and angles in the borders (negligibly exceeded) of the measurement errors of the same magnitudes as in the case of aerial imaging with similar pixel sizes. The above considerations are applicable to large-scale studies in the range from 1:1000 to 1:10 000. In such scales the creation of orthophotomaps should take place on the basis of high resolution imaging data, with smaller scales from 1:10 000, high resolution data are required – you may use imaging with a smaller spatial resolution, e.g. 5 m or create analyses on the topographic map. In addition, in scales smaller than 1:10 000, orthophotomaps should be made legible to ensure the possibility of the proper interpretation of the presented contents.

Conclusions

The presented method in a comprehensive way presents the study of the fast-changing data, from the moment of the occurrence of the crisis event (flood), to the moment of obtaining the map (orthophotomap), with the current and predicted location of the model object (flood tide). The usage of the O-GIS system for obtaining data about the flood enables both, the fast acquisition and transmission of data to the crisis centre (server). The conducted test proved the large usefulness of the built system in the acquisition and management of data concerning the flood. The performance of measurements was quick and did not cause any problems. The acquired data were transmitted smoothly to the server and recorded in the data base. The distribution of a larger amount of observers along the shoreline would cause the acquisition of the current and precise information about the spread of flood for a greater area. The conducted tests have shown that one observer is able to acquire the current information on the section of about 2 km. The next stage of the system's development would be the

location along the shore the automatic system of data acquisition transferring information up to date to the server. The cartographic development of fast-changing data should take place with the usage of the orthophotomap or large-scale topographic map. Orthophotomaps in scales smaller than 1:10 000 should be made readable.

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Peculiarities of use of speech acoustic environment while embedding into it of hidden message codes

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Key words: communication channel, model, message, hidden message, acoustic message

Abstract
The problems of embedding of message codes into Acoustic environment of speech are researched. The peculiarities of speech perception by human hearing are analyzed. As an example of acoustic message environment and codes of hidden messages embedded into it is reviewed a channel of mobile communication in the part of transformations which are implemented with acoustic signals. Approach to build a model of process of transmission of speech via non-linear channel basing on imagination about speech signals spectrum is developed. The proposals on methods of use of such models for analysis and interpretation of distortions of signals made by transformations, implemented in example channel are presented.

Introduction

Embedding messages into acoustic stream, formed during conversation of two subscribers and implemented by mobile communication means, is quite effective mean of protection of part of transmitted information which subscriber likes to secure. Such method of protection of personal information is known as steganographic method of hiding messages in acoustic environment [1]. Matter of steganographic hiding is in that for subscriber not supposed to receive hidden message cannot hear it. Technical implementation of this method hiding information sets a number of additional requirements, to which belong following:

- resistance of entered information to technological transformations (noise masking, lossy compression, filtering etc.);
- hidden information must not place visible to subscriber distortions into environment being used;
- embedding messages into acoustic stream must be implemented in real time mode;
- embedded messages must not show themselves as audible fragments during audition of sound stream by subscriber;
- embedded message must not lead to change of voice image of subscribers, exchanging messages and generating acoustic environment for such embedding.

As mobile operators implement services according to standards, made by international center for standardization of mobile communication services, so the technological transformations used by them are known. According to algorithms of those transformations, fragments of record into acoustic voice environment compensation (SEC) are implemented, in such way that embedded message code would not be distorted. For example, for reduction of size of acoustic stream is used lossy compression, then codes of the message are located in the part of signal, not excluded from signal. This is done in framework of implementation of used method of selection of place of embedding the elements of message code.

Second requirement is mostly a reflection of nature of steganographic methods of message hiding which are in that message must not be heard. This requirement is satisfied by code in which message is recorded, should not be connected to acoustic form of such message presentation. Due to that this requirement deals with distortions in acoustic

stream which can appear as distortions of voice percepted by target subscriber. Such distortion may arise while embedding codes into acoustic environment. Forming the method of embedding and use of basing on this method algorithm of embedding is one of main targets being solved during development of corresponding stenographic models. Such model should be based on analysis of following factors:

- peculiarities of frequency representation of SEC and their connection to peculiarities of human earing (SEH) from the side of receiving subscriber;
- peculiarities of perception and interpretation of SEC by SEH system and other factors leading to distortion of SEC.

Requirements to implementation of process of embedding message into SEC in real time mode is specific to SEC, as voice information is percepted with the speed of its generation by source subscriber. Delay of such speech due to some reasons leads to detection of this fact and its interpretation as malfunction of communication channel. Known approaches to solve this task in case when algorithms of processing current signals are not fast enough is in implementation of next phoneme. Solving the task of ensuring real time mode can be based on creation of new algorithms which ensure necessary speed of processing of the acoustic signal. To solve task of ensuring required speed of voice signal processing is used decreasing density of message packing.

Modification of acoustic voice signals together with technological transformations can lead to appearance of separate fragments of audible distortions, which can be associated with clear separate sounds which can be heard at background of transmitted speech. Thou such sounds will not comply to interpretation which is related to text of transmitted message, but can effectively influence on interpretation of the transmitted voice information. In that case can appear an effect of overlay of various voice messages one of which is a sound of transmitted message and other overlaying sound can appear due to described above reasons.

The last requirement is connected to the fact that sound of voice, generated by separate man contains acoustic signs which have personal character. In connection with that embedded messages should not significantly affect personal characteristics of acoustic stream. This condition can be easy enough to reach because especially in mobile communication systems, voice bandwidth is quite narrow which results in significant distortions of personal characteristics of sound, generated by subscriber. At the background of such distortion it is easy to ensure the formulated requirement.

Formalized description of requirements to method of embedding of messages into acoustic environment

During embedding message code into acoustic signal, as an object of modification can be used outgoing radio signal which itself is coded message containing information about sound of transmitted voice or incoming formant which needs to be presented as fragment of amplitude modulated signal. Modern systems of voice signal transmission, the most spread of which are mobile communication systems, designed for voice transmission between subscribers, implement such signal transformations, which ensure minimum necessary parameters of transmitted speech and ensure required level of expression and clarity of speech [2]. This is caused by a need to ensure maximum speed of voice data transmission aimed to increase signal bandwidth.

There are a lot of factors which influence audibility of changes in voice stream and mostly they are more or less connected with each other. So, it should mark factors which in most cases have dominating role during influence of appropriate acoustic wave SEH. Such factors include:

- rapid frequency changes;
- rapid amplitude changes.

Size of change of those parameters can be determined by derivative in time from value of appropriate parameter in case of determination of local acoustic environment component modification. As far as SEH system is integrating element of acoustic information perception, it seems appropriate to overview possible evaluations of changes in acoustic environment which are caused not only by its target modification but also by modifications which characterize one or another fragment of channels, taking part in voice transmission. Separate fragments of voice transmission channels in general should be treated as non-homogenous environment in which information messages are transmitted. Such environment could be a digital system or network, but most common system of that type is a mobile communication system. In mobile communication system quite complex transformations of acoustic signals are made which are in signal encoding, transformation of it into data package and in transmission of corresponding package to radio channel which is connected to mobile phone of the subscriber in which reverse transformations into acoustic image of voice message are made [3]. Main peculiarity of those transformations is their orthogonallity. During modification of incoming

signal due to encapsulation in it of message codes, changes in signal are taking place which are overplayed by changes caused by transformations, made according to standards, determined in appropriate documents of ETSIEN series, for example by document [4]. Let us mark totality of transformations as some transmission function $H(\varphi)$. Incoming voice data will marked $x(t)$, and outgoing voice data will marked $y(t)$. Identifier of data x_i is some structure $x_i = f(\xi_{i1},...,\xi_{in})$, where ξ_{ij} is a parameter, which describes incoming signal. In the same way outgoing signal $y_i = f(\xi^*_{i1},...,\xi^*_{in})$. It is obvious that ξ_{ij} in incoming signal x_i and ξ^*_{ij} in outgoing signal y_i can differ for not more then allowed value δ_{ij}, or $|\xi_{ij} - \xi^*_{ij}| \le \delta_{ij}$. This condition means requirement of orthogonality of two components of transformations, which form transmission function $H(\varphi)$. As far as such transformations in the framework of communication channel are made sequentially, so it can write down a correlation:

$$H(\varphi) = W_i(x_i,\varphi) + W_i^*(z_i,\varphi) + \delta_i(W_i,W_i^*) \quad (1)$$

where: W_i – function of transformation of incoming signal $x_i(\xi_{i1},...,\xi_{in})$, and W_i^* – function of reverse transformation of data z_i, which are formed by transformation $W_i(x_i,\varphi)$. Value $\delta_i(W_i,W_i^*)$ describes level of difference between x_i and y_i, which can be interpreted as a value of non-orthogonality of transformations W_i and W_i^*, which can be described as some transmission function $H(\varphi)$. If $W_i(x_i,\varphi) = W_i^*(x_i,\varphi)$, then $H(\varphi) = 0$. But this is impossible despite appropriate algorithms of transformations which are described by W_i and W_i^*, they are from the point of view of logic of their functioning identical. Value $\delta_i(W_i,W_i^*)$ appears due to following factors:

- mistakes in quantization and other methodic mistakes of implementation of transformation algorithms;
- intentional distortion $x_i(\xi_{i1},...,\xi_{in})$, which allows to increase speed of transmission and bandwidth of transmission channel, but with that ensures required quality of transmitted voice message;
- SEH system has a number of features, allowing it to reproduce interpretation of accepted voice signals even in case when signal $y_i(\xi_{i1},...,\xi_{ik})$ is not described by all parameters $\xi_{i1},...,\xi_{in}$, which characterize incoming signal x_i, during that $k < n$.

First factor is methodical and significantly depends on current parameters of ξ_{ij}, which by its nature can take random nature. For example, different subscribers have different tone, determined by power of various frequency components, by various speed of speaking etc.

Second factor is in intentional narrowing of voice bandwidth or consists in change of other parameters allowing decreasing volume of impulses designed for transmission via communication channel, during that is ensured affordable distortions of voice signals.

Third factor allows exclusion from acoustic voice stream of parameters, which do not influence perception of voice acoustic streams by SEH system. For example, if harmonic components are even and their sums and differences are multiple to components, then they slightly influence perceptibility and only change quality of sound. Second example of that modification type can be the following factor. Amount of information in flat sounds depends on amount of their use, for English language it means that the more frequent they are used the more information they carry. This means that it is possible to modify number of vowel sounds if there is pretty enough flat sounds in text etc.

As second factor can consist of few components use of which is determined depending on incoming signal, then its influence on modification of signals can be supposed accidental. Third factor is determined by subjective features of SEH system, from one side and voice sound generation system from other side, which are individual for each subscriber. That's why such factors can be treated as accidental which allows treating as accidental all events in communication channel which are caused by those factors.

Factors shown above can be treated as mutually independent and their influence on communications channel is supposed to be accidental. So, cumulative impact of those factors on data transmission process in communication channel we will review as noise influence or demonstration of non-linearity which take place in communication channel.

To determine level of non-linearity of system there can be used a function of coherency $\gamma^2_{x,y}(f)$ of incoming process $x(t)$ and outgoing process $y(t)$, which is an actual value, if $G_{xx}(f)$ and $G_{xy}(f)$ differ from zero and do not contain delta functions, which is according to [5], can be written down as:

$$\gamma^2_{xy}(f) = \frac{|G_{xy}(f)|^2}{G_{xx}(f)\,G_{yy}(f)} = \frac{|S_{xy}(f)|^2}{S_{xx}(f)\,S_{yy}(f)} \quad (2)$$

where: G – single sided spectrums, and S – double sided spectrums. As by their nature incoming and outgoing voice signals are periodic, so for their

formal description it is appropriate to use Fourier transformations [6, 7].

Steganographic hiding of messages in voice acoustic environment

Target of steganographic hiding of messages in voice acoustic environment or in SES, is in embedding of message codes into elements of acoustic environment in such way that following conditions are satisfied:

- fact of embedded codes presence must not be audible for subscriber, receiving the acoustic stream;
- distortions setting non-linearity of transmission function of communication channel must not lead to distortions of hidden code in SES;
- graphical images displayed on acoustic signal visualization devices must not show distortions caused by embedding of message codes into SES.

Above conditions are typical for systems of steganographic hiding of messages in digital environment [6]. First condition is determined by parameter of non-audibility of message η. Second condition is determined by parameter of resistance to noise or to technological transformations of digital environment which will marked $\aleph$. Third condition is determined by parameters of hiding the presence of message codes in acoustic environment which will marked $\Im$.

In general case model of steganographic system of hiding messages in acoustic voice environment which is transmitted via digital communication channel with non-linearity can be presented in following way. As we review presentation of $x(t)$ and y(t) as periodic functions, so transformation $x(t)$ in channel $H(f)$ we interpret only in framework of appearance of distortions which are caused by non-linearity $\gamma^2_{x,y}(f)$, which we describe basing on use of spectral densities of incoming and outgoing signals $S_{xx}(f)$ and $S_{yy}(f)$. Spectral densities are integral characteristics which describe influence of channel non-linearity $H(f)$ on transmitted through it signal $x(t)$. As message codes, embedded into SES do not have simple enough interpretation in acoustic environment, which complies to voice sounds, then they do not lead to such values of parameter η, which are unacceptable. Only their effect on acoustic stream is its noising if changing of sound parameters leads to its significant distortions. According to principles of steganography, environment modification during embedding message codes is made in such way that it must not result in audible changes of the environment [8, 9].

Parameter of resistance of message codes $\aleph$, embedded into SES can be ensured by following methods of functioning of steganographic process:

- SES modification by message codes must be in framework of general characteristics of outgoing signal $y(t)$, which is $\gamma^2_{x,y}(f)$, to exceed the last or must be satisfied correlation:

$$\left[\varepsilon[x(f)] \subset \gamma^2_{x,y}(f)\right] \rightarrow \left[\gamma^2_{x,y}(f) < \varepsilon[x(f)]\right] \quad (3)$$

- as there is a lot of components, which form coefficient of coherency $\gamma^2_{x,y}(f)$ so for steganographic modification of SES $\varepsilon[x(f)]$, are selected signal parameters, which are least influenced by non-linearity factors, existing in $H(f)$.

In steganosystems most frequent is second method of ensuring required value of $\aleph$ parameter [10].

One of methods of ensuring required value of $\Im$ parameter is that modification $\varepsilon[x(f)]$, if it is greater than allowed is masked by noise $m(t)$ with preset parameters which before extraction from SES of message codes is filtered from that noise.

The reviewed model, describing transmission function of transmission channel $H(f)$ as coherent function from incoming $x(t)$ and outgoing $y(t)$ signals is written down as correlation:

$$y(t) = \frac{\left|S_{xy}(f)\right|^2}{S_{xx}(f)\,S_{yy}(f)} \cdot x(t) \quad (4)$$

allows to interpret processes causing non-linearity of $H(f)$, as influencing separate components of their spectral reflection of transmission function $H(f)$. As spectral components are known functions, so changes of their parameters can be interpreted as changes caused by appropriate transformations of signals in channel by quantification, encoding, package forming algorithms and algorithms of their reverse transformations into voice image sent to subscribers speaker input.

Conclusions

Forming of interpretation of results of action of factors, causing non-linearity in data transmission channel as modification of spectral components can be implemented in following ways.

First way is in conduction of experiments in which is initiated influence on acoustic signal which itself is a fragment of spectrum equal to one formant of voice sound and on receiving side after influence which is reverse to first one are analyzed changes in spectrum. It is obvious that such experiment is possible with adding each next transformation on next step of its conduction.

Second way is in analytical description and calculation basing on appropriate description of value of possible influence on corresponding image of outgoing signal. For implementation of such method of forming of interpretational description of implementation of non-linear influence on processes in transmission channel, it is necessary to interpret each step of discrete transformations in images of sound which are their spectral description. In many cases this is quite simple to implement basing on physics of acoustic waves.

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Synthesis of text models with information streams

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Key words: models, semantics, synthesis, texts, grammar, objects, functioning, output

Abstract
The methods of synthesis of text models with information streams are researched. In the process of functioning of system of text models, which model systems of social objects the following are implemented: analysis of models of monitoring of information means, used by social objects, control of adequacy of models to objects and objects management. The synthesis of text models with information streams is implemented basing on use of semantic parameters. In process of text forms synthesis of models description and information streams appears necessity to output new text fragments, reflecting synthesis result. Such output processes are procedures based on use of logical schemas and grammar rules.

Introduction

Process of functioning of text models system (STM_i) is not only in implementation of actions, connected to management of social objects (SO_i), being modeled with help of text models (TM_i). This process supposes implementation of following functional possibilities: analysis of current state of TM_i, monitoring of STM_i, management SO_i basing on use of information streams (IP_i) and TM_i, control of adequacy of current state TM_i to corresponding objects SO_i. Monitoring of STM_i is necessary to determine moments of activation of actions, connected to detection of factors, influencing current state of TM_i, which are not caused by managing actions initiated against TM_i. Such factors include: procedures, connected with identifying models TM_i with corresponding objects SO_i; procedures connected to analysis of TM_i; procedures connected t to modification of TM_i, which is not caused by managing actions IP_i etc. Because imagination about management of TM_i is quite wide, let us create definition of such imagination.

Definition 1. As management action on TM_i we mean actions which are determined by following conditions: managing action to TM_i for change of corresponding state of SO_i; managing action is implemented by external relative to TM_i, factors by forming appropriate IP_i; any managing action is caused by target, description of which is included into IP_i.

One of main tasks which is solved with the help of monitoring system is a task of ensuring adequacy between TM_i and SO_i. Solving that task is based on following methods: forming short and long term reverse connections between system of social objects (SSO_i) and STM_i; stand-alone analysis of TM_i; extending interpretations, which are related to SO_i. Reverse connections between SO_i and TM_i are implemented basing on following components: obligatory data about SO_i, which are formed from data of various structures, orientated on work with SSO_i; data from electronic mass media; data from other sources, which appear randomly. Monitoring system solves following tasks: analysis of data about SO_i and forming of image of SO_i and its current state SO_i relative to TM_i; forming process of monitoring of system STM_i and pseudo monitoring SSO_i, which is in definition of process parameters, for example, value of period of one cycle of monitoring of mass media, depth of monitoring, forming additional processes if there is a necessity in their initiation; implementation of processes of modification of TM_i, if last appeared to be necessary because of the results of adequacy check between SO_i and TM_i.

Monitoring system (SM) makes during its function only analysis of data about SO_i. Basing on that

analysis a new model TM_i is formed, if it was detected that new SO_i object appeared, or modification of TM_i is conducted, if changes of parameters in corresponding SO_i were detected. Feedback which supplies data to STM_i about SO_i, which is modeled in STM_i, is generally passive because capacity of activation of data transfer from SO_i to STM_i is quite limited. Due to existence of electronic communication means such activation can be implemented but not in determined form. This means that actions implemented by STM_i lead to corresponding reaction from SO_i through some period of time. STM_i system from one side is a system of images SO_i in form of TM_i, and from other side STM_i is a system helping to make modeling of management actions on separate SO_i objects, or on whole system SSO_i. Reliability of results of such modeling is determined by level of distortion or level of inadequacy between SO_i and TM_i.

Components used in process of synthesis and synthesis of text models with information streams

As far as system STM_i describes SSO_i, then besides methods which describe separate SO_i as TM_i, necessary methods which describe relations between TM_i and TM_j in STM_i, which correlate with relations between SO_i and SO_j in SSO_i. Such components should not necessarily be objects separated from TM_i in STM_i. Connections between TM_i and TM_j can be implemented basing on level of similarity between separate TM_i and TM_j, or, basing on similarity of SO_i and SO_j, which is obvious for SSO_i. Such relation is implemented basing on following: level of structural similarity between separate TM_i; level of functional dependence if TM_i and relative SO_i are implementing predefined processes in SSO_i; level of dynamic similarity which can be in functional similarity of semantic; level of activation or other parametric similarity [1, 2].

Let us review method of description of structural connections which are implemented as separate text elements STM_i, which will be marked TZ_i [3, 4]. Keeping in mind imagination about text methods of description let us accept that TZ_i is some text form which dislike model TM_i identify not object SO_i, but describes conditions of activation of connection between TM_i and TM_j. Physical implementation of such connection is in transmission of data from one model TM_i to other TM_j. Function of component TZ_i is implemented by following steps: TM_i and TM_j are determined, which can implement relation in form of exchange of information; basing on analysis of TM_i data for information package IP_i^V are selected in TM_i; corresponding IP_i^V is transmitted to TM_j as information extension in framework of TM_j is made corresponding modification of TM_j.

To analyze more deep processes of functioning, implemented by TZ_i which can be written down as: $TM^*_j = TZ_i(TM_i, TM_j)$, it is necessary to stop on structure of TM_i in projection on subject area, which is described by STM_i and separately by TM_i. In that case structure of TM_i will be characterized by following aspects: own structure aspects; structure aspects connected to subject area; general aspects of structure TM_i.

Existance of structure in TM_i allows to form some rules of conduction of synthesis of TM_i and IP_i, when IP_i extends TM_i in form of usual concatenation $J(TM_i)$. Obviously IP_i must be isomorphic to TM_i not only at the level of language, used to describe TM_i, but also at level of structure and rules of its forming [5, 6]. In that case it can talk about following rules of analysis which are used on separate step of functioning of STM_i, which is defined or activated by management action of IP_i.

PR1: Determination of difference between separate fragments of interacting text descriptions can be formally described by following correlation:

$$\begin{aligned}&\left[S_i^t\left(j(tm_i)\right) = S_i^t\left(j(ip_i)\right)\right]\rightarrow\\&\left[j(tm_i) - j(ip_i) = R_i^t\left(tm_i, ip_i\right)\right]\end{aligned} \quad (1)$$

where: $S_i^t(j(tm_i))$ and $S_i^t(j(ip_i))$ – structural characteristics of fragment tm_i and ip_i, correspondingly, $R_i^t(tm_i, ip_i)$ – level of structural correspondence of two interacting objects in STM_i, which are TM_i and IP_i.

PR2: Synthesis of two fragments at level of their phrases is described by following correlation:

$$\begin{aligned}&\left\{\left[R_i^t\left(tm_i, ip_i\right) \le \alpha\left(TM_i\right)\right]\rightarrow\left[tm_i\left(\varphi_{i1}^m, ..\varphi_{im}^m\right)\&\right.\right.\\&\left.\left.\&\left(ip_i\left(\varphi_{i1}^p, ..., \varphi_{ik}^p\right) = tm_i^*\left(\varphi_{i1}^{m*}, ..\varphi_{im}^{m*}\right)\right)\right]\right\}\vee\\&\left\{\left[R\left(tm_i, ip_i\right) > \alpha\left(TM_i\right)\right]\rightarrow\left[tm_i^* = \left(tm_i * ip_i\right)\right]\right\}\end{aligned} \quad (2)$$

where $\alpha(TM_i)$ – threshold of allowed semantic difference between fragments tm_i and ip_i, φ_{ij}^m – phrase, which comes out of tm_i, φ_{ij}^p – phrase which comes out of ip_i, φ_{ij}^{m*} – phrase which comes out of tm_i^*, tm_i^* – fragment which is synthesized at level of phrases from tm_i and ip_i, * – sign of concatenation of two text fragments tm_i and ip_i at level of phrases.

RP3: Rule of reduction of semantically exceeding phrases from text fragment tm_i^*, which is formally written down as following correlation:

$$\exists\left[\left(\varphi_i^m,\varphi_i^p\right)\in tm_i^*\right]\left[S^e\left(\varphi_{ij}^m\right)-S^e\left(\varphi_{ij}^p\right)\le\alpha\left(tm_i\right)\right]\rightarrow$$
$$\rightarrow\left[\left(\frac{tm_i^*}{\varphi_i^p}\right)\rightarrow\left(\varphi_i^p\notin tm_i^*\right)\right] \quad (3)$$

where $S^e(\varphi_{ij})$ – value of semantic significance of phrase φ_{ij}, $\alpha(tm_i)$ – boundary allowed value with which semantic difference between two phrases is allowed or not allowed.

In process of synthesis TM_i from IP_i can appear necessity of output of new phrase. Then with the aim of forming phrase $\varphi^*_i(TM_i)$, which semantically will be equivalent to phrases $\varphi_i(tm_i)$ and $\varphi_i(ip_i)$.

Definition 2. Semantically equivalent phrases φ_i and φ_j are phrases, for which semantic conformity is greater then threshold value $\Delta\sigma^{\mu}$.

In case of use of imagination about semantic conformity, it is necessary to take into account following peculiarity of text representation of information which is in fact that semantic content is influenced not only by level of average semantic significance of words in two different fragments, but also a place of some words in corresponding phrases. Some meaning of semantic controversy is accepted as not allowed meaning of its value between words which are part of the same phrase in correlation:

$$\sigma^S\left(\varphi_i,\varphi_j\right)=\left|\sigma^S\left(\varphi_i\right)-\sigma^S\left(\varphi_j\right)\right| \quad (4)$$

Level of semantic conformity can be divided into two types, one of which is a general conformity defined basing on difference $\sigma^S(\varphi_i, \varphi_j)$ relatively to preset threshold of allowed significance of value $\sigma^S(\varphi_i, \varphi_j)$. It does not depend on method of placement of words in φ_i and φ_j, as semantic conformity significantly exceeds value of controversy which is set by word replacement. In framework of $\sigma^{\mu}(\varphi_i, \varphi_j)$ appears necessity to take into account influence of words order in φ_i and φ_j, to define level of conformity. Let us review method of definition of $\Delta\sigma^{\mu}$, which divides $\sigma^{\mu}(\varphi_i, \varphi_j)$ into σ^{u} and σ^{e}. Such division is level of conformity of curve which interpolates change of value of meaning $\sigma^S(\varphi_i)$ in framework of one phrase. In that case corresponding line is built on plane in which Ox axis reflects words in order of their placement in phrase φ_i. Each point on Ox which is equal x_i reflects $x_i \in \varphi_i$, and $\Delta x = x_{i+1} - x_i$ means following word x_i. On axis Oy is set value $\sigma^S(x_i, x_{i+1})$, which is integer, as $\sigma^S(x_i, x_{i+1}) = |\sigma^Z(x_{i+1}) - \sigma^Z(x_i)|$ – where corresponding values can be integers if it is accepted to define $\sigma^Z(x_i)$ by number of words, used to describe interpretation x_i in semantic vocabulary S_C. In case of other approaches to definition of value of $\sigma^Z(x_i)$, for example approach basing on definition of frequency of use of word x_i in texts describing TM_i and IP_i, which interact with them during definite period of time then value $\sigma^Z(x_i)$ can be fractional or rational. Semantic controversy between phrases φ_i and φ_j is defined according to following correlation:

$$\sigma^S\left(\varphi_i,\varphi_j\right)=\left|\frac{\sum_{i=1}^{m}\sigma^S\left(\varphi_j\right)}{m}-\frac{\sum_{i=1}^{n}\sigma^S\left(\varphi_i\right)}{n}\right| \quad (5)$$

During definition of semantic conformity $\sigma^{\mu}(\varphi_i, \varphi_j)$ it is necessary to take into account semantic differences between φ_i and φ_j, which are conditioned by replacing words for extension or modification of semantics during building of phrases in which semantic controversy is prohibited. In that case, $\sigma^{\mu}(\varphi_i, \varphi_j)$ beside general value of $\sigma^S(\varphi_i, \varphi_j)$, which is medium value, must account the above change of semantics which will be called objective change of semantic parameters value. Each segment presenting relation $\sigma^S(x_i, x_{i+1})$ in phrase φ_i, must have same angle as connection described by $\sigma^S(x_j, x_{j+1})$ for phrase φ_j. Formula for definition $\sigma^{\mu}(\varphi_i, \varphi_j)$ will be:

$$\sigma^{u}\left(\varphi_i,\varphi_j\right)=\sigma^S\left(\varphi_i,\varphi_j\right)+\left|\sum_{i=1}^{m-1}\alpha_i-\sum_{j=1}^{n-1}\alpha_j\right| \quad (6)$$

Due to above formula it gets possible basing on a priory data to determine value of possible threshold $\delta\sigma^{u}$, which divides σ^{u} from σ^{e}. Due to use of imagination on interpolation curves, value of equivalence of two phrases can be determined not only as summary or middle deviation of values α_i with $\Gamma_i(\varphi_i)$ and $\Gamma_j(\varphi_j)$, but also as local parameters, localization of which is implemented basing on binding coefficients α_i and α_j to order number of words in phrases φ_i, φ_j. In that case it can determine maximum adequate value σ^{u}. Formula to determine such value σ_{Δ}^{u} will be:

$$\sigma_{\Delta}^{u}=\sigma^S\left(\varphi_i,\varphi_j\right)+\sum_{i=1,\,j=1}^{m,n}\left[\alpha_i\left(x_{i+1},x_i\right)-\alpha_j\left(x_{j+1},x_j\right)\right] \quad (7)$$

In that case it can get dependency $\sigma_{\Delta}^{u} = f(x_i, x_j)$, where x_i, x_j are coordinates in φ_i, φ_j.

Method of output of phrases in text models

Changes taking place in SO_i must also take place in TM_i. Speaking about functioning of TM_i, it means functioning of $\{TM_i \,\&\, SO_i\}$ system. To activate processes of modification or any other changes

in TM_i, excluding those changes which take place under influence of IP_i on SO_i and TM_i, it can define following factors: changes in objects SO_i; optimization processes in TM_i; results of current analysis of system $\{TM_i \,\&\, SO_i\}$. Peculiarity of objects SO_i is in fact that they do not have direct influence on TM_i, as there is no direct links between SO_i and TM_i. Such relations are information only. So, reaction of TM_i on changes in SO_i can be quite complex and can be characterized by following peculiarities: reaction of TM_i on changes in SO_i can have different value of delay, as it is accepted that SO_i and TM_i are informational standalone; such reaction can have different level of adequacy relatively to real changes in SO_i; reaction of TM_i on changes in SO_i can have different level of distortion of one or other changes or states to which comes SO_i as a result of initiation of internal modifications. Specific characteristics of TM_i and STM_i, in general is a level of informational masking of TM_i relatively to SO_i, level of formality of TM_i relatively to SO_i, or level of completeness of reflection of SO_i.

Basing on peculiarities of systems like SSO_i fact of existence or use of systems STM_i must be informational masked [7, 8]. Informational masking in that case means following. Fact of possibility of creation and use of systems STM_i can be known in general. But various methods of implementation of specific STM_i must not be available or known to SSO_i. This parameter is a key one due to following: if it is not used then there could be possibility of direct control of objects SO_i, and directly own whole information on SO_i, and absence of that parameter causes necessity of full control of the whole system SSO_i, that from the point of view of natural conditions of function of SSO_i is a negative factor. Formalization of description of TM_i is fact that elements which are supposed to be formally described are joined into appropriate classes and then the whole class of objects is marked in some formal way, mostly by various symbols [9, 10].

One of basic functions of system STM_i is detection of various critical situations in SO_i and detection of processes which lead SO_i to such situations. After detection of critical situations, system STM_i, at least must activate processes of informing external members of modeling about that. Besides, as functions which can be implemented in STM_i there can be function of counteraction critical situations. As modeling means TM_i do not have direct influence on SO_i then appropriate functions are in forming IP_i, which contain information capable to initiate counteraction of critical situations escalation in SO_i. Such IP_i can be transmitted to external means orientated on execution of such influence directly guiding formed stream to corresponding SO_i to initiate elimination of critical situations in SO_i. Obviously STM_i forms streams that are related to SO_i in general but not streams which could be guided to separate components of SO_i, as analysis in TM_i is made only regarding SO_i. In mentioned cases need of use of methods of output of new phrases φ_i appears, as activation of process of functioning SO_i and respectively, TM_i can require new text descriptions. Let us review some approaches to build output of phrase φ_i^* from some totality of phrases $\{\varphi_{i1},...,\varphi_{in}\}$. In most cases such totality forms one sentence ψ_i or one paragraph π_i.

Procedure of output of text fragments like in most of cases, especially logical, represents itself as sequence of elementary transformations [11, 12]. Despite logical schemas, during output of phrases in text environments there are following peculiarities.

1. On each output step before its realization following types of analysis are made: conducted analysis of semantic parameters of two elements between which transition is implemented, which is interpreted as one step, let us formally describe it as:

$$[\varphi_{i1},..\varphi_{in}] \rightarrow [\varphi_{i1},...,\varphi_{ij}^*,...,\varphi_{in}] \qquad (8)$$

where φ_{ij} – random phrase of sending output step, φ_{ij}^* – phrase, which arise in environment as a result of one output step; analysis of grammar correlations between words in new construction of phrase φ_{ij}^* is made, which is formally written down as:

$$\Gamma_i(x_{i1},...,x_{ik}) \Rightarrow \gamma_{ij}(x_{i1}^*,...,x_{ik}^*) \qquad (9)$$

where Γ_i – grammar rules, used in natural language of text models, γ_{ij} – separate grammar rule $\gamma_{ij} \in \Gamma_i$, which is schema of use of separate types of words during constructions of phrase φ_{ij}^*; check of built phrase φ_{ij}^* is made if it comply to requirements of normalization, which formally can be written down as follows: $\lambda(\varphi_{ij}^*) \rightarrow N(\varphi_{ij}^*)$, where $\lambda \in \Lambda$ – system of rules of normalization of structure of phrase or paragraph, $N(\varphi_{ij}^*)$ – normalized form of description of phrase φ_{ij}^*.

2. Implementation of output step is in use of one of operations, to which belong: elimination of words from phrase; replacement of one or couple of words with another word or group of words; adding word to phrase which is supposed to be transformed during output; changing places of words in phrase.

3. After execution of section 2 all checks described in section 1 are implemented against new phase, and they are conducted at all levels of trans-

formed elements hierarchy, for example: (level φ_{ij}^{*}) $\rightarrow$ (level ψ_{ik}^{*}), where ψ_{ik}^{*} – sentence, containing created phrase.

4. Sections 1, 2, 3 are repeated until output process is complete.

Basing on analysis conducted according to sections 1, 2, 3 are formed some conditions which are considered during implementation of step of evaluation of such analysis on definite criteria. In most simple case for decision making such evaluations could be fixed binary bounds for all values of parameters or characteristics being analyzed. In cases of analysis of text forms of information presentation, making decision basing on such results is sufficient.

Let us review analysis of semantic parameters of text fragments at level of phrases φ_i. First let us write down general analysis procedure $\{\varphi_i \,\&\, \varphi_j\}$:

$$\begin{aligned}&(\varphi_i \,\&\, \varphi_j) \rightarrow \left[\sigma^S(\varphi_i, \varphi_j) \le \delta\sigma^S(\varphi_i * \varphi_j)\right] \vee \\ &\vee \left[\sigma^S(\varphi_i, \varphi_j) < \delta\sigma^S(\varphi_i * \varphi_j)\right] \rightarrow \exists(\varphi_i * \varphi_j) \rightarrow \\ &\rightarrow (\varphi_i \,\&\, \varphi_{j+1})\end{aligned} \quad (9)$$

Semantic analysis mostly begins from definition of value of semantic controversy $\sigma^S(\varphi_i, \varphi_j)$. If it is less then $\delta\sigma^S(\varphi_i)$, then takes place transition to next steps of analysis. If $\sigma^S(\varphi_i, \varphi_j)$ is greater then $\delta\sigma^S(\varphi_i)$, then analysis is conducted $\sigma^S(\psi_i, \psi_j)$, which includes appropriate phrases. If $\sigma^S(\psi_i, \psi_j)$ is less then threshold $\delta\sigma^S(\psi_i)$, then next phrase φ_{j+1} is selected instead of φ_j. In that case we accept that φ_i is element from TM_i, and φ_j is element from ψ_j, where ψ_j is sentence from IP_i of some source IP_i (DIP_i), or element IP_i from feedback channel, which in difference from DIP_i we will call KIP_i. Corresponding transition from φ_j to ψ_j is continued until level of paragraph π_j, which can be written down as correlation: $\varphi_j \rightarrow \psi_j \rightarrow \pi_j$, if it would appear that takes place:

$$\begin{aligned}&\left[\sigma^S(\pi_i, \pi_j) > \delta\sigma^S(\pi)\right] \rightarrow \\ &\{[KIP_i \rightarrow KR(SO_i)] \vee [KIP_i \rightarrow KR(DIP_i)]\}\end{aligned} \quad (10)$$

Value $\delta\sigma^S(\varphi_i)$ can be formed for subject area W_i, or for each separate interaction of TM_i with IP_i, or KI_i, where KI_i – channel stream of information and can depend on level of necessary sensitivity TM_i to changes which take place under influence of IP_i, which like KI_i we will call DI_i.

Phrase φ_i^{*} received on previous stage is analyzed for compliance to requirements of normalization. If rule of absorption of phrase uses operations of adding words and replacement of words, then rule of normalization uses operations of elimination and replacement of words. In process of analysis of normalization requirements for words or word pairs their semantic values are determined. If $\sigma^Z(x_i^{*}) - \sigma^Z(x^{*}_{i+1}) \le \Delta\sigma$, then x_i^{*} and x^{*}_{i+1} are checked for excessiveness. Such check is in calculation of same words in $j(x_i^{*})$ and $j(x^{*}_{i+1})$, which are located in semantic vocabulary S_C. If number of different words with $j(x_i^{*})$ and $j(x^{*}_{i+1})$ is less than some threshold $\varepsilon[j(x_i^{*}), j(x^{*}_{i+1})]$, then words x_i^{*} and x^{*}_{i+1} in framework of system of normalization Λ are accepted as synonyms and elimination of one of the words x_i^{*} or x^{*}_{i+1}, which belong to TM_i is made. This circumstance is important because it has characteristics of renewing of word reserve which is used in TM_i. According to $\lambda(x_i, x_{i+1})$ it can appear that in S_C exists x_i^D so that exists correlation:

$$\begin{aligned}&\{\{\varepsilon[j(x_i) - j(x_{i+1})] \le \delta\lambda_i\} \,\& \\ &\& \exists(x_i^D \in S_C)\left[j(x_i^D) - j(x_i) < \delta^1\lambda_i\right] \& \\ &\& \left[j(x_i^D) - j(x_{i+1}^D) < \delta^2\lambda_i\right] \& (\delta^1\lambda_i > \delta^2\lambda_i) \& \\ &\& \delta\lambda_i > (\delta^1\lambda_i \,\&\, \delta^2\lambda_i)\} \rightarrow \left[(x_i * x_{i+1}) \rightarrow x_i^D\right]\end{aligned} \quad (11)$$

Then two words x_i and x_{i+1} are eliminated, and instead of them is used word x_i^D.

Conclusions

Method of synthesis of text models with text information streams which are orientated on performing managing actions on social objects which are described by text models is developed. Analysis of components of process of text models functioning to which belong: analysis of models; monitoring of mass media, used by social objects; analysis of implementation of processes of model modification etc. is made. The developed methods of synthesis of text models with text images of information streams are based on use of structural characteristics of models and streams and also are based on use of semantic parameters of text images.

It is shown that during synthesis process arises necessity to implement processes of output of new text fragments which own interpretation in subject area of practical tasks of social objects management. Procedure of output of text fragments based on use of logical schemas is developed, interpretation of which does not contradict data, presented in subject area of task and is based on use of semantic parameters which characterize text forms of model presentation.

Main aim of use of text models is description of social objects which are hard to be described in formal way at necessary level of details which is a requirement to effective management of such objects. Results mentioned in work illustrate possible approach to tasks of automation of processes of synthesis and managing social objects.

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Traffic engineering methods solutions of problems concerning ship's manoeuvres and sailing on the large rivers of Central America

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Key words: ocean going ships river's navigation, manoeuvres, traffic engineering, sea transport safety, navigational practice

Abstract

The paper introduces some aspects of maximum size ocean going ship's safety during the sailing on Central American rivers. Based on solution of above problems, presented necessary hydrographical information concerning River Orinoco, Mississippi, Rio Magdalena and the most biggest of the World – Amazon River. Solutions of several river's navigational and manoeuvres problems suggested by Traffic Engineering have also been presented. Independently, there are suggestions concerning improvements of the sea transport safety in the river's estuary.

Introduction

The center of global economy moves from stagnant traditional areas hitherto regarded as highly industrialized countries, in the direction of the dynamically developing countries of the Far East region. At the same time, economists see huge growth potential latent in the economies of Latin America. New economic centers are formed wherever it is possible to navigate the ocean-going vessels on tropical and subtropical waters and inland areas. Therefore, expansion of ocean going ships into areas of rivers and their river basins and estuaries to the sea is observed. The direct result of ocean going ships on these waters is the need to solve extremely important problems related to safety of navigation. Relocation of centers of global economy has an influence on safety of navigation in confined areas. These phenomena will be described in the paper on the example of the four rivers of Central and South America: the Mississippi, the Amazon, the Orinoco and the Rio Magdalena.

Threats to safety of navigation on the rivers

The Mississippi River

Transport of goods by means of a system of waterways of this river plays the major role in international and internal trade of the United States. Ocean-going vessels arrive at a distance of more than 200 miles up the river. On this distance the river is completely settled. Mandatory fully professional pilotage concerns any vessel engaged in the international navigation on the river. U.S. Corps of Engineers and the U.S. Coast Guard maintain high safety standards throughout the basin. The intention of the services is, among other things, constant updating of hydrographic data. Formation and maintenance of waterways is carried out to meet all criteria for assessing the safety of navigation [1].

The Mississippi River along its length transports and deposits annually about 500 million tons of material. At the lower Mississippi, especially in the delta, there are areas of formation of new shallows and as a result of the shallows, the parameters of shipping areas are changed. Due to the lack of significant effect of tidal currents, the shallow effect is observed on the open sea near the mouth of the river. In these locations, a rapid slowdown of the current generates the deposition of heavier fractions of sediment. To bypass the silt deposition region lying opposite the mouth of the river, ships make a turn of about 45 degrees just before the entrance to the river track. Following the optimization of the costs, one of the arms of the Mississippi Delta,

South West Pass was selected for ocean-going vessels where, despite the continuous silting and the natural tendency for changes in river bed, safe dimensions of manoeuvring area are provided. According to the available nautical publications on board the ships, the Mississippi settlements take the form of gelatinous substance by an average of a meter thick. This occurs especially at low water level. Therefore, a systematic and extensive dredging involving the removal of sediment is conducted. The designed minimum depth of 13.70 m (2011) is kept. River current is adjusted by using hydro-engineering buildings. What is achieved, is a compromise between the capacity to carry sediment possible at high flow velocity and decreasing the current of the river that provides the required level of safety manoeuvre. This approach to the maintenance of water bodies manoeuvring enables to omit the impact of siltation of the navigable waters to the Mississippi River. Therefore, the accuracy of computational methods of resistance to motion, drive efficiency and settling vessel in force for clean waters available on the side of the ship are satisfactory [2]. When realization of a well-conceived plan, the manoeuvre on the Mississippi may proceed without excessive increase in risk of navigation.

The Rio Magdalena River

The mouth of the Rio Magdalena contrary to the Mississippi, has no features characteristic of delta. But there are many hydrographic similarities of this funnel-shaped mouth of the Mississippi branch of the river to South West Pass. The shape of the Rio Magdalena river generates high velocity of the stream, sometimes it exceeds 6 knots. The allowable safety draft on the river is 9.1 m (2011).This value may be changed at any time, depending on the conditions of the river. Similarly to the Mississippi delta, there are no significant tides and for this reason, the deposition of silt carried by the river is just at its mouth to the sea.

A considerable stream, severe weather, lack of direct shelter at the mouth of the river from the prevailing strong north-easterly winds entail considerable difficulties in carrying out any of engineering works. On the other hand, definitely inadequate is the accuracy and timeliness of maps and navigation aids. Relying on them can cause serious accidents during navigation. The entrance to the Rio Magdalena, as the entrance to SW Pass, is preceded by the sudden 45° change of the course. Just before this manoeuvre, the ship, in accordance with the local regulations should reach a minimum speed of 10 knots. This should provide ship handling at the edge of six knots outgoing river current. Acceleration of the ship is possible only at the distance of a few cables before the entry into the head of the breakwater. In this area ships encounter shield from heavy sea waves caused by the previously mentioned north-east winds. For this underwater breakwaters that are piled up with mud shoal are responsible. This shows that the strong shallows caused by deposition of sediments in the immediate vicinity of the mouth of the river do have also their positive side. The manoeuvre to enter the river is difficult because of the following reasons:

1. The limited available distance to accelerate the ship to the required by the rules speed of 10 knots.
2. The narrow, 150 meter deep channel limited by the breakwater heads just after the sudden 45° change of the course.
3. The phenomenon of strong asymmetric squat in the bow area of the vessel and the drift of the bow when entering into six knots current of the river
4. The strong river current that interferes with ship's turn at a critical moment in the heads of the breakwater.

Provisions for the pilotage are defined in tabular form binding the basic data with acceptable performance of the vessel drafts at different states of the river. The rules are based on practitioners' experience rather than theoretical calculations. At the expense of limiting the size of vessels and reducing the allowable squat, a satisfactory level of safety of navigation is achieved. Lack of accuracy of hydrographic data and notices to mariners, the difficulty of maintaining manoeuvring areas result in the need to enter the port of Barranquilla not fully loaded vessels. Lack of precise sources of the Port Regulations imposes the necessity of tightening the criteria which allow ships to navigate the river. Liberalizing the restrictions may improve the situation and provisions will be based on the calculation methods of marine traffic engineering [3]. The phenomenon of a substantial safety margin in determining the rules were observed during entry on the Rio Magdalena by ship m/v "Podlasie": $L = 190$ m, $B = 28.5$ m, $T = 9.1$ m. According to current regulations, in the described conditions, this ship was close to the maximum sizes for that basin.

The Amazon River

Fluctuations up the river reach several meters. This seasonal phenomenon typical of tropical regions is reduced in the lower reaches of the river. The effect of changes in water level is strong erosion of the river which is, next to the continuous

washing away of the soil due to rainfall, the cause of siltation of the Amazon River (Fig. 1).

Fig. 1. Cliff on Amazon River

500 miles upstream from the mouth of the river water level changes can be observed due to tides. The first 300 miles up from the mouth the river, the current also changes its direction to the rhythm of tidal currents. In these places the strongest effect of silt deposition in the river occurs. The greatest changes in the river delta area are especially dangerous for ocean-going vessels. The responsibility for navigation on the last 170 miles of the river lies mostly on the ship's captain – there is no requirement of local pilot jobs. In addition to the shallowing caused by deposition of river silt, fast migrating shoals is an additional obstacle for navigating ships. In the absence of sufficient available depth examination, the knowledge about the phenomenon is usually discovered during subsequent accesses to the grounding. This happens several times in a month. During the ship's passage on the river, the navigational notices concerning another ship aground are usually obtained. For the vast delta of the Amazon, it is difficult to accurately determine the place where the stream experiences rapid slowdown. The mass of waters and the presence of tidal currents (tide up to several meters) create in the edge of the open sea shallows – Barra Norte. It is a vast sandy and muddy bank, where according to navigation maps the available depth is about 7–8 meters. The maximum permissible draft in ports across the Amazon reaches over 10 meters. In such cases, the passage through the heavily silted area is possible only at high water. The designation in this area the recommended two-way approach fairway, may be helpful as a method of providing navigable depth. Such action may allow the maintenance of and continuous leaching of the sediment. It is noteworthy that on the Amazon there is no systematic dredging conducted for the maintenance of navigable depth. In part, this approach to maintain the navigability is dictated by the fact that in compulsory pilotage on the river area depths are sufficiently large, sometimes reaching well over 100 meters. Also, in view of the large width of the naturally-shaped fairway, there is usually no need to use day or night marking for navigation.

Currently it is believed that Brazil has strong potential for economic development. Huge business opportunities exist particularly throughout the Amazon basin. Since in this region there is practically no alternative to water transport, the transformation of the Amazon waterways to the level of use such as the Mississippi River in the United States seems to be inevitable. Not all engineering methods used in the USA will apply to the Amazon. It is possible to avoid the errors committed there, mainly because of advances in science and the need to take into consideration the protection of sensitive equatorial rain forest area. The problem may be lack of capacity of the organization of work and systematic activities of all the services and coordination such as is the case of the Mississippi.

The Orinoco River

This river has long been used for the transport of goods by ocean-going vessels. Its basin is much smaller than the Amazon, all the phenomena previously signaled to the river can also be seen on the Orinoco. Similar to the Amazon's Barra Norte shoal is Orinoco Boca Grande shoal. Passage through is possible along the deepened fairway. The river, due to a smaller size, has not been such potential for development of transport as in the case of the Amazon. The maximum draft of vessels that can reach the Matanzas is 12.7 m. This value is significantly reduced in some cases up to around 9 m in the case of low water levels.

The maximum draft in force is available on a daily basis and is published in regular messages. Maintaining proper depth is provided by dredging being carried out continuously. One unit of a fleet of dredgers with low speed 1–2 knots proceeds along a nearly 200 mile waterway intended for ocean-going vessels. Sediments are pumped from the middle of the channel outside the fairway, kept in motion, and thus maintaining the proper navigable depth. On its way to Matanzas, large ocean-going vessels meet many shallows and river meanders. The fairway although sometimes quite narrow, is the most well marked by light buoys. The river no longer has any natural reserves to increase the scale of ocean-going ships. Maintaining navigable Orinoco requires currently incurring large

financial outlays. Because of the tendency towards the shrinkage of rain forests, tributaries of the Orinoco provide less and less water. In such a situation the costs of maintaining the waterway will be increasing.

The problems of navigation of ocean-going ships in the muddy waters on the example of Barra Norte and Boca Grande shallows

It is difficult to find in the available literature, satisfactory and universal mathematical description of the behavior of the ship's hull during navigation on muddy areas. At the same time the complexity of hydrodynamic phenomena that occur between the hull, the propeller and the muddy environment are observed. The problems are compounded by changes in the distribution of mud density for different water bodies. Practitioners should also be aware of the fact that the same density distribution and the same depth of the reservoir do not guarantee the similar manoeuvrability of the ship. The reason for this phenomenon is the difference in the composition of the mud, and thus different properties in different waters. According to the PIANC [4], two conditions for the safe bottom have been defined:

1. The hulls of ships may not be subject to damages even if their immersion depth reaches the full value of nautical depth;
2. Manoeuvrability of the vessel cannot be in such conditions considerably limited.

In view of the set of individual characteristics on several areas safe depth of navigational areas is defined on the basis of long-term hydrographic surveys in close relation with indication of practice [2].

For non muddy areas formulas, graphs and tables are available enabling to describe the behavior of the ship to shallow waters. In this case, the speed achievable, taking into account the maximum speed of gravitational waves for the parameters of the vessel can be described and is capable of being used in practice by the formula:

$$V_{OS} = \sqrt{gh_o}\left(\frac{h_o L}{80BT}\right)^n \qquad (1)$$

where:

$n = 0.125$ for shallow waters;

$n = 0.24\left(L/b\right)^{0.55}$ for the channel;

b – the width of the dredged channel.

The speed of the Polish Steamship Company bulk carrier m/v "Podlasie" (2012) $L = 190$ m, $B = 28.5$ m, $T = 9.5$ m during the transit at high water in the most shallow Barra Norte (the Amazon) does not exceed 6 knots. The attainable speed value calculated from the formula applicable to clean water at shallow waters was about 9 knots. The speed of the same vessel m/v "Podlasie" (2012) during the transition time at high water for most shallow depth of the fairway leading through Boca Grande (the Orinoco) was about 5 knots. The achievable speed rate V_{OS} calculated by the formula applicable for clean water in the canal is about 7 knots. The attainable speed value V_{OS} should be lower because the Boca Grande has in-depth seaway. The difference in the calculated attainable and observed speed in reality for the Amazon and the Orinoco, in both cases can be explained by the influence of significant silting.

Based on research conducted by the Ghent University, Maritime Technology Division and the Flanders Hydraulics Research in Antwerp in 2010, the mathematical model applicable for muddy areas [5] was published. The model was developed for the outer harbor of Zeebrugge. It was built on the basis of data from the years 1997–1998. Attempting to use the model, difficulties may be encountered due to the lack of availablility of data that characterize other than Zeebrugge areas of silting.

In the available English language nautical publications the subject of the impact of sediment on the shipping speed of the pilot areas does not go beyond the fact of the occurrence of the phenomenon of silting. The information on the subject is skimpy. Only in the British Admiralty Sailing Directions there is a brief record of the possibility of slowing down the speed of the vessel up to 50 percent, when entering the Orinoco river.

No approximate data on the subject, with poorly planned high water transit through extensive shallows may result in running the ship aground. In the case of Barra Norte on the Amazon it will only result in a threat to one unit. At Boca Grande vessels follow a one-way narrow channel deepened during high water. Not only may transition delay result in the grounding of the ship going at the beginning of the group. For subsequent ships it can cause a very dangerous situation, it may threaten their grounding.

The increasing influence of silting of navigable waters, together with the increasing size of vessels and the increasing intensity of shipping may result in multiple violations to the considered safe bottom area [4]. In such situations, even without a ship touching the ground, the damage to the structure of the ship's hull may occur. The occurrence of risks can only be manifested by larger than usual speed slow down in muddy areas.

Conclusions

It seems to be necessary to carry out an analysis of the impact of siltation on the safety of ocean-going vessels on inland muddy waters by the relevant departments, research centers and hydrographic offices from the interested countries. Influence of the deposition of mud on the practice of inland shipping is also important, however, touching the bottom of ocean-going vessel, which is acceptable for barges, is in any case a serious danger for the ship and brings in consequence the loss of the ship class. The difficult navigation of the muddy areas should force the hydrographic offices to pay particular attention to the up-date maps and nautical publications. The level of safety of navigation, may also be increased by means of marine traffic engineering methods. An example is described in this paper, a proposal to establish two-way water path leading through the Barra Norte. With the appropriate technical and financial resources, methods carried out on the Mississippi River may be followed by maintaining a high level of care for the shipping waters.

Another type of action should aim to present to the navigators the knowledge of the phenomena occurring in the muddy waters. Mandatory presentation on charts or navigational publications the graph with sediment density as a function of depth seems to be advisable for individual areas. The graph should indicate water density levels on for the designated safe depth of the basin and values of density for which echo sounders receives the echo of the acoustic waves of the bottom. This information, in addition to knowledge concerning single area, would allow captains to work out on the basis of previous experience and reviews for own ship manoeuvring the characteristics of a new, hitherto unknown muddy area. Additional benefit of the publication charts indicating the density as a function of depth is that the ship's crew will be able to anticipate possible problems with the engine cooling regarding the minimum height of water intake from the bottom.

A major challenge for theorists and practitioners is to develop and publish, as soon as possible, the graphs for the individual muddy waters enabling the inference of reducing the speed of the main types of ships as a function of drafts taking into account the different levels of tide. In studies for tropical rivers, seasonal changes in the composition of the mud will have to be taken into consideration. Failure to research the solution to the set of problems may have serious consequences for the economy or environmental disasters in the areas of special importance for the global climate.

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Water absorption of thermoplastic matrix composites with polyamide 6

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Key words: thermoplastic composites, absorption, humidity, polyamide 6

Abstract
This paper describes the process of drying of thermoplastic composites warp knows polyamide 6, an engineering polymer material. The results of absorption measurements of pure and polyamide 6 reinforced with cut glass fiber. Composite for injection molding processing conditioned in conditions similar to those prevailing in industrial warehouses and exposed to direct contact with water. Both, in one and in the second case of modified natural polyamide 6 cut glass fiber polymer material reduces the susceptibility to moisture absorption. Being the most important for the moisture content in the material has the first 10 hours of exposure of granules to various weather conditions.

Introduction

Thermoplastics due to their advantageous properties are widely used in the technique and in the production of consumer products. The requirements for the quality are increasing. Therefore, it is important to know the characteristics of a good plastic material and the possibilities and limitations resulting from them. Associated with thermoplastics absorption phenomenon has both negative and positive meaning. One possible use of this phenomenon are superabsorbent materials that are used in many fields such as medicine [1] and construction [2] and they are now developing rapidly.

The problem of the absorption capacity is also related to a number of problems both in the use of thermoplastics and their processing. In the case of injection molding, which is currently the predominant method of processing thermoplastics, including increasingly used in engineering thermoplastics, there are many ways to reduce or eliminate adverse effects on the absorbency of processing, such as storing and drying the correct inputs. Another way of influencing the size of the phenomenon of absorption materials is to modify the various fillers.

Sorption is a phenomenon of the surface (adsorption) or by volume (absorption) to take the plastic vapors, gases or liquids. The phenomenon of physical adsorption is a surface binding substances and is based on the interaction of short-range intermolecular. Chemical adsorption is to create a chemical bond between the sorbent and sorbate. As a result of adsorption forces in the unimolecular layer adsorption of the adsorbate is formed [3]. Since the physical sorption absorbed particles do not form chemical bonds with the sorbent may be removed in the drying process [3, 4]. With the concept of absorption is necessary to clarify the meaning of terms such as moisture related material, absorption, absorption and hygroscopicity. Absorption, and adsorption are terms often used interchangeably. However, it should be noted that the adsorption may refer to the absorption by the material, both liquids and vapors and gases, whereas absorption refers to the absorption of liquids. Hygroscopicity is the tendency of material to absorb water [4, 5]. However, the material moisture content refers to the percentage of water contained in it.

For this reason, almost the crystalline phase does not absorb moisture, it is assumed that the water absorption is proportional to the contribution of the amorphous structure. This assumption suggests the method of determining participation in the

plastic crystalline phase or post-assessment allows for water absorption in the material partially crystalline. However, to determine these values need to know the boundary conditions, and in particular, absorption material in a completely amorphous and crystalline phase involving the maximum [5]. The absorption materials are also affected by the type and proportion of fillers in the plastic, which can cause an increase (organic fillers such as wood flour, cellulose fibers), or decrease in absorption or may not have a material effect on the absorption of [4, 5].

Impact on the absorption properties of polymeric materials

Group of thermoplastics is the most widely used group of modern materials and thermoplastics are used as construction materials for the machinery and equipment [6].

The phenomenon of absorption of thermoplastic characteristics affect their exploitation. The absorption of liquid by the plastic, mainly water, can cause changes in their mechanical properties such as elasticity, tensile strength, impact strength [7]. The absorption of the substance may also lead to changes in mass and dimensions of the products caused by the swelling, and the stress caused by this can lead to damage to the element or the entire structure. Dimensional stability is particularly important in the implementation and operation of components with narrow tolerances, shape and position. The improvement of the dimensional stability of the hydrophilic materials is affected by adding an extender type, such as glass fiber [4, 8, 9].

Absorption phenomenon is particularly detrimental to the plastic products, which in contact with the substances absorbed is long (pipes, container, tank), due to a transfer of the absorbed liquid to the inside of the element. The wet material is also more permeable to gases. For moist PA6 CO2 permeability is three times greater than for PA6 dried. As a result, changes cannot be stored in the properties of products, such as taste, odor. The presence of moisture in the material structure is also influenced by the deterioration of the thermal insulation and dielectric properties [3].

Methods for determining the absorbency of materials based on measuring the change in weight, and the linear dimensions of the mechanical properties of the sample. Absorbence measurements is applicable to all polymers and porous solid. In the method of determining the boiling water absorption is not applicable materials, which at 100°C are seen to change shape. For measuring the absorption liquid is used, such as distilled water and oil.

The absorption and the presence of moisture in the polymer structure is one of the factors causing aging of the material. In industrial environments, the air contained in the aggressive factors as oxides of sulfur, carbon and nitrogen oxides formed in conjunction with moisture, strong organic acids. Long-term effects of water and aqueous solutions of acid and alkaline hydrolysis work. As a result of the aging process is changed appearance material (by sandblasting, exfoliation of the surface) and mechanical properties, thermal, optical, electrical, physical and chemical [8, 10].

Water absorption is significant also a factor in the use of the polyamide-du. The presence of moisture has a major influence on the properties of the material. Dried polyamide is fragile and low impact, and has high tensile strength and flexural strength. Increasing moisture content increases the impact resistance and flexibility, and loss of strength (Fig. 7), in that the modulus of elasticity. Therefore, the results of strength tests of administration is important to provide information about the moisture content of the polyamide structure [8].

Effect of absorption on polymer processing

Plastic water absorption is an important aspect in the process of thermoplastic processing, in particular in an injection molding process. In injection molding, extrusion, and other materials are used in the form of pellets, regrind or scrap recycled. Polymeric materials absorb in these forms are more or less moisture [11]. Hydrophobic materials such as PS, PE, PP, PVC water absorb minimally and appearing in the process of injecting water comes mainly from moisture condensing on the surface of the granules [12]. Partially crystalline plastics, such as technical POM, PA, PET, PBT have properties superior to amorphous materials [12], however, due to hygrophilic properties may take up water to the inside of the structure [11].

During the processing of plastic materials humidity level may not exceed the limit values. If the injection molding process is used wet granulation, the plasticization stage, the reaction occurs in water. Hydrolysis leads to structural changes in the material (degradation) and the result of the deterioration of the mechanical properties, particularly toughness and resistance [12].

The presence of excessive moisture will reduce the viscosity of the plastic, which is the cause of many processing problems [13]. Moisture in the material also affects the appearance of the part.

Such defects can easily be seen because of their extensive nature. [14] They come in a clear, oblong, dull streaks on the surface of the molding, KOTRA is always oriented in the direction of flow of plasticized material. The cause of the formation is the presence of phase plasticizing or injection of water vapor bubbles, which are apart at the surface of the molding and formed into elongated ribbons for fast material. Other visual defects are wrinkle the surface corrugation [13]. Visual defects moldings, due to the high demands on the surface of the finished products, disqualify them further use [11].

The use of moist granules by PMMA injection causes the matured parts with poor surface quality and the POM injection also leads to a raid in shape. In the case of PET and PBT materials can lead to shorter-chain molecules present in the hydrolytic decomposition. This results in a significant deterioration in the mechanical properties of the material. For example, when the moisture content in PBT at 0.1% (0.04% limit) the tensile strength is reduced by 12% compared to the optimal, but the impact strength decreases by 25%. The deterioration of the mechanical properties of the granules as a result of moisture is also strong in the case of PA or TPE (thermoplastic elastomers) and less in the case of other plastics [14, 15]. Effect of moisture on the processing conditions and properties to work outsec is presented in table 1.

A special case for the processing of plastic materials are phenolic compounds. The presence of water in the material during processing, particularly during the injection, improves the flowability of the material and facilitates the process of processing. At the same time the evaporation of water during the drying molding makes it a significant contraction. Therefore, the amount of water must be adjusted to allow easy processing and phenolic plastics for molding to obtain a satisfactory properties [16].

In order to achieve the process of injecting high-quality finished products should be used-core preventive measures or carry out the drying process of wet granulation. Preventive measures must be adequate storage materials:

– use of bags with a special layer of aluminum to limit the penetration of moisture to the inside;
– start to sealing the packaging;
– storage regrind, ingots and scrap in closed containers;
– use of closed hoppers.

Preventive measures can significantly reduce moisture content material, but due to the highly hygroscopic properties of some materials is often necessary to carry out the drying process [11].

Experiment

The study used three polymeric materials of nylon 6 in the form of a granulation. Polyamide produced by Polimarky SA was used in three typestries:

1) VIRGIN-PA6 polyamide 6 with no additives as fillers. Manufactured in a translucent pellet. Granulate properties consistent or similar to the reported in the literature.
2) RESTRAMID PA6 20GF – polyamide 6 with a filler in the form of a glass fiber in an amount of 20%. Partially crystalline material in granular form.
3) RESTRAMID PA6 35GF – polyamide 6 with a filler in the form of a glass fiber in an amount of 35%. Produced in granular form. Partially crystalline material.

Preparation of the samples. On a laboratory scale weighed about 20 gram portions of the pellets for each type of granules and the length of time of exposure to moisture. Weighed, placed in a container, one part was quenched with distilled water at 20°C, so that the whole granules was immersed in water. The remaining samples were left in a high relative humidity about 70–80% and a temperature of about 5°C. These conditions largely correspond

Table 1. Effect of humidity on the material processing conditions and properties of the molded [11, 12]

Material	Injection process	Presence of plastic moulding	Mechanical characteristics
PA	The presence of bubbles in the stream of injected plastic or plastic moulding	– The presence of streaks in the direction of material flow – Increased bead	Deterioration of impact strength and mechanical strength
POM	– The presence of bubbles in the stream of plastic moulded – A raid on a form	The possibility of streaks on the finished item	No effect
PET PBT	No effect	No effect	Significant deterioration in impact strength and durability
TEEE	No effect	Increased bead	Deterioration of impact strength and mechanical strength

to existing conditions at industrial buildings (excluding the summer period, in which the air temperature is usually higher), on which the pellets are stored and subjected processed. All of the sample containers placed in the pellet was exposed to water, both air and in direct contact, for a specified time: 0.5 h, 1 h, 2 h, 4 h, 10 h, 24 h, 48 h, 168 h.

After a fixed time of exposure, the samples were thoroughly dried pellets of filter paper in such a way that the granule remains dry to the touch. This procedure allowed the reduction of the measurement error in the case of granules kept in water. In this way, the drying was measured only the content of water absorbed by the material.

Measurement of moisture content. Humidity measurement performed on wagosu granule blender WPS-50SX. The measurement was performed at 120°C. The drying time was variable dependent on the amount of water in the material. The measurement is continued to determine the mass of material constant. At the end of the drying process the information recorded with a mass of wet granulation and drying, the percentage of moisture content and drying time, which was used to determine the rate of moisture by putting pellets. Donating speed-ing moisture quotient amount of water evaporated during drying to its length, is a measure of the efficiency of drying.

Results

Polyamide granules undergo immersed in distilled water at 20°C the amount of water absorbed vary according to their kinds. The output was the amount of moisture they contain material upon receipt from the manufacturer.

The greatest amount of water absorbed pure polyamide 6th after 7 days of immersion in water, the moisture content in the granules was 4.8%, about half of the theoretical values of the plastic water saturation of approximately 9–10% [8]. The presence of the filler significantly reduced absorption granules. The moisture content of the granules PA6 20GF after 7 days immersion was less than half than in pure PA6 (2.29%) and granules PA6 35GF more than three times less (1.49%), which is presented in figure 1.

The samples conditioned at a temperature of 5°C, 70–80% relative humidity at the start of the test contained the same initial moisture content of the sample as to be immersed in water. Polyamide granules exposed to moisture in the air atmospheric moisture absorbed different. Measurements have shown (Fig. 2) that in the pure PA6 after 7 days of exposure to moisture, water was 2.83%. Due to the addition of glass fiber moisture content of the granules PA6 and PA6 35GF 20GF was relatively smaller (PA6 20GF – 25% less, and PA6 35GF – 60% less moisture than pure PA6).

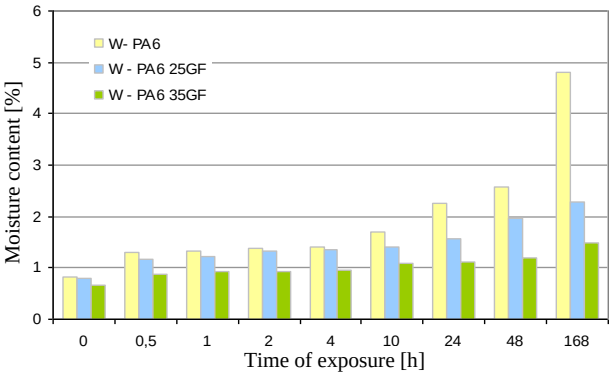

Fig. 1. The moisture content of granule of pure PA6 and PA6 with glass fiber according to the time of exposure to the time length of waters immersion

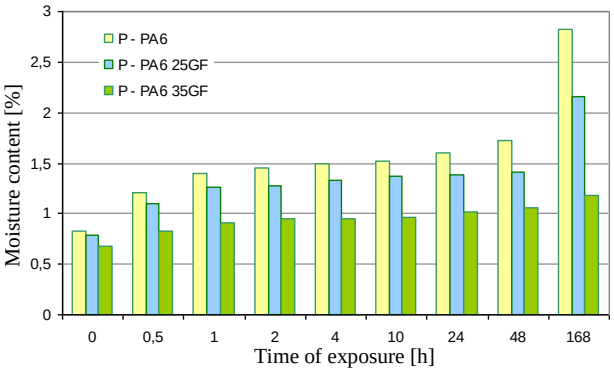

Fig. 2. The moisture content of granule of pure PA6 and PA6 with glass fiber according to the time of exposure to the atmospheric air

For each type of granules, both immersed in the water and exposed to the atmosphere rapid increase of water content in the material in the first hour followed absorption which is shown in figure 3 (in order to distinguish the samples soaked in water, the following curves are marked with W, while the air in the air means P). For example, after 1 hour, the moisture content of pure PA6 soaked in water was 1.32%, which is 58.5% moisture absorption after 24 h and 27.5% moisture content, after one week immersion in water. The granulate moisture content of PA6 35GF after 1 h of absorption was 0.93%, and therefore the moisture content of 62.5% after one week of absorption.

Smaller differences occurred when the moisture absorbent granules from the air. The moisture content in the PA6 after 1 hour was 1.4%, which was 49.5% of the quantity of water in the material after a week. The water content in the pellets PA6 35GF after 1 hour was 0.9%, and so much as 76% percent of water content absorbed after 7 days.

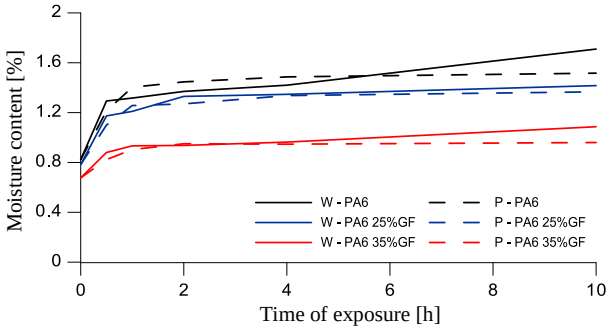

Fig. 3. The amount of moisture absorbed by the granules in the 10 hours test

In figures 3 and 4 depicting the process of water absorption by the granules are visible at some deviations from the trend of increasing the amount of moisture in the granules. This is particularly evident for the first 2 h period of the study (Fig. 3) and for PA6 due to absorption in the 24 h as a result of absorption for PA6 20GF after 48 h (Fig. 4). This may be due to heterogeneity of respondents granules.

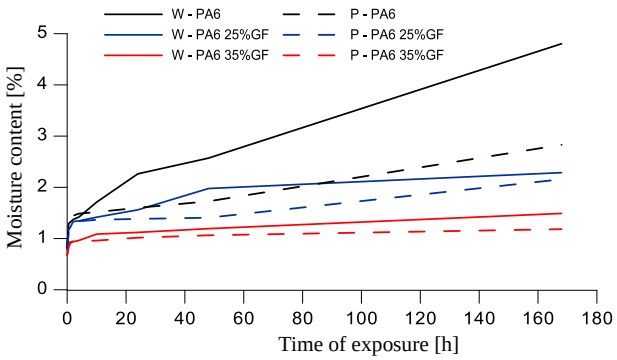

Fig. 4. The amount of moisture absorbed by the granules in the 7 days test

From the graphs shown in figure 3, both as figure 4 shows that adding 35% fiberglass significantly reduced absorption particularly in relation to pure polyamide and the process of absorption during the first 10 h runs almost linearly. The addition of PA6 20% glass fiber reduced the absorption to a lesser extent. Cost increase the moisture content of granules PA6 20GF placed in water and air, and soaked in water PA6 are close to each other. Line increase the moisture content in the pellets PA6 moczonym in water is the most reward-womb of the others and has the strongest upward trend.

From the graph shown in figure 4 can be seen that the increase in moisture content is higher in the long term test. The exception is the line on the chart corresponding to the PA6 25GF W, which indicates progress to stabilize the moisture content of the granules.

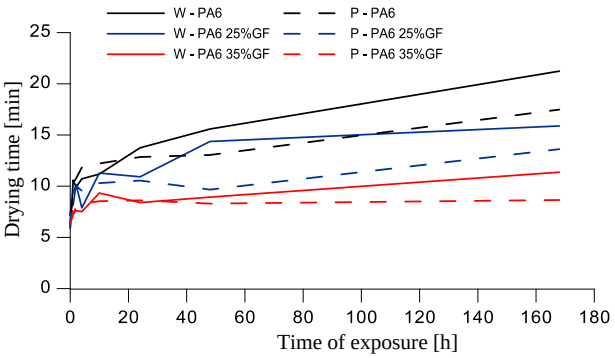

Fig. 5. Average drying time of granule depending on the exposure time

Minor differences between the water content in the pellets after 1 h and 7 days, in the granules between absorbing moisture in the air due to the lower concentration of moisture in the environment. After a certain period, and the absorption of water reaches a certain level of moisture absorption by the pellets approaches the equilibrium state. In the case of granules lats soaked in water the concentration of the absorbed (water) in the environment is much higher and thus the faster moisture absorption. Clearly visible is the comparative charts absorption granules immersed in water interne out in air (Fig. 5 and 6). In the first 4 h difference between

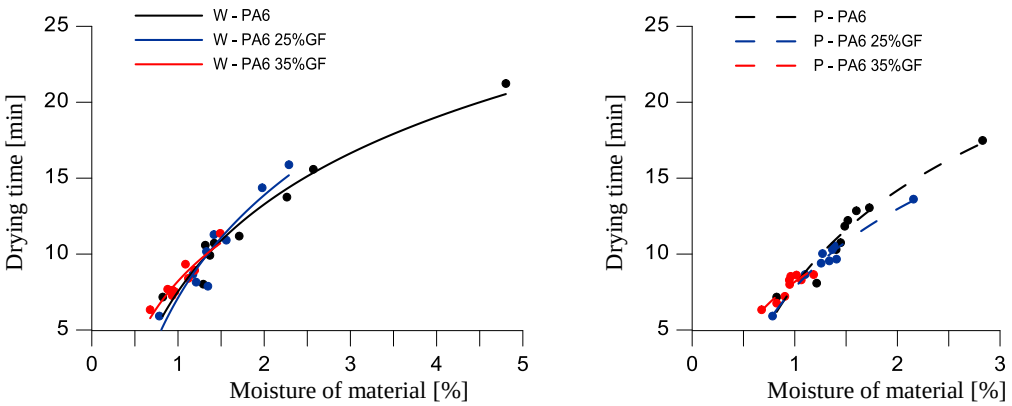

Fig. 6. Average drying time of granule depending on the amount of moisture content, a) exposure to water, b) exposure to air

the rate of uptake-nanny are insignificant. However, at longer times the difference is noticeable, and shows that the sample immersed in water faster moisture absorption.

Time of drying moist granules increases with increasing moisture content of the granules. For example, the average drying time for moist granulation samples weighing 5 g of PA6 and the average moisture content of 0.82% was 7 minutes 17 seconds, while the average drying time for moist granules PA6 samples weighing 5 g and an average moisture content of 4.8% was 21 minutes 23 seconds. Average granule drying times are shown in figures 5 and 6.

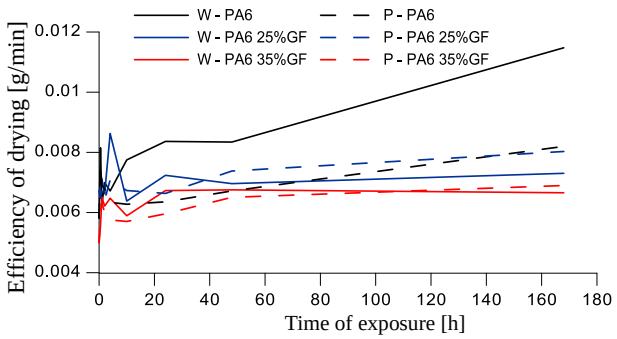

Fig. 7. Average efficiency of drying the granulate according to the exposure time

The rate of moisture it (Figs 7 and 8) of the granules in the drying process was relatively constant at an average of 0.006–0.008 g/min, which gave from 0.11 to 0.16 percent of moisture per minute. Only in the case of PA6 granules immersed in water for 7 days (4.8% moisture content) the rate of moisture it was significantly higher-strength and amounted 0.011 g/min (about 0.23 percent moisture per minute). Result of the drying rate of the granulate containing 4.8% indicates the impact on the speed of this phenomenon is the difference in concentration of the agent, in this case water, between the environment and the material.

From these data also show that the presence of an additive in the form of glass fiber has a negligible effect on the speed of the granulate moisture donation. Rendering the speed of moisture in the pellets according to the type of the granules was conditioned: PA6 – 0.007 g/min, PA6 20GF – 0.007 g/min, PA6 35GF – 0.006 g/min. For pellets soaked in water: PA6 – 0.008 g/min, PA6 20GF – 0.007 g/min, PA6 35GF – 0.006 g/min.

Conclusions

Moisture granules for processing, it will need to dry, which increases the production process and increases the cost of production and causes heat aging plastic. Reducing the moisture content of granules during processing can be achieved by appropriate measures, such as sealing the packaging and containers for granulation, drying in a drying apparatus and the introduction of the injection molding process in the drying hopper.

The research described in the above refer absorbent granules work polyamide 6 in most industrial environments granules absorb moisture from the air, in extreme cases, such as flooding absorb moisture through contact of liquid. The study focused on the absorption of moisture from the air at 5°C and 70–80% relative humidity largely correspond to the conditions prevailing for industrial buildings. However, the results of tests made on samples immersed in water allowed to obtain a comparative scale phenomena in a variety of environments. Based on the results it can be seen that the phenomenon of absorption materials can be significantly reduced by the modification. One way is to add the modified filler in the form of glass fibers. Modification of glass fiber reduces absorption of granules, even several times. During the study period, addition of 20% glass fiber resulted in approximately 2-fold, and 35% of the approximately 3-fold decrease in absorption for pellets soaked in water. The addition

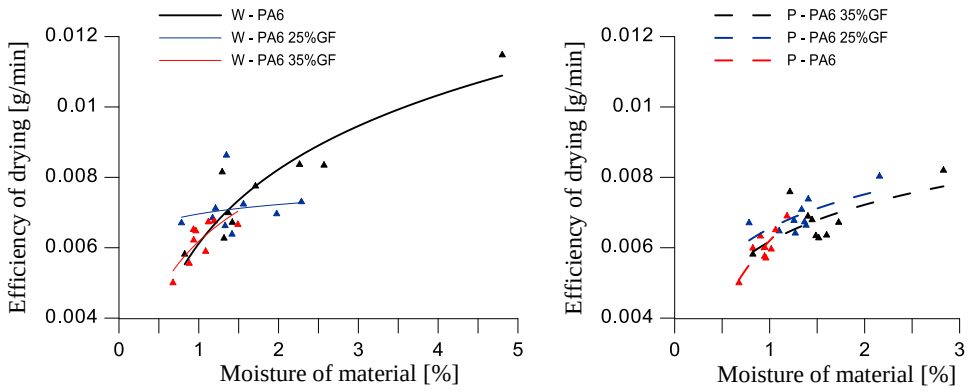

Fig. 8. The average efficiency of drying the granulate material according to the moisture content, a) exposure to water, b) exposure to air

of air conditioning raw fibers caused a 20% decrease in absorption of about 1/4 and the addition of 35% fiber by 1/2. Decrease in absorption is due to negligible water absorption of glass fibers, which filling material, reduce the volume of the moisture-receptive.

The moisture absorption is the fastest in the dry granules. This is due to the desire to achieve a balance between the amount of moisture in the material and its environment. Similarly dries quickly in the case of granules, in which the concentration of moisture absorbed is much higher compared to the concentration of moisture in the environment. The drying process is a wet sample, the longer the greater the moisture content of the granules. For pellets containing 4.8% was 21 minutes 23 seconds. In industrial environments, where the drying is subjected to a large number of granules, large moisture will result in time-consuming drying process.

Absorption air polyamide granules depends on the environmental conditions (temperature and humidity). Also reaches a value lower than the water absorption, especially with a long exposure time, because of the limit to the steady-state moisture in the material and the environment. The use of modified processing raw fiber glass allows you to limit the negative impact of the water. This allows to shorten the drying process due to the lower absorption, and thus saving energy. In addition, the properties of articles made of plastic-modified, although also are reduced when exposed to moisture, they still have better mechanical properties than the unmodified material.

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The impact of the change of river channel geometry on the size and range of backwater from the receiving body

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Key words: backwater, backwater range, river water level rise, depth

Abstract

This study is an analysis of the possibility of harnessing backwater in open river channels to create waterways in the area of the river mouth. To accomplish this, simplified methods of analysing non-uniform flow have been assessed, with the use of Rühlmann's, Tolkmitt's and Bresse's equations. It was demonstrated that Bresse's method is the best of the three – the results obtained by using it to determine the range of backwater from the receiving body are much closer to true values than for the other two, and it is the only method that meets the physical criterion of backwater size with the boundary condition of Chezy depth tending to 0.

The carried out analyses demonstrated that it is possible to create high-class waterways in lower reaches of rivers by modifying the geometry of their channels, namely the depth and slope of their bottom.

Introduction

The effect of backwater from the receiving body occurs in lower reaches of rivers that flow into large receiving bodies. The size and range of backwater vary depending on the position of water in the receiving body.

This backwater effect occurs in the area of the estuary of the Oder and in the rivers that flow into Bay of Szczecin and Lake Dąbie. Backwater in lower reaches of rivers can be harnessed i.e. for the purposes of navigation: a high-class waterway can be created by dredging (instead of damming up). The determination of the size and range of backwater in the lower reaches of rivers by approximation is difficult in such conditions because of the selected method, as well as due to the definition of the values of key parameters such as the water level rise at the mouth cross-section, as well as filling "h" for uniform flow. Variable bottom slope is also often the case.

The subsequent section of the paper analyses three different methods of calculating backwater range (Rühlmann's, Tolkmitt's and Bresse's) and assesses their usefulness. It also includes a number of analyses on the example of a 0.00–12.00 km section of the selected river, taking into account certain parameters (hydrographic, hydrological and hydraulic) approximate to this section.

Assumptions simplifications and input data

Modifications of the geometry of a natural watercourse flowing into the receiving body, which causes backwater at the tributary, can be basically divided into three categories:

1) modification of the width of the watercourse (tributary);
2) modification of the depth (dredging – lowering the bottom);
3) modification of the slope.

Additionally, two or all three of these categories can be used simultaneously (mixed case).

The categories of modifications listed in points 1, 2 and 3 were considered in terms of the possibility of creating an international class waterway for a theorised case. This allowed to answer the question whether it is possible to obtain the desired geometric parameters of a high-class waterway in the lower ("mouth") reaches of a river by changing the geometrical parameters of the river channel.

The following assumptions and simplifications were used to analyse the calculations of backwater range:

a) The river flows into a large receiving body whose influence in the lower reaches of a river causes non-uniform flow (backwater).
b) The river has the channel of a constant width B (calculated for the assumed set of calculation parameters) and there is a constant flow Q and of constant slope I. Therefore, there is a uniform flow above the zone of influence of the receiving body.
   Given the conditions a) and b) it can be concluded and further assumed that for the mouth cross-section $Z + h = \text{const}$ (as long as the bottom is not lowered).
c) Modifying the width of the channel, slope of the bottom, position of the bottom and flow rates may influence the backwater range from the receiving body.
d) The influence of such modifications of channel geometry was analysed for the following data:
   – flows: $Q_1 = 10$ m^3/s and $Q_2 = 20$ m^3/s;
   – bottom slope: $I_1 = 0.0002$ and $I_2 = 0.0003$;
   – channel width: $B_1 = 5$ m, $B_2 = 10$ m, …, $B_{20} = 100$ m;
   – $Z + h = \text{const}$: $\text{const}_1 = 2.0$ m, $\text{const}_2 = 3.0$ m, $\text{const}_3 = 4.0$ m.
e) The assumed channel roughness coefficient was $n = 0.03$.
f) The analysis was based on the following simplified equations for non-uniform flow: Rühlmann's, Tolkmitt's and Bresse's. The reason was that these three equations are used if the detailed geometry of the watercourse is not available.

Mathematical model of the effect

Two sections were considered: I and II located in a very small distance of ds from each other [1].

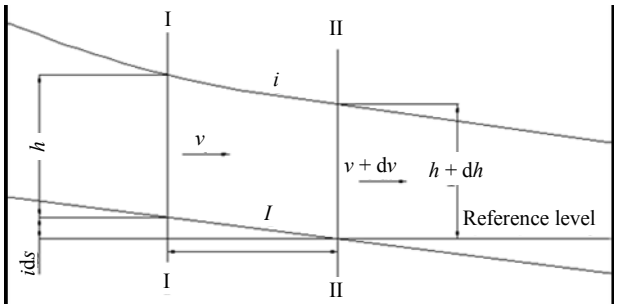

Fig. 1. Graphical calculation scheme for non-uniform flow

Bernoulli's equation for the two analysed cross-sections can be expressed as follows:

$$h + i\,\mathrm{d}s + \frac{\alpha v^2}{2g} = h + \mathrm{d}h + \frac{\alpha(v+\mathrm{d}v)^2}{2g} + \Sigma h_{str} \quad (1)$$

If it is assumed that: pressure $p = \text{const}$ and $\alpha = \text{const}$, and $v = Q / A$ and $Q = \text{const}$, $\mathrm{d}v = -(Q / A^2)\mathrm{d}A$, $da = BDH$ (B – the width of the table of liquid for the analysed cross-section).

This can be transformed into:

$$\frac{\mathrm{d}h}{\mathrm{d}s} = \frac{1 - \dfrac{Q^2}{c^2 R_h A^2}}{1 - \dfrac{\alpha Q^2 B}{gA^3}} \quad (2)$$

or

$$\frac{\mathrm{d}h}{\mathrm{d}s} = i \cdot \frac{1 - \dfrac{Q^2}{i \cdot c^2 R_h A^2}}{1 - \dfrac{\alpha Q^2 B}{gA^3}} \quad (3)$$

Equation (2) and (3) are the general equations of steady non-uniform flow in open channels.

For the special case of uniform flow where $I = i$, and $\mathrm{d}h/\mathrm{d}s = 0$ we obtain:

$$1 - \frac{Q^2}{Ic^2 R_h A^2} = 0 \quad (4)$$

It can be transformed to obtain Chezy equation for uniform flow:

$$Q = Ac\sqrt{IR_h} \quad (5)$$

The following assumptions and simplification are used to analyse the course of the table of liquid for non-uniform flow in a simple channel with constant cross-section, where the table of the liquid is parallel to the bottom and the slope of the bottom is in the direction of the flow.

The case where $i > 0$ was considered.

The following designations were added:

$$K_0 = A_0 c_0 \sqrt{R_{h0}} \quad (6)$$

that allowed to obtain the following relation:

$$Q^2 = K_0^2 i \quad \text{or} \quad K_0^2 = \frac{Q^2}{i} \quad (7)$$

The value of K_0 does not depend on the slope but only on the shape and the filling of the cross-section. Thus, the following designation was used by analogy:

$$K = Ac\sqrt{R_h} \qquad \frac{K}{K_0} = \kappa \quad \text{and} \quad \frac{h}{H} = \eta$$

where:

H – normal depth,

K_0 – flow rate corresponding to the depth.

Therefore:

$$\frac{\mathrm{d}h}{\mathrm{d}s} = i \cdot \frac{1 - \dfrac{Q^2}{ic^2 A^2 R_h}}{1 - \dfrac{\alpha Q^2 B}{gA^3}} = i \cdot \frac{1 - \dfrac{K_0^2}{K^2}}{1 - j \cdot \dfrac{K_0^2}{K^2}} \quad (8)$$

When the following formula is introduced:

$$\left(\frac{K_1}{K_2}\right)^2 = \left(\frac{h_1}{h_2}\right)^x \tag{9}$$

where:

h_1 and h_2 – filling of the cross-section corresponding to coefficients K_1 and K_2,

x – a fixed power coefficient.

Taking into account the relation:

$$\kappa^2 = \eta^2,$$

the following can be derived:

$$\frac{\mathrm{d}h}{\mathrm{d}s} = i\,\frac{\eta^x - 1}{\eta^x - j} \tag{10}$$

and

$$j = \frac{i\,\alpha\,c^2}{g} \tag{11}$$

$$\mathrm{d}h = H\,\mathrm{d}\eta.$$

The final equation is obtained as [2]:

$$\frac{i\,\mathrm{d}s}{H} = \frac{\eta^x - j}{\eta^x - j}\mathrm{d}\eta = \frac{\eta^x - 1 + 1 - j}{\eta^x - 1}\mathrm{d}\eta = \\ = \mathrm{d}\eta + (1-j)\frac{\mathrm{d}\eta}{\eta^x - 1} \tag{12}$$

If const is:

$$\frac{i}{H}(s_2 - s_1) = \eta_2 - \eta_1 + (1-j)\int_{\eta_1}^{\eta_2}\frac{\mathrm{d}\eta}{\eta^x - 1} \tag{13}$$

and where:

$$l = s_2 - s_1 \quad \text{and} \quad -\int\frac{\mathrm{d}\eta}{\eta^x - 1} = \varphi(\eta),$$

the following is derived:

$$\frac{il}{H} = \eta_2 - \eta_1 - (1-j)\left[\varphi(\eta_2) - \varphi(\eta_1)\right] \tag{14}$$

or

$$\frac{il}{H} = \eta_2 - \eta_1 - \left[\varphi(\eta_2) - \varphi(\eta_1)\right] = \\ = \varphi_1(\eta_2) - \varphi_1(\eta_1) \tag{15}$$

where:

$$\varphi_1(\eta) = \eta - \varphi(\eta) \tag{16}$$

If j is omitted, that is, if it is assumed that $j = 0$, the formula (16) can be used. The value of $j = 0$ only slightly differs from $j \neq 0$ for the equations, therefore it can be omitted in the calculations.

To analyse the impact of modifications of the geometry of the river channel on the size and range of backwater, the following calculation scheme was adopted (Fig. 2) [3]:

– the river flows into the receiving body causing backwater at the tributary;
– the level of the receiving body water for the calculation scheme is constant;
– the cross-section of the channel is rectangular;
– the slope of the bottom of the channel is constant.

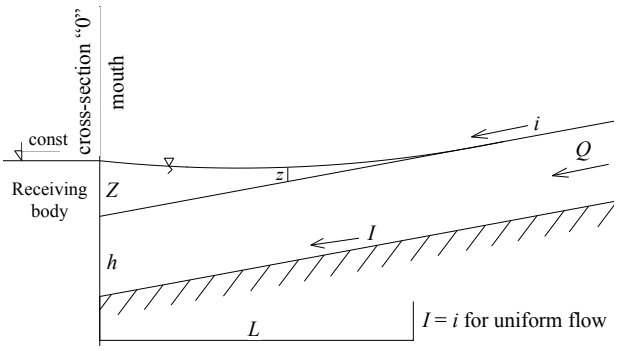

Fig. 2. Calculation scheme

The adopted constant level of the water table in the receiving body means that the value of $Z + h =$ const, for various values of channel width B, flow rate Q and bottom slope "I" gives different values of Z but their sum is always constant. Changing const value equals to lowering the bottom (dredging). Approximated equations were used to calculate the range of backwater:

a) Rühlmann's [4]:

$$\frac{i \cdot L}{h} = f\left(\frac{Z}{h}\right) - f\left(\frac{z}{h}\right) \tag{17}$$

if: $z = 0$ and $f\left(\frac{z}{h}\right) = 0 \Rightarrow$

$$L = \frac{h}{I} \cdot f\left(\frac{Z}{h}\right) \rightarrow \text{backwater range} \tag{18}$$

b) Tolkmitt's [4]:

$$\frac{i \cdot L}{h} = f\left(\frac{Z+h}{h}\right) - f\left(\frac{z+h}{h}\right) \tag{19}$$

if: $z = 0$ and $f\left(\frac{z+h}{h}\right) = 0 \Rightarrow$

$$L = \frac{h}{I} \cdot f\left(\frac{Z+h}{h}\right) \tag{20}$$

c) Bresse's [4, 5]:

$$L = \frac{1}{I}\left[Z + \left(h - \frac{v^2}{2g}\right)\phi\left(\frac{h+Z}{h}\right)\right] \tag{21}$$

where:

v – velocity acc. to Chezy [m/s] [6],

$$v = \frac{Q}{A} = \frac{Q}{Bh} \tag{22}$$

Therefore:

With $h \to 0$, $\phi\left(\frac{h+Z}{h}\right) \to 0$,

$$v \to 0, \left(h - \frac{v^2}{2g}\right) \to 0, \text{ thus } L = \frac{Z}{I} \qquad (23)$$

The following calculation scheme was adopted for cases a), b) and c):

h – acc. to Chezy [m],

$$v = \frac{Q}{A} = \frac{1}{n} h^{\frac{1}{6}} \sqrt{Ih} = \frac{1}{n} h^{\frac{2}{3}} I^{\frac{1}{2}} = \frac{Q}{Bh} \qquad (24)$$

therefore:

$$h = \left(\frac{Qn}{I^{\frac{1}{2}} B}\right)^{\frac{3}{5}} \qquad (25)$$

Although Rühlmann's and Tolkmitt's equations apply only to rectangular and parabolic channels, they can be successfully used for natural channels with cross-sections similar to a rectangle or a parabola.

According to various authors, if the cross-section of the channel is more or less regular for the analysed area, the obtained results are sufficiently accurate for practical calculations. Thus, Rühlmann's equation applies to channels with steep banks, whereas Tolkmitt's equation to channels with flat banks.

Example calculations

The following parameters were assumed for further calculations:

$Q_1 = 10$ m^3/s and $Q_2 = 20$ m^3/s;
$I_1 = 0.0002$ and $I_2 = 0.0003$;
$Z + h = \text{const}$, thus: $Z = \text{const} - h$.

The calculations were performed for different values of $Z + h = \text{const}$;

$\text{const}_1 = Z + h = 2.0$ m,
$\text{const}_2 = Z + h = 3.0$ m,
$\text{const}_3 = Z + h = 4.0$ m.

First, the changes in the channel depth versus the changes in the width (i.e. widening the channel) were calculated. Figure 3 presents the calculated results showing that for an increase of B there is a corresponding decrease of h and increase of Z (with $Z + h = \text{const}$).

Figures 3a and 3b present the relation between the change of the depth of the river channel and its width for various slopes of the bottom and the various flow rates Q in a rectangular channel.

It can be observed that, naturally, with the increase of the channel depth, its width decreases. Nonetheless, it should be emphasized that above certain width values (for the assumptions made in this paper – above 60–80 m) depth changes are minimal.

The subsequent part is a calculation of backwater with the use of the different specified above methods.

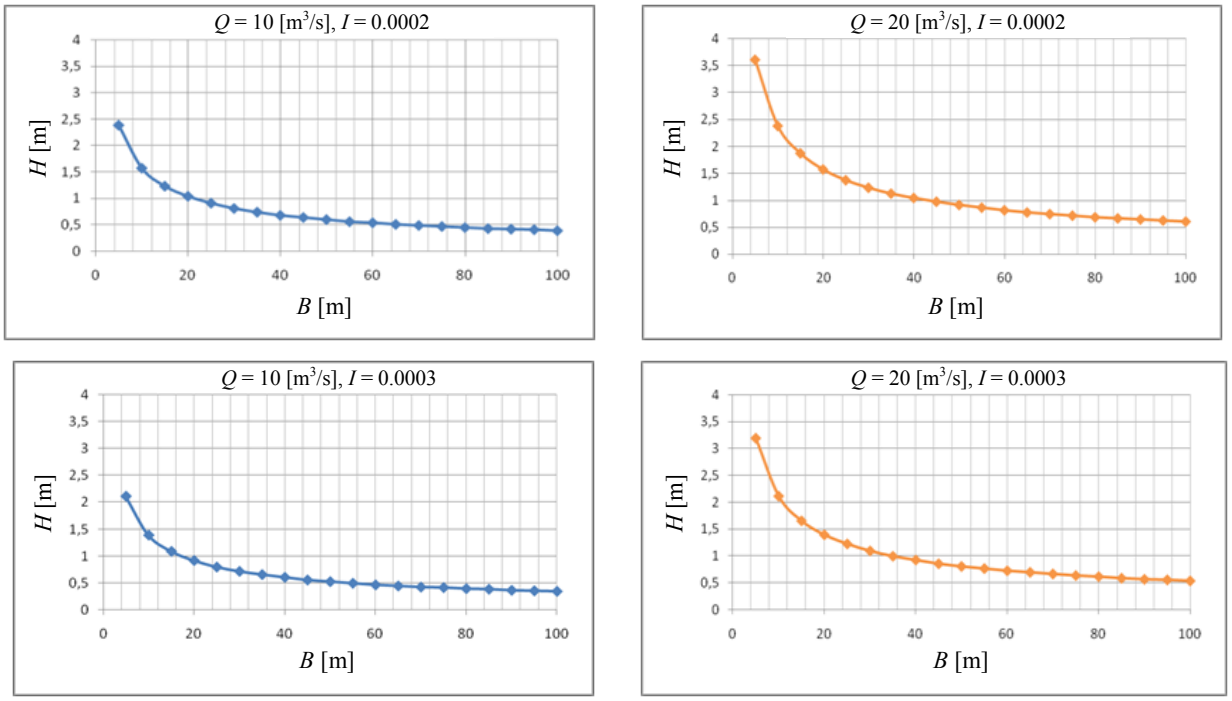

Fig. 3. Changes of filling H for different widths B acc. to Chezy-Manning

The results are shown as graphs in figures 4–9 [3].

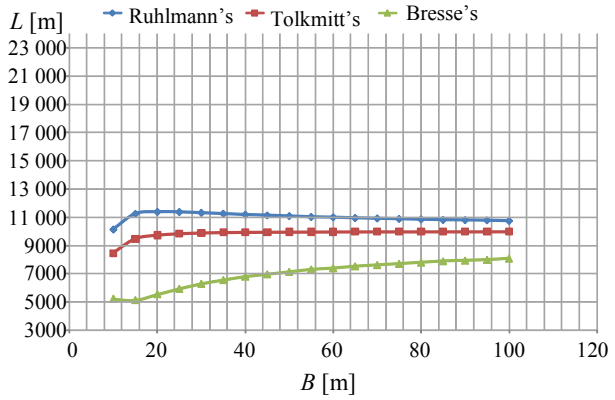

Fig. 4. Backwater range acc. to Rühlmann, Tolkmitt and Bresse – $Z + h = 2$ m, $Q = 10$ m^3/s, $I = 0.0002$

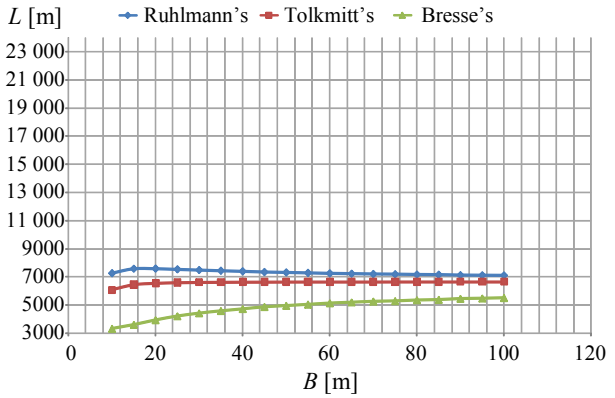

Fig. 5. Backwater range acc. to Ruhlmann, Tolkmitt and Bresse – $Z + h = 2$ m, $Q = 10$ m^3/s, $I = 0.0003$

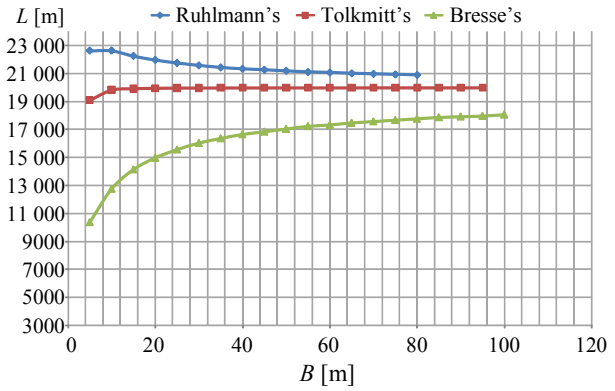

Fig. 6. Backwater range acc. to Rühlmann, Tolkmitt and Bresse – $Z + h = 4$ m, $Q = 10$ m^3/s, $I = 0.0002$

The results clearly show that changing the geometry of the watercourse in its the lower reaches ("mouth" section) has a significant impact on the size and range of the backwater, and prove that deepening and widening the channel may allow to achieve the desired characteristics of the waterway for a certain section of the watercourse.

An analysis of the results allows to draw the conclusion that different calculation methods yield

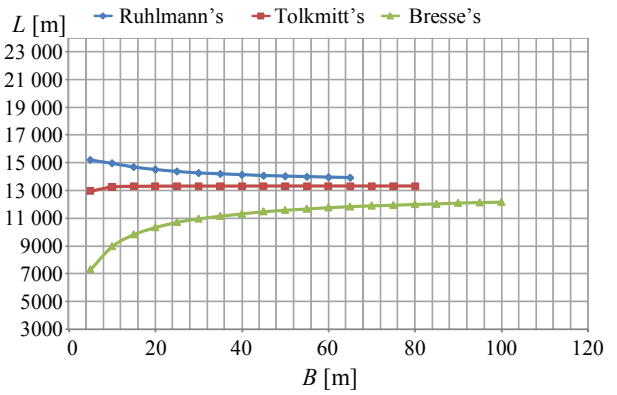

Fig. 7. Backwater range acc. to Ruhlmann, Tolkmitt and Bresse – $Z + h = 4$ m, $Q = 10$ m^3/s, $I = 0.0003$

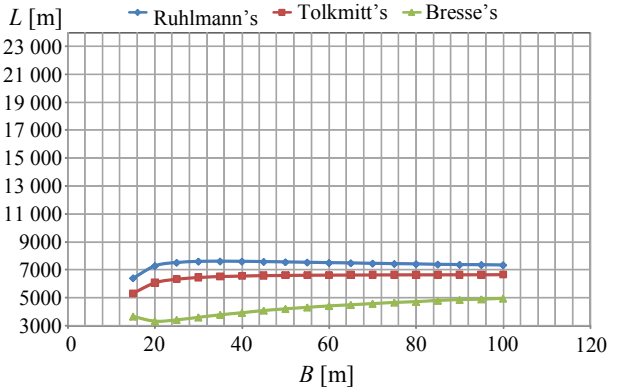

Fig. 8. Backwater range acc. to Ruhlmann, Tolkmitt and Bresse – $Z + h = 2$ m, $Q = 20$ m^3/s, $I = 0.0003$

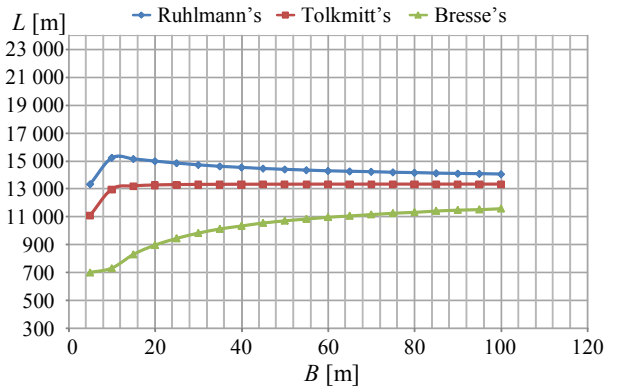

Fig. 9. Backwater range acc. to Ruhlmann, Tolkmitt and Bresse – $Z + h = 4$ m, $Q = 20$ m^3/s, $I = 0.0003$

highly different values of backwater range – the greatest ranges were obtained by using Rühlmann's method, whereas the results for Bresse's method were the lowest. This begs the question – what method to use in the absence of detailed geometric data?

To answer this question it was analysed whether the following criteria were met for all cases:

- supercritical flow (Froude number $F_r < 1$) [6],
- turbulent flow (Reynolds number $R_e > 6000$) [7].

The values of Froude number (F_r) were determined for different widths and a flow rate $Q = 10$

m^3/s and $I = 0.0002$. F_r value varied from 0.25 to 0.01.

This allows to draw the conclusion that the criteria for supercritical flow are met. Additionally, Reynolds numbers were calculated, assuming that the temperature of water $t = 10°C$, and thus by assuming a kinematic viscosity coefficient $\vartheta = 1.31 \cdot 10^{-6}$.

In all cases, even at a depth of 0.02 m, the obtained values of $R_e > 6000$. Thus, the criteria for turbulent flow are also met.

Interesting results were obtained when calculating the backwater range for a flow rate $Q = 10$ m^3/s and $I = 0.0002$ and if extreme conditions were assumed – width of 5000 m and depth h tending to "0". The calculated backwater range is then:

- acc. to Rühlmann $L = 95{,}414$ km
- acc. to Tolkmitt $L = 76{,}598$ km
- acc. to Bresse $L = 9{,}800$ m = 9.8 km

This makes it clear that the results obtained using Rühlmann's and Tolkmitt's methods are completely unrealistic.

There exist a very simple method of determining the maximum range of backwater for extreme conditions. Assuming that the depth of the channel tends to zero ($H \to 0$), the backwater range will be equal to the length of the section where the water table of the receiving body (horizontal) "penetrates" the bottom.

That is:

$$\text{with} \qquad H \to 0,\ L_{\max} = \frac{Z}{I} \tag{26}$$

which is shown as a graph in figure 11.

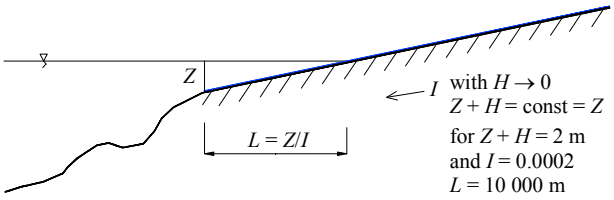

Fig. 11. Boundary conditions diagram for $H \to 0$

With the conditions thus defined, it is possible to verify whether the equations (methods) satisfy this condition. It is easy to demonstrate that only Bresse's equation (method) satisfies this boundary condition.

Therefore, it was decided that Rühlmann's and Tolkmitt's methods should not be used due to the following:

- irregular course of the water level rise curve, for which there is no physical explanation;
- too great value for backwater ranges, for which there is no practical explanation;
- obtaining completely unrealistic results for extreme conditions (which affects the quality of the equation);
- failure to meet the boundary condition for $H \to 0$.

Conclusions

The theoretical analysis presented in this paper demonstrates that by changing the geometry of a watercourse at its mouth it is possible to achieve the desired waterway parameters by harassing the backwater effect caused by the receiving body.

The results of the calculations clearly show that the size and range of backwater increase with the increase of channel width and lowering of the bottom – the increase of $Z + H$. On the other hand, greater slope and increased flow rate reduce the range of backwater.

It was found that Rühlmann's and Tolkmitt's methods should not be used in practice, as they completely fail to model the physics of the effect. It is preferred to use Bresse's method as a specific case of Bakhmeteff method.

Modifying roughness coefficient "n" changes the filling of the channel h, and in consequence affects the size and range of backwater.

A practical case for the lower reaches of the Ina analysed in another paper [8] demonstrated that by changing the parameters of the river channel (width, slope and position of the bottom) it is possible to obtain, at the analysed section, a IV international class waterway, by changing the size and range of backwater.

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Using eye tracking data for evaluation and improvement of training process on ship's navigational bridge simulator

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Key words: eye tracker, gaze data, statistical analysis, mental workload

Abstract
The paper presents basics of the eye tracking methodology and results of preliminary test on multi-purpose marine ship's navigation bridge simulator. The use of the eye-tracker on the navigation bridge makes it possible to objectively measure the ergonomics of the individual interfaces, as well as to evaluate the decision-making process itself, including the mental workload and stress. In the experiment, officers were faced with an unexpected and sudden situation leading to a collision. The simulated situation required the officer to act immediately and resolutely, taking into account all his/her knowledge about the ship, and interpreting the available data correctly. Outcome of this test was compared with gaze data and it was proved that experienced group with best results suffered lowest level of mental workload and was most efficient in decision making process. Based on those results a possibility of improving simulator training with the use of eye tracking data is discussed.

Introduction

Eye-tracking is concerned with methods and techniques used for registering eyes' movements and points of gaze with the use of specially designed equipment – an eye tracker. In one of its most basic form, eye tracker uses one or more cameras to register so called Purkinje images (Fig. 1) or Purkinje reflections and based on this data, calculates Point of Regard (POR). This allows for precise identification of visual scene's elements on which subject focuses his/her attention [1]. Two most important type of eye movements that can be registered with an eye tracker are fixations and saccades.

Fixations are eye movements, lasting for around 200–300 ms, that are stabilizing the retina on a stationary object or area [1] – point of fixation. In neuropsychology fixations are directly related to cognitive processing meaning that during fixation, subject is analyzing and interpreting information from the object or area of focus. This can be directly connected to process of searching required information on the visual scene: fixations shows where and for how long subject focused his/her attention [2].

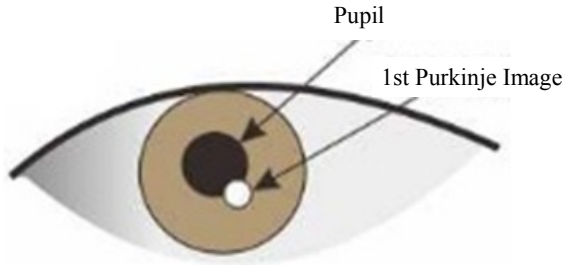

Fig. 1. Purkinje reflection [3]

To analyze fixation data two factors have to be taken into consideration: location of fixations with regard to the visual scene and fixations characteristics (duration time, frequency, quantity, etc.). With such approach it is possible to visualize gathered data in form of so-called Heat maps or Focus maps (Fig. 2). Both includes coordinates and number of fixations but Heat map additionally allows for coding average time of fixation with different colors. Fixations can also be analyzed as a series of events that forms so called Scan path allowing for evaluation of specific task. Fixations are often interpreted as an indicator of mental workload and thus can be used as an objective measure of task's difficulty [3].

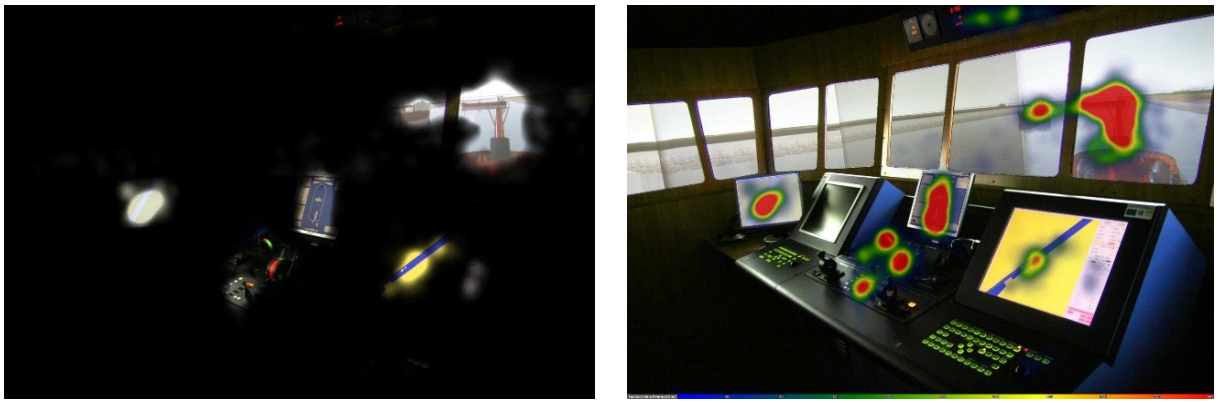

Fig. 2. Focus map (left) and heat map (right) created from eye tracker data

Saccades are rapid eye movements between two fixations, lasting around 10–100 ms, that are connected to changing position of the fovea to another location [1]. Opposite to fixations, saccades are not related directly to cognitive processing – this eye movement is too fast to register and analyze visual information. Having data about number, frequency and duration of a saccadic movement conclusions about proportion of time and effort between process of searching and analyzing specific object in a visual environment can be drawn out. Saccadic movements are also related to higher levels of stress and nervousness [4].

Most of modern eye trackers measure and record much more information about human eye and its movements allowing for even deeper analysis of cognitive processing. Among those, two are valuable as indicators for levels of mental workload, cognitive processing and stress [5]:

1. Pupil diameter;
2. Number, duration and frequency of blinks.

Eye trackers are, in majority, stationary devices suited for registering eye movements on a single screen – a visual environment that itself is stationary, covered by subject's field of vision and does not require any head movements. Such approach could not be implemented on ship's navigational bridge nor in any environment that requires subject to move around and constantly change head position to collect set of data. For this reason a mobile eye tracker was proposed as a best solution for initial tests, specifically Eye-Tracking Glasses (Fig. 3) manufactured by SensoMotoric Instruments (SMI). Aside from being mobile, this particular eye tracker is lightweight and does not restrict nor hamper any head movements. It is recording data with 30 Hz frequency and provides accuracy up to 0.5°. Following data can be obtained:

– Fixations: location, duration, start time;
– Saccades: location of start and end points, duration, start time, velocity;
– Pupil diameter;
– Blinks: duration, start time.

Fig. 3. Eye Tracking Glasses [6]

Experiment proposition

Eye trackers are widely used in cognitive processing researches, human-computer interfaces usability and in marketing (website and advertisement design). Few researchers pointed out usefulness of gaze tracking data in predicting skill-level differences in collaborative tasks [7], assessing situational awareness of VTS's operators [8] and evaluation of interruption modality influence on task resumption [9]. Such approach could be modified and used on the full-mission navigational bridge simulators. Such study could lead to several conclusions:

1. Evaluation of bridge design in ergonomic aspect;
2. Evaluation of radar, ECDIS and conning interfaces in usability and ergonomics aspects;
3. Evaluation of Officer of the Watch situational awareness;
4. Evaluation of differences in decision making process and information analysis between experienced and junior officers;
5. Evaluation of simulator training efficiency.

Based on this a set of experiments is being planned. In its final stage it should be possible to collect and analyze complex data acquired during 4-hours watch in simulated conditions.

During first stage it was planned to test initial hypothesis about differences in eye tracking charac-

teristics between experienced and unexperienced officers. It was also important to develop a method for analysis and interpretation of collected data.

The participants of the experiment included:

– 3 captains, male, of the average age of $m = 51$, $\sigma = 6.2$, with at least 7 years of experience in the position of the captain (group No. 1);
– 4 officers of the watch, male, of the average age of $m = 27.5$, $\sigma = 0.8$, with at least 2 years of experience in the position of the third officer (group No. 2);
– 3 students of the last year of studies, male, of the average age of $m = 21$, each of whom had an independent practice of at least 6 months on marine ships (group No. 3).

None of the participants has any visual impairment, nor wore contact lenses or glasses during the experiment.

The experiment was conducted entirely in the multi-purpose marine ship's navigation bridge simulator in the Marine Traffic Engineering Centre located at the Maritime University of Szczecin, Poland. The simulator works under the Polaris System by Kongsberg Maritime AS, which was granted the certificate of compliance with the international convention of Standards of Training, Certification and Watchkeeping.

For the purpose of this experiment a script of overtaking and bypassing of ships in a narrow canal was created. Three ships took part in the scripted manoeuvre, of which ship A was steered by the examined participant and ships B and C were controlled by simulator. During the manoeuvre, a failure of another ship (ship B) was simulated. The failure made it impossible to bypass or overtake that ship, which in turn forced the officer to immediately bring his ship to halt. An incorrect performance of the manoeuvre led to losing control over the ship, a collision with another ship, or running into the waterfront.

Data analysis

The gaze data analysis was conducted mainly with the BeGaze software by SMI. To analyze data from a visual scene it is necessary to set up so called Areas of Interest (AOI) – specified regions on visual scene for which certain eye tracking characteristics (like number of fixations and dwell time) are calculated. At this moment AOI can be pinned to specified coordinates in relation to subject's field of view, not to certain object. With mobile eye tracker the visual field, and AOIs with it, are changing in time, dependently on officer's head movement. To analyze this part of data it is necessary to use Semantic Gaze Mapping function that allows to copy information about every fixation from video stimulus onto static picture (Fig. 4). This single option allows for creation of heat and focus maps, detailed statistics for every AOI and comparative analysis between single subjects and whole groups. Being essential for every eye tracking experiment of this type it has a distinctive drawback – it is

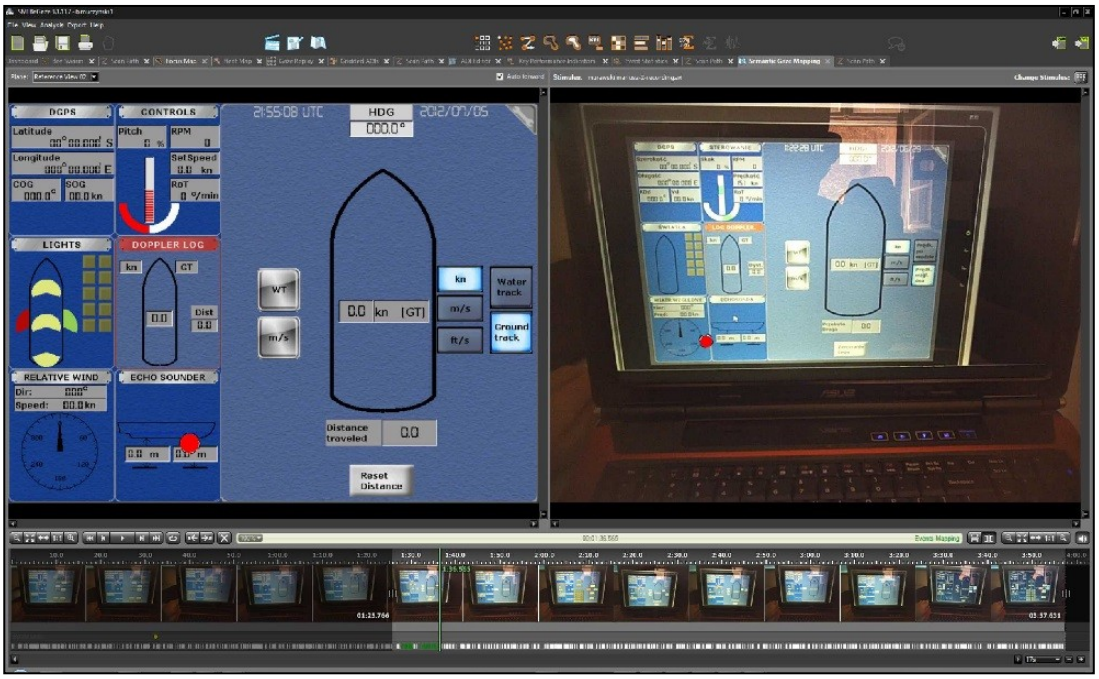

Fig. 4. Sematic Gaze Mapping function. Right side shows recorded video stimulus, left side shows static stimulus – image of tested interface. Red dot on both sides is a recorded fixation point

time-consuming. In described experiment a single trial took around 12 minutes, during which 1500 fixations were registered on average. Mapping such a single trial required 45–60 minutes.

Second part of the analysis was concentrated on statistical and time-series analysis and it was made independently in Microsoft Excel software.

Results

No significant differences were found pertaining to the domains on which the officers of the watch focused their attention. Each of the participants concentrated predominantly on observing the two other ships in the canal, the controls, and the conning display. In the case of the experienced captains, the importance was attached mainly to the visual observation of the position of the three ships and the assessment of the distance between them. Group No. 3 concentrated more on radar screen than two other groups and at the same time had lower fixation count on both ship B and C (Fig. 5).

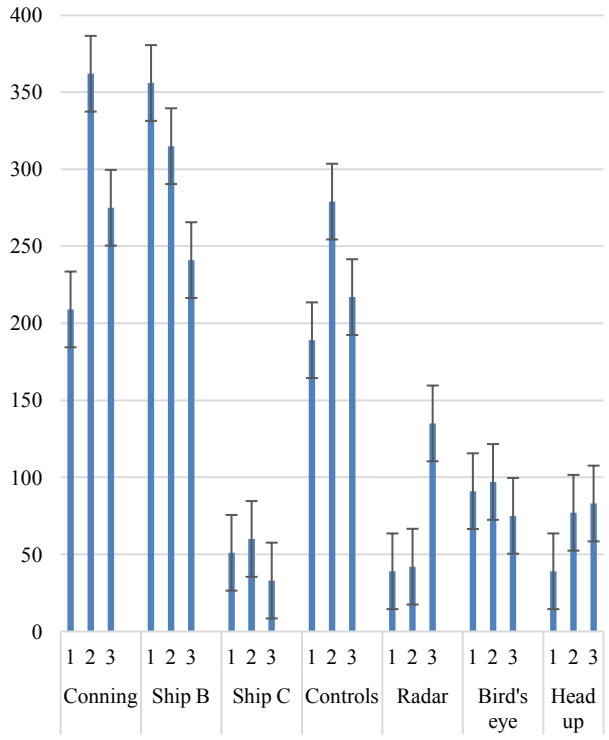

Fig. 5. Fixation count for selected Areas of Interest for groups 1, 2 and 3

The analysis of the average number and frequency of eye fixations and the frequency of saccades and blinking showed that the level of mental workload was the lowest and the ability to interpret data correctly was the highest in group No. 1 (Tab. 1). This group's performance of the manoeuvre was at the same time assessed as the most correct and effective.

Table 1. Basic eye metrics for each group

	Fixations	Fixation fq. [s^{-1}]	Saccade fq. [s^{-1}]	Blink fq. [s^{-1}]
Group 1	1154	2.03	1.7	0.875
Group 2	1731	2.60	2.3	0.950
Group 3	1615	2.33	1.9	1.067

Conclusions

Analysis of the collected data proved that basic eye tracking characteristics, namely number and frequency of fixations, saccades frequency and blinks frequency can be used as an indicator of mental workload that correlates with the correctness of a manoeuvre, its effectiveness and the level of the experience of a participants. It is expected that further experiments will prove that gathered data can be used to improve simulator training by mapping gaze data of unexperienced students and presenting main distractors during standard navigational watch. The results of the experiment should not be treated as final nor as a statistical representation of the general tendencies in the eye movement characteristics for Officers of the Watch. It was designed for limited number of participants and scripted in a way that expected the officer to focus his attention only on the two other ships in the narrow canal.

Further experiments will require a different approach to data analysis, especially in aspect of mapping fixations from video to static stimulus.

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Methods of learning outcomes assessment in the light National Qualifications Framework requirements

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Key words: education requirements, system implementation, examination, module, exam forms

Abstract
In the years 2011–2012 Polish universities were obligated to implement education requirements in compliance with the National Qualifications Framework. First the universities defined intended learning outcomes, a basis on which curricula were drawn up. The most difficult part of the implemented system is the appropriate identification of method(s) to assess whether the expected learning outcomes have been achieved. This article discusses an examination system commissioned by maritime administration for seafarer examining, and indicates possibilities of using the developed solutions in the process of learning outcomes assessment at technical universities and academies.

Introduction

The European Qualifications Framework (EQF) was introduced into the European Higher Education Area by the recommendation of the European Parliament and of the Council of Europe as of 23 April 2008 on the establishment of the European Qualifications Framework for lifelong learning. The recommendation of the European Parliament binds the EQF and associated documents into an education system common for national education systems in Europe and will allow to compare qualification levels between countries. On the basis of the European Parliament guidelines, countries in Europe create their own systems of National Qualifications Framework (NQF) that determine educational levels comparable with those of other countries.

Each NQF and EQF level is defined by a set of descriptors. These indicate the learning outcomes achieved at that particular level of education corresponding to qualifications at that level in any European country qualifications system. EQF comprises the entire educational spectrum: general, vocational education and training, higher education and adult education. It has been assumed that each of the eight levels should be achievable via various educational paths, including non-formal education. EQF provides three groups of descriptors for conforming whether the expected outcomes have been achieved [1]:

- knowledge (effect of the assimilation of information through learning; knowledge is the body of facts, principles, theories and practices that is related to a field of work or study);
- skills (cognitive – involving the use of logical, intuitive and creative thinking, and practical – involving manual dexterity and the use of methods, materials, tools and instruments); the term skills means the ability to apply knowledge and use know-how to complete tasks and solve problems;
- competence (means the proven ability to use knowledge, skills and personal, social and/or methodological abilities in work or study situations and in professional and personal development.

It was agreed that from 2012 each officially issued qualifications certificate should contain a clear reference by way of national qualifications systems, to the appropriate European Qualifications Framework level [1].

In Poland, higher technical studies can be undertaken in three cycles: 1st cycle leads to a profes-

sional title of engineer, 2nd cycle leads to a master's or master of engineering degree, while the third cycle means doctoral studies. They are referred to EQF as the sixth, seventh and eighth level, respectively. Polish universities took no time to implement NQF. However, the question arises whether this implementation is complete. Can NQF be fully implemented at universities considering the present condition of the remaining part of the educational system and regulations in force? For the time being the answer is *no*. The regulations are not consistent and do not permit to precisely define the methodology and procedures for the verification of qualifications achieved. The development of preliminary guidelines for validation system solutions and recognition of learning outcomes in the higher education system is in progress. The following arrangements are under consideration [2]:

1. The learning outcomes validation will be conducted by specialized university units.
2. These units will offer advice to learners comprising the identification of achieved learning outcomes and their documentation. The learning outcomes will be verified and confirmed by issuance of a relevant document. A document confirming the learning outcomes will include their detailed description and a description of methods and scope of verification.
3. These units will have to comply to their own quality assurance system for the process of validation and will be subject to periodical external audit by the National Accreditation Committee (*PAKA*).
4. Learning outcomes confirmed by a validation centre of one university may be recognized by another institution of higher education in Poland, however, such decision on recognition will be an autonomous decision of the university hosting the learner.
5. Learners will be able to make use of the confirmed learning outcomes in graduate and postgraduate programs, and in any types of training undertaken for qualifications.
6. If a validation process attests all learning outcomes expected to be achieved for a given qualification, on its basis a university may award this qualification – a diploma of completion of first or second cycle studies.
7. At a national level, an advisory body will be established to run audits of learning outcomes in cases where learners will not find an appropriate validation unit. As a result of such audit, the learner will be directed to a validation unit competent for the scope of learning outcomes being validated.

In order to achieve this aim, the system of examining in Poland, including universities, has to be completely remodeled. One of the arguments for it is that there are a number of academics who will not change their skeptical thinking and attitudes about effective education within system changes enforced by NQF. That unwillingness is even more visible in people engaged in lower levels of education [2]. Implementation of standardized methods of verification of achieved learning outcomes may be inconvenient for poor educational institutions.

Examinations

An exam (Latin *examen*) – till recently was perceived as a form of checking one's knowledge. At present, when it comes to verifying one's competences that involve practical skills the term *assessment* seems more proper, as it refers to both knowledge and skills. Accordingly, the scope of examining has been extended to include practical tasks, so that the term examination evaluates skills an applicant has at a required level of competence. Competence is understood as theoretical knowledge and practical skill distinguishing a person by his/her ease of efficient, effective and quality-satisfying performance of tasks. Additionally, the above definition of competence is broadened with expected attitudes and personal qualities of the applicant. Actions of a person competent in a given field should meet criteria adopted in a given community / organization [3]. According to the National Qualifications Framework adopted in Poland, the process of assessment should confirm that the assumed learning outcomes have been achieved [4].

An academic team established at the Maritime University of Szczecin, to respond to the request of maritime administration to work out a concept of seafarer examination. The concept utilizes long experience of the authors in this respect [5, 6, 7, 8], and takes into account national and international trends and STCW Convention requirements for the verification of skills [3, 9]. Adoption of such exam model will allow to assess examinee's competences and to assess and verify training standards applied at various training centres for seafarers. The authors' intention concerning the examination system was to separate a theoretical exam of knowledge from a practical exam assessing skills and to formulate objective assessment criteria [1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]. The examination form and structure were based on an assumption that they have to assure:

– transparency of exam principles and requirements,

– clear user-friendly form,
– objectivity ensured by system-enforced supervision and elimination of personal subjectivity.

An exam in course units (subjects) comprising a wide scope of knowledge and skills and several learning outcomes subject to evaluation was divided into modules. Depending on the specifics of a course unit module, all or selected forms of examination are used, as defined in attached exam sheets. Each module has functions assigned to it, which result from the learning outcomes of the course units covered by an exam.

The following exam forms are used in the proposed assessment process:

1. A theoretical exam, divided into:
   a) a multiple choice test;
   b) a written exam.
2. A practical exam, divided into:
   a) exam on real objects;
   b) exam on a simulator.

Each course unit making up part of a function and module has a defined method of testing knowledge and skills, that is it has an assigned form of exam(s) conducted within a module. An example structure of a module is shown in figure 1, while figure 2 depicts an organization of a one-day exam for a recognition of competences as required in a training program. Exams in case of more extensive programs may take two or three days.

The structure of exams may include various modules, depending on the scope of assessed skills and knowledge. To ensure that the exam result is reliable and the education or training is appropriate, the exam methods have to be clear and known to both examiners and examinees alike, and assessment criteria should be such that any distortion of exam results by the "human factor" will be impossible. For these reasons, the exam system developed at the Maritime University of Szczecin is characterized by a system-based solutions instead of personal decisions, that are reduced to a minimum. Examinees will have access to an electronic data base, a bank of test items, written tasks and scenarios for practical exams on real objects or simulators.

Four basic forms of exams have been used: multi-choice test and written exam, making up a written part of the exam; exam on real objects and on a simulator or ship, a practical form of assessing trainee's ability to use skills and knowledge in practice.

Theoretical exam

A multiple choice test

The test may have either of two forms:

a) computer-based, conducted in a room equipped with single user computer stations, one for each examinee;
b) recorded on paper exam sheets, organized in a room with traditional desks for applicants, a computer with an access to exam task base and a fast printer.

Written exam

Two methods of written exams can be implemented:

a) computer-based, conducted in a room equipped with single user computer stations, one for each examinee;
b) recorded on paper exam sheets, organized in a room with traditional desks for applicants, a computer with an access to exam task base and a fast printer.

Both test and written exam in a transition period may be prepared outside the exam room, printed under a supervision of an examination board.

Practical exam

Exam on a real object

The exam is conducted with the use of a real object specified in tasks covering a certain scope of topics, recorded in exam sheets (e.g. AIS receiver, fuel purifier).

Exam on a simulator / ship

The exam is conducted on a ship or a simulator. If the latter is used, it has to satisfy standards of an operational simulator. If a practical exam takes place on a ship, it has to carry equipment the handling of which is to be examined.

Figure 2 illustrates a serial arrangement of exams in each module, such that passing each exam form in a module allows the applicant to take the next exam component within that module. If the overall examination consists of more than one module, failing one module does not exclude the examinee from taking exams in other modules.

The first part of the overall examination, a theoretical exam, consists of a test and a written exam. If the theoretical exam (test and written) is conducted in a room equipped with individual computer exam stations, the examinee gets a set of questions / tasks drawn at random by a dedicated computer program, started by an exam board member that supervises the exam. If this exam takes place in a room equipped with traditional separate exam tables and a computer electronically connected to a data base of exam tasks and an efficient printer, exam participants will get exam sets printed on paper. The sets of exam questions and written tasks, like above, are drawn by a computer program

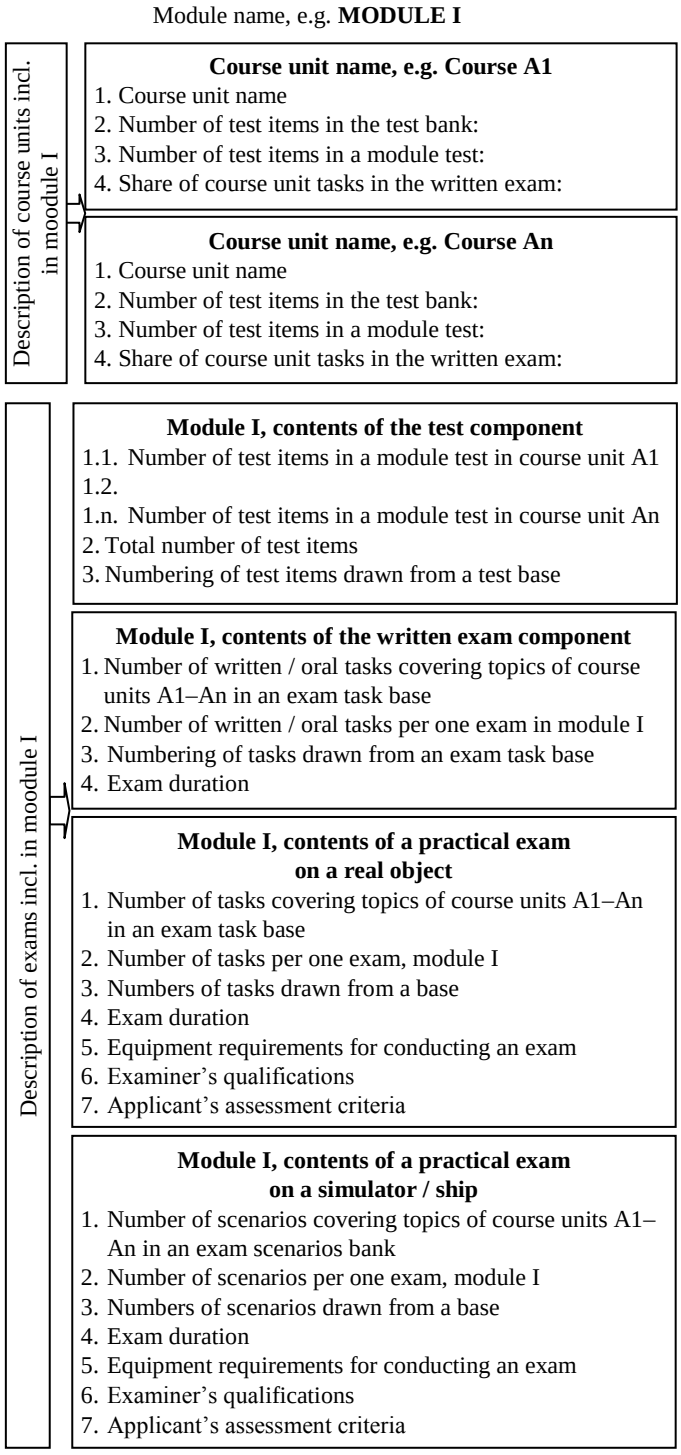

Fig. 1. Model of an exam module

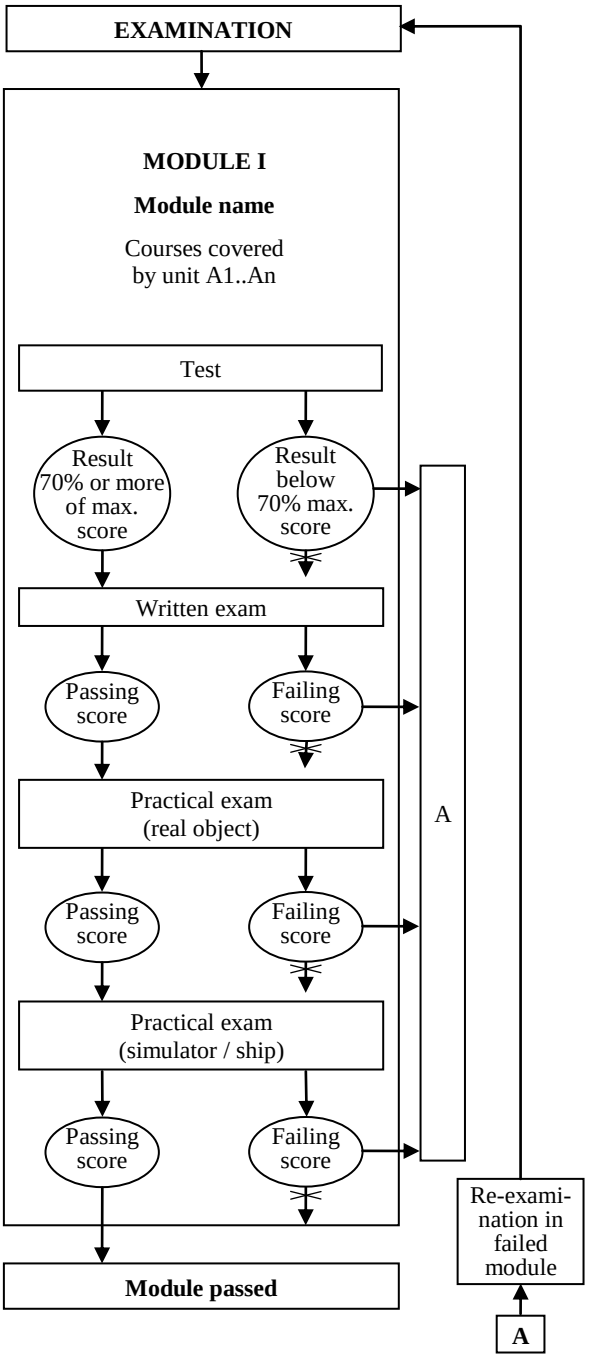

Fig. 2. Block diagram of a one-module exam

activated by an examination board member who supervises the exam. It is assumed that exam sets should be coded.

The test results are only the first element of verifying examinee's knowledge and skills. The test in each module will be regarded as passed, if a preset minimum score is achieved. This is a prerequisite for taking the written exam, where a minimum answer of correct answers has to be given. A result below a preset minimum excludes the examinee from taking the other part of the exam module. Examinees should be informed about the test results not later than three hours after the last group takes the test. The next session is intended for written exams in each module. Exams in each module are divided into sessions, not more than three. Each will take no longer than 90 minutes. There are 30-minute breaks between the sessions. The written

exam in each module contains one theoretical problem (task) that can be solved within allocated time. The written exam time should not exceed 90 minutes. Tasks are solved individually by examinees, who are informed about the results of the written exam not later than one day after the completion of this part of the overall examination. If the written exam is passed, the examinee can proceed to further exam module component.

The last part of the examination (for an examinee it can be the first, third, seventh or any other day counting from the start of the examination session) includes practical exam in particular modules, if such are applicable. The practical exam covers a randomly selected scenario to be implemented on a real object and/or simulator that meets operational requirements. Tasks are at random drawn by an examiner from an appropriate data base of exam problems.

The practical exam on a real object includes one practical task that an examinee is able to solve in allocated time. Tasks are done individually by each examinee, and it should last no longer than 30 minutes. The examiner announces the result to the examinee immediately after the exam.

The practical exam on a simulator or ship includes one scenario that can be executed in an allocated time, assumed to be 60 minutes at the maximum. Scenarios are chosen at random by the examiner from an appropriate data base of exam scenarios. Like in the real object exam, tasks included in a scenario are performed by examinees individually and the result is announced by the examiner right after the exam.

Exams that cover a narrower scope of topics may have subjects grouped within one or two modules, and their forms may be restricted to, for instance, a test and written exam, or only a test and practical exam, as indicated on examination sheets. In such cases, the whole exam will take one or two exam days.

According to EQF and NQF requirements [2, 13] it is assumed that passing a module is equivalent to a recognition that the examinee has mastered the skills and knowledge included in that module and possible re-examination will not comprise the

Table 1. An exam sheet for marine engineering at the management level [10]

6. Engine Department										
Management level – STCW Table A-III/2							Exam form – Type I/Ie (Fig.12/ Fig.15/Fig.20)			
Module	Function	Course unit	Theoretical exam				Practical exam			
			Multiple choice test		Written exam		Real object		Simulator	
			number of items in a test	time min.	Tasks per exam	time min.	Tasks per exam	time min.	Scenarios per exam.	Time min.
I Type A	Marine engineering, management level	Marine Diesel engines	20	90	1	60	1	30	1	60
		Marine power plants	20							
		Marine machinery and equipment	20							
		Marine boilers	10							
		Marine refrigeration, ventilation and air conditioning	5							
		Thermodynamics	5							
		Working fluids	10							
II Type A	Electrotechnology, electronics and automation, management level	Marine electrotechnology and electronics	30	90	1	60	1	30	1	60
		Marine automation	20							
	Maintenance and repairs, management level	Mechanics and strength of materials	5							
		Repair technology	25							
		Ship building theory	10							
III Type H	Care for the ship and personnel, management level	Safe operation of the ship	10	50	1	60	none	30	1	60
		Marine environment protection	10							
		Law and marine insurance	10							
	Marine engineering	English	20							

module already passed. If the examinee fails re-examination, the next exam will cover the complete scope of knowledge and skills assessed by the given examination.

An example examination sheet

The transparency of the examining process strictly depends on the transparency of the exam forms and the associated scope of subjects, available to examiners and examinees alike. Examination sheets have the same form for each component required for a given level of competence. Table 1 presents an example examination sheet for engine department management level candidates.

Verification of learning outcomes at universities

One of the basic factors allowing to implement NQF (following its logic) at higher education institutions is the transformation of academic teachers' awareness concerning methods of achieving assumed learning outcomes, and first and foremost, assessment of competences students have acquired. For this to happen, it has to unequivocally and precisely formulate learning outcomes and corresponding assessment criteria. The appropriate identification of learning outcomes for many authors of syllabuses, making up a curriculum for a field of study, is difficult, and consequently these outcomes are defined improperly and superfluously. Competences and learning outcomes are a basis for exam requirements, sets of problems and tasks, also practical ones, or test item data banks. Therefore, they determine the equipment of an exam centre, choice of exam procedures and vocational training programs.

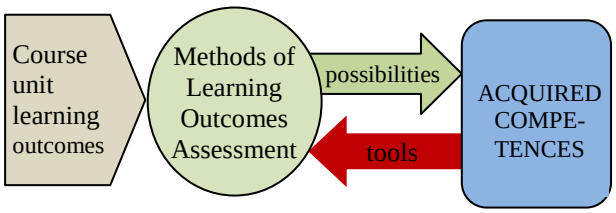

Fig. 3. Relations between competences, learning outcomes and methods of their assessment

Assessment at a university is a continuous process, composed of various forms of verifying learning outcomes, with a diversified scope within a course unit or module, from laboratory classes, through tutorials, lectures and seminars to vocational in-company training. Before receiving a diploma of qualifications, the university under/graduate has to pass all exams indicated in the study plan, as well as a diploma exam.

An exam model commonly used in Polish universities is the testing of knowledge or skills excluding the practical component. Besides, the preferred forms of written or particularly oral exam inevitably lead to the subjective assessment of the examiner. In many cases the exam mark is stained with based selection of questions, or even questions improperly formulated by examiners. Non-substantial factors, for instance examinee's appearance, may have an impact on the evaluation by the examiner. The methods of examining used to date are very traditional and do not meet standards of modern methodology of competence verification, and, undoubtedly, do not satisfy the EQF requirements in this respect, which is particularly visible when it comes to the verification of competences acquired through non-formal methods [2]. Professor Macukow of Warsaw University of Technology, an expert in NQF implementation in Polish higher education institutions, in his talk at the meeting of deputy rectors responsible for education in technical universities, emphasized the importance of developing the methods of verifying whether the intended learning outcomes have been achieved.

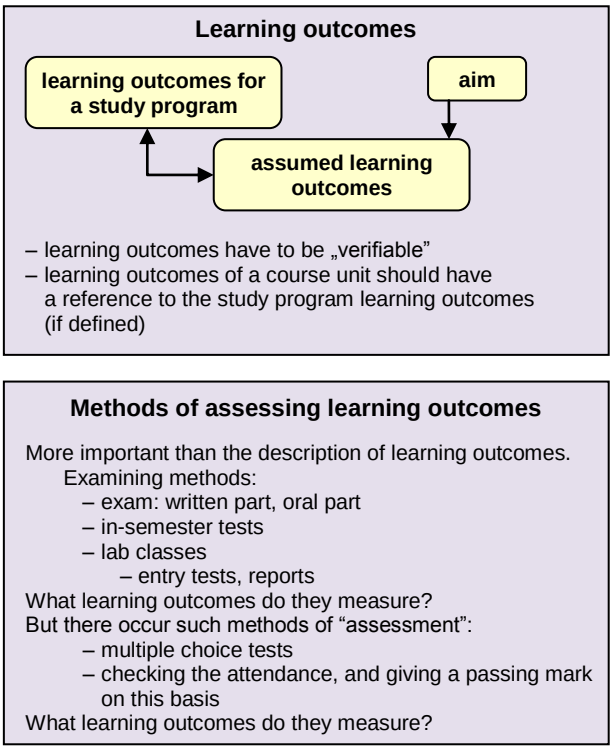

Fig. 4. Methods of learning outcomes assessment [13]

Assessment should start at a level of lab classes. These should be remodeled so that their objective will be measurable effects or competences, not just activities determined by the class topic. The study program should differentiate between "knowledge and skills" exams and competence exams. The latter often require more complex "instrumentation" for the examining process. This means that the

methods of competence demonstration on real objects or simulators should be assigned to teaching / training, as well as examining. The selected demonstration method, in turn, determines what examiners should have to appropriately conduct an exam: assessment criteria, sets of exam tasks, exam procedures and technical equipment, the latter sometimes unavailable at a given institution. Therefore, maritime universities, too, even if fully equipped with simulators and real objects, should partly assess the learning outcomes on real objects during vocational training. In the light of NQF requirements, practical training should become integral to education at all technical universities.

Such approach to examining may necessitate and lead to a system of verifying learning outcomes similar to the one discussed earlier. The system developed at the Maritime University of Szczecin for education via training courses may to a large extent be implemented in higher education institutions, including maritime universities or academies. One obstacle for many technical universities is that they have no possibility to carry out the practical part of exam in course units involving lab classes.

Conclusions

The implementation of the National Qualifications Framework cannot be completed just by determining the expected learning outcomes and developing a program leading to their achievement. One of the most important components, if not the most important, is the definition of methods of learning outcome evaluation. The system of exams originally developed for specialized course-based training, may provide a basis for adopting similar solutions at technical universities. One advantage of such solution is that some components of overall examination may be incorporated into e-learning system, which sooner or later will become a common approach.

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The usage of DEM to create the 3D cadastre

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Key words: DEM, cadastre, 3D, GIS

Abstract
The article presents the analysis of possibilities of using the Digital Elevation (Surface) Models for creation of the 3D cadastre. The authors present the characteristics and meaning of the three-dimensional modelling of objects in the context of solving problems occurring with the traditional two-dimensional cadastre. The paper presents imperfections of the 2D cadastre and indicates possibilities of their removal based on altitude data acquired from the laser scanning. It determines the accuracy of data obtained with lidar techniques and indicates their limitations in specifying the exceeding. As a result of the carried out analysis and theoretical considerations, the authors have indicated the potential possibilities of the usage of Digital Surface (Elevation) Models for the construction of the three-dimensional cadastre system.

Introduction

Cadastre systems are the information systems about the subjects, objects and rights, which combine the subjects and objects. Such data serve three basic functions [1]:

- fiscal;
- legal;
- geodetic – cartographic.

Development of numeric and cadastral maps makes the usage of cadastre become wider. Computerization of the graphic and descriptive part of the land and buildings register creates new possibilities of their use (database, analytical).

The use of electronic registration tacheometers, GNSS technique, photogrammetry methods or the laser scanning, and not only as it has been used so far the descriptive documentation about the object, enables now the acquisition of the third coordinate with the cadastre measurements, and what follows it significantly saves time with these types of studies. Another issue is the accuracy of generating 3D information referenced to the land surface, which is connected with the accuracy of measurement, approximation and representation of this surface.

Cadastral data are more often used for the needs of national economy, especially in the activities of the local administration and government. The existing method of geodetic determination of the height (exceeding) are the methods of measurement:

– levelling (geometry levelling (including precision), trigonometric, barometric, hydrostatic, satellite);
– gravimetric;
– based on Numeric Models (Surface) of the Land;
– combined.

In this publication the authors undertake the problem of specifying the accuracy of the height (exceeding) of the objects for the purposes of multidimensional cadastre, based on the available height models, with the special consideration of lidar techniques.

3D cadastre

The issues of the multidimensional cadastre was undertaken for a broad scale at the beginning of the XXI century, however, contemporary technical conditions and organisational ones did not allow its further development [2]. In the recent years the matters connected with the multidimensional cadastre, called the *3D cadastre*, were once again undertaken at first in the countries of the Western

Europe. In the spatial cadastre the digital models of the field with various levels of accuracy are used. Development of cadastre 3D registrations is caused most of all by a significant increase of the properties' values, the growing number of technical infrastructure and the development of modern methods of analysis and presentation of data using the GIS systems.

Classic cadastre system, containing the basic information about borders of the property and the way of its usage in 2D dimension, in such situations is no longer sufficient. Most of all, it prevents the spatial (three-dimensional) localisation of the object in relation to borders and the surface of the plot. These deficiencies are visible especially in situations, when [4]:

- in particular parts of the building there is a various number of storeys or there are other additional elements;
- buildings' shapes are untypical or irregular and there is a difficulty in presenting them on the map;
- owners or users of "irregular" properties are different (the owner of the plot is different than the users of the building);
- buildings are differently built in the ground and underground part and the presentation of such state on the map is difficult.

Creation of a uniform three-dimensional cadastre is not a simple matter, especially in the international or world scale. The way of complicating the cadastre in each country depends on many factors, such as legal and organisational conditions, or technical possibilities. That's why there are various ideas connected with the creation of 3D cadastre and its various terms.

As 3D cadastre, apart from objects of traditional cadastre, we also understand the systems of registration of the infrastructure network in parts of underground buildings, ground and above ground ones. The accomplishment of the cadastre is possible as [2]:

- minimal 3D cadastre, which will not consider the infrastructure network, such as roads and railways and underground objects, and information about the flats will be available through layers;
- topographic 3D cadastre, which will define objects by the reference to their physical boundaries without the creation of own geometry for legal objects;
- polyhedral 3D cadastre, in which plots in 3D will have own geometry, represented by polyhedrons, limited by flat surfaces;
- non-polyhedral 3D cadastre, similar to polyhedral one, however allowing also other surfaces;
- topological 3D cadastre, in which plots having the volume will be topological structures, based on bonds, edges and surfaces;

Currently, the objects of land and buildings register are the plots, class-uses, buildings and flats, and the introduction of the 3D cadastre requires the application of the right measurement techniques, resulting from the demand for information (legal requirements, user requirements, etc.). In the opinion of the authors of this publication, the construction of the three-dimensional cadastre is only the matter of time, and its foundation will be the altitude data acquired by Digital (Surface) Models.

DEM and DSM

For the creation of 3D cadastre (on large areas), it should consider the method of determining the altitude based on the Digital Elevation Models. Due to the specificity and construction of numeric altitude models, it should take into consideration most of all models considering the surface of the land, together with the anthropogenic objects (ground and underground infrastructure for the description of which it can use the technical documentation of the object) and the covering of the land (trees, bushes, etc.), and not reflecting only the delevelling of the land. Due to the accuracy of the determining of the exceeding, it should consider the use of lidar techniques – laser scanning. In order to three-dimension model the objects it can perform the air or ground laser scanning. The method of the air laser scanning ALS (Airborne Laser Scanning) is based on the cooperation of the following elements [5]:

- airship – on which there are placed essential transmitting-receiving devices and operators;
- laser rangefinder with the recorder – performing measurements and recording the reflected signals – scanner;
- recorder of the image – video camera or multispectral photographic camera, in some cases also theatre camera, where the recorded images may be used in filtering of the cloud of points as well as to attribute the points with colours, including the contractual ones, and when necessary the temperature;
- INS, GPS systems – determine the location of the scanner and angle leans;
- ground part in the form of reference stations.

The points recorded during the raid have XYZ coordinates, and data files are usually registered in the LAS format and reflect these elements, from

which the reflection of the laser beam started. Filtering the selected points with specific assumptions, it obtains the following products:

- Digital Elevation Model (DEM);
- Digital Surface Model (DSM);
- Orthophotomap and the so-called true-ortho (by using additional photos and further transformations).

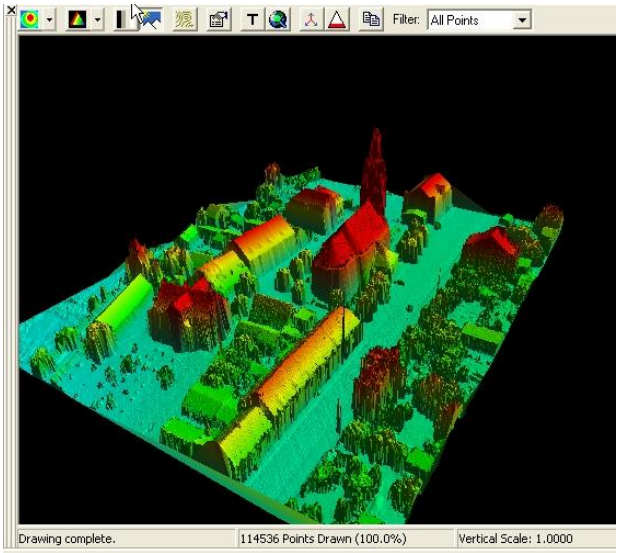


Fig. 1. Digital Surface Model created as a result of the laser scanning [5]

Analysis of the accuracy of the altitude model

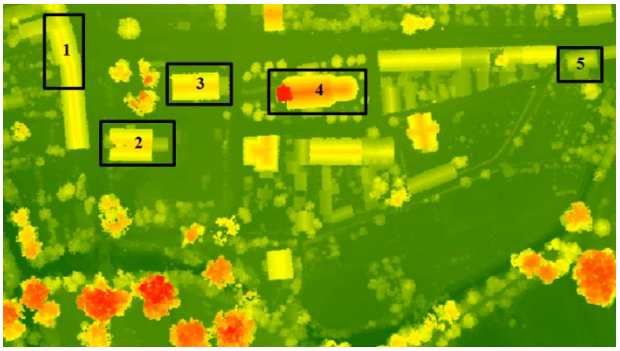
The use of the laser scanning for the construction of the 3D cadastre is limited most of all by the accuracy of determining the differences of altitude, and not the absolute accuracy of determining the altitude in the global altitude system. This results from the fact that, e.g. for the determination of the building's volume it needs the precise determination of the altitude difference, and the absolute determination of the altitude in the altitude system has no influence on the size of this volume. While in case of the insufficient accuracy of altitude binding of measurements to the global altitude system, it can use the traditional method of geometric leveling (in respect also of the precise needs) and bind the building (object) to the altitude points (level marks) with the right, demanded accuracy. In this respect the authors subjected to the analysis the use of the lidar model in respect of the accuracy of the specification of exceeding.

Checking the accuracy of determining the altitude differences based on the lidar model was made with the geometric levelling on the selected test objects (embankment, elements of the building).

Tab. 1. Measurements of altitude differences with various techniques (average values)

Flood banks	Measurements of altitude differences of the bank [m]
Difference of the altitude on the LiDAR model [m]	1.76
Difference of the altitude from field measurements [m]	1.83

Flood bank was measured at length of about 100 m. On the LiDAR model the altitudes of the bank top-bottom on 20 pairs of points selected at random were measured. Differences of exceeding were also obtained as a result of geometric levelling on 20 pairs of pickets selected at random (top-bottom). Levelling measurements were taken from three locations. Accuracy of determining the exceeding of the flood bank fit in the borders of 0.1 m (tab. 1).



Rys. 2. Digital Surface Model with the indicated objects used for testing

For measurements of the building's elements five test objects (among others the church tower – object No. 4) according to figure 2 were selected. The average value of the obtained error of the average measurements of exceeding was 0.33 m. For measurements objects with various construction, with sloping roofs and various number of storeys were subjected. The values of the obtained errors (tab. 2) indicate that the explicit identification of single elements of the buildings (roof's edge) causes difficulties, what translates into the obtained values of average surface (mean) errors, proving the relatively large deviations of the obtained (single) values from the average value. In case of altitude measurements on single, flat elements of buildings the values of surface mistakes of altitude measurements of these elements (but not the exceeding) fit the borders of 0.1 m. These values are coincident with the values obtained with measurements of the exceeding along the flood bank. This gives us a fact that in case of measurements of flat elements, the accuracy of the altitude / exceeding measurement equals about 0.1 m, while in case of

diversified surfaces this accuracy falls to about 0.3 m. This difference also results from the spatial resolution (thickness of the cloud of points) of the used model, which equalled 0.5 m.

Tab. 2. Average (mean) errors of the exceeding measurement on the model Fig. 2 /LiDAR/

No. of the object (acc. to Fig. 2)	Average error (surface) of determination of altitude differences [m] on the LiDAR model
1	0.24
2	0.41
3	0.34
4	0.29
5	0.36

From the above results that for the analysis of the usefulness of the given altitude model for the purposes of 3D cadastre it should also take into consideration the second parameter, connected with the thickness of the cloud of points. This parameter has significance in case of numeric study of the lands intensively developed or the inventory of buildings with diversified shape. On the lands developed in a smaller degree, or on objects with a smaller diversification of constructions the number of points per square meter of the surface is sufficient on the level of 3–5. For the purposes of accurate inventory, the reproduction of the architecture objects, this accuracy depends on specific needs and requirements, assumed accuracies of the reproduction of the surface and determination of the exceeding or altitude (creation of smaller or larger surfaces, in which the values are interpolated) and should be increased to at least 10 points/m^2. This resolution has also importance in modeling the flood phenomena. In figure 3 the simulation of the increase of the water level by 6 m is presented.

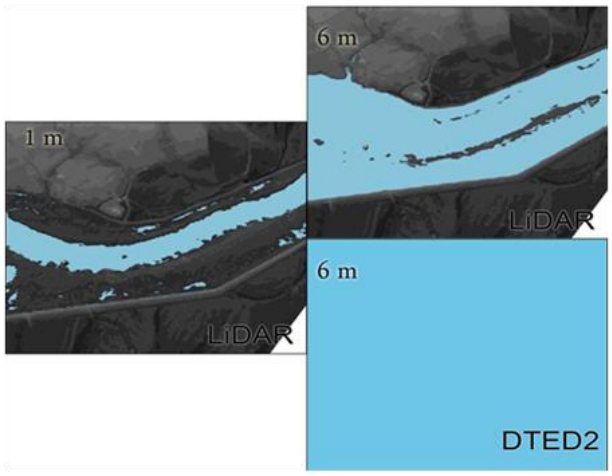


Fig. 3. Model's resolution (thickness of the cloud of points) in modelling the exceeding

The obtained results show that using the model with too low spatial resolution (horizontal and altitude) – DTED2, which vertical accuracy fluctuates in the borders of 5–10 m, and the spatial resolution equals 30 m, may lead to incorrect results. Thus, for the precise modelling of the land shaping, especially for the purposes of 3D cadastre, it should use data from the laser scanning, where both the vertical accuracies and the spatial resolution are usually one-decimetre.

Conclusions

As a result of the performed analyses and considerations, it was stated that:

- accuracy of determining the exceeding based on the LiDAR model on the analysed area (for the analysed set of data) fits the borders of 0.10 m for the flat elements and 0.33 m for elements with the complex and diversified surface;
- altitude models not taking into consideration the surface of the land (natural and anthropogenic) should not be considered in the process of the creation of 3D cadastre (only as the supplementing material, e.g. for the goals of specifying the flood land);
- possibility of using the lidar model of the land for purposes of the 3D cadastre limit two factors: altitude accuracy of the model (specifications of the exceeding) and spatial resolution (thickness of the cloud of points);
- use of the laser scanning for the construction of 3D cadastre depends on the accuracy of specification of altitude differences, and not the accuracy of specification of altitude in the global altitude system.
- altitude models constructed based on the laser scanning enable the solution of problems of the 3D cadastre connected with the modelling of objects with irregular shapes and various number of storeys.
- with the help of the air laser scanning it can identify objects with the complex structure and indicate which ones of them, depending on the further needs and desired accuracy, should subject to further measurements with the help of ground scanning.

Moreover, the authors of this study think that the construction of the three-dimensional cadastre will enable its implementation to the GIS environment, taking into consideration the database specificity of the cadastre and the spatial (topological) relations of the objects presented in "three-dimensions". The construction of the 3D cadastre based on the tools and GIS techniques will enable the fuller manage-

ment of the data resources, faster acquisition of information from it (combined) and the potential integration of the cadastre with other spatial systems. Creation of the three-dimensional model of objects (and land) this way may constitute valuable supplementation of the developed Database of Topographic Objects by order of the Main Office of Geodesy and Georeference Cartography (in Poland). Currently the objects in this database do not have altitude data, which are acquired from DEM (DSM), constituting the separate part of the system, and the specification of the buildings' altitude takes place through their "projection" on DEM. Such solution from the point of view of the creation of 3D cadastre is not satisfactory. The projected altitude is not the attribute of the building in the database, but it only depends on the accuracy of the used model of the land. Such structure prevents, in addition, the creation of attribute analyses in the system and makes this georeference databese constitute the limited source of data for the 3D cadastre.

Due to the above, it is suggested to construct the three-dimensional cadastre model based on the laser scanning with the attributed ordinates to particular elements of the buildings directly in the base of the cadastre data.

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Способы повышения экономической эффективности перевозок на судах внутреннего плавания

Ways to improve economic efficiency of inland shipping

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Ключевые слова: экологичный транспорт, инновационные решения, энергосбережение, альтернативные виды топлива

Резюме

Внутренний водный транспорт является наиболее экологичным способом перевозки грузов. Этот вид транспорта также генерирует значительно меньшие внешние издержки по сравнению с автомобильным транспортом. В статье представлен анализ европейского рынка перевозок внутренними водными магистралями. Предложено ряд инновационных изменений на речных судах с целью реализации основных направлений транспортной политики ЕС до 2050 г., включая снижения выброса вредных веществ и минимализации расхода нефтепродуктов путем перехода на альтернативные виды топлива и внедрение новых типов двигателей.

Key words: eco-friendly shipping, innovative solutions, resource – efficient transport, alternative fuels

Abstract

Inland shipping is the most eco-friendly way to move goods. This transport mode creates smaller external costs in comparison with road transport. The paper presents both inland shipping market analysis and innovative solutions for river ships with the purpose of EU transport policy realization, including environmental negative impacts reduction, minimization of oil-fuel consumption and cleaner energy use through alternative fuels and new propulsion systems.

Анализа рынка перевозок внутренними водными путями

Транспорт играет одну из главных ролей в развитии как мировой экономики, так и экономик стран – членов ЕС. 28 марта 2011 года Европейская Комиссия приняла Белую Книгу „Транспорт – 2050". Этот стратегический документ, носящий название „Дорожная карта создания единого европейского транспортного пространства – стремление к достижению конкурентной и ресурсосберегающей транспортной системы" содержит основные направления европейской транспортной политики до 2050 года. Среди них особое внимание отведено [1]:

– повышению мобильности;
– снижению зависимости транспорта от нефти и нефтесодержащих продуктов;
– внедрению энергосберегающих решений;
– редукции вредных выбросов в атмосферу;
– переориентированию грузопотоков с автомобильного транспорта на железнодородный или водный;
– оптимизацию мультимодальных транспортных цепей с учетом широкого задействования в них более энергосберегающих и экологически видов транспорта, ключая внутренний водный транспорт.

Общемировой потенциал внутренних водных путей насчитывает около 600.000 км, из чего 123.700 км проходит по территории Китая, 102.000 км – обладает Россия, 40.700 км

приходится на Соединенные Штаты Америки, а 41.000 км – на страны Европы. Среди 27 стран-членов ЕС восемнадцать обладает внутренними водными магистралями. Удел внутреннего водного транспорта в реализации процесса перевозок составляет около 6,1%.

Основным энергетическим ресурсом используемым в транспорте является нефть и нефтепродукты с уделом около 96%. На долю транспорта приходится примерно одна треть всего объёма эмиссий загрязняющих вредных веществ, из которых удел морского транспорта составляет 13,5%, а на долю речного судоходства приходится 1,8%.

На территории стран-членов ЕС перевозки внутренним водным транспортом осуществляют около 8900 компаний с общим оборотом 6,1 млрд. евро [2]. Объем грузоперевозок внутренним водным транспортом в выбранных регионах мира представлен на рис. 1.

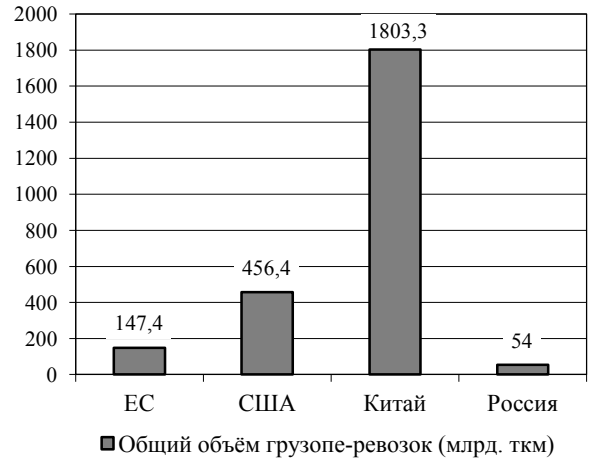

Рис. 1. Объем грузоперевозок внутренним водным транспортом в выбранных регионах мира EU (на основе [3])

Внутренний водный транспорт относится к наиболее экологичным видам транспорта, генерируя при этом внешние издержки, в несколько раз низшие, чем автомобильный транспорт, и только незначительно превышающие транспорт железнодорожный. Например, по данным голландских исследователей, внешние транспортные издержки при перевозке внутренними водными магистралями 1000 тонн груза на расстояние один километр составляют 11,2 евро, железнодорожными путями – 7,9 евро, а автомобильными дорогами – 50,5 евро (без учета издержек, генериремых заторами). Величина внешних издержек как следствия заторов на дорогах незначительно ниже самой себестоимости перевозок автомобильным транспортом, а общие внешние издержки примерно в два раза выше [4].

Объем грузоперевозок в Европе с каждым годом растет, и только внутренние водные пути имеют в себе достаточные возможности для удовлетворения этого роста.

Потенциал тоннажа внутреннего водного транспорта ЕС на 01.01.2012 распределяется следующим образом: 86,8% принадлежит фирмам Западной Европы, а только 13,2% – Восточной Европы (Рис. 2) [5].

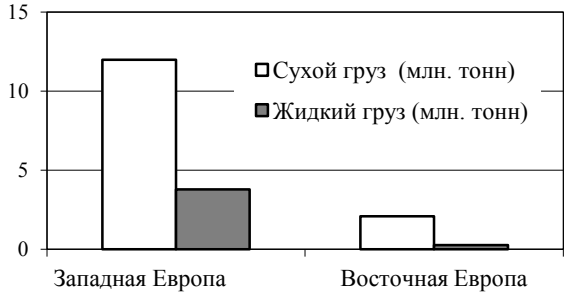

Рис. 2. Потенциал тоннажа внутреннего водного транспорта ЕС (состояние на 01.01.2012) (на основе [5])

Среди восточных стран-членов ЕС лидирует Румыния, а западных – Голландия (Рис. 3).

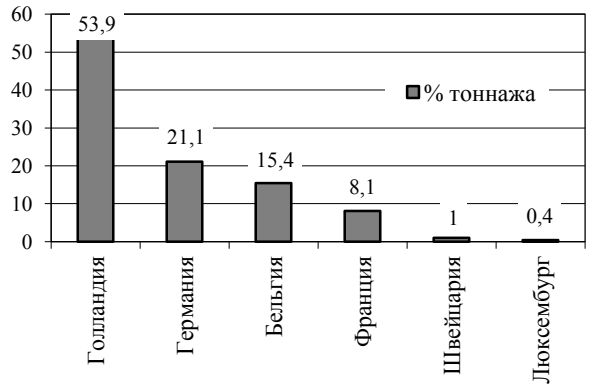

Рис. 3. Распределение тоннажа внутреннего водного транспорта среди стран-членов ЕС-15 и Швейцарии (состояние на 01.01.2012) (на основе [6])

Общий объем грузоперевозок внутренним водным транспортом ЕС хотя и незначительно, но уже превысил докризисный показатель. Следует обратить внимание, что это коснулось не всех стран. Например, если объем грузоперевозок румынских перевозчиков в 2010 вырос по сравнению с 2009 годом на 21,7%, то в Польше за тот же период отмечен спад в размере 35,6%, что является наихудшим результатом среди стран – членов ЕС [3].

Одной из главных задач европейской транспортной политики до 2050 года является проблема инновационного развития и интеграции транспортных систем Западной и Восточной Европы в единое европейское транспортное пространство.

Достижение полного успеха в ее реализации не возможно без использования потенциала внутренних водных путей в более широком масштабе.

Стремясь к оптимизации функциональной структуры европейской транспортной системы и повышению экономической эффективности ее эксплуатации, необходимо минимализировать как внешние транспортные издержки, так и внутренние затраты на реализацию процесса перевозок.

Способ снижения расхода топлива на судах

Среди основных статей расходов, генерируемых реализацией транспортных заданий внутренним водным транспортом, главное место занимают топливные затраты с уделом 24% от общих расходов. В настоящее время наблюдается рост расходов на бункеровку, которые в соответствии с прогнозами Европейского Союза Речного и Прибрежного транспорта к 2020 г. могут достигнуть 1000 долл. США на 1 т [2, 5]. Снижение расхода топлива является одной из первостепенных задач на пути как повышению экономической эффективности процесса перевозок, так и реализации стремления европейской транспортной политики к построению до 2050 года конкурентной и ресурсосберегающей транспортной системы.

Существенную часть флота судов внутреннего плавания составляют танкера, предназначенные для перевозки разнообразных жидких грузов. Например, доля нефтехимический продуктов в общем объеме перевозок этим видом транспорта превышает 22%. Отличительной чертой эксплуатации судов внутреннего плавания является то, что судно, как правило, идет с грузом только в одну сторону. Это означает, что танкер после доставки нефте-химической продукции до порта назначения возвращается к порту приписки либо направляется к месту погрузки нового груза в балласте, т.е. с водой с взвешенным в ней веществом, принятой на борт для контроля дифферента, крена, осадки, остойчивости или напряжений судна [7].

Перевозка значительного количества балласта необходимого для безопасной и эффективной эксплуатации судна приводит к дополнительному расходу топлива, в следствии чего повышаются внутренние затраты перевозчика на реализацию транспортного процесса. Балластные воды на танкерах, перевозящих нефтехимической продукции представляют серьезную угрозу экологии в связи с тем, что:

– содержат во взвешенном состоянии вредные водные и патогенные микроорганизмы;
– ими заполняются емкости (танки), из которых только что была произведена выгрузка груза, т.е принятые на борт воды загрязняются остатками нефтехимической продукции.

По правилам проводить очистку балластной воды необходимо в танкерах-отстойниках, а очищать танкеры и сливать балластные воды – на специальных станциях промывки. Нередко этими рекомендациями пренебрегают [8]. При сбросе балласта с судна с целью приема в порту следующей партии груза, создается угроза сохранению и устойчивому использованию биологического разнообразия экосистем гидросферы.

В настоящее время производятся различные системы очистки балластных вод, которые могут быть установлены как на новых, так и на уже эксплуатируемых судах в процессе их модернизации. Основными недостатками применения систем очистки балластных вод являются:

– конструкторские сложности установки систем очистки балластных вод на уже эксплуатируемых танкерах осуществляющих перевозки нефте-химической продукции по внутренним водным путям;
– значительные затраты, причем не только на приобретение и установку системы очистки балластных вод, но также и на ее эксплуатацию, так как большинство таких систем имеют значительный показатель енергоемкости, т.е. потребляет значительное количество ресурсов – электроэнергии или непосредственно судового топлива.

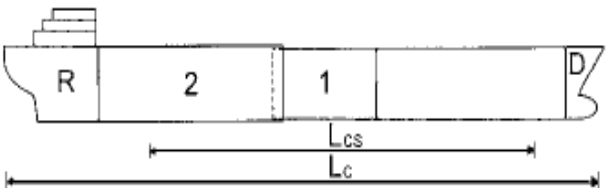

Рис. 4. Схема вложения друг в друга секции конструкции корпуса судна [9]

Одним из вариантов разрешения обсуждаемой проблемы может быть снижение перевозимого на судах количества балласта в обратном рейсе. Это приведет не только к улучшению экологиеской обстановки, но к снижению затрат на топливо. С целью реализации поставленной задачи предлагается следующее инновационное решение, касающееся конструкции корпуса судна.

После разгрузки судна уменьшается длина его корпуса L_c путем частичной редукции

длины цилиндрической вставки L_{cs}, что может быть достигнуто трямя способами (рис. 4) [9]:

- вложением друг в друга запроектированных соответствующим образом секции конструкции корпуса судна (1) и (2);
- сложением по типу "гармошки" запроектированных соответствующим образом секции конструкции корпуса судна (1);
- путем демонтажа части цилиндрической вставки, с последующим смещением носовой части цилиндрической вставки (*D*) до части кормовой (*R*).

Использование альтернативных видов топлива в водном транспорте

В последнее время, учитывая основные направления транспортной политики ЕС, все чаще обращается внимание на использование на внутреннем водном транспорте альтернативных видов топлива [10]. Такой подход даст возможность достижения как минимализации топливных затрат и использования нефтепродуктов при реализации перевозок внутренними водными путями, так и снижения негативного влияния на экологию. Одним из путей является использование сжиженного в качестве судового топлива, который все шире используется не только в автомобильном транспорте, но и в морском флоте.

Природный газ, охлажденный после очистки от примесей до температуры конденсации (–161,5°C), превращается в нетоксичную криогенную жидкость, называемую сжиженным природным газом – СПГ (англ. *Liquefied Natural Gas* – LNG). Плотность сжиженного природного газа, как правило, находится в диапазоне 430–470 кг/м^3. Сжиженный природный газ представляет собой смесь метана, этана, пропана и бутана с небольшим количеством более тяжелых углеводородов и некоторых примесей, в частности, азотных и комплексных соединений серы, воды, углекислого газа и сероводорода, которые могут существовать в исходном газе, но должны быть удалены перед сжижением. Метан является самым главным компонентом, в большинстве случаев его удел составляет более чем 85% по объему.

Большие объемы СПГ возможно хранить в специальных теплоизолированных наземных резервуарах при атмосферном давлении. Для использования СПГ подвергается испарению до исходного состояния без присутствия воздуха.

При регазификации (возвращении газа в исходное парообразное состояние) из одного кубометра сжиженного газа образуется около 600 кубометров обычного природного газа. Это повышает эффективность и удобство не только эго хранения, и транспортировки, а также использование в качестве энергоносителя. Сжиженный природный газ примерно на треть легче, чем воздух, а также имеет меньшую плотность, чем вода, что позволяет ему находиться на поверхности в случае разлива и вернуться к парообразному состоянию достаточно быстро. Сжиженный природный газ представляет собой, безопасный, экологически чистый вид топлива с высокими энергетическими характеристиками и октановым числом. Цена СПГ по стоимости у потребителя ниже цены как сжиженного нефтяного газа, так и мазута, а тем более дизельного топлива [8].

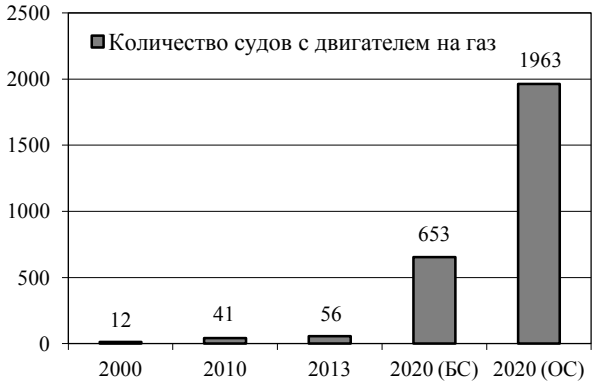

Рис. 5. Развитие флота морских судов с двигателем на газ (БС) – базовый сценарий, (БС) – оптимистический сценарий

На рис. 5 показана динамика развития флота морских судов с двигателями на сжиженый газ с учетом базового и оптимистического сценариев разработанных ведущим классификационным обществом Ллойд Регистр (Лондон, Великобритания). Переориентация на альтернативное топливо в морском транспорте обусловлена тем, что сжжиженный газ не только на 20–25% дешевле, чем традиционное топливо, но и является более экологичным. Например, в результате его применения можно достигнуть снижения выбросов CO_2 на 25%, NO – на около 85%, а взвешенных твердых частиц почти на 99%.

К сожалению, примениение сжиженного газа на судах предназначенных для перевозок внутренними водными путями до настоящего времени не нашло широкого распространения. Пионером в проектировании и использовании таких судов является европейский лидер в речном судоходстве – Нидерланды. В мае 2011 года в порту Роттердама был введен в эксплуатацию

построенный на судоверфи “Трико” танкер “Аргонон” длиной 110 м, шириной 16,2 и провозной способностью 6100 тонн, имеющий гибридный двигатель (20% – дизель, а 80% – сжиженный газ). В настоящее время танкер осуществляет перевозки по маршруту Роттердам – Базель на расстояние 800 км (Рис. 6).

Рис. 6. Танкер “Аргонон” [11]

В документе ECE/TRANS/WP.15/AC.2/2011/38 представленном Нидерландами в 2012 года на Совместном совещании экспертов по Правилам, прилагаемым к Европейскому соглашению о международной перевозке опасных грузов по внутренним водным путям, имеются сведения о разработке проектов, в рамках которых на четырех судах в качестве топлива для их двигателей будет использоваться СПГ [2].

На газовых двигателях можно применять в качестве топлива также и биогаз. Дальнейшие варианты сконцентрированы на разработке газоэлектрический привода [2].

Ранее в Нидердандах был введен в эксплуатацию в ноябре 2010 года построенный в Китае и дооснащенный в Веркедаме (Ниерланды) дизель-электрический экотанкер “Амулет”. Длина этого судна составляет 135 м, ширина – 14,5 м а провозная способность 6752 тонн. В настоящее время танкер осуществляет перевозки по маршруту Антверпен – Амстердам – Роттердам. Эффектом примененния на “Амулете” дизель-электрического двигателя является снижение выбросов до 32%.

Заключение

Основным энергетическим источником в транспорте является нефть и нефтепродукты, удел которых в транспортном топливе до 2050 года должен быть значительно сокращен.

На фоне развития перевозок большинства стран-членов ЕС, имеющих внутренние водные пути, речное судоходство Польши находится в рецессии.

При постоянно растущим объеме грузоперевозок только внутренние водные пути обладают достаточным потенциалом, полнейшее использование которого даст возможность снизить внешние транспортные издержки.

Внедрение инновационных разработок в судостроении может существенным образом повысить экономическую эффективность танкерного флота.

Применение как сжиженного газа, так и других видов альтернативного топлива, даст возможность достижения как минимализации топливных затрат и использования нефтепродуктов в осуществлении перевозок внутренними водными путями, так и снижения негативного влияния на экологию.

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Change of composition and structure of diffusion chrome coating during friction

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Key words: diffusion, friction, phase matrix

Abstract
The paper studied the behavior of the composition and structure of the diffusion of chromium coatings in sliding. It was found that the strain in friction generates the secondary structure of chromium coatings and as a result of the deformation effect wear is accelerated due to separation of the coating.

Introduction

Treatment of composition and structure of diffusion chrome coating during friction is considered in the article. It was determined that in the chrome coating deformation created during friction forms the second structure and exploitation created as a result of deformation accelerates wear and tear. Coating of stable and safe coatings by diffusion method is widely spread in the industry and this is conditioned by useful increase opportunities of operational characteristics of articles in comparison with base of material. Coating characteristics are determined by distribution of alien element, feeding with gas and oxidation of materials. Taking into consideration the large tendency of chrome to oxygen and nitrogen, the chrome coatings will subject to oxidation. The first and second works are devoted to electron-microscopic investigations of structure of gasothermic coatings. Small number of such investigations is connected with complication of preparation of analysis object. The structure of surface and structure of layers near it after the friction is not learnt completely.

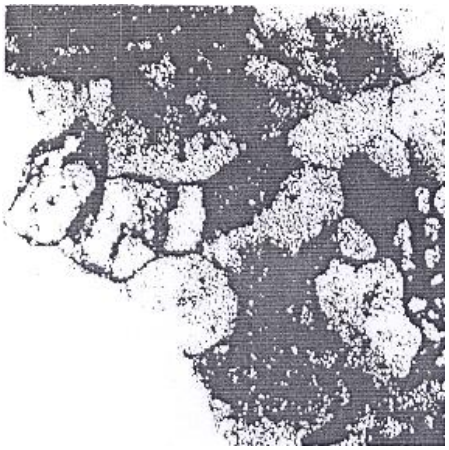
Aim and Objectives

That is why the structure of diffusion chrome coating in primary condition and after the friction have been investigated in this section. Chromium plating operation is done in solid medium. Feeding composition and feeding regimes are given in previous works [1, 2]. Bedding and as counter body material cast-iron of A-WP-CrNiMo mark is taken (A – class, WP – high-duty cast iron). Piston rings of vessels' Diesel engines are made of such cast-iron. Authors have investigated the structure of coatings by electron microscopic method in examples tested in friction mechanism, within unheated friction condition during 10 hours in 1 MP load, at a speed of 15 m/s sliding. Authors have studied the phase composition by oje-electron microscopic method.

The chemical analysis showed that the amount of oxygen reaches 2–3% (mass) nitrogen and carbon 0.1–0.2%. The micro structure of such coatings consists of connection of disk shaped grains. Matrix consists of polycristallic creations being of equal size grains of 0.1–10 μm. The phase composition of electrons corresponds to HMK cage close to chrome parameters. This composition is characteristic both for coarse and small grains and they create the layers of small disperse material among coarse grains. Sometimes characteristic enlargement of small grains is observed around coarse grain. The border of grains is smooth enough, but it is impossible to find out the striped contrast and it is conditioned with the high gathering of defects in the grains and around them. In the chrome coating the defects are disposed heterogeneously, the mean density differs locally, but it does not exceed 10^9–10^{10} sm^2. The large part of grains has the dislocation structure of compact and twist shape, and close

to them the clusters created the dislocation of fringe type and compactness of following defects are observed (Fig. 1b). There is a compactness of small dislocation loops in some grains of 0.1 μm size (Fig. 1c). The loops are usually disposed unequally on volume of grain; their density is decreased to the centre, but near the boundaries it is so high that the individual loops are not seen. In small size grains the density of defects often exceeds 10^{10} sm^2; in this case it is impossible to choose the individual defects equal contrast of speckled form is observed.

a)



b)

c)

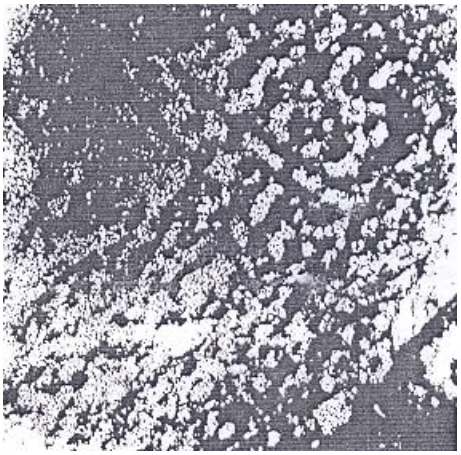
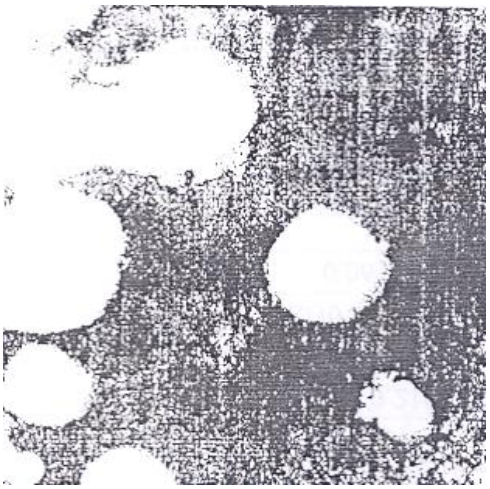


Fig. 1. Electron microscopic structure of the diffusion chrome coating of iron-cast base

The characteristic feature of detraction sight is the pulling down the reflexes (the radial pulling down of matrix phase – diffusion flashes and weak reflection around intensive reflexes). Such diffusion effects [4, 5] are usually connected with the presence of transitional condition of excessive feed solid solution or their prevention of destruction. Besides reflexes of matrix phase, weak reflexes not concerned to the solid solution in the chrome base are observed. They are identified as metastable tetragonal Cr_3O_4 if they are concerned to the chrome oxide. Side by side with matrix surface structure anomaly is found out. Two or more met surfaces may be differed. On the individual fields of the first coating, existence of great number of small circle (up to 1 km) shape pores are seen (Fig. 2a). Many pores are connected with the second phase separation (oxides). By means of rough grounding coating it was found out that the oxides are crumpled not only in the pores but in the boundary of grains too. The numerous fields of micron size between grains of matrix phase are second type of anomaly.

a)



b)

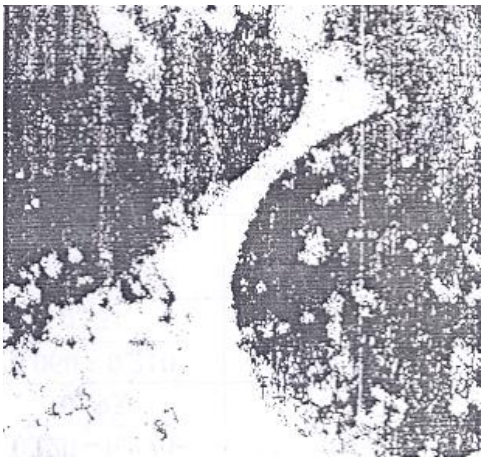


Fig. 2. Some anomaly in the primary structure of diffusion chrome coatings

They consist of small pores of solid solution not to be subjected to identification, oxides and mixture of heterphase phases (Fig. 2b).

Comparing the structural and local X-ray structural analysis, we shall get the results that the alloyed elements in the matrix are distributed equally enough. In all examples the main matrix phase is in the broken stage of excessive fed and hard solution. These diffractions show the great role of oxidation process in the formation of structural features of coatings. Revealing of separation of coarse and small pores is connected with creation of oxides, the formation of heterogeneous phase fields.

The second structures are created in the friction contact in the condition of boundary friction, created which supply the steady working mode [3]. The second structures, having the oxygen in the composition, may create both oxides and main metal excessively fed by the oxygen structures. The various amounts of oxygen and carbon were revealed in the primary condition and after friction by means of investigation of surface and around boundary layers of diffusion coatings by electron spectroscopic method.

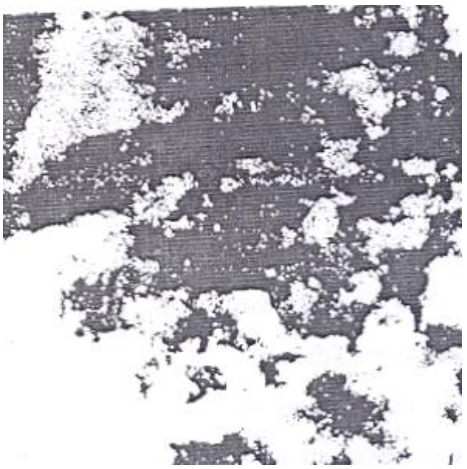
The information in the table shows that the useful changes occur in the surface layer of material, linked in the friction process. The predominant process is its saturation with oxygen. On diffusion coating on chrome base, the oxygen amount in the surface layer increases four times, but on the cast-iron surface increases two times. Although the friction occurs in the carbon composition medium, after well wash and degassing the amount of carbon is in the primary level. Sometimes the gathering of mass of surface material on a counter body is remarked, in this case on the primary surface of contra-substance being of non-noted chrome and other elements in the contact fields are adopted.

Table 1. The amount of elements on the diffusion coating and contra-substance before and after friction depending on the place of analysis, % (mass)

Place of analysis	Coating				Contra-substance			
	Cr	Fe	O	C	Fe	Cr	O	C
Surface								
Primary	41	36	12	11	75	–	10	11
After friction	40	25	28	14	38	25	30	12
Distance below friction surface, μm								
0.5	42	28	18	12	40	17	28	13
3.0	45	35	10	11	62	–	13	11

The investigation of structure in the delicate surface layer after the friction by the pellucid electron microscope methods is difficult due to sufficient development of relief of surface. The method of continuous eruption by the opposite friction surface allowed to observe the deepest layers. Around the surface layers the three main microstructure conditions are revealed. The first is primary size grains and close to primary inside grain, but they have the high density of micro crashes. The second type is the primary size grains, but they are substructures sharply differed from primary ones: grains are filled with cloud shaped mass; the azimuth throwing of reflexes is characteristic for diffraction (Fig. 3a). The third type of structure is formed on the basis of primary grains as a result of fragmentariness. Fragments are of 0.2÷0.3 μm size. It is possible to choose the boundary of primary grain against a background of fragment boundary in the individual fields. This fact and also the occasional disposition of circle pores of primary structures in relation of fragments allow the consider that the fragments have the origin fragmentary structural deformation and appears on the base of primary structure, but it does not occur at a result of wear and tear of products and consolidation of oxidization (Fig. 3b).

a)



b)

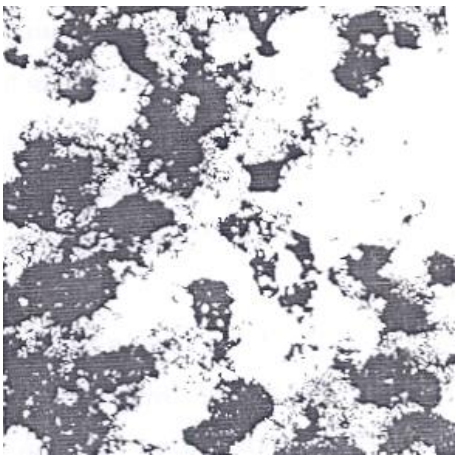


Fig. 3. The structural types of around boundary layers of chrome diffusion coatings after friction

Obtained structural characteristics show that if remarked oxidization processes are gathered in the most delicate surface layer, then the deformation processes are distributed up to 10 μm depths. The three structural types may prevail in the process of formation of layers. The main of them is moving deformation which allows finding out the second and third structural types. The second structural type may be considered as the beginning stage of the deformation of primary grain; and the second type may be considered as the stable structure. The first structural type is characteristic for the wear and tear fields. Fragmentary structure, on the chrome surface layer of coatings is subjected to the highest plastic deformation during friction.

The fragmentary base structure fact formed on the surface layer of diffusion coatings during friction shows the cyclic recurrence, temperature and hydrostatic pressure of process in the mutual contact influence places.

The greatest number of around-boundary layer of structure weakens the connection between the second structure and base of coating. The local moving deformation causes wear-and-tear and exfoliation of the second structure.

Conclusions

So, during the friction of chrome diffusion coatings the deformation processes result the formation of the second structures; they are on the depth of 10 μm and they are created by means of fragmentariness of the primary structure.

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Computer aided maintenance management of electronic equipment used in transport

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Key words: maintenance, reliability, routine inspections

Abstract
Electronic equipment used in transport operates under various conditions. Due to characteristic nature of their application, they should be highly reliable. This paper presents a methodology of optimising a bistable operation process of those systems factoring in economic factors, i.e. the funding allocated to routine inspections. Its practical application was also discussed, which would entail computer aided maintenance software.

Introduction

The issue of maintaining electronic equipment, particularly those used in transport is an important problem. This stems from the fact correct reliability and operating parameters have to be assured. Many renowned papers have already been written on the matter [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]. By carrying out an adequate reliability analysis of systems, their reliability structures are determined which provide correct reliability parameters. This applies both to the entire system [12, 13, 14, 15, 16], as well as its constitution elements, e.g. power supply [17, 18] and transmission media [19]). Due to this approach, the designed system becomes more reliable. It does not, however, assure high enough availability of the system. Hence, maintenance analysis has to be carried out taking account of selected operating properties of the systems (e.g.: failure rate, routine maintenance intensity) [20]. Findings of that analysis enable to fine-tune the maintenance strategy, including rationalisation of routine inspections and their length relative to requirements to those systems in respect of their availability in the transport process [21, 22, 23, 24]. The costs it generates are also factored in by the strategy [25, 26, 27].

Computer aided maintenance is the latest trend in managing maintenance. This solution could be used in the subsystem of maintaining electronic equipment used in transport. From the standpoint of travel security this is an exceptionally important issue. If applied, computer systems collect data (databases containing information about operation of given equipment) and then process them. This enables to draw conclusions about basic operating parameters. Thus, optimum decisions concerning operation process could be made (e.g.: routine inspections and their length, overhaul), which assured to maximise the end effects provided given base conditions were met. Among the effects were maximised availability, minimised repair times, optimised servicing intensity. In face of limited funding for maintenance, a decisional issue arises: how to maintain continuity of operations (system's availability) with restricted financial resources whilst assuring desired security level and meeting all objectives (e.g.: maximisation of operating parameters, cost-cutting, maximisation of financial efficacy). The answer is creating many computer programmes, which support decision making.

Bistable maintenance strategy maximising availability

The availability rate is given by:

$$K_g = \frac{T_m}{T_m + T_n} \tag{1}$$

where: T_m – mean correct operation time between failures, T_n – mean time to repair.

The given relation shows that the system can be in one of two states (Fig. 1):

- usage state (S_0);
- repair state (S_1).

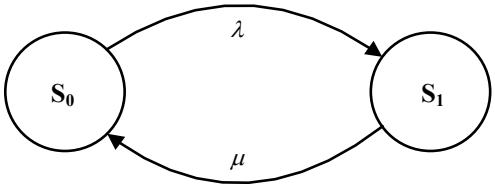

Fig. 1. Graph showing switching between usage and repair states; λ – failure rate, μ – repair rate

Through analysing electronic equipment operating in transport the following state were determined:

- usage state S_{00};
- repair state S_{10};
- I type inspection S_{01} (basic servicing required by specification);
- II type inspection S_{11} (extended servicing required by specification).

The graph in figure 2 illustrates switching between above states. Switching between states includes the coefficients:

- k_1 – I type inspection coefficient – determines linear relation between current I type inspection rate, and optimum I type inspection rate for which availability rate is maximum;
- k_2 – II type inspection coefficient – determines linear relation between current II type inspection rate, and optimum II type inspection rate for which availability rate is maximum.

An important issue occurring in practice, is limited funding allocated for routine inspections of electronic equipment used in transport, available to the user. Hence, the impact has to be determined of financial outlays allocated to routine inspections on availability rate of the system. Therefore, the C coefficient was introduced, which determined available financial resources allocated to I and II type inspections. Let us assume that:

- $C = 2$ for optimum I and II type inspection rates (K_g = max. for $\lambda_1 = \lambda_{1\text{optym}}$ and $\lambda_2 = \lambda_{2\text{optym}}$; because in equation (2) $k_1 \cdot C = 1$ and $k_2 \cdot C = 1$);
- $C = 0$ for I and II type inspection rates equal naught (no inspections; because in equation (2) $k_1 \cdot \lambda_{1\text{optym}} \cdot C = 0$ and $k_2 \cdot \lambda_{2\text{optym}} \cdot C = 0$).

By carrying out a mathematical analysis the following relation was obtained (2).

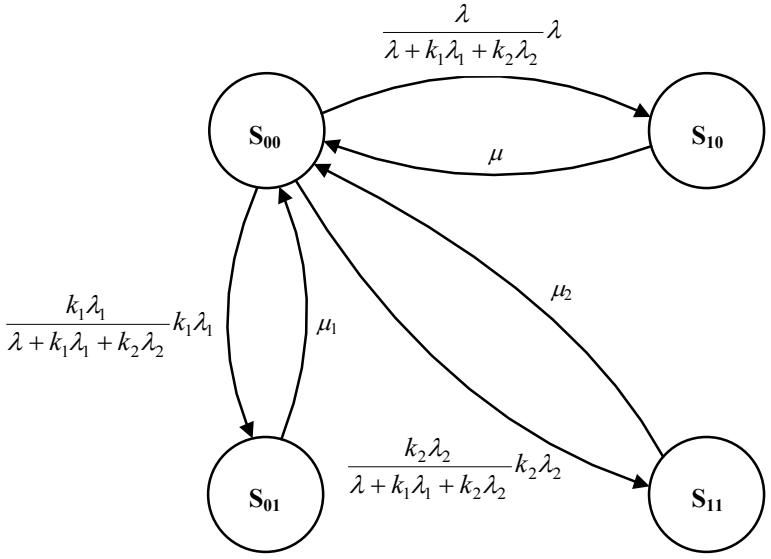

Fig. 2. Graph showing switching between usage state (S_{00}), repair state (S_{10}), I inspection state (S_{01}) and II inspection state (S_{11}); λ – failure rate, μ – repair rate, λ_1 – I type inspection rate, μ_1 – I type routine maintenance rate, λ_2 – II type inspection rate, μ_2 – II type routine maintenance rate, k_1 – I type inspection coefficient, k_2 – II type inspection coefficient

$$K_g = \frac{(\lambda + k_1\ \lambda_{1\text{optym}} C + k_2\ \lambda_{2\text{optym}} C)\ \mu\ \mu_1\ \mu_2}{(\lambda + k_1\lambda_{1\text{optym}} C + k_2\lambda_{2\text{optym}} C)\mu\mu_1\mu_2 + \lambda^2\mu_1\mu_2 + \left(k_1\lambda_{1\text{optym}} C\right)^2 \mu\mu_2 + \left(k_2\lambda_{2\text{optym}} C\right)^2 \mu\mu_1} \tag{2}$$

$$K_g = \frac{(\lambda + k_1\ \lambda_{1\text{optym}} C + (1-k_1)\lambda_{2\text{optym}} C)\ \mu\ \mu_1\ \mu_2}{\left[\lambda + k_1\lambda_{1\text{optym}} C + (1-k_1)\lambda_{2\text{optym}} C\right]\mu\mu_1\mu_2 + \lambda^2\mu_1\mu_2 + \left(k_1\lambda_{1\text{optym}} C\right)^2 \mu\mu_2 + \left[(1-k_1)\lambda_{2\text{optym}} C\right]^2 \mu\mu_1} \tag{3}$$

3D graphical representation of equation (2) is impossible due to three variables: k_1, k_2, C. Therefore, the following relation was used:

$$k_1 + k_2 = 1$$

and the following equation was obtained (3).

Example 1

Assumptions taken were:

- failure rate $\lambda = 1.2027 \cdot 10^{-5}$ [1/h] (representing system whose reliability is 0.9);
- repair rate $\mu = 0.0666$ [1/h] (representing repair time of 15 [h]);
- I type routine maintenance rate $\mu_1 = 0.5$ [1/h] (representing inspection time of 2 [h]);
- II type routine maintenance rate $\mu_2 = 0.1666$ [1/h] (representing inspection time of 6 [h]);
- I type inspection rate $\lambda_{1optym} = 2 \cdot 10^{-5}$ [1/h];
- II type inspection rate $\lambda_{2optym} = 6 \cdot 10^{-6}$ [1/h].

For the assumptions taken, a chart was obtained illustrated in figures 3 and 4.

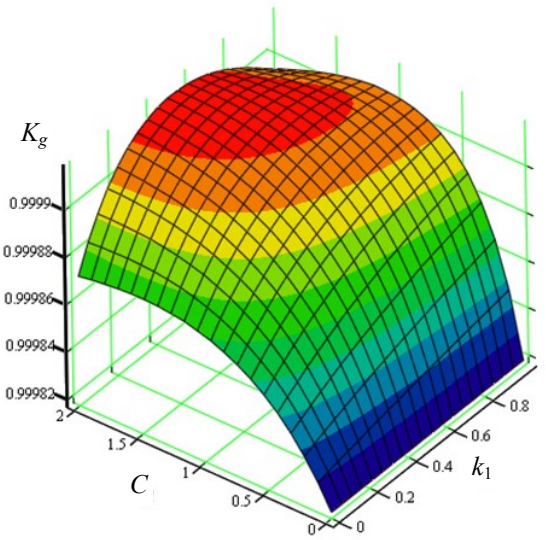

Fig. 3. Relation between availability rate K_g as function of I type inspection coefficient k_1 and financial outlays coefficient C (general view)

End of example 1.

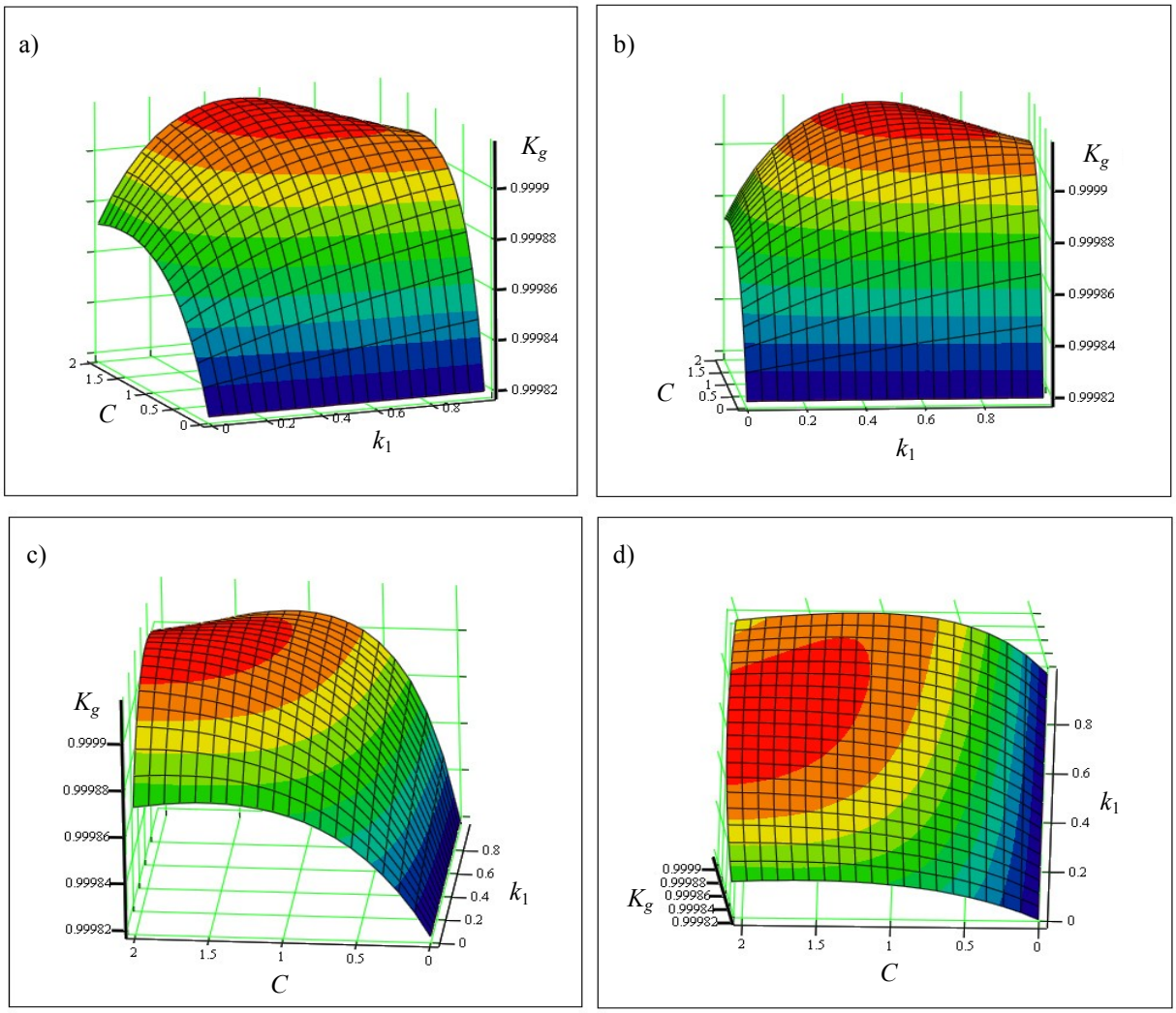

Fig. 4. Relation between availability rate K_g as function of I type inspection coefficient k_1 and financial outlays coefficient C: a, b – k_1 axis view, c, d – C axis view

By studying figures 3 and 4 the following could be concluded:

– availability rate K_g reaches its maximum for $C = 2$ and $k_1 = 0.5$. For lower C (lower financial outlays) K_g decreases;
– there is a non-linear relation between financial outlays coefficient C and inspection coefficient k_1. Therefore, in case of financial outlays lower than optimum to get the maximum K_g, one should determine new inspection rates for both types of inspections generating maximum availability rate.

Computer aided maintenance

In order to facilitate managing the maintenance and reliability process for users of electronic equipment used in transport, a programme has been developed: "Support of Maintenance Decisions in Transport Surveillance Systems" [27] (WDNETSN in short) (Fig. 5). Initial values:

– number of studied systems;
– time spent on studying systems;
– mean time to repair;
– mean time to completion of I type inspection;
– mean time to completion of II type inspection;
– financial outlays coefficient;
– number of elements damaged in studied system

and by using equations and relation given in the previous chapter, the programme determines the following:

– reliability of individual constitutive elements;
– reliability of the entire system;
– failure rate of individual constitutive elements;
– failure rate of the entire system;
– mean operating time of individual constitutive elements;
– availability rate of individual constitutive elements;
– availability rate of the entire system;
– for systems of mixed and parallel structure:
  • the likelihood function of system in state of full operational capability R_O;
  • the likelihood function of system in state of state of security threat Q_{ZBi};

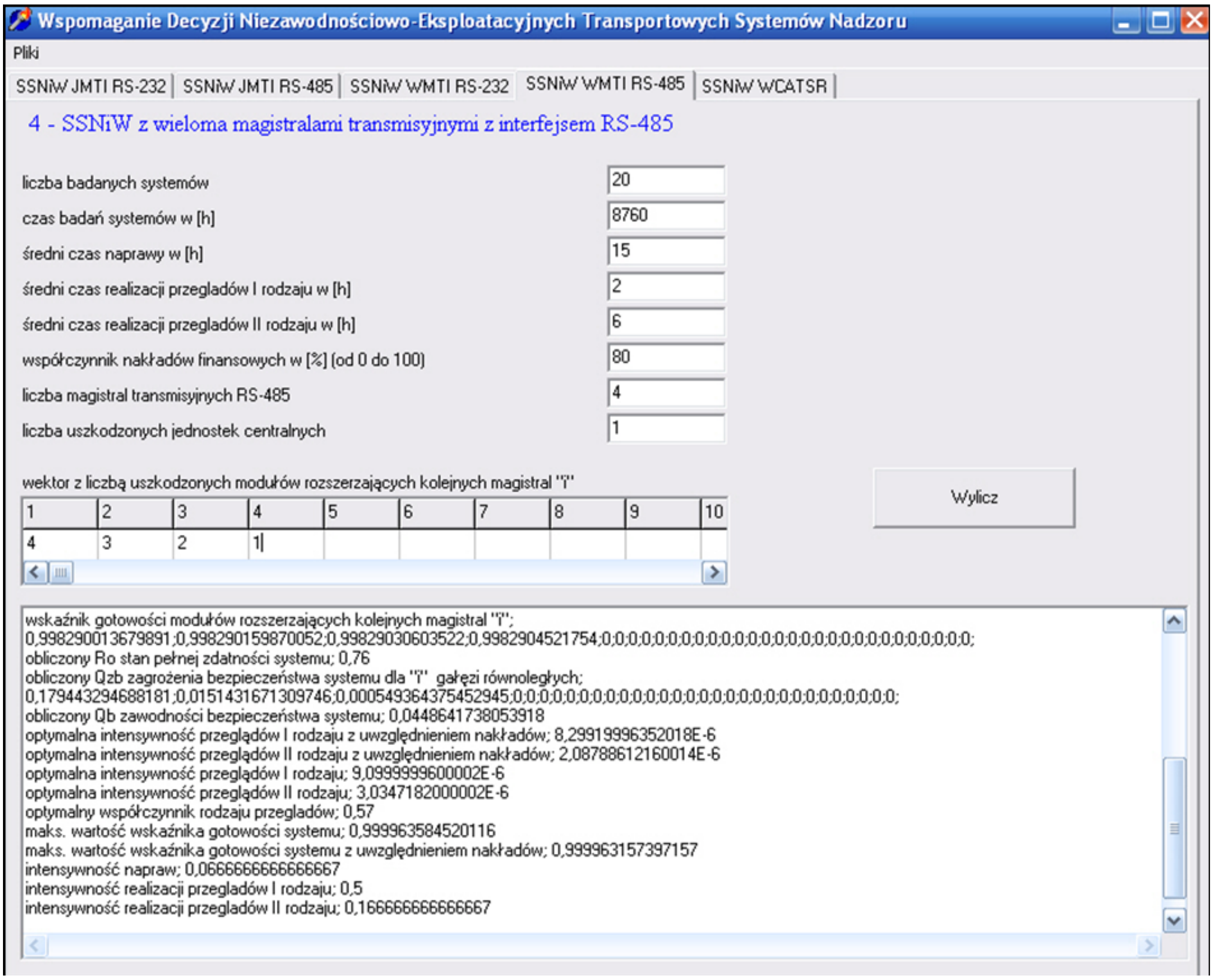

Fig. 5. Screenshot of "Support of Maintenance Decisions in Transport Surveillance Systems"

  - the likelihood function of system in state of failing security Q_B;
- repair rate;
- I type inspection rate;
- II type inspection rate;
- max. availability rate of the system;
- optimum I and II type inspection rates for max. availability rate of the system;
- optimum coefficient of inspection types;
- availability rate of the system including financial outlays;
- optimum I and II type inspection rates for availability rate of the system including financial outlays.

Screenshot in figure 5 gives a glance at the programme.

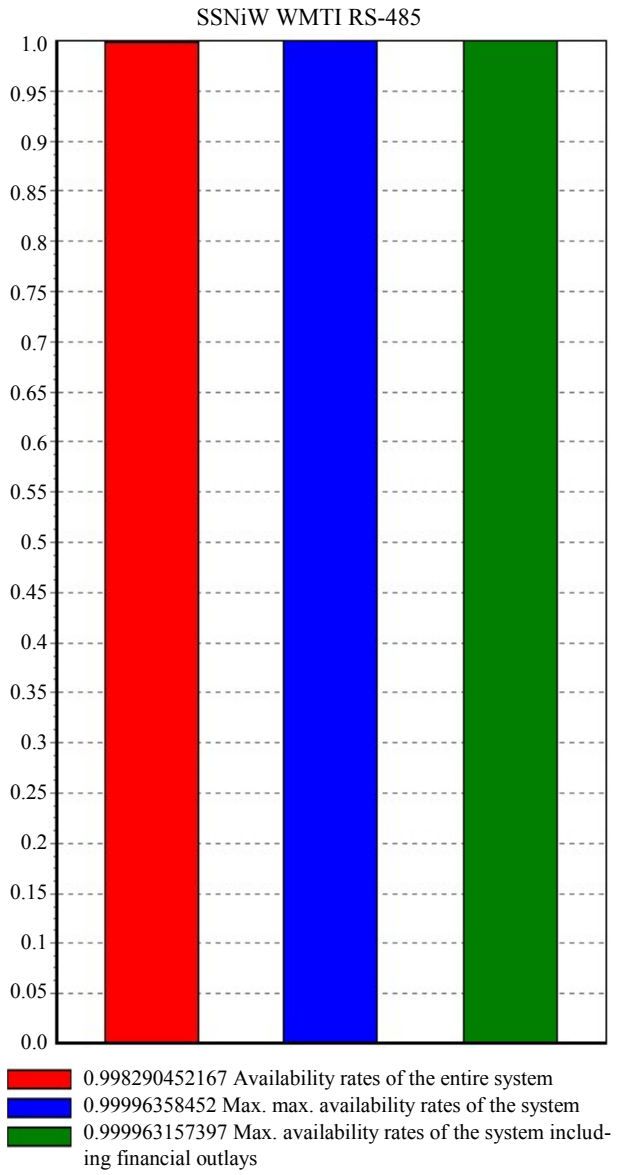

Fig. 6. Graphical representation of availability rates

Another function of the SMDTSS programme is visualisation of obtained results:

- comparison of all systems (Fig. 6):
  - availability rates of the entire system;
  - max. availability rates of the system;
  - availability rates of the system including financial outlays;
- comparison of likelihood function of system in following states, Fig. 7 (for systems of mixed and parallel structure):
  - full operational capability R_O;
  - security threat Q_{ZBi};
  - failing security Q_B.

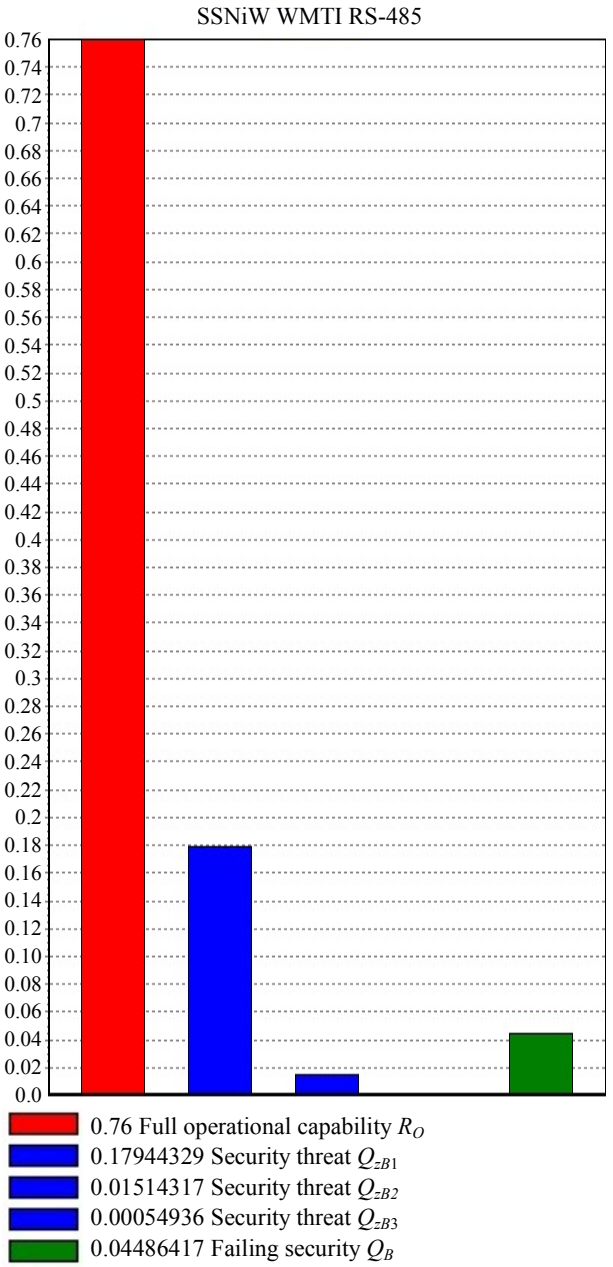

Fig. 7. Graphical representation of likelihood functions of the system in R_O, Q_{ZBi}, Q_B states

Conclusions

A method of optimising maintenance of electronic systems (for two types of routine inspections) was presented in this paper, which factors in selected reliability parameters (failure rate), operating parameters (repair rate, routine maintenance rate) and economic parameters (financial outlays on routine inspections). It enables to determine optimum routine inspection rates, provided the optimisation criterion is taken as maximisation of the availability rate.

In the author's computer application is used, among the others, the equation (3) which allows to determine analytically the values of intensity of periodic inspections for which the value of the avliability rate is maximal.

Presented computer application is being used as a learning aid by students at Faculty of Transport of Warsaw University of Technology (specialisation of Transport Telematics) and students at Faculty of Military Electronics of Warsaw Academy of Technology (specialisation of Security System Engineering). Hence they were able to acquaint themselves with reliability analysis and functional properties of different systems.

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Речные трамваи в общественном транспорте

Water-bus in the public transport

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Ключевые слова: речной трамвай, городской общественный транспорт, водный общественный транспорт

Резюме

Проблемы сбалансированного экономического развития касаются также и городского транспорта. Европейский Союз настаивает на создании устойчивой транспортной системы, в которой будет более эффективно функционировать общественный городской транспорт. В настоящее время в общественном городском транспорте не используются все возможные транспортные средства. Попытки введения водных транспортных средств в общественный транспорт не всегда заканчиваются успехом. Используемые решения не отвечают в полной мере требованиям, поставленным к пассажирским перевозкам.

В статье проанализированы основные технические и финансовые условия и приведены предложения, необходимые для функционирования водного общественного транспорта. Особое внимание в этих предложениях уделено щецинской агломерации.

Key words: water-bus, public transport, water public transport

Abstract

Problems of sustainable economic development also apply to urban transport. The European Union emphasizes the creation of a sustainable transport system in which public transport will function more efficiently. Currently not all possible means of transport are used in public transport. Attempt to introduce transport water means in public transport does not always have a successful result. Existing solutions do not fully meet the postulates requested in passenger transport.

The article analyzes the main technical and financial conditions and makes proposals necessary for the implementation of water public transport. Special attention in these proposals is paid to Szczecin agglomeration.

Введение

Растущие из года в год требования Европейского Союза (ЕС), в так называемых климатических пакетах, касающихся ограничения эмиссии CO_2, обязывают государства, входящие в состав ЕС, принимать решения, учитывающие критерии и факторы сбалансированного экономического развития [1]. Эта проблема касается также транспорта, генерирующего высокий уровень загрязнения воздуха. А зонами, которые характеризуются наибольшей концентрацией CO_2, являются городские агломерации. В их границах находится значительная концентрация транспортных средств, причем индивидуальный транспорт, в большей степени загрязняющий воздух, доминирует над общественным транспортом. Осознание этого факта должно способствовать развитию городских коммуникаций, основанных на общественных транспортных средствах. Пассажирские перевозки в общественном транспорте, в основном, обеспечиваются сухопутными транспортными средствами, которые включают в себя: наземные железные дороги, подземные железные дороги (пр. метрополитен), автобусы, трамваи

и троллейбусы. В агломерациях, насчитывающих несколько сотен тысяч жителей, в общественном транспорте, как правило, широко используются только автобусы и трамваи.

Ограничения динамики развития городского общественного транспорта возникают из-за недостаточного уровня удовлетворения требованиям пассажиров, касающихся качества транспортных услуг. Требования касаются комфорта, длительности и безопасности маршрутов, а также стоимости транспортной услуги [2]. Из результатов наблюдения на улицах городов (Москва, Варшава, Щецин) можно сделать вывод, что ожидания пассажиров, касающиеся качества перевозки, до сих пор лучше выполняет индивидуальный транспорт, чем общественный. Поэтому, общественный транспорт должен совершенствовать свои возможности путем создания привлекательных технических, организационных и экономических предложений. Решения следует искать в транспортных нишах, путем внедрения инноваций на рынке транспортных услуг городских коммуникаций. В агломерациях, которые располагают соответствующими акваториями, одним из предложений может быть попытка использования в городском транспорте пассажирских судов. Если сухопутное пространство городов разделено акваториями портов, то водные коммуникационные сообщения могут их соединять.

Обзор существующих решений водного городского транспорта

Под понятиями общественного транспорта подразумеваются такие виды транспорта, которые характеризуются регулярностью, всеобщей доступностью, определяемой чаще всего расписанием движения и безопасностью маршрутов [3].

Пассажирские суда, осуществляющие городские перевозки водным путем в литературе называются гидробусами, водными автобусами, речными трамваями [4]. Наиболее популярным названием, используемым в публикациях и разговорной речи, является «речной трамвай». В одном из определений [4] речной трамвай представлен как пассажирское судно, используемое для содержания водного транспорта и туризма в пределах городов и портов. Другое определение, более близкое к тематике городского общественного транспорта, говорит, что речной трамвай – это маленькое речное или портовое судно, перевозящее людей между разными пристанями городской агломерации с постоянным маршрутом и соответствующим расписанием движения. В отличие от паромных переправ, которые соединяют только два пункта, разделенных водным пространством, речной трамвай перемещается по назначенному маршруту.

В Польше имели и имеют место случаи применения речного трамвая в городских пассажирских перевозках в Быдгоще, Кракове, Варшаве и во Вроцлаве.

В Быдгоще судно «Bydgoszcz» (рис. 1) ходит по реке Брдзе с 2004 года. История судна начинается с 1913 года и за этот долгий период менялись как владельцы, так и его эксплуатационное назначение. В настоящее время судно ходит по туристическому маршруту, только по выходным, размещая на борту 24 человека. Скорость судна не превышает 10 км/ч.

Рис. 1. Судно «Bydgoszcz» на водах Брды [5]

О новом этапе развития водного транспорта в Быдгоще можно говорить в связи с вводом в эксплуатацию водных трамваев, работающих на солнечных батареях, «Słonecznik» (рис. 2) и «Słonecznik II». Эти суда, курсирующие по водам Брды, являются первыми пассажирскими речными судами в Польше, на которых основным источником энергии являются солнечные батареи. Генерированная этими батареями энергия накапливается в двух комплектах аккумуляторных батарей, емкости которых хватает на 10 часов плавания со скоростью 6 км /ч. Максимальная скорость передвижения судна – 12 км/ч. Высокую маневренность судну обеспечивают два кормовых азимутальных

Рис. 2. Судно «Słonecznik» в Быдгоще [6]

подруливающих устройства и гидравлический рулевой привод**.** Пассажировместимость судна составляет 30 мест. Каждое судно проходит свой маршрут шесть раз в день.

Краков гордится своим водным городским транспортом, осуществляющим рейсы по двум маршрутам с высокой периодичностью движения. Одно из судов ходит по городскому маршруту (рис. 3), а второе – по маршруту Краков – Тынец. Поскольку «Краковский речной трамвай» может забрать на борт только 12 пассажиров, его нельзя отнести к судам городского общественного транспорта.

Рис. 3. «Краковский водный трамвай» [7]

Во Вроцлаве интенсивное развитие водного транспорта начиналось с судна «Kaczuszka» (рис. 4), которое в прошлом функционировало как речной трамвай. В настоящее время «Kaczuszka» ходит по туристическому маршруту, базируясь на пристани Звежинецка во Вроцлаве.

Рис. 4. «Kaczuszka» на маршруте рейса [8]

В Варшаве также используется свой речной трамвай. Судно 3–4 раза в день ходит по маршруту Подзамче – Понятовский – Ципель – Подзамче и называется «Generał Kutrzeba». Это судно на польских внутренних водах появилось в 2005 году. Оно строилось под надзором

Рис. 5. Речной трамвай «Generał Kutrzeba» [9]

Польского Реестра Судов. В 2006 году было протестировано на водах Ногату в Мальборке. Благодаря двигателям мощностью 2 × 120 кВт, судно развивает максимальную скорость 33 км/ч, а экономическую – 17 км/ч. В его закрытых и открытых помещениях могут одновременно находиться в общей сложности 110 пассажиров, при наличии 52 сидячих мест.

Данный обзор городских агломераций, в которых использовались или используются речные трамваи, указывает на недостаток эффективных решений основных проблем городского общественного транспорта. В Быдгоще, несмотря на внедрение современных технологий при создании судов, скорость их движения невысока, что не соответствует требуемым значениям этого параметра для использования этих судов в городских пассажирских перевозках. Краковские речные трамваи, в связи с очень маленьким количеством пассажирских мест, трудно зачислить к средствам городского общественного транспорта, предназначенного для большого количества пассажиров. Вроцлавский речной трамвай обслуживает туристические пассажирские перевозки.

Практически, только варшавское решение отвечает основным требованиям, поставленным перед средствами городского общественного транспорта, как по скорости, так и по количеству пассажирских мест. Однако, в данном решении тоже есть недостатки:

- сезонность предоставляемых услуг,
- небольшое количество маршрутов,
- небольшая частота рейсов,
- как правило, небольшая скорость,
- высокие цены на билеты.

Поэтому, важным является поиск концепции развития водного трамвая, выполняющего основные требования, поставленные перед городским общественным транспортом.

Требования, необходимые для функционирования водного городского транспорта

Использование речного трамвая в городском общественном транспорте должно быть обусловлено потребностью в его услугах, как в транспортном средстве. Он должен быть конкурентоспособным по отношению к индивидуальным перевозкам, а также общественным, осуществляемым трамваями и автобусами. Конкурентоспособность должна вытекать, прежде всего, из возможности длительного переезда, высокой скорости движения, большой

пассажировместимости и комфорта переезда, а также, его стоимости и безопасности. Все эти требования создают группу, так называемых, перевозочных признаков (рис. 6), отнесенных к городскому общественному транспорту.

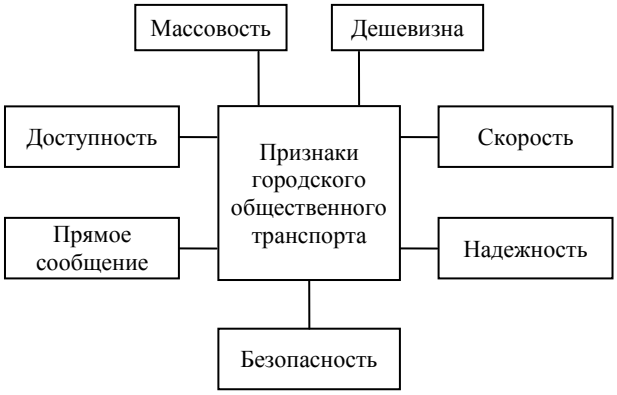

Рис. 6. Перевозочные признаки городского общественного транспорта [2]

Важность этих основных признаков, определяющих качество городского общественного транспорта, не одинакова. Нельзя установить одну обязывающую шкалу признаков, так как она может вытекать из существующих на рынке условий функционирования городского общественного транспорта. Иерархию признаков следует определять систематически, через маркетинговое исследование требований к перевозкам. В большинстве таких исследований не рассматриваются требования к безопасности, поскольку, они бесспорно наиболее важные по сравнению с остальными требованиям.

Чтобы осуществлять перевозку пассажиров, современный речной трамвай должен развивать среднюю скорость, сравнимую с наземными транспортными средствами. Легковые автомобили перемещаются по городу со средней скоростью 35 км/ч. Скорость движения средств городского общественного транспорта следующая [10]: наземной железной дороги – 40–50 км/ч, метрополитенов – 36 км/ч, автобусов – 22–25 км/ч, трамваев – 25 км/ч. Таким образом, средняя скорость речного трамвая должна составлять 25–30 км/ч. Кроме того, вопреки некоторым мнениям, речной трамвай не является городским пассажирским туристическим судном. Кроме развиваемой высокой скорости, он должен быть массовым транспортным средством, т.е. обеспечивать большому количеству пассажиров сидячие и стоячие места, быть удобным, а также давать возможность быстрого перемещения пассажиров между судном и причалом, что непосредственно влияет на время и безопасность перевозки. Речной трамвай должен располагать несколькими «входами и выходами», подобно наземным транспортным средствам. Системы швартовки речного трамвая должны ему обеспечивать быстрое и автоматическое причаливание и отчаливание от берега.

Наиболее близкой к этим требованиям является концепция речного трамвая, основанного на многокорпусном решении (рис. 7) типа катамаран (а), который можно эксплуатировать на мелководье, или судно типа Swath (б), которое может работать на глубоких водах.

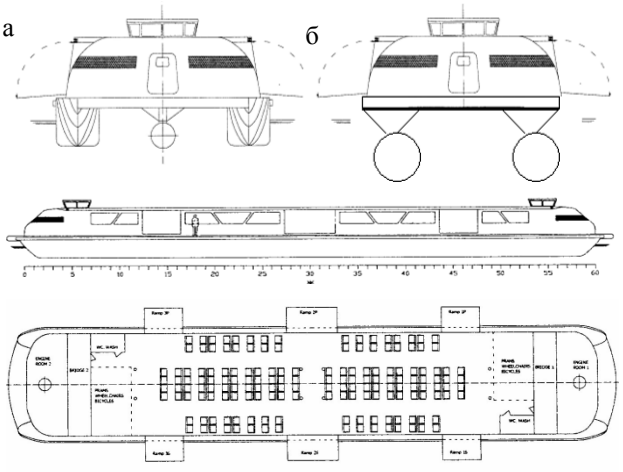

Рис. 7. Многокорпусный речной трамвай; вид спереди, вид сбоку, вид на пассажирскую палубу [11]

В представленном решении основные размеры трамвая составляют:

- длина – 45,0 м,
- ширина – 9,0 м,
- осадка – 1,0–1,5 м,
- число перевозимых пассажиров – приблизительно 200 человек.

Многокорпусное решение позволяет судну развивать скорость от 30 до 40 км/ч без одновременного волнообразования, разрушающего берега акватории.

При расчете экономической эффективности данного или другого предложения, решающей о его использовании в городском общественном транспорте, необходимо учитывать затраты на эксплуатацию транспортных средств, величину бюджетной дотации, спрос на такие перевозочные услуги, стоимость проезда, а также доходы от продажи билетов. Схему типичного финансового потока в системах городского общественного транспорта демонстрирует рисунок 8.

Таким образом, уровень цен на услуги городского общественного водного транспорта будет зависеть от величины дотации Горсовета,

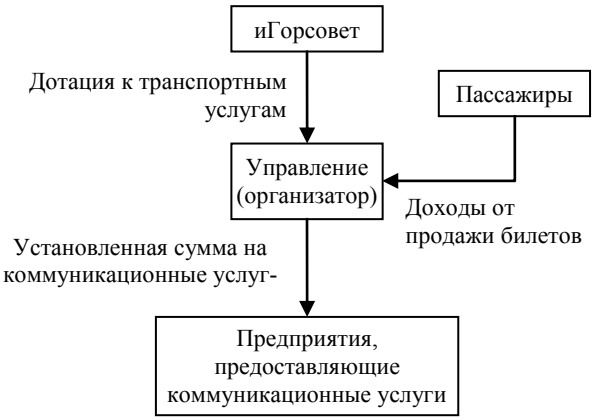

Рис. 8. Схема типичного финансового потока в системе городского общественного транспорта [2]

а также от доходов, полученных от продажи билетов. Стоимость билетов на речные трамваи должна быть сопоставима со стоимостью билетов на другие виды городского общественного транспорта. Доля дотации в общих доходах перевозчиков, как правило, колеблется от 35 до 50%. А спрос на транспортные услуги, который влияет на доходы от продажи билетов, прежде всего, зависит от выбранных коммуникационных маршрутов. Эти маршруты необходимо составлять учитывая районы со значительной плотностью населения, рассчитывая на большое количество потенциальных пассажиров.

Так же, как и в наземном транспорте, продолжительность маршрутов водного общественного транспорта предопределяет доступность услуг. Параметром доступности является отношение между суммарной продолжительностью маршрутов и площадью обслуживаемой населенной территории. В связи с этим, можно сделать вывод, что большую доступность и эффективность в использовании водного городского общественного транспорта, представляют те агломерации, в которых можно создать целую сеть водных маршрутов.

Водный транспорт в щецинской агломерации

Вышеперечисленные требования указывают, что к введению данных водных транспортных решений на территории Польши приспособлена щецинская агломерация. Часть ее территории включает водный узел реки Одра, который располагает особыми демографическими и коммуникационными условиями.

Число жителей Щецина составляет 377 362 человека (состояние на 16.12.2012 г.), а городская территория равна 300, 83 км^2. Функционально-пространственная структура города сформировалась в естественных условиях возле устья реки Одра. Центр города и 60% его структуры расположены по левой стороне реки. В районах правобережья сосредоточено примерно 25% жителей [2]. Обе части города разделяет широкая долина реки Одра (Мендзыодже). В этой долине находится значительный промышленный потенциал с наибольшим скоплением рабочих мест. Современные урбанизационные процессы вызывают динамическое разрастание города в западном и юго–западном направлениях. Географическое расположение Щецина вынуждает жителей города перемещаться между правым и левым берегами дельты реки Одра. В непосредственной близости к реке сосредоточено 32% жителей. Щецинская агломерация соединена дорожными и железнодорожными маршрутами. Протяженность этих маршрутов на отрезках, проходящих через водный узел, составляет от 10 до 20 км. Соответствующие им водные маршруты длиннее на 25–50%. Поэтому, желательна высокая скорость речного трамвая, чтобы, в сравнении с наземным транспортом, время перемещения пассажиров было сопоставимо. Дополнительным аргументом введения на щецинских акваториях речного трамвая является тот факт, что возможно расширение территории обслуживания. Возможно также обслуживание соседних прибрежных местностей, таких как Грыфино, Дольна Одра и Полице, которые в будущем могут стать частью щецинской мегаполисной области (рис. 9).

Рис. 9. Щецинский Водный Узел

Транспортные маршруты, проходящие через акваторию Щецинского Водного Узла и соединяющие ранее перечисленные местности, имели бы длину примерно 50 км.

По мере отдаления от центра мегаполисной области, растет роль индивидуального транспорта, согласно принципу ошибочного нескончаемого круга, который иллюстрирует рисунок 10.

Рис. 10. Принцип ошибочного нескончаемого круга [2]

Речной трамвай, перемещающийся между Полицами и Грыфинэм, увеличил бы доступность услуг общественного транспорта для жителей этого района и использование естественной инфраструктуры водного транспорта. Мог бы послужить также ограничивающим фактором в рассредоточении жилых районов щецинской метрополии.

Выводы

Проведенные во многих странах анализы показывают, что в случае применения радикальных мер для решения транспортных проблем, связанных со сбалансированным экономическим развитием, эффект можно ожидать не раньше, чем через 25–35 лет.

Однако, развитие внутреннего водного транспорта, как компонента городского общественного транспорта, совместимо с общей целью современной транспортной политики.

Любые другие решения несут в себе большие расходы, к которым можно зачислить инфраструктурные инвестиции, например, мостовые переправы, а также могут оказывать усиленное влияние на окружающую среду, в результате увеличения передвижения наземных транспортных средств.

Единственным недостатком водного городского общественного транспорта, который нельзя ликвидировать, является его сезонность. В зимнее время возможно обледенение акваторий, через которые проходят коммуникационные маршруты. Зато влияние метеорологических условий на пассажиров можно ограничить, применяя в речных трамваях закрытые и кондиционированные пассажирские помещения.

Тем не менее, все решения, касающиеся пассажирских перевозок судами внутреннего плавания, по городским и внегородским акваториям, служат рекламе урбанизированных и ландшафтных районов, и тем самым, требуют безусловной поддержки со стороны местных органов власти.

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The use of the simulator a tool for training staff LNG terminals

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Key words: LNG, education, simulator, training

Abstract

Some possibilities of using computer simulation methods for LNG terminals operators have been presented in this article. A simulator in a training system is a very crucial tool because of practical application of the gained skills and knowledge. Maritime University is the only educational centre in Poland having the teaching base built on modern technical solutions allowing to train operators for LNG terminals.

Introduction

Having in mind the forecast for a considerable increase of natural gas consumption, the large potential to meet its daily requirements is attributed to LNG (*Liquefied Natural Gas*). It is produced from natural gas, after the removal of contamination and heavy hydrocarbons and is next condensed in the atmospheric pressure by means of lowering the temperature to – 160°C. The volume of LNG is approximately equal to 1/600 of natural gas volume in normal conditions, which allows for a relatively cheap transport at long distances. Natural gas transport by means of land installations is impossible and non – profitable but in the condensed form it can be shipped or transported by means of special LNG autocisterns at shorter distances [1].

Maritime University has developed its training base that allows present and future marine crews and land staff to gain knowledge and necessary qualifications and skills in that field.

That has been the answer to the dynamic development of Polish marine economy with safe liquid and gas fuels transport in mind. It is done, among others, by means of the building of condensed gases terminal in Świnoujście.

At present, the best way to improve qualifications any staff is training on different types of simulators. This type of training provides maximum real situations at minimum consequences due to made mistakes / errors. Proper preparation for the job "to be done" for the LNG terminal service is simply essential. Yet, there is LNG Operator Terminals Simulator [OTS] which plays an important role in the training process of the staff responsible for gas receiving, re-gasification and gas supply service to land network. It belongs to Polskie LNG and system operation training or system procedure supervision training are performed on it, at Maritime University of Szczecin.

LNG Terminal General Simulator simulates a standard LNG terminal and comprises the infrastructure for discharging of units transporting LNG, devices for LNG gas storing, boil off gas installations, degasification system and gas supply service.

The schema is presented in figure 1.

Systems simulated on the LNG operator training simulator:

1. Discharging system – from the ship – consists of 3 unloading arms: an arm for the boil off gas return [BOG] to the ship, an unloading arm, a boil off gas arm and a desuperheater for the gas return installation.
2. LNG Storing system, comprising 3 storing tanks equipped with 9 low pressure pumps (LP pumps).
3. Boil off gas system management comprising a desuperheater on the suction side of compressors, a separator on the suction side of compressors, a low pressure tank for condensate, 3 boil off gas compressors, a recondenser and a desuperheater.

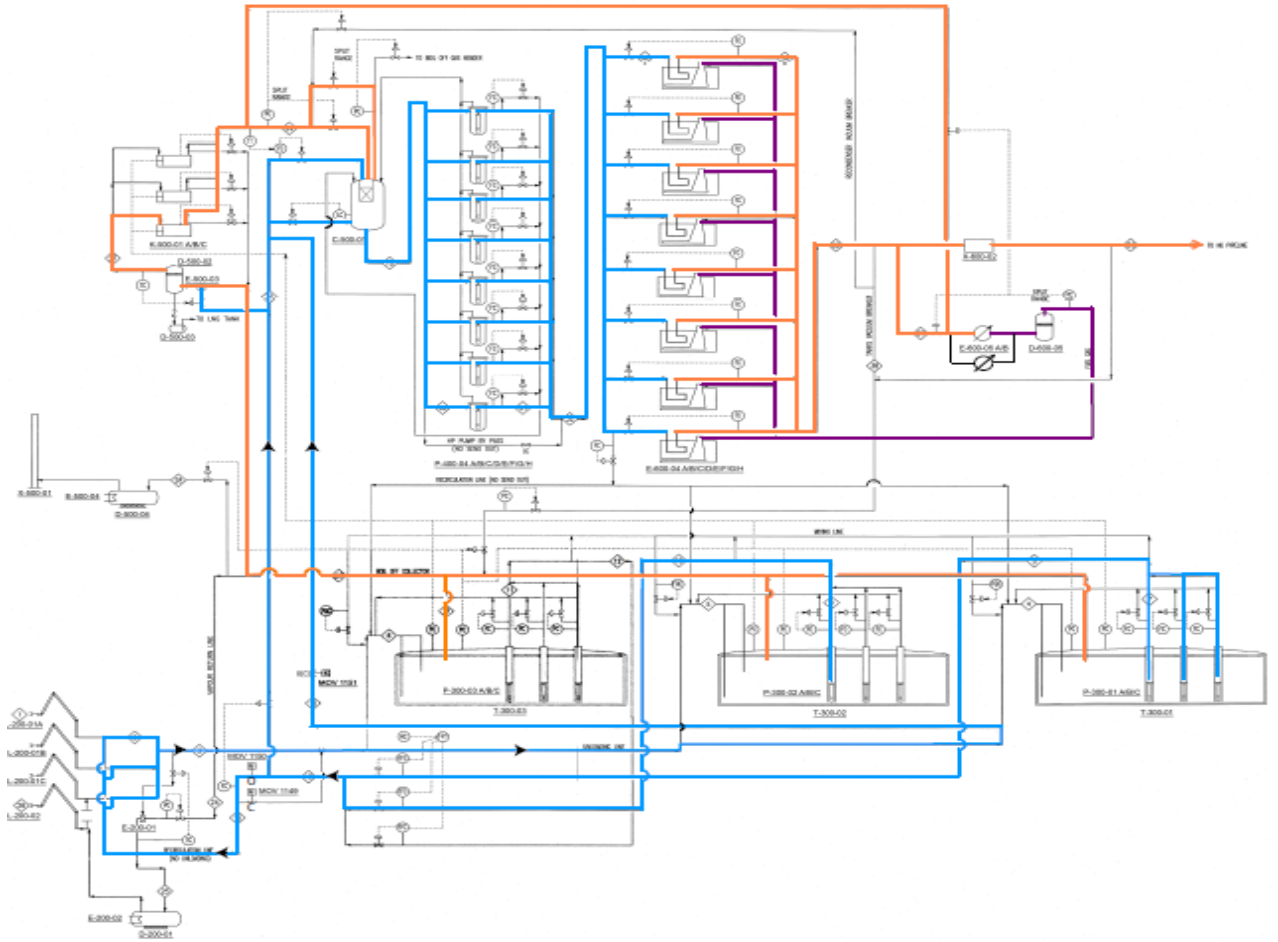

Fig. 1. OTS simulator systems schema

4. Dispatch system comprising: 8 high pressure dispatch pumps (HP pumps), 8 regasifiers SCV (Submerged Combustion Vapouriser – they burn the boil off gas in order to get necessary heat for LNG regasification), gas fuel installation equipped with two preheaters and a separator.
5. Exhaust system comprising a tank for the condensate from the exhaust and a ventilation stack.

The simulator works based on highly real dynamic simulations platform that has been provided by a set of well developed technological components and libraries based on fundamental technical principles.

Training supported by the simulator is created on scenarios and virtual environment which allows the trainees to get to know typical and exceptional situations that may happen during the operation in a relatively short time, even before starting of the operation. The trainees have a choice of many programmed scenarios. After the start of the simulator, the training participant can remotely begin one of the procedures (for example start, shut down, bypass) or respond to one or many alarms signalling deviation of parameters from normal values.

The platform also contains special tools for the instructors dealing with the training to change one or a few working parameters, to generate disturbances (for example stop or emergency shut off of a device, introduction of deviation for a sensor indication etc.). These operations allow to check how the trainees manage some problems in non-standard situations.

There are 4 monitors in use by the LNG OTS and each of them shows the following information (Fig. 2):

Screen 1 – graphic presentation of the terminal (no change possible) (Fig. 3);

Screen 2 – list of alarms, graphic elements of Human Machine Interface, specific screens or front panel (depending on the operator's choice);

Screen 3 – main tool bar, graphic elements of Human Machine Interface, front panel, trend screens (Fig. 4) (depending on the operator's choice);

Screen 4 – status and alarm line, graphic elements of Human Machine Interface and one front panel (depending on the operator's choice).

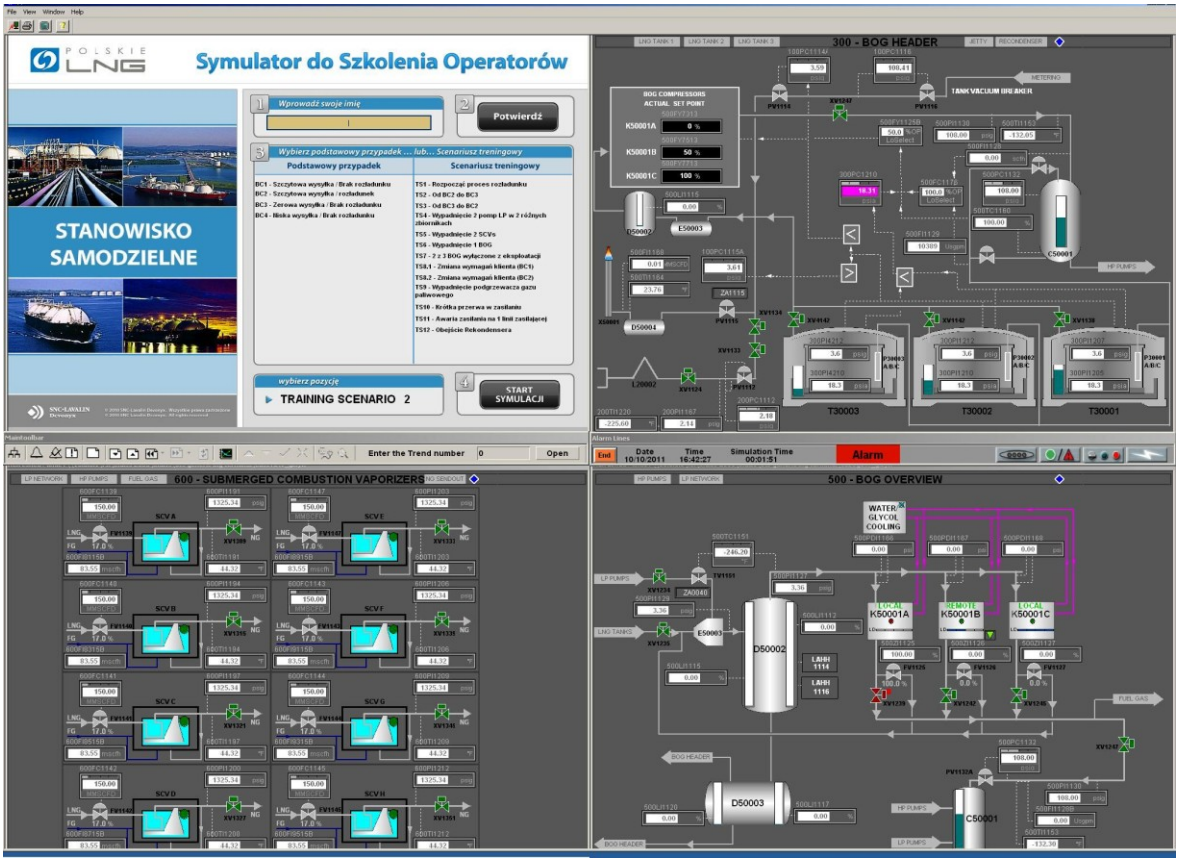

Fig. 2. Operational screens of the simulator [3]

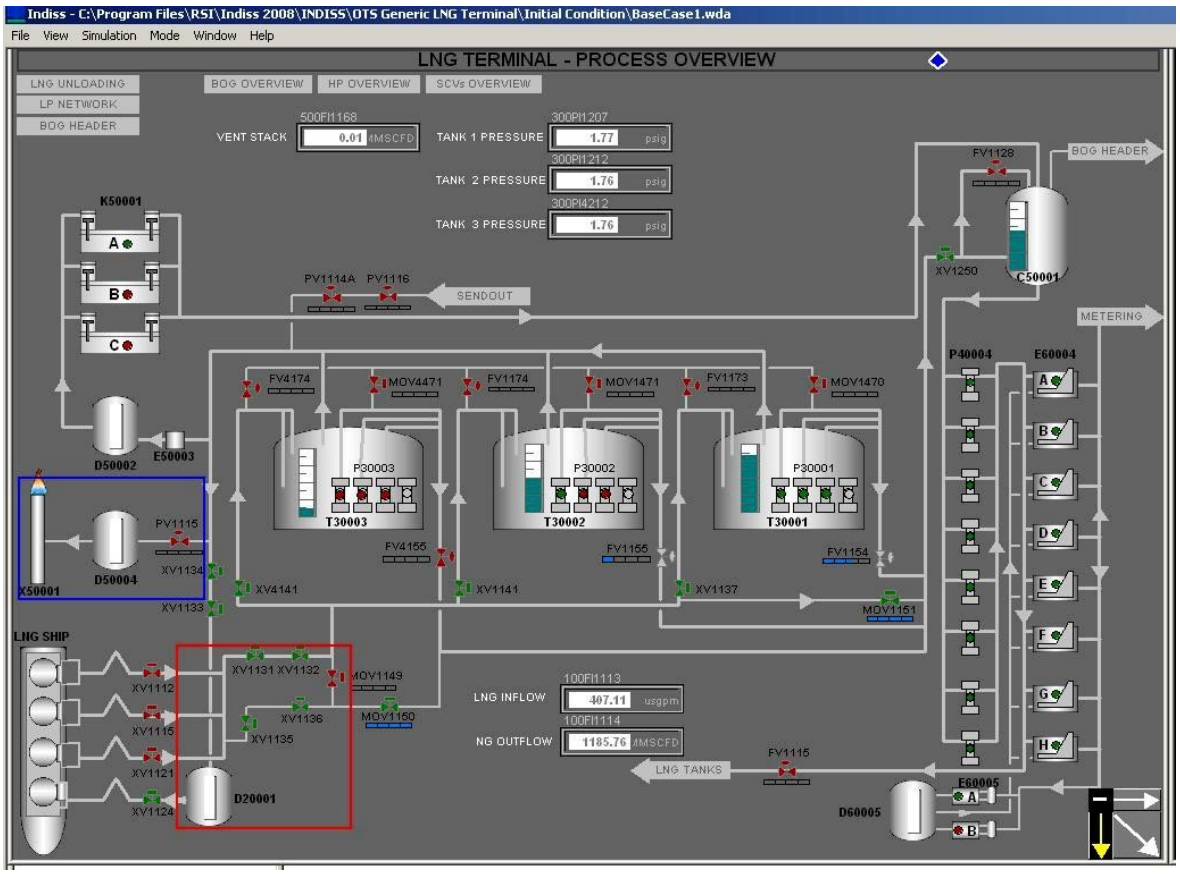

Fig. 3. Schema of the terminal system

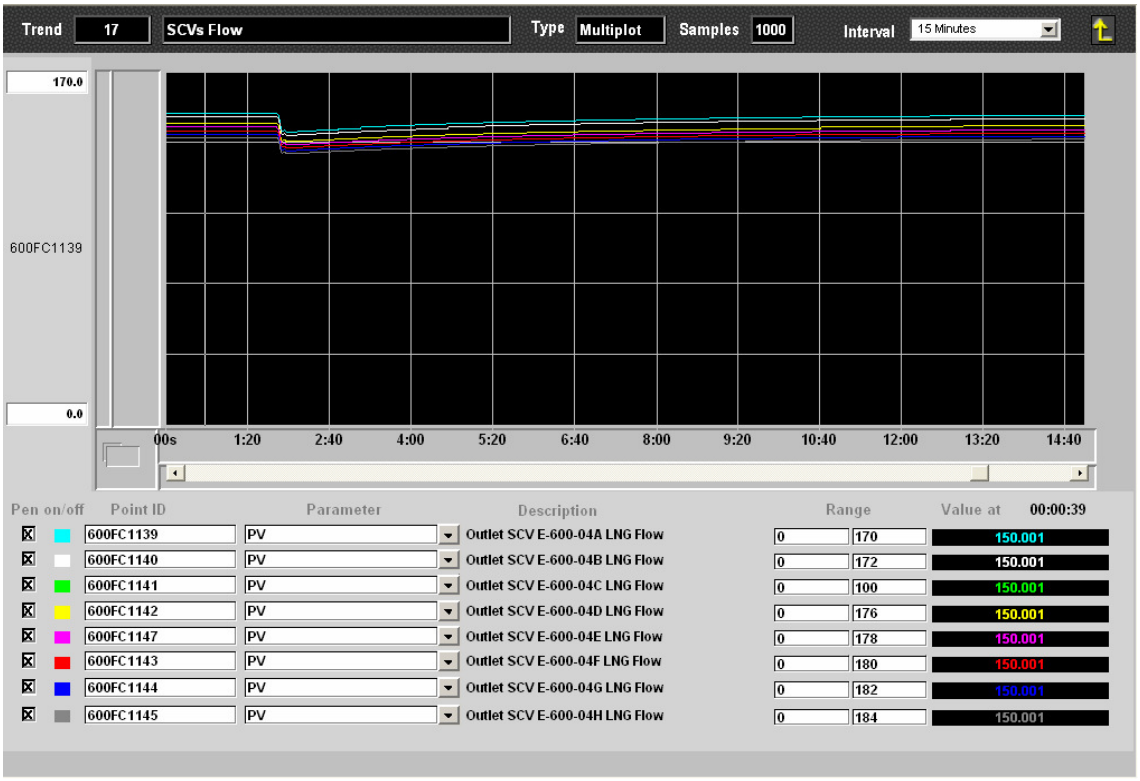

Fig. 4. Trend displays present values of process variables against the selected time axis

An example of a view of operational screens is presented in (Fig. 2).

In order to create real training conditions, for the interaction of simulated processes in the simulator, Honeywell Process Knowledge System (PKS) Experion emulation of the following interface types has been applied:

1. Fifty two pages of graphic processes (Distributed Control System – DCS) for simulated processes.
2. Eight front panel of the device giving the possibility to access working parameters indications (process values), controls (adjustment, operating modes etc.), valves (open/closed, propulsion) and engines (shut down, start).
3. Nineteen defined ready trends that meet training scenarios goals.
4. Three specific screens allowing to get access to visualized LNG ship systems, normal/critical situations and devices controlled from the object.
5. Thirty four screens of Emergency Shut Down – (ESD) system.
6. Alarm list with the possibility of acknowledging them.

Basic cases and training scenarios:

OTS libraries are based on typical cases, that means operating conditions in a fixed time. The following instances have been considered as the a/m:

1. Top dispatch ability / no loading of the ship.
2. Top dispatch ability with unloading of the ship.
3. Zero dispatch ability / no loading of the ship.
4. Low dispatch ability / no loading of the ship.

Having in mind basic cases, the following training scenarios have been worked out, including all elements and procedures, which are necessary for correct service of the handling infrastructure.

1. Terminal changeover from top dispatch ability with discharging of the ship to zero dispatch ability / unloading of the ship.
2. Terminal changeover from zero dispatch ability and no discharging of the ship to top dispatch ability with discharging of the ship.
3. Damage to two SCV regasifiers.
4. Damage to one boil off gas [BOG] compressor.
5. Discharging operations while 2 from 3 compressors are non – operational.
6. Dispatch mixture adjustment, in order to consider the required increase of High Heating Value [HHV].
7. Dispatch mixture adjustment, in order to consider the required decrease of High Heating Value [HHV].
8. Terminal changeover to low ability of gas dispatch with no discharging of the ship after the fuel gas preheater damage.

Fig. 5. Tasks assessment screen

9. Restarting of the terminal operation after a short power supply breakdown.
10. Staring the discharging process of a LNG tanker.
11. Power supply breakdown on one supply line of the electric power.
12. Recondenser bypass and maintenance of terminal shipment ability.
13. Two low pressure pumps damage in two different LNG tanks.

Assessment

There is an application allowing for automatic training results assessment in the simulator software after the trainee completes the task. The system counts the working time and presents the exercise time, time of activities not connected with the task and finally it gives the score in numbers (Fig. 5). The rule is, that the lower the score, the higher the note because it shows the execution of activities strictly connected with the simulated situation. It is all connected with the fact, that there is strictly determined time for the task execution for all scenarios and it permits the operator to assess the tasks exactly after each one has been completed.

Conclusions

The use of the simulator as a tool for training staff connected with LNG shipment is a key issue, due to practical application of acquired skills. Practice on the most corresponding to reality object with the possibility of supplying scenarios based on used at work procedures, tools and probable emergency situations allows the trainees to perform technological operations safely and learn from their mistakes without any influence on reality.

It is difficult to estimate how much the training on computer simulators improves safety, yet most terminals are equipped with simulators being exact copies of real systems, where new or emergency operations are tested. It permits to prepare terminal crew to possible situations that can happen during LNG terminals operation.

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