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Certain issues to minimize the human factor impact in transportation security

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Abstract. Aviation security as a topical area of scientific research is marked contrast to other application tasks of security sector. The specific nature aims at dealing with research objects that differ in considerable uncertainty of identification and description. In such a case, the requirements for aviation security systems are constantly becoming more complex, and the methodology of scientific research on security issues lags far behind the common trend of civil aviation development.

In the last few years, the trend to improve aviation security management systems in transportation industry has become a transition from classical schemes of regulatory management to schemes of computer-assisted management using procedures with the challenge of reducing the human factor. In fact, the human factor is not the only criterion for management in such systems. We can identify a number of factors that reduce the effectiveness of security management in the current system, and their impact is not fully investigated. A system analysis of these factors shows that each of them is not only related to the human factor, but the parameters of these factors’ influence on the management efficiency are largely determined by the human component. In this case, the human factor becomes the main criterion for optimal aviation security management. There is a problem of minimizing the negative impact of the human factor on aviation security management procedures. The authors of this work offer and study an original approach to solving this problem.

KEYWORDS: SECURITY, AVIATION SECURITY, AUTOMATED MANAGEMENT, MINIMIZATION OF THE HUMAN FACTOR.

The human factor (HF) in the field of security, especially in the field of aviation security (AS), is purely negative, and it is clear that it cannot be excluded. The aviation security management system, being the ergatic system, has a superior human component. The overall level of aviation security is largely determined by the level of personnel’s professional training and adequate results of their professional activities, even if there is a developed system of the object’s protection equipment. In-depth studies of the human factor in security show the negative impact of personnel on security parameters [1].

When switching to AS management in modern security systems, the task is to minimize the human factor and replace human impact on security processes with automated procedures without human participation.

The authors consider this approach as inappropriate for the following reasons.

1. Fully automated security systems are utopian in some sense, since any automation involves almost complete algorithmization of the procedures that implement it. Most processes are difficult to formally describe and algorithmize in aviation security, and the tasks to be solved are poorly formalized and poorly structured.

2. The proportion of the human factor in implementing security procedures are notably increasing to the extent that security systems develop and become more complex. Hence, there is a rather serious contradiction between the human factor and the problem of forming and using a complex of technical means in a real situation, where minimizing the human factor is hardly an option.

3. Mud-slinging a person as the weakest unit is crucially ineligible, because there is a wide class of tasks, processes, procedures, where a person (specialist), and only he, has essential advantages compared with technology.

In other words, the question should not be about minimizing the human factor, but about a significant change in the meaning and content of the human factor concept (Picture 1).

We can select the personality factor (PF) from the human factor concept, in other words, everything related to the characteristics of a person. In this part, the study of the HF consists of strengths and weaknesses of a specialist as a participant in the production process, with the consequent limitation of his participation in accordance with professional capabilities.

In the second part, you can concentrate on what is related to technology and its interaction with a specialist. Here the issue is whether the mutual adaptation of human and technical parameters to the conditions and tasks are solved within the framework of AS management.

We wish to draw attention to the third aspect, which in modern works on the human factor remains outside the scope of the study. During production operations in progress, the personnel of aviation organizations often exceeds the defined activity algorithm, guided not necessarily by any negative intent. Mostly on the contrary, in order to improve the efficiency of their work, the personnel makes while attractive decisions that can lead to highly negative results, up to an aviation accident with disastrous consequences. In this case, the personnel of the aviation organization involved in aviation security becomes a source of danger and is able to bring the situation with the object of study out of balance, which is manifested, at least, through deviations from the requirements for aviation security to the object.

In this case, there is a task to manage these deviations in order to minimize them, and the control parameter becomes a threat from the aviation organization’s personnel in relation to the safety of the object. This is now the most urgent and timely task.

There is proposed an innovative approach, focusing on the following. The main problem of the human factor’s study is the lack of opportunities to unify the parameters of the object of study, determined by the insurmountable complexity of the human component. It is enough to say that today there is no human (operator) model that is sufficiently adequate from a practical point of view. The author puts forward the following hypothesis to solve this problem: it is proposed to consider the human factor as a complex system in terms of system engineering, consisting of many elements, each of which represents a human operator, whose functions are different, but which are united by a single goal of professional activity. In this case, the human factor can be considered as a certain threat, which becomes comparable to the threats defined in the intruder model [2].

From the point of view of aviation security, it is proposed to consider the human (personal) factor as an unavoidable evil, excluding the useful component, and all its negative manifestations are classified as security threats. In this case, the methodological apparatus developed for the protection of transport infrastructure objects can be applied to the study of the human factor in order to reduce and / or exclude its influence in aviation security, i.e. the well-known formula begins to work: detection-reflection-elimination.

The personnel threat (PT) in aviation security is a state of inadequacy of the operator’s professional readiness and the parameters of the situation in the security system defined by the limiting level of psychophysiological parameters of the person, allowing the occurrence of negative events.

As a result, a new situation emerges when it is necessary to minimize not the human factor, but the task is to regulate the negative influence of the aviation organization’s personnel on the procedures for performing production activities, considering this influence as a threat to the object’s security. In this case, they change approaches to solving the problem and research methods.

The personnel threat is not always a potential event. These threats are quite often implemented, manifesting as negative results of the aviation specialist’s activity, which can be an act of unlawful interference (AUI) or even a terrorist act. Scientific research of personnel threats is aimed at developing and implementing a special
methodology for working out such threats according to the formula “detection-reflection-elimination”, i.e. threats to personnel are included on equal terms in the set of potential threats to the transport infrastructure object.

Personnel threats as threats to airport security are implemented in the form of unauthorized interference in aviation security procedures. This means that in the course of their professional activities, aviation security personnel perform certain actions that are not provided for by their functional responsibilities and are not included in their target functionality. These actions may occur as a result of personnel mistakes or some other reasons, but in any case, they lead to deviations from certain standard operating procedures (SOP) of the activity.

Personnel threats are considered to be some by-product of a professional activity of an aviation security specialist. This means that it is impossible to single out a separate threat or classify them in any way. It is impossible to study the threats of personnel as potential for the same reason, i.e. it is impossible to develop a counteraction device for each threat in advance. This is the main difficulty in investigating personnel threats, which prevents the use of mathematical models and other classical research methods.

The problems associated with the human factor are multifaceted and quite complex. Classical approaches to solving these problems have almost run out. The idea of the new approach consists of a fundamental revision of the physical meaning of the human factor, understanding that the HF is still not a factor, but a much more complex and multifaceted category that belongs to complex systems and has a cost functional that does not subject to strict mathematical description.

An entirely new situation occurs when you need to not minimize the human factor, but the task is to regulate the negative influence of the aviation organization's personnel on the procedures for performing production activities, considering this influence as a threat to the object’s security. In this case, they change approaches to solving the problem and research methods.

**Picture 1. On the new content of the human factor concept**
The reasons that determine the factor of personnel’s negative influence are associated with mistakes in the wider sense of this term; the conditions for the implementation of production activities; the level of professional readiness of aviation personnel and the state in which the specialist is in the process of work. These reasons are apparent in the main point, namely: there are discrepancies, deviations, inconsistencies with the algorithm of activity. The fact is that in aviation security, all production activities are strictly regulated and legalized in the format of standard operating procedures (SOP), which assume compliance with the established requirements. The personnel of an aviation organization in the implementation of their professional function is in a certain situation, the parameters of which are determined by the parameters of the SOP and the parameters of the real algorithm of professional activity of a particular specialist. A security threat to the object under study appears if there are discrepancies between these parameters. In this case, in order to minimize the negative impact of personnel, it is necessary to monitor the situation, evaluate emerging inconsistencies, and analyze them from the point of view of the measures taken. Minimization of the negative is possible in two directions: correction of the algorithm (SOP) and correction of the procedure of the specialist's activity. In both cases, certain resources are required, the inclusion of which in the process minimizes the negative impact of personnel. In this case, the negative influence of the staff becomes manageable.

Further study consists of developing methods and procedures to minimize the negative impact of aviation organization personnel in the aviation security system.

Unauthorized interference of aviation security personnel represents certain deviations or inconsistencies from the standard operating procedures (SOP) approved in advance. These deviations are recorded and evaluated during the monitoring process. They are thus the negative impact that is called unauthorized interference or personnel threat in the field of aviation security [3,4,5].

Therefore, reducing the level of negative influence of airport security personnel is contemplated on the basis of managing unauthorized interference by the criterion of personnel threat using the method of instrumental correction of the algorithm of professional activity of an aviation specialist and the method of managing aviation personnel by the criterion of the quality of their professional readiness to perform their functional duties.

REFERENCES

The change in energy flow streams for main marine propulsion steam turbine at different loads

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Abstract: This paper present analysis of energy flow streams through the main steam turbine (the turbine is used for commercial LNG carrier propulsion) at three different loads. An increase in the propulsion plant (and proportionally increase in the main turbine) load resulted with an increase in energy flow streams and with an increase in the amount of water droplets inside steam at the main turbine outlet. Analyzed turbine has three steam extractions which opening as well as the amount of energy flow stream delivered through each extraction, significantly differs at various loads. The analysis shows that the highest energy flow stream consumers from the main turbine are deaerator and high pressure feed water heating system.

KEYWORDS: MAIN MARINE STEAM TURBINE, ENERGY FLOW STREAMS, LOAD CHANGE, POWER DISTRIBUTION

1. Introduction

In a worldwide fleet, the dominant power producers for ship propulsion are nowadays internal combustion engines [1-3]. Steam and gas turbines are usually rarely used, but however, they have application in engine rooms of a certain ship types [4] and they are (or can be) a baseline for new complex marine propulsion plants [5, 6].

In propulsion of LNG carriers, steam propulsion plants still have a dominant role caused by its operation specificity and characteristics of transported cargo [7, 8], but also, the internal combustion engines impact in this ship type is each day more and more evident [9].

This paper presents analysis of energy flow streams through main marine propulsion steam turbine, which operates at the LNG carrier. Analysis was performed at three different turbine loads. It is analyzed and explained the dynamics in energy flow streams change during the change in turbine load, and the influences of such change on the entire marine propulsion plant operation are discussed. At the end is presented cumulative produced power distribution at each turbine cylinder (for each observed turbine load) and the guidelines for a future research are provided.

2. Description and operating characteristics of main marine propulsion steam turbine

Main marine propulsion steam turbine analyzed in this study is used for the conventional LNG carrier drive. The main specifications of the LNG carrier are presented in [10]. Turbine consists of two cylinders - HPC (High Pressure Cylinder) and LPC (Low Pressure Cylinder), Fig. 1. Both turbine cylinders are connected to a gearbox, through which is obtained propulsion propeller drive.

The marine steam propulsion plant has two identical steam generators (due to safety reasons). Cumulative produced steam mass flow rate is mainly delivered to all turbines which exist inside the power plant (main propulsion turbine, turbogenerators and steam turbine for the main feed water pump drive [11, 12]), while one smaller amount of steam (with reduced temperature) is delivered to other ship systems (auxiliary steam).

Steam delivered to the main propulsion turbine expanded firstly through HPC and after expansion in HPC, steam is delivered directly to LPC (analyzed steam turbine did not posses steam reheating like newer versions of such turbines [13]). After expansion in LPC, steam is delivered to the main marine steam condenser.

Entire main marine propulsion steam turbine has three steam extractions, as presented in Fig. 1. First extraction is from HPC (extracted steam is used for ship auxiliary systems heating), second extraction is located between HPC and LPC (extracted steam is used for steam delivery into the deaerator and high pressure feed water heating system); while third extraction is from LPC (extracted steam is used for heating low pressure condensate heating system components). It should be noted that steam extractions opening/closing as well as steam mass flow rate extracted from each extraction depend on current steam propulsion plant load (steam propulsion plant load is proportional to main propulsion turbine load). Also, in this analysis, steam mass flow rates lost through both gland seals of each main propulsion steam turbine cylinder are neglected [14] in order to present the change of dominant energy flow streams through turbine at different loads.

3. Governing equations required for the analysis

All of the equations in this section are based on the observed main marine propulsion steam turbine and its operating points presented in Fig. 1.

Energy analysis of any plant, system or a component is based on the first law of thermodynamics [15, 16]. The main energy balance equation can be expressed as presented in [17]:

\[ (\dot{Q} + P + \sum (m \cdot h))_{in} = (\dot{Q} + P + \sum (m \cdot h))_{out} , \] (1)

where \( \dot{Q} \) is heat transfer in kW, \( P \) is power in kW, \( m \) is operating medium mass flow rate in kg/s and \( h \) is operating medium specific enthalpy in kJ/kg.

For any fluid stream (for each operating point in Fig. 1), energy flow is calculated as presented in [18]:

\[ E_{en} = m \cdot h , \] (2)

where \( E_{en} \) in kW is energy flow of any fluid (operating medium) stream.

HPC developed power in each turbine load is calculated as:

\[ \dot{H}_{HPC} = m_1 \cdot (h_1 - h_2) + (m_1 - m_2) \cdot (h_2 - h_3) , \] (3)
while LPC developed power in each turbine load is calculated as:

\[ P_{\text{LPC}} = \dot{m}_S \cdot (h_{5} - h_{6}) + (\dot{m}_S - \dot{m}_6) \cdot (h_{5} - h_{7}) \]  \hspace{1cm} (4)

Cumulative produced power for the main propulsion propeller drive (cumulative power produced by the main turbine) is:

\[ P_{\text{cumulative}} = P_{\text{HPC}} + P_{\text{LPC}} \]  \hspace{1cm} (5)

The share of each cylinder in cumulative main marine propulsion steam turbine developed power is:

\[ Z_{\text{HPC}}(\%) = \frac{P_{\text{HPC}}}{P_{\text{cumulative}}} \cdot 100 = \frac{P_{\text{HPC}}}{P_{\text{HPC}} + P_{\text{LPC}}} \cdot 100 \]  \hspace{1cm} (6)

for HPC, while this share for LPC is:

\[ Z_{\text{LPC}}(\%) = \frac{P_{\text{LPC}}}{P_{\text{cumulative}}} \cdot 100 = \frac{P_{\text{LPC}}}{P_{\text{HPC}} + P_{\text{LPC}}} \cdot 100 \]  \hspace{1cm} (7)

4. Measured steam operating parameters at different loads

For the accurate and precise analysis of energy flow streams through main marine propulsion steam turbine, at each observed load are required steam mass flow rates, pressures and temperatures in each turbine operating point from Fig. 1. Such steam operating parameters are presented in Table 1 for low turbine load, in Table 2 for middle turbine load and in Table 3 for high turbine load [19]. Presented steam operating parameters are measured during marine steam propulsion plant operation by using calibrated measuring equipment which is mounted inside engine room and is used for power plant regulation and control [20].

Along with steam mass flow rates, pressures and temperatures, in Table 1, Table 2 and Table 3 are presented specific enthalpies for each steam flow stream, calculated by using NIST REFPROP 9.0 software [21]. Analysis of energy flow streams is not dependable on the conditions of the ambient in which observed steam turbine operates, therefore the ambient temperature and pressure do not have to be defined [22, 23].

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<th>Table 1. Steam operating parameters at low turbine load</th>
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<th>Table 3. Steam operating parameters at high turbine load</th>
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<td>High load (Operating points - Fig. L.)</td>
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5. Results and discussion

All energy flow streams (energy of steam and each cylinder produced power) for the main marine propulsion steam turbine at low load are presented in Fig. 2. The steam energy flow stream which enters in the main turbine from marine steam generators at low load is equal to 15646.52 kW. That steam energy flow stream at low load is used only for power production in HPC and LPC, because all steam extractions (from HPC, from LPC and between cylinders) are closed and energy flow through each extraction is equal to 0 kW. Therefore, it can be concluded that at low load, steam generators produce steam energy flow stream sufficient only for power production by both main turbine cylinders.

At low propulsion plant loads, steam required for all marine elements operation is delivered from steam generators (auxiliary steam), not from main turbine [24]. Steam energy flow stream which is, at low load, delivered to the main marine steam condenser (at the LPC outlet) equals 11677.46 kW and can be calculated as inlet steam energy flow stream (delivered from steam generators) reduced for the produced power of both main turbine cylinders.

Fig. 2. Energy flow streams through main marine propulsion steam turbine - low load

The steam energy flow stream which enters in the main turbine from marine steam generators at middle load is significantly higher in comparison to low load (62391.66 kW in comparison to 15646.52 kW), Fig. 3. Such higher steam energy flow stream is used for much higher power production of both steam turbine cylinders when compared to low load. In addition, at middle load are open two of three steam extractions.

HPC steam extraction is still closed at middle load, so steam for ship auxiliary systems is still delivered from steam generators (auxiliary steam). Steam extractions between two main turbine cylinders as well as LPC extraction are open and cumulative steam energy flow stream extracted from the main turbine at low load is
equal to 5449.31 kW, Fig. 3. From Fig. 3 should be noted that deaerator and high pressure feed water heating system requires more than double steam energy in comparison to low pressure condensate heating system at middle load. Steam energy flow stream delivered to main marine steam condenser at middle load is equal to 38698.09 kW.

Fig. 3. Energy flow streams through main marine propulsion steam turbine - middle load

At high propulsion plant load, steam energy flow streams delivered into the main turbine form steam generators (91765.53 kW) and delivered from main turbine to main condenser (50264.66 kW) are the highest in comparison with lower loads, Fig. 4. Also, at high load both main turbine cylinders produce significantly higher power when compared to lower loads. High propulsion plant load is characterized with a fact that all of three steam extractions are open, and steam is delivered to almost all steam plant components directly from the main steam turbine. Comparison of steam energy flow streams extracted through each main turbine extraction at high load shows that the highest steam energy flow consumers are deaerator and high pressure feed water heating system elements which uses four (or more than four) times higher steam energy flow stream than other extractions. At the same time, ship auxiliary systems and low pressure condensate heating system use steam energy flow streams equal to 2856.50 kW and 2591.83 kW, respectively.

Fig. 4. Energy flow streams through main marine propulsion steam turbine - high load

From the previous observations can be concluded that power produced by main marine propulsion steam turbine cylinders increases in each cylinder during the increase in steam plant load. It is interesting to observe the share of each main turbine cylinder in cumulative produced power. In Fig. 5 is presented that at low propulsion plant loads, the dominant power producer inside the main turbine is HPC, while an increase in steam plant load resulted with a fact that at middle and high loads the dominant power producer is LPC. The highest difference between the main turbine cylinders share in cumulative produced power can be seen at the middle power plant load where HPC takes a share of 47.54%, while the LPC takes a share of 52.46%.

Proper main steam turbine operation significantly depends on the proper operation of the main steam condenser. Steam in each operating point of main marine steam turbine from Fig. 1 is superheated with an exception of operating point 7 (entrance into the main condenser) where the steam is saturated, regardless of the observed steam plant load. For the proper main condenser operation it is interesting to note that an increase in steam propulsion plant load resulted with a decrease in steam content at the main condenser entrance (LPC outlet). This element resulted with a fact that increase in steam propulsion plant load resulted with higher amount of water droplets inside steam at the last LPC stages and at the main condenser inlet, which is valuable information for designing and maintenance of both main steam turbine and main steam condenser.

Fig. 5. Cumulative produced power distribution on both main marine propulsion steam turbine cylinders and steam content at the LPC outlet for all observed loads

Based on the previous researches of the same authors, further improvement and possible optimization of presented main marine propulsion steam turbine will be performed by using advanced artificial intelligence methods and algorithms [25, 26].

6. Conclusions

This paper presents an analysis of energy flow streams through the main propulsion steam turbine at three different loads. The analysis is based on measured steam operating parameters from conventional LNG carrier on which observed turbine operates (the main turbine is used for LNG carrier propulsion). The main conclusions obtained in this analysis are:
- Energy flow streams notably increases during the increase in propulsion plant load.
- At low propulsion plant loads, all steam extractions from the main turbine are closed. Increase in propulsion plant load resulted with the opening of some steam extractions (middle loads), while at high loads all steam extractions from the main turbine are opened.
- Energy flow streams delivered from main turbine to the steam consumers (through extractions) significantly differs. The highest energy flow stream consumers are deaerator and high pressure feed water heating system.
- At low propulsion plant loads the highest share in cumulative main turbine produced power takes High Pressure Cylinder (HPC), while the dominant power producer at other loads is Low Pressure Cylinder (LPC).
- Increase in propulsion plant load resulted with higher amount of water droplets inside steam at the LPC outlet (main condenser inlet).
- This analysis will be used as a baseline for further research of presented main propulsion steam turbine and for the possible

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improvement of the whole propulsion plant in which main turbine operates.

7. Acknowledgment

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Abstract В статье анализируя понятия "логистика", исследуется совокупность функций этой плановой работы с безопасностью, надежностью и гарантированностью. Далее, исследуя факты происхождения логистики, обосновывается более раннее проявление этой специальности. Согласно Ветхому завету фараон обратился к Иосифу: «я фараон; без тебя никто не винит на руки своей, на ноги своей, во всей земле Египетской»; подтверждая тем самым его полномочия Верховного Министра. Данное историческое событие позволяет судить о раннем проявлении специальности с более широкими полномочиями по накоплению, разделению и распределению, не смотря на то, что в источниках того времени не встречается непосредственно термин «логистика» (латынь) или слово «Мантиг» (Арабский), которое имеет эквивалентное значение.

КЛЮЧЕВЫЕ СЛОВА: ЛОГИСТИКА, ЛОГИКА, ТАЛАНТ, ТРАНСПОРТ, БЕЗОПАСНОСТЬ, НАДЕЖНЫЙ, ГАРАНТИРОВАННЫЙ, ЗАПАСАТЬСЯ (ЗАКУПКА), РАСПРЕДЕЛЯТЬ.

Abstract. In the article, by analyzing the concepts of "logistics", we study the constellation of the functions of this planned work with safety, reliability, and guarantee. Further, by examining the facts of the origin of logistics, the earlier appearance of this specialty will be grounded. According to the Old Testament, Pharaoh said to Joseph, "Though I am Pharaoh, yet without your permission no one shall raise his hand or foot in all the land of Egypt", thereby confirming his authority as the Supreme Minister. This historical event allows us to judge the early manifestation of a specialty with wider powers of accumulation, division and distribution, although the sources of that time did not directly refer to the term "Logistics" (Latin) or to the word "Mantig" (Arabic), which has the equivalent meaning.

KEY WORDS: LOGISTICS, LOGIC, TALENT, TRANSPORT, SECURITY, RELIABLE, GUARANTEED, STOCK UP (PURCHASE), DISTRIBUTE.

Введение. Прежде чем приступить к исследованиям, была поставлена цель выяснить, что такое логистика и может ли эта плановая работа выполняться не соблюдая безопасность, надежность и гарантированность? Если транспортную логистику можно представить отдельно от функций безопасность, надежность и гарантированность, то каким же образом, в случае грузоперемещений, исполнитель может заслужить доверие клиентов -заказчиков (поставщика-потребителя)? Исходя из изложенного, решено, что с целью безопасной, надежной и гарантированной эксплуатации водного транспорта (любого вида транспорта) планирование требуется обеспечения подбора, накопления, разделения (распределения), размещения, закрепления и перемещения на транспортном средстве товара (груза) должно выполняться под руководством логистического органа, или другой подчиненной этой системе структурой. Тогда, для достижения поставленной цели определимся задачей и ее решением в научном аспекте.

Основная часть. Авторы в своих толкованиях и в других научных источниках, с целью научного обоснования предположений о «логистике», превращают объективное в субъективное, и по итогам этих исследований формулирует свои заключения. Если даже в этих толкованиях «логистика» разъясняется с разными подходами и анализами, то почти у всех смысл и суть понятия «логистика» возникнет не реально. Можно адекватно утверждать, что без логистического подхода обычное управление или работа нереально. Таким образом, неотрицаемым фактом является то, что логистическое управление без соблюдения требований безопасности, надежности и гарантированности не к чему.

Да, при нашем подходе к определению могут возникнуть вопросы о том, что при отсутствии безопасности, надежности и гарантированности речь о перевозке нереальны. Можно адекватно утверждать, что без логистического подхода устойчивое управление или работа нереально. Таким образом, неотрицаемым фактом является то, что логистическое управление без соблюдения требований безопасности, надежности и гарантированности не к чему.

Далее, отмечается, что, логистика впервые использовалась в интендантской службе вооружённых сил, и означало «счетное искусство» [2]. Первоначально можно представить логистика просто главнокомандующим по счетоводству. Но слово искусство при счете, это многообразная и более обнаружена специализация. Во всех случаях специалист по «счетному искусству», находясь в тылу и занимаясь надлежащим формированием (организаций), тут должен был владеть так...
жем искусством распоряжения материальными ресурсами. Он обязан был с велиkim искусством рассчитывать, определять, запасаться (накапывать), распределять и безопасно, надежно и гарантированно снабжать (доставлять) передовую в нужном количестве и качестве, в точное время, продовольствием, военной техникой и средствами (имуществом). При обеспечении передовой, логистик должен был предвидеть всю опасность, учсть предвиденные и непредвиденные препятствия, преодолеть все трудности безопасно, надежно и гарантированно снабзить (доставить) и обеспечить передовую нужды.

Поэтому можно утверждать, что логистик, владеющий счетным искусством, являлся высокоответственным, решительным специалистом и личностью обладающей отличным логическим мышлением. Он, не допуская и малейших ошибок, должен был управлять своим делом, соблюдая все требования по функциям безопасности, надежности и гарантированности.

Однако, внизу содержал специалиста «логистика» с обязанностью обеспечения передовой. Он, не допуская и малейших ошибок, должен был управлять своим делом, соблюдая все требования по функциям безопасности, надежности и гарантированности.

По нашем исследованиям, появление «мантиг» (арабский) - логически размышлять и владеть «счетным искусством», и на основе этого, соответствующего специалиста, датируется XVII веком до нашей эры.

Так в XVII веке до нашей эры пророк Иосиф, в возрасте 30 лет, исполнял фараону сон о «семи толстых коровах, пожирающих семь тучных коров» и о «семи зеленых и семи сухих колос». Он исполнял два сновидения фараона, предсказывавшие близкое семь лет будут плодородными, затем наступит семь лет голода. Первые семь лет надо запасаться (накопить), а последующие семь лет снабжать (распределить и раздать) [8].

Таким образом, в результате известных событий, появились в течении пророка Иосиф, исполняя сны фараона, точно же был освобожден из темницы и назначен верховным министром (начальником флота). Фараон повелел толковать снов, и он, сначала, владыка «поставил пророка Иосифа на свой землей Египетской» и сказал: «убирайся и не двинут ни руки своей, ни ноги своей, во всей земле Египетской» [8]. Фараон сделал это визирю Египта, возможно своим соправителем, и даже дворцовым «мантигом» или как подчеркивалось во времени Византийского императора Льва VI двоцовым «логистиком». Из чего следует, что ставший соправителем Египта Иосиф, пророк Иосиф спас богатейшую страну древнего мира от бедствий и голода своей мудрой предусмотрительностью и дальневидностью.

Обратите внимание, в XVII веке до нашей эры пророк Иосиф назначается на должность …, с обязанностью распределения продуктов питания, а спустя достаточно время, в нашей эре (VII-IX век), в армии и во времена Византийского императора Льва VI, при дворе содержат логистика с обязанностью распределения продуктов питания. Назначение фараоном Льва VI, мудрого, рассудительного специалиста по распределению, естественно, запасного продукта это случайность или закономерность. Появление этой функции у указанных специалистов диктуется наличие связи, то есть после проведения закономерности. Второе назначение, естественно, исходит от первоначального события происходящего с пророком Иосифом, из начала до конца, подробно описаны в Евангелие, Торе и Коране, тем самым, исключается вероятность отсутствия информации о существующей связи. Так, священные книги человечества однозначно утверждают более ранее происхождение специальности по наименованию, разделению и распределению, где роль транспорта (ручной квадриги) очевидна и объективна. Если даже в то время это не называлось «мантиг» (арабский) или «логистика» (греческий), работа выполнялась на высочайшем уровне, на логистической (мантиги) основе.

Да, нельзя отрицать связь слова «логистика», «мантиг» или ряд других подобных слов, определяющих специальности с идентичными функциями. Мы лично согласны с тем, что для одного понимания и избежания сложных ситуаций, всемирное использование термина «логистика», вполне приемлемо и даже логично.

Согласно источникам, в русский язык термин «логистика» ввел в начале XIX века французский военный специалист Антуан Жомини. В Советское время, условия плановой экономики, он был заменен термином «снабжение» [2]. Хотя «снабжение» не так охватывает и уподобляется многочисленные функции, как «логистика».

Таким образом, при Совете Союза, Госплан СССР был закреплен за именем известного руководителя «Байбакова», который, плохо или хорошо, выполнял обязанности главного логистика (логистического центра) страны по всем аспектам и направлениям, без исключения какой-либо отрасли. «Госплан СССР» во главе с «Байбаковым» занимался не только в буквальном смысле «снабжением» и нахождением нужного, а в
прямом смысле обеспечивал и удовлетворял потребности каждого и каждой отрасли [1]. Будучи транспортником, могу утверждать, что если даже в те времена не существовал термин «логистика», то «Госплан СССР» работал на этих принципах. Мы знали свой транспортный парк, списание и прибавление транспортных единиц. Когда, сколько и откуда поступят шины, аккумуляторы и другие запасные части, в целом весь объем, сдача металла и утилизации. Мы знали, что, сколько, куда, когда и за сколько должен перевозить товар (груз) и т.д. транспортный парк в текущем году. Таким образом, планировалась поставка, производство и потребление, определялись продукция транспорта, строилась транспортная цепочка и утверждалась в этой цепочке каждый исполнитель (автомобиль, железная дорога, водный транспорт, авиация, трубопровод), да и как говорится, плохо или хорошо контролировалось.

Сегодня при рыночной экономике, ради развития государства и государственности, частной собственности, благосостояния нижеследующее должны быть не отдельной единицей и видеть свою роль и деятельную зависимость в этой транспортной цепочке.

В общем, по результату исследований можно утверждать нижеследующее:

1. Логистика, для безопасного, надежного и гарантированного решения поставленных вопросов обязана подбирать соответствующий управленческий аппарат. В нашей ситуации аппарат управления, предоставляющий соответствующую обширную информацию о потребности требуемого грузопотока, транспортных средствах и транспортных расходах, определение и обладание продукцией транспорта, изучать грузопоток и транспортный процесс этого потока, стараться быть не отдельной единицей и видеть свою роль и деятельную зависимость в этой транспортной цепочке.

Таким образом, существование сильной рыночной экономики и конкурентоспособности, как государства, так и предпринимателей (юридические и физические лица) не только обязывает, а даже будет принуждать в каждой деятельности, в какой бы то ни было, когда имеет место, и известный термин «логистика».

Тут и возникает вопрос почему в какой бы то ни было, когда имеется, а равно и известный термин «логистика».

Таким образом, в силу суждения, раз приведя термин «логистика», то почему ограничиваться, так как «логическое рассуждение», «чтение искусство», «статистический анализ» во всех отраслях пригодны (транспортная, снабженческая, складская, бухгалтерская, и т.д. логистика). Тут и можно придумать соответствующую интерпретацию для каждой области. Например, мы знаем, что для транспортной логистики существует 6 правил:

1. Груз – продукт транспортного процесса.
2. Качество – как транспортные, так и потребительские качества груза (товара).
3. Количество – как в весовом, так и в объёмном смысле груз подлежащий транспортировке.
4. Время – запланированное или требуемое время доставки груза по назначению.
5. Куда, кому – доставка груза по месту, назначению, требуемое место, адрес и кому.
6. Расходы – транспортные и сопутствующие расходы, связанные с транспортировкой груза (товара).

Таким образом, существует 6 правил «логистики».
что без логического мышления "работе" не бывать, следовательно, не пройдет и долгового времени, как обесценивание "логистики" приостановится. Таким образом, будем принудительно возвращать "логистику" в свое настоящее, историческое руслò с учетом современных требований.

Русло, где логистика, исследуя задачи, вкладывает информацией, изучая экономическую географию, экономическую географию транспорта мира, товаров, направления потоков с помощью логистических трудовых ресурсов, планируя оптимальное перемещение за оптимальные расходы, организует и обеспечивает исполнение и контроль выполняемых обязательств, услуг (планирование работ) безопасно, надежно и гарантированно.

Выводы:
1. Мантиг (Араб) – Логистика, история образования специалиста владеющего "счетным искусством" приходится на XVII век до нашей эры, период правления фараона и пророка Иосиф, а не как принято считать VII–IX век нашей эры;
2. Исходя из изложенного и в науке, и в жизни особо важным является восприятие логистики логически, без формирования ревности.
3. Безопасность, надежность, и гарантированность является функциями логистики.

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Измерване на температурната динамика на атмосферата в регион стара зогара във връзка с глобалното затопляне

Measurement of temperature dynamics of the atmosphere in the region of Stara Zagora in relation to global warming

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Abstract: The development and establishment of trends in the temperature changes of the atmosphere in the region of Stara Zagora have been followed for the last 10 years since 2011. To trace the climate temperature use data obtained from sensors of the automatic meteorological Vantage station Pro 2 Plus. The purpose of the study is to check the extent to which the repeatability of temperature values during different periods and whether there is local warming. The data collected by the sensors is processed, average and ordered by hours, days, months and years. The resulting results are shaped in graphical and tabular form. The current development explores the temperature dynamics without taking into account the contribution of the individual factors for heating and cooling the atmosphere.

KEYWORDS: AIR TEMPERATURE, SOLAR ENERGY, MEASUREMENT OF METEOROLOGICAL PARAMETERS

1. Въведение.
Когато количество то топлина, кога загрява въздуха е по-голямо от количеството то топлина, която охлажда въздуха, температурата на атмосферата се покачва и обратно. Топлината, която загрява въздуха зависи от температурата на земната повърхност и от топлината, която нагрява въздуха между топлината, която нагрява въздуха и топлината, която охлажда въздуха.

Действителното количество то топлина се определя като разлика на температурата в дневни, месечни и годишни цикли. Съответните периоди. В този смисъл са проследени промените на температурата в дневни, месечни и годишни цикли в зависимост от пораждащите я причини и в зависимост от адиабатното изстиване, излъчване на топлина и предаване на топлина при съприкосновение с по-хладната повърхност на земята.

Изстиването на въздуха става за сметка на съдържащата се в него топлинна адвекция — пътят, по който нагрети въздух страва над по-хладна повърхност. Изстиването на въздуха се осъществява със земната повърхност и от обтичането на въздушния поток по неравнините (дървета, храсти, хълмове, стради и др.). Тя е съществено изразена в пресен месец местност.

Топлината възниква от нееднородното нагряване на отделни места от повърхността — различия в цвета и влажността на почвата, различия в изложенето и т.н. При това се проявява температурна нееднородност на въздуха — над по-нагретия участък той се издига по-високо и обратно. По този начин в непосредствена близост възникват въздухови струи, които предизвикват характерно трептене на въздуха (забелязват се при слънчево време над асфалтови пътища, уаги и т.н.).

Изстиването на земната повърхност също допринася за нагряването на въздуха. Атмосферата също е безпорядъчен вихров системен и притежава значителна част от нея.

Изстиването на въздуха става по няколко начини:

2.2 Основните фактори за отнемане на топлината от въздуха са:
• Адабатното изстиване е основна причина. С издигане на въздуха на височина се появява и височината на въздуха, през което се връща в атмосферата за момент на въздухен цикъл на височината височината на въздуха. Височината на въздуха става за сметка на съдържащата се в него топлинна адвекция.

• Други, по-малкови, причини са:
• Излъчване на въздуха;
• Предаване на топлина при съприкосновение с по-хладна повърхност.

3. Изчисляване на часовия и дневния ход на температурата.
На фиг. 1 са показани с жълти ленти средните стойности на температурата на атмосферата за всеки час. С червени линии са извеждани стойностите на температурата на атмосферата за всеки час. С червени линии са извеждани стойностите на температурата за всеки час, а с червени линии минималните и максималните стойности на температурата за всеки час. С червени линии минималните и максималните стойности на температурата за всеки час.
Фиг. 1. Средна температура измерена за всеки час на 15 юли 2011-2019 г.

В същото време слънчевата радиация е най-висока от 11 до 14 часа, а през нощта е практически нула. Това фазово оттегляне от 4-5 часа между двата екстремума се дължи на времето необходимо на слънцето да загрее земята, а тя от своя страна въздейства. С този факт се потвърждава теорията, че земята е основния фактор за загряване на атмосферата, а слънчевата радиация е вторичен.

В обществото, обаче съществува мнение, че температурите са най-високи по обяд между 12 и 15 часа. Това мнение е погрешно и хората, които имат здравословни проблеми трябва да се съобразят с научните изследвания.

Фиг. 2. Средна температура измерена за всеки ден от Юли 2011 до 2019 г.

На фиг. 2 са показани с жълти ленти средните стойности на температурата за всеки ден от месеците Юли в продължение на 9 години, т.e. на 1 юли 2011г., 2 юли 2012г. и т.n. Температурните отклонения от средната стойност са означени с червени линии.

На тази графика ясно се вижда, че динамичните промени са много по-малки от тези за всеки час, тъй като се получава усредняване в рамките на всеки ден. Тези вариации имат случай характер и се дължат на сравнително къса извадка от наблюдения от 9 години, с които разполагаме.

Към казаното дотук трябва да се добави, че фазовото оттегляне между максимумите и минимумите съответно на слънчевата радиация и температурата е минимално. От това следва, че средните дневни стойности на температурата в значителна степен зависят от слънчевата радиация и само косвено от температурата на земята.

4. Изследване на месечния ход на температурата.

На фиг. 3 са показани измерените температури за всеки едноименен месец Юли 2011 до месец Февруари 2020 г.

Фиг. 3. Средно измерена температура за всеки едноименен месец от Юни 2011 до февруари 2020 г.

За всяка година лентите са оцветени с различен цвят. От графиката се вижда, че най-високи са температурите през месец юли и август, а най-ниски през месеците януари и февруари. Тук основна роля е в игрите количеството на слънчева радиация, съсем малко земната повърхност. В този случай месечната динамика на температурата е по-малка от дневната и се дължи на инертността, която внася земната повърхност. С по-голяма динамика се отличават месечите април и февруари, а с по-малка месечните август и септември на фиг. 3.

На фигура 4 са показани с жълти ленти изчислените средни стойности на температурата за всеки месец в продължение на 9 години. Температурните отклонения от средната стойност са означени с червени линии.

Най-малки са отклоненията през месеците септември и август през деветте години, а най-големи през месеца февруари и април. Данните за слънчева радиация показват, че има известни отклонения в динамиката между месеците най-висока температура. Следователно съществуват и други фактори, които оказват влияние върху температурата на въздуха.

Определено може да се каже, че тези фактори със същия характер при слънчевата радиация, но има и други за които може да се обобщи, че са свързани с групови синоптични процеси свързани с активността на циклоните над територията на Балканите, която е минимална през август-септември и максимална през февруари-април. На фиг. 5 са показани центрирани математически срещу 12-месечната средна с период от 12 месеца на годишната температура, както и средно месечната температура с жълти ленти.

Фиг. 4. Средно изчисленна температура за всеки месец

Математическата средна е с период от 12 месеца, което съответства на една година в продължение на 9 години. От графиката се вижда, че стойността на математическата средна е почти постоянна, защото променливата е около 2С. Динамиката на годишната температура е много по-малка от измерената и не се наблюдава ясно изразена тенденция за повишение или
понижение на температурата. Разбира се това търсене не може да бъде категорично, защото става въпрос за твърде кратък период от време.

Въпреки че измерените температури през едноимените месеци си приличат много, има и някои изключения. Например само месеците януари и февруари 2012 година и месец януари 2017 година имат отрицателна средна температура видно както от фиг. 5 така и от таблица 1.

**Табл. 1 Развълноване на температурата във въздуха по едноименни месеци**

<table>
<thead>
<tr>
<th>Година</th>
<th>Януари</th>
<th>Февруари</th>
<th>Март</th>
<th>Април</th>
<th>Май</th>
<th>Юни</th>
<th>Лястовици</th>
<th>Септември</th>
<th>Октомври</th>
<th>Ноември</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>0,25</td>
<td>1,36</td>
<td>0,70</td>
<td>12,93</td>
<td>16,23</td>
<td>22,91</td>
<td>29,29</td>
<td>24,76</td>
<td>20,04</td>
<td>16,05</td>
</tr>
<tr>
<td>2011</td>
<td>3,72</td>
<td>3,66</td>
<td>4,45</td>
<td>13,84</td>
<td>20,17</td>
<td>23,93</td>
<td>28,03</td>
<td>24,60</td>
<td>18,08</td>
<td>15,99</td>
</tr>
<tr>
<td>2012</td>
<td>4,22</td>
<td>5,09</td>
<td>11,99</td>
<td>13,37</td>
<td>19,77</td>
<td>22,18</td>
<td>28,22</td>
<td>23,92</td>
<td>19,02</td>
<td>16,89</td>
</tr>
</tbody>
</table>

В таблица 1 са показани измерените е и изчислени средни стойности за всички месеци в периода от юни 2011 г. до февруари 2020 г. В графа “Максимална разлика” е изчислена разликата между максималната и минималната стойност на температурата за едноимените месеци в този период. Най-големи разлики в температурата на едноимените месеци е през месец февруари 9,05°. Тези разлики имат статистически характер.

Същото може да се обеляжи и за най-малките разлики в температурата. Например за месец август тя е 2,35°, а през месец юни 3,65°. В същото време годишното отклонение на фиг.5, както обелязахме е около 2°, Следователно средно годишните отклонения са значително по-малки от средно месечните на едноимените месеци. Движенията се средна на фиг. 5 нарича си е избрана с период 12 месеца за да съответства на период от една година. Въпреки, че температурата варира през годината температурата през един месец януари със средна стойност 23,68°, а през месец юни 3,65°. Движещата се средна на годишните отклонения са значително по-малки от едноимените месеци. Движещата се средна на физ. 5 ще виждаме, че от година до следващата година разликата е около 3°, а през месец май, (Таблица 1), както виждахме в графа “Максимална разлика”, разликите са по-големи от годишните. Следователно отново не се наблюдава възходен или възхил на температурата. От сравнение на резултатите във формулите (1) и (2) се вижда, че месечните отклонения са по-големи от годишните. От по-горе в текста също установихме, че месечните отклонения са по-големи от годишните. Следователно отново се наблюдава извод, че колкото е по-голям период на измерване, толкова разликите и бъдещите прогнози са по-точни.

От фиг. 5 виждаме, че средната стойност на центрираната годишна температура е около 13°. Със същото време се наблюдава годишна температура, че годишната средна температура на температурата е 13.01°. Тъй като тези 2 числа са много близки се наблюдава извод, че центрираната годишна температура е средна температура във въздуха за месец май, (Таблица 2), изчислена средна годишна температура от тази таблица е 13.01°.

От друга страна, ако направим изчисления за месечните отклонения с данни за месец май, й, (Таблица 1), където максималното отклонение е средно голямо ще получим следните резултати:

(2) $T_{разл} = 18.93 - 14.71 = 4.22^\circ C$.

От сравнение на резултатите във формулите (1) и (2) се вижда, че месечните отклонения са по-големи от годишните. От по-горе в текста също установихме, че месечните отклонения са по-големи от годишните. Следователно отново се наблюдава извод, че колкото е по-голям период на измерване, толкова разликите и бъдещите прогнози са по-точни.

5. Заключение.

От теоретична гледна точка споменатите фактори, които оказват съществено влияние върху загряването и охлаждането във въздуха, възможна неговата температура. От направените изследвания се оказа, че средната температура на атмосферата при краткосрочните периоди, като часове и дни зависи повече от температурата на земята отколкото от слънчевата радиация. При дългосрочните, като месец и година по-сильно влияние оказва слънчевата радиация отколкото температурата на земята. Това се дължи на факта, че слънчевата радиация загрява първо земята, а тя от своя страна атмосферата. Другия важен извод е, че средната годишна температура се променя много слабо и не се наблюдава тенденция за трайно повишение или понижение. Ако разглеждаме внимателно кривата на центрираната годишна температура математически средна е около 13°, а през месец май, (Таблица 1), изчислена средна годишна температура през месец май е 13.01°. С други думи отново не се наблюдава тенденция за покачване или намаляване на температурата.

Натрупания база данни е все още сравнително малка за да се направят категорични научни заключения, но се надяваме, че следващите изследвания ще потвърдят направените в този план първоначални констатации. Резултатите от това изследване могат да послужат като важен ориентир, за да се изчисли предварително очакваната температура в дългосрочен план за определен географски регион, както и очакваните температурни промени.

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The future of moto auto world

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Abstract: The new decade symbolically heralds the year of innovations and advancements in automobile sector. Dutch company “Lightyear” has announced that the first “long-range” solar-powered car arrives in 2021. “Lightyear One” will be charged on the household socket, and with a charged battery will be able to cover a distance of 725 kilometers.

At the fair in Las Vegas, a special place was given to electric “Mustang” with 900 hp. Among the many versions of “Ford Mustang”, for this model six-speed manual transmission was designed and the driver has at disposal three regimes, and the system is controlled by a large central touch screen.

The new European drone regulation, in effect July 1st 2020 will require new compliance and registrations by their users. Unfortunately, during 2019, the public learned that “Audi” is withdrawing 138,000 A3 models of the following class, because their airbag does not open due to a malfunction, (models were manufactured between years 2015 and 2019) and these are: 2015-2019 A3 Sedan, 2015-2019 A3 Cabriolet (convertible), 2016-2018 A3 E-Tron (plug-in hybrid), 2017-2019 RS3 (based on the A3), 2015-2016 S3 Sedan (based on the A3).

At the end of 2019, the merger of “Fiat Crasler” and “Peugeot - Citroen”, the two auto giants on the basis of 50:50 and production of 8.7 million cars a year were announced. More recent information comes with the knowledge that these car companies which are in negotiations will sign the merger agreement, which would create the fourth largest car producer in the world.

In Serbia there is shortage of about 10,000 drivers and from 80,000 active, already about 10,000 so far took the card and certificate for driving motor vehicles through Europe. Drivers are still in the category of the most wanted professions. In Belgrade City Transportation Enterprise is planning to hire 110 new drivers for the largest city carrier.

Interesting is also the phenomenon of electric scooters that became almost mandatory means of transport in cities throughout the world. These vehicles necessarily need legal restrictions, and it is interesting that Germany already limits the use of electric scooters.

KEYWORDS: AUTO, REGULATION, WORLD, SERBIA

Introduction

We are witnessing that numerous car shows have been canceled due to the crisis caused by the emergence and spread of the virus corona throughout the world. An epidemic caused by a corona virus has put a stop to the European auto industry. Car manufacturing is at the heart of European industry, as it employs directly or indirectly, almost 14 million people and this message comes from the European Automobile Manufacturers Association.

Today in the time of pandemic the workers of factory “Fiat” in Serbia are on the forced leave.

NEWS IN THE AUTO MOTO WORLD

The transport sector is the fastest growing energy consumer and producer of greenhouse gases. The new decade symbolically heralds the year of innovations and advancements in automobile sector. Dutch company “Lightyear” has announced that the first "long-range" solar-powered car arrives in 2021. “Lightyear One” will be charged on the household socket, and with a charged battery will be able to cover a distance of 725 kilometers.

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Also the new “Audi S8” is highlighted. During July 2019, unfortunately, the public learned that the Volkswagen’s choice was: Turkey is more important than Republic of Serbia, i.e., the Volkswagen’s Board of directors announced that it has chosen a location for a factory near the Turkish coastal city of Izmir, and Qatar has probably contributed to this decision (holding 17% of the capital in the German giant). However, a decision has not yet been made...the outcome is expected!

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“Folkslsvagen” is also preparing a boom on the market and that is the ordinary Golf, the eighth generation technically superior to the previous or electrical ID.3, with a range of up to 330 kilometers. Company “Mercedes” does not surrender, and so a new version of the recently updated models GLC and GLC cupe has arrived.1 Production of the new “Nissan Juke” began in October 2019, while production of the “Toyota Land Cruiser” has already exceeded 10,000,000.

The premiere of the totally all-new “Yaris” came next. The big small “Yaris” is designed for urban life today. The small electric “Renault” arrives in Europe. Reno's affordable model “City K-ZE” is currently sold only in China, but the special version of the “K-ZE” is coming to Europe, where it will be more expensive due to certain changes and upgrades. Otherwise, the “City K-ZE” is powered by a 44hp electric motor, reaching a maximum of 105 km/h.

Interesting is also the phenomenon of electric scooters that became almost mandatory means of transport in cities throughout the world. These vehicles necessarily need legal restrictions, and it is interesting that Germany already limits the use of electric scooters.

1 It is “Mercedes GLC 43 AMG”.
2 There are 44,000 electric cars registered in Norway and 48,000 in Germany.
Europe by the number of sold electric cars. Far ahead of everyone is still China, with about 628,000 E-vehicles registered between January and June 2019.

The famous British brand "Lotus" with a new owner from China ("Gili") presented a new hypercar, "Evia"\(^3\), an electric two-seater with 2000 horses, which will be produced in only 130 copies, as the most expensive project in the history of "Lotus". Production should start next year.

The Japanese "Korola" is a hybrid version of the best-selling car of all times. It emerged in 1976, and today the 12th generation of this Japanese car with the new platform and the new look is in front of us. Experts say also with the new sensation in driving, because there is no more diesel engine. The gasoline engine is now lighter and the consumption and emissions of harmful gases are lower.

It is said about smart cities and buildings, alternative energy, energy savings, recycling; the bike is being used more and more, electric scooters have covered the city. In Finland, for example, you can book the nearest city car for you through the mobile phone application, drive it and leave it, where you want. The applications also serve for noise measurement in the city, and citizens of the Finnish capital, Helsinki, are the moving noise measuring devices.

It is interesting that during Auto Fair in Frankfurt thousands of citizens demonstrated asking for more activities because of climate changes. It was announced that "strong cars are climate killers", and the protest organizer’s demands were: to stop using combustion engines, climate-neutral traffic by 2035, speed limits on the highway and a strong German climate policy package.

Environmental groups cite the trend toward bigger and more powerful cars, especially SUBs, contrary to the increase in fuel efficiency in recent decades.

**AUTO WORLD IN THE PERIOD OF PANDEMIC**

We have witnessed the great struggle of the Chinese people with the epidemic of the deadly corona (Covid-19) virus. All over the world people faced the same problem, especially in Italy, Spain, USA, England, Romania, Brasil, in Serbia too. One can say a superhuman struggle for every life and the effects of calming the epidemic and the gradual normalization of the situation are slowly coming to light, especially in parts of China that have been the most exposed and with the highest casualties among the population.

And before the outbreak of the pandemic caused by this virus, information from exhibition in Tianjin in China came on the helicopter called a "super-sized white shark"\(^4\), which resembles a flying saucer, and its prototype is scheduled to launch its first flight in 2020.\(^5\) That's how it was planned, and today it is certain that the term has been changed. American National Aeronautics and Space Administration (NASA) has unveiled the “Mars 2020 Rover”, which was planned to be launched in July 2019, with its destination in a dried up lake bed on Mars, where it should land in February 2021.

The significant is success of the Korean manufacturers of "Kia" and the electric models that are increasingly in demand. The largest city carrier.

**EXPERIENCE OF SERBIA**

In Serbia there is shortage of about 10,000 drivers and from 80,000 active, already about 10,000 so far took the card and certificate for driving motor vehicles through Europe. Drivers are still in the category of the most wanted professions. In Belgrade City Transportation Enterprise is planning to hire 110 new drivers for the largest city carrier.

What are citizens of Belgrade transported by? By the “Spaniards” (trams), scooters and "sparrows" (electrical buses operating in the pedestrian zone of the center of the city).

Belgrade needs a metro, though metro is not the only criterion of a smart city. Metro is being built to reduce the number of cars on the streets and to reduce the pollution. The task for all urban transport vehicles is to be "Euro 6" standard, in order to reduce nitrogen oxide emissions for about 80% and to reduce PM emissions by half.

The public vehicles began to transport the inhabitants of our capital 127 years ago and there were various vehicles, the public transport were horse-drawn trams. Today arrival announcements have been modernized .... More decades of traffic problems will largely be resolved by the first subway lines.

Waiting for the metro, the cornerstone should be put in 2020 and today the citizens of Belgrade use rail transport - BG train (established in 2010) and considered to be the most accurate public transport in the capital. The BG train network has been expanding in recent years, and the authorities promise not to cancel this train with the departure of the first subway. In September 2016, the first e-buses, which became passengers' favorites, began to cruise. There are more and more electric scooters\(^6\) today, and their introduction in the law is also planned.

**CONCLUSION**

The state of our planet continues to deteriorate at an alarming rate. Viruses are the most serious threat to humanity. There is a race around the world for a vaccine against this viremia. Despite all the technical advances across the globe, we are experiencing today with significant climate change also the damage in traffic of about € 120 million that due to the pandemic is caused, i.e. consequences are suffered by road, rail and water traffic, while the most affected is air traffic.

And when the epidemic lets up and stops, the electric car for everyone - the “Opel Corsa” with a range of 337 km - will make us happy. Corsa’s “Selection” is the new sixth generation, as well as the “Edition” and Corsa’s “Elegance”, that won the prestigious “Connected Car Award”. There was a revolution in transportation. Britain is legalizing electric scooters, because the proposed amendments to regulations will allow electric scooters to become legal. The Ministry of Transport in the United Kingdom is responsible for harmonization of regulation and technical rules in order to ensure that electric scooters can be safely used on the British roads (for start in 4 zones: Portsmouth and South Hampton; West England; Derby Nottingham, as well as the West Midlands). Hoping that Great Britain will consolidate a position of leading innovator.

We hope that vaccine against corona virus will be found soon having in mind that numerous scientists all around world are working on its invention.

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4. Electric scooter (from the company Denver electronics SCO-54220, product from Denmark) with a power of 300W is sold in Serbia for 32 ooo dinars, with maximum speed up to 20kms/h, the electric brake is on the front wheel and the foot brake on the rear, the diameter of the wheel is 6.5 inches, weighing 9.9 pounds and capacity of up to 100 pounds. Display: review - speed, distance, battery consumption.

\(^3\) It uses 4 electric motors with a total of 2000 horsepower, and at its most efficient driving, the range with a single charge of batteries 70 kWh / should be up to 400 kilometers.

\(^4\) This aircraft will weigh 6 tons, it can fly at altitudes up to 6,000 meters, at speeds of up to 650 kilometers per hour. Military experts said that with great speed, the low noise level of this aircraft of the future was achieved.

\(^5\) The first flight of this futuristic aircraft will be at the "Air show China 2020" event in the city of Duhai, southern Guangdong province.
Alternative fuels for public transport vehicles – actual trends

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Abstract: Strategies for sustainable transport, and consequently sustainable mobility, require the use of cleaner vehicles without harmful emissions. The use of alternative fuels contributes to realization of set strategies and different types of alternative fuels are increasingly present in the transport sector. There is great potential in the use of alternative fuels in public transport systems, since this mode of transport plays a very important role in sustainable mobility. The aim is to replace the conventional bus fleets with vehicles with newer and cleaner technologies. Within this paper, alternative types of fuels used in public bus transport will be presented, as well as practical examples of the application of these modes of transport.

Keywords: SUSTAINABLE TRANSPORT, ALTERNATIVE FUELS, PUBLIC TRANSPORT

1. Introduction

The traditional approach to meeting the requirements for passenger vehicle travels by further building the capacity of the street network has been replaced by an approach that involves managing travel requests to make greater use of public transport system and other environmentally friendly modes of transport. In recent years, with the aim of identifying and reducing harmful agents by air, land and water, various strategies have been adopted and legislative and policy adjustments have been made, both nationally and internationally. The modes of traffic that can equally affect the living space and the ability to provide efficient service are emphasized. Particular emphasis is placed on reducing the use of conventional fuels by alternative fuels and promoting renewable energy sources. Developing technologies are pushing the boundaries we know today, and the future are the use of clean technologies, or technologies that are environmentally friendly. Although there has been a major improvement in internal combustion engines which has resulted in a reduction in specific fuel consumption at the level of total passenger transport activity by passenger cars, the efficiency has remained unchanged because at the same time there has been a negative effect of the reduction of occupancy of passenger cars. Therefore, the promotion of production of new vehicles that will use alternative fuels is encouraged.

2. European strategies

The global climate situation is worrying, so goals that have been set earlier need to be constantly revised and updated. The transport is one of the major pollutants [1], which is why there are specific strategies that apply only to the transport sector. The main challenges for the transport sector in the EU include creating a well-functioning single European transport area, connecting Europe with modern, multi-modal and safe transport infrastructure networks, and shifting towards low-emission mobility [2].

The use of alternative fuels is one of the measures for low-emission mobility achievement. In Europe, there is a generalized uncertainty about alternative fuels (in terms of fuel types, necessary infrastructure, technical and economic viability, sustainability) that leads to a fragmented market with unstable conditions [3]. Nevertheless, the use of alternative fuels is becoming more and more certain. There are different strategies, both nationally and globally, for implementing environmentally friendly vehicles and alternative fuels, especially those that can be obtained from renewable sources.

Concerned about the overuse of oil and its depletion, as well as the decarbonisation and combustion of fuel that is damaging to the environment, EU has adopted Directive 2014/94/EU of the European Parliament and of the Council [4], that seeks to encourage its members towards sustainable mobility and a healthier life. This document provides guidance for the use of alternative fuels and setting up of infrastructure that will enable supplied of vehicle with alternative fuels. The Directive sets out the minimum requirements that are necessary when planning infrastructure. The construction of the infrastructure must be technically and financially justified. It must also enable the movement of alternative fuel vehicles in urban/suburban agglomerations and within the network developed by other EU Member States.

All EU Member States were obliged to adopt plans for the construction of infrastructure for alternative fuel vehicles, with completion of construction planned for 2020 and 2025, respectively, depending on using of types of alternative fuel vehicles. The strategy presented under this Directive can be implemented through the national frameworks and policies of the EU Member States. This policy implies that it is necessary for national authorities to establish good cooperation with local and regional authorities with their own country and to facilitate the exchange of experiences of each individual local and regional government. In addition, cooperation with other EU Member States is crucial, to work on joint development and implementation of prescribed strategies. The Directive contains guidelines for the national policy framework that must be formed to meet infrastructure requirements, supply of traffic by electricity, hydrogen, natural gas and other alternative fuels. Aim of the Directive is dual: it is necessary to reduce the use of oil and to mitigate negative transport impacts on environmental. At the same time, the Directive agrees with the document White Paper adopted by the European Commission [5], where is a key part of the strategy phasing out of conventional cars in cities by 2050 - with switching to electric vehicles, hydrogen vehicles, hybrid vehicles, public transportation and walking or cycling.

It is also planned to reduce emissions of harmful gases to zero by the same period. Since it is already late in fulfilling the set plans and strategies, the long-term climate target alone will not be sufficient. Experts consider If the EU takes action now to drastically reduce emissions by 2030, we could prevent the most severe consequences for our planet [6].
3. Types of alternative fuels

The Directive [3] defines which substances are considered as alternative fuels:

1. Electricity
2. Hydrogen
3. Biofuels
4. Natural gas – CNG (compressed natural gas) and LNG (liquefied natural gas)
5. Liquefied petroleum gas (LPG)

Electricty – Countries with a large production of electricity from renewable energy sources have great potential for the application of electric vehicles. Electricity is widely available so that it is possible to provide charging infrastructure on the entire street network.

Hydrogen – Hydrogen can be used in a converted petrol engine or to power a ‘fuel cell’, which acts rather like a battery. Hydrogen fuel can be produced by reforming steam from natural gas, by breaking down a hydrocarbon source (such as natural gas, fossil fuels or ethanol) or by the electrolysis of water [7].

Biofuels are renewable transport fuels that are made from biomass materials. There are different types of fuels covered by this name such as biomethane, biodiesel, bioethanol, etc. However, although biofuels are beneficial to the environmental, many critics express concerns about the scope of the expansion of certain biofuels because of the economic and environmental costs associated with the refining process and the potential removal of vast areas of arable land from food production [8].

CNG is produced by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. Using CNG as fuel reduces carbon monoxide and nitrogen oxide emissions by up to 80%, CO₂ emissions by up to 25%, and the proportion of methane hydrocarbons by up to 73%. Another advantage of CNG is that its processing into a fuel doesn’t require any additives or complicated refining processes [9].

LNG is natural gas in its liquid form. LNG is produced by purifying natural gas and super-cooling it to -260°F to turn it into a liquid. During the process known as liquefaction, natural gas is cooled below its boiling point, removing most of the extraneous compounds found in the fuel. Because of LNG’s relatively high production cost, as well as the need to store it in expensive cryogenic tanks, the fuel’s widespread use in commercial applications has been limited [10].

LPG or autogas is an alternative fuel, derived from natural gas processing and oil refining, with a lower carbon footprint and significantly less pollutant emissions than conventional fuels [4].

Alternative fuels are essentially fuels that should be a substitute for conventional fuels, oil and coal. Environmentally, these fuels are a transitional solution in the search for more efficient and renewable energy. As world stocks and world production, as well as the monopoly of conventional fuels, shrink, alternative fuels become the ultimate solution. When we talk about alternative fuels, we mean mainly motor fuels for transport vehicles, which produce less pollution than conventional fuels. Which technology to choose largely depends on the local situation, political motives, specific operational and environmental requirements that need to be met.

The some basic criteria for evaluating alternative fuel are reflected in the following:

- The impact on the environment is becoming increasingly important, because the introduction of new fuels sets strict regulations for environmental protection.
- The degree of danger during manipulation is a criterion, which is also related to the impact of fuel on the environment, whereby the technological process of production and manipulation during exploitation must be taken into account.

All the above criteria are important when choosing an alternative fuel and its subsequent development. In road transport, it is most realistic to expect that the economic aspect will decide especially because the price of the fuel itself affects the price of transport, and especially the price of freight transport. It should be taken into account that the prices of alternative fuel vehicles are significantly higher than the prices of conventional vehicles. The availability of alternative fuels also reduces their use, as petrol stations for conventional fuels are currently incomparably more accessible than the infrastructure for refueling with alternative fuels.

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It is expected that alternative fuels will only gain in importance in the coming years, since many European and world countries have started the production and application of vehicles with alternative fuels. The development of infrastructure and the application of vehicles on alternative fuels have recorded significant growth in the last few years. Technological innovations which significant investments are made and pilot projects implemented within individual countries, contribute to the fulfillment of the set European strategies on cleaner vehicles. Many cities, encouraged by European Union policies, have implemented a range of measures that have resulted in reduced dependence on car use and greater use of environmentally friendly modes of transport, including public transport.

Public transport has very important role in sustainable transport, apropos in sustainable mobility. Therefore, it is very important that public transport of passengers is performed by vehicles that use alternative types of fuel. Many more developed countries and cities, which have adopted different environmental strategies, are gradually replacing conventional fuel buses with buses that use alternative fuels.

Although the purchase of new buses cost twice as much as conventional vehicles, the savings resulting from the use of these vehicles are numerous. In addition to reduced noise in the city center, the most obvious result is certainly a reduction in fuel costs, as well as the absence of harmful gas emissions. According to calculations of the Technical University of Graz, electric buses will reduce emissions of CO₂ by 5.3t, of NO by 1.7t and of NO₂ by 0.06t per year compared to the liquid gas buses which had been used before [11].

The Reading public transport operator (UK) introduced 34 CNG buses in april 2013, which at the time was the largest fleet of CNG buses in that country. A major advantage of using CNG over the Euro V diesel buses (the comparable traditional technology) at the time of purchase was the reduction of harmful tailpipe emissions including particulates, which are negligible. Estimates from Reading Transport are that NOx emissions of their fleet of biomethane buses are 30%-50% lower than comparable Euro V diesel buses. As well as low emissions the buses are smoother and quieter than conventional diesel engine buses [12].

In the autumn of 2019, London got two routes 43 and 134, which are the first bus lines in the UK that use only electric double-decker buses. It has the largest electric bus fleet, with over 200 electric buses. For this year, an increase in this number of electric buses is planned, as Transport for London (TfL) has awarded contracts to operators for a further 78 electric double-decker buses. Generally, for the past 10 years, London has been considered a city...
that has one of the largest fleet of green buses in Europe. In some areas of the city there were 90 per cent fall NOx emissions [13].

The Italian city of Turin has also replaced existing vehicles with electric buses in the city center. In addition to the stated advantages of zero emissions, vehicle maintenance costs have been reduced by 20%, while the life of the vehicle has been extended by also 20%. The overall experiences of the operator and passengers have been very positive [14].

Porto’s public transport operator (STCP) has operated a fleet of 255 standard and articulated CNG buses since 2009. The models used are MAN NL 233 CNG and MAN NL 310 CNG. These vehicles performed better in terms of emissions than comparable diesel models, produced less noise emissions and have been well accepted by drivers and passengers [14].

In 2011, the city of Umea in Sweden tested electric buses on certain bus routes, with very good results. According to data from 2016, in the city of Umea there were nine electric buses and two hybrid buses on three lines 6, 9 and 80. In June 2019, an additional 25 electric buses are planned to be introduced [15]. Due to the fact that there is clean wind energy and hydroelectric power plants in Umea, buses can run entirely on clean energy. Buses use LTO batteries that can be charged within 6 minutes for an hour’s drive [16].

In the summer of 2019, the formation of public transport lines with zero emission in Barcelona has begun. TMB company has procured 23 e-buses, which will replace existing diesel vehicles. They have a plan to renew the fleet of city buses in Barcelona with the introduction of 266 electric, hybrid and natural gas buses in the period 2019-2021. The final plan is that by 2030 the whole TMB fleet will be made only of alternative drive buses [17].

5. Conclusion

With the global energy system at a crossroads and current European and global trends largely based on fossil fuels, the future of alternative fuels and vehicles using alternative fuels is yet to come. It seems that the demands of climate policy and the economic interests that are placed before society have found their place in the politics of most European and world countries. Attempts are being made to change the current position on mobility, ie transport, in favor of modern and obviously necessary strategies on sustainability. Since there are different alternative fuels, it is necessary to make a detailed analysis before introducing vehicles with these types of fuels into the transport system. Countries that have not yet started using vehicles with alternative fuels can use the experience of countries that have already started using them.

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The possibility and analysis of using gas as an alternative fuel in the diesel engine

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Abstract: the article considers the possibilities of diesel engine operation on gaseous fuels, as well as their advantages over standard engines. The focus is on the possibility of running effectively the gas-diesel cycle so that it is brought to the processes occurring in the engine with forced ignition as close as possible. The article also discusses the issues related to optimization of the processes occurring in the gas-diesel engine, which will bring the gas-diesel cycle close to the petrol-running cycle. There are also identified ways to improve the economic and environmental performance of the diesel engine.

KEY WORDS: DIESEL ENGINE, CARBURATION, FUEL INJECTION, TOXICITY.

1. Introduction

Vehicle Internal combustion engines (ICE) mainly use the liquid fuels of petroleum origin, which are characterized by intensive pollution of the environment, e.g. by existence of a large amount of various harmful substances in the exhaust gases. Use of alternative fuels is an option to reduce environmental pollution. First of all, such fuel is a natural gas (NG), as it’s resource is large and at the same time NG is cheap, as unlike a liquid fuel obtained from oil, NG does not require significant recycling before use. The uniformity of the composition and the absence of contaminating substances give the NG fuel a number of positive properties. The main components of natural gas are: methane, ethane and butane. Methane has the ability to generate greater specific weight heat compared to gasoline, although its ability to generate volumetric heat is much smaller than that of gasoline or diesel fuels. In addition, for combustion of different types of fuels in engines, it is particularly important not the calorific value of the fuel itself, but the ability to generate heat from the Air-Gas working mixtures. It is known that the calorific value of the Air–Methane mixture is 90% of the same characteristic of the Air-Gasoline mixture, and 95% in the case of Air-Diesel fuel mixture, which should lead to a reduction in liter capacity of an ICE in the case of natural gas use. The ignition temperature of the Air-Methane fuel mixture exceeds 180-220 °K compared to the the Air-Gasoline fuel mixture, indicating the ability to work with high compression rate, which is essential for a diesel engine.

Due to its physico-chemical properties, NG provides the possibility of some expansion of the ignition interval, which, in turn, ensures better regulation of the internal combustion engine power. When using gas fuels in engines, a Air-Methane mixture is more advantageous than Air-Liquid fuel vapor mixture, as the air to fuel volumetric ratio is smaller - \( L_0 = 9.52 \text{ m}^3/\text{m}^3 \). Under other equal conditions, the smaller the \( L_0 \), the easier it is to ensure good working mixture. It is also important that both components of Air-NG mixture are in a gaseous state.

A number of negative properties of NG as an engine fuel should also be mentioned: a relatively low combustion speed compared to the Air-Liquid fuel mixture; there may be other hydrocarbons in natural gas such as: propane, butane, pentane, etc., which makes the fuel more prone to detonation. Estimation of overall properties of fuel energy presumes determination of the quantity of heat which can be obtained in the process of transforming into the mechanical work in each cycle of ICE. In this regard, the heat of combustion of fuel mixture is also influenced by two other factors: a) the effect of fuel properties on the filling degree of cylinders and b) the composition of the working mixture during which the engine develops nominal power.

One of the most promising workflows for a diesel transport engine is the Natural Gas / Diesel dual fuel cycle. The NG/Diesel dual fuel process has potential advantages over the spark ignition process. It is known that the efficiency of diesel engine \( \eta \) is not less than 0.42-0.44. Both external and internal formation of air-fuel mixture are used in the NG / Diesel cycle.

External formation of the air – fuel mixture due to its simple construction has gained wide application in transport ICES. In this case, the mixer is made in the form of a nozzle built into the air tract. Gas is supplied to the mixer at a pressure close to atmospheric, in order to exclude both gas leakage into the environment and outside air penetration into the intake tract. The NG attractive properties for better air-gas mixture formation also make it possible for wide application of internal mixing. A particular difficulty is the high temperature (650-700°C) of NG self-ignition, which significantly exceeds the self-ignition temperature of diesel fuel (320-380°C).

For the maximum approximation to this process, we can consider the injection of NG into the cylinder at the end of the compression process and ignition of mixture with a small dose of the diesel liquid fuel not exceeding 15-20% of total fuel amount. That will allow to use a serial diesel engine without changing the compression rate.

Due to the low density and low volumetric heat of combustion the cryogenic storage methods are increasingly being used for the NG. That requires the development of special System for fuel preparation and delivery. Reducing toxic emissions and defining promising ways to increase fuel economy and reliability in this type of prospective engines also is a very urgent task. It is important to implement an external mixing process in the diesel engine, which directly determines both the economy of the ICE and the importance of environmental parameters in the exhaust. During such a cycle, it is important to note that the Air-Gas mixture is ignited by a small amount of liquid fuel (explosive quantity) and in this case can be used a) a conventional standard diesel engine fuel system that provides engine performance on two types of fuel (in such case consumption of liquid fuel can’t be less than those on idle and small loads) or b) with a specially designed fuel delivery system that provides a minimum of 7-10% supply of combustible liquid fuel. In addition, it is difficult to regulate the load of engine, as it is difficult to regulate the quality of the air-fuel mixture and it is necessary to provide such a fuel supply equipment that convincingly provides qualitative regulation of engine load.

2. Preconditions and means for resolving the problem

The above stated helps us to carry out such a task formulation, which allows the conversion of diesel engine into NG / Diesel dual fuel engine, particularly a) creation of such high effective working process with good ecological characteristics, in which the use of diesel fuel is limited and NG is used in all the intervals of engine speed and loading b) use biofuel with better characteristics in combination with NG instead of diesel. This is directly related to the air-fuel mixture formation in the combustion chamber from the moment of fuel injection to the ignition of the last element of the combustible fuel. These goals include the process of macro-distribution of the elementary volumes of fuel in the space occupied by the oxidizer, as well as the subsequent micro-mixing, i.e. the provision of contact between the molecules of both components required for the combustion reaction. The air-fuel mixture formation process can be divided into the following stages:
1. The introduction of liquid fuel in the form of a jet into the Air-NG mixture volume. In this case, the defining parameter is the hydrodynamic conditions of the fuel supply system.

2. The disassembly of the supplied liquid fuel jet into separate droplets (foggy condition). The efficiency of this process in terms of dispersion and volume distribution depends on both: the conditions of the first stage (fuel jet outflow velocity, fuel initial concern, physical properties, etc.), as well as environmental conditions (degree of Air-Gas mixture turbulence, flow direction and physical characteristics);

3. The steam micro-mixing - the process of liquid fuel evaporation and diffusion by the joint heat exchange between the diesel fuel and the Air-NG mixture. These processes take place mainly in parallel with the combustion and end in the flame zone. Although the pre-flame stage directly determines spatial distribution of the flame zone, the conditions of its state, and so on, on different work regimes of ICE. Therefore, the nature of the NG / Diesel dual engine process is affected by the proportion of heat injected by the fuel, the pre-injection angle, and the mixing method. NG / Diesel dual fuel cycle is characterized with two peaks of heat emission. The first peak corresponds to the combustion process of the combustible liquid fuel. By reducing the dose of this fuel and increasing the dose of NG, the first peak decreases, while the second increases, and after reaching a certain ratio, the first peak may disappear. In this case, if an increase in the second peak is achieved, then it is possible to reduce the dosed amount of combustible liquid fuel, which will positively affect the parameters of the NG / Diesel dual cycle.

NG / Diesel dual cycle approach to the spark ignition cycle will allow us to analyze its advantages when using different types of gaseous fuels. An essential condition in the engine is the external formation of Air-NG mixture. It should also be noted that in this case the construction of the diesel engine remains unchanged, only the gas fuel system is added with minor changes. Required gas fueling system is already used in engines with spark ignition.

Let consider the ideal cycles of diesel engine running on standard and gaseous fuels, which are shown in PV and TS diagrams in Fig. 1. and Fig. 2:

**Fig. 1. The ideal cycles of diesel on standard fuel**

As can be seen from the figure the construction parameters of the engines (V, V, v, and air distribution phases) are the same. The standard diesel cycle on the PV diagram corresponds to the ac'z'ba diagram, where the supplied heat is q1 = q1 + q2, while the heat dissipated is q2. The NG engine cycle corresponds to the ac'z'ba diagram, where the supplied heat is q1 and the dissipated heat is q2.

It is likely that the gas-powered engine diagram may be more or less equal to the standard diesel engine diagram space, which corresponds to the amount of heat expended in favor, which means that at equal conditions ηsd ≥ ηgd also, if we consider their meaning ηsd = 1 – 1/ε1 and ηgd = 1 – 1/ε1 = 1 – 1/ε1 = 1/ε1. From the comparison of the formula, it seems clear that they will be equal to each other when = 1 (v, = v, = v), then ηsd = ηgd.

If (v, > v), then under conditions of constant pressure on the z = z line, an increase in heat losses occurs, which is transmitted to the cooling environment due to an increase in the volume. Also noteworthy is the fact, that the standard diesel engine uses more heat to evaporate the fuel during Air – Fuel mixture formation than in case of Air -NG mixture as the amount of injected liquid fuel here is considerably less. Reduction of the pressure at the end of the compression, as the volume of the Air-NG mixture is greater than in case of liquid fuel. Besides, the heat dissipation during formation of Air-NG mixture is reduced, which can lead to a heat compensation of about 80-90%. It can also be noted that if the supercharging is to be carried out, then a complete compensation of power of the NG / Diesel dual cycle is possible. The efficiency of engine operation can also be assessed by the coefficients:

\[ \begin{align*}
\theta &= \frac{T_{max}}{T_{min}} = \frac{T_z}{T_a} = \frac{T_z}{T_b} = \theta'\theta'' \quad \text{and} \\
\pi &= \frac{P_{max}}{P_{min}} = \frac{P_{max}}{P_{b}} \frac{P_{b}}{P_{min}} = \pi'\pi''
\end{align*} \]

In this case values of θ’ and π’ are important, as high values of these coefficients provide more perfect work of ICE.

**Fig. 2. The ideal cycles of diesel on gas fuel**

3. Conclusion

Therefore, natural gas, both liquified and gaseous, is a clean, safe, economical, and practical fuel that meets existing and planned regulations and requirements for internal combustion engines: it can significantly reduce solid particles (C) and
greenhouse gases (CO2); emission of Sulphur oxides as well as solid particles is almost at zero level. Unlike liquid petroleum fuel, liquefied NG technologies lead to the 90% less emission of nitrogen oxides (NOx), 20-25% less emission of carbon dioxide (CO2). At the same time content of other harmful substances in the form of CO and CH is also very low.

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Fresh drinking water as the necessary component of freight base of container line

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Abstract: Existence of reliable/safe freight or transportation base is a requirement for establishing maritime transportation company. Therefore, Georgia has to search for internal freight base necessary for container transportation which is highly and permanently demanded on a global market. Pure drinking water represents such product for Georgia.

According to UN, the world demand on the fresh water is increasing rapidly. The accessibility of it is decreasing day by day on our planet. It’s proved by the macroeconomic researches that Georgia possesses the resources of the world importance in the form of the fresh drinking water.

The paper presents the methods of the transportation of fresh drinking water; calculation of the potential income received from the export and its role in the development of Georgian economy.

KEYWORDS: TRANSPORTATION OF CONTAINERS, MARITIME TRANSPORT, FRESH DRINKING WATER, CONTAINER, ECONOMICS.

1. Introduction

The history of the European-Asian trade development is inalienably related to the long trade roads. In the beginning these were inner land routes. Alongside to the appearance of marine fleet, which has the higher load capacity than the overland transport, the main cargo flow of Eurasia transferred from the land trade routes to the maritime transportation. Eurasian intercontinental trade routes through the central and lesser Asia, Caspian region, Russia and Eastern Europe has become empty. The cargo shifted to the south marine routes through the tree oceans – Pacific, Indian and Atlantic.

From the beginning it used to be the path around the Africa continent, while after the construction of the Suez Canal the shorter marine route has developed. Georgia is situated in one of the most significant and geopolitically complex regions of the world - on the knot of the Silk Road, which historically played a vital role in the development of and communication between Europe and Asia. After the escape from the geopolitical captivity of the Soviet Union Georgia became a new geo-economical center between Europe and Asia, Russia and Near East due to its own geographical space, history, political significance and economical capacities. Correspondingly, an increasing interest toward Georgia, as the new geo-economical center, has evolved on the regional, as well as on the international arena.

2. Preconditions and means for resolving the problem

The trading-economical relationship between Georgia and its neighbor or remote countries has a long history. Old trading transit roads of Transcaucasia historically were a component part of the existing international systems of land, marine and inland waterway routes [1]. From the Bronze Age (III-II millennia BC) the communication between the people from east world and European territories took place exactly through the Caucasus. The trade road which connected India to the Mediterranean countries in the beginning of Christian age was passing through Georgia [2]. In the III-II millennia BC there was created the land and marine route system which connected quite remote cultures and civilizations in wider regions – from the lowland of Mesopotamia to the Indian fields, from the desert of Central Asia to the Arabian Sea. Later those routes conditioned the development of “Silk Road” routes [3]. The most significant road – “Silk Road”, which is mentioned as transcontinental caravan route in the historical sources, was connecting the China to the European coasts of the Mediterranean Sea through the Black Sea. It has to be mentioned, that the “Silk Road” has promoted the political, economic and cultural rapprochement of the East and West worlds.

In the present, in the conditions of globalization, the role of independent Georgia as a significant connecting transit artery of the West and East, North and South, is becoming even more actual and appears to be in the geo-economic interest of such a huge countries as USA, EU countries, Russia, Turkey, Iran and China. This transit artery is also important for economic interests of Armenia, Azerbaijan and Central Asian countries. Therefore, Georgia appeared in the global interest fields due to its geo-economic positioning [4]. The developed countries have actively begun cooperation with Georgia in order to maximally realize their preferential geo-economic significance.

Asian countries located on the coast of Pacific Ocean are connecting to the developed countries of the west Europe on the coats of Atlantic Ocean using the five existing international transit corridors: 1. North marine corridor; 2. South marine corridor; 3. Trans-Cyberia railway transit corridor; 4. South land transportation corridor; 5. Multimodal, or mixed type, transit corridor of Silk Road, so called TRANCECA.

On the Figure 1 presents multimodal transit corridor of Silk Road, or TRANCECA, and the marine Eurasian routes of South and North. Compared to the all other competing transit corridors of TRANCECA have its advantages and deficiencies: Advantages: a) shorter transit time; b) shortest distance; Deficiencies: a) Multimodal/mixed types of transportation; b) absence of common tariffs; c) operational complexity of transportation; d) absence of agreed common custom procedures; e) inappropriate level of technical/logistical support. Existence of reliable/safe freight or transportation base is a requirement for establishing maritime transportation company. Therefore, Georgia has to search for internal freight base necessary for container transportation which is highly and permanently demanded on a global market [5]. Pure drinking water represents such product for Georgia.

Authoritative ecologists and UN experts think that water will become more significant strategic resource in 21st century than oil and gas. In the hot climate conditions of Asian, African and Australian deserts the cost of 1 ton of pure water exceeds the cost of 1 ton of oil. The third of the world reserve of pure water is found in Latin America, primarily in Brazil. The least water reserves come to Middle East and tropical Africa, as well as on central Australia.

Figure 2 represents the distribution scheme of pure water in the world according to regions. According to UN, the world demand on the fresh water is increasing rapidly. The accessibility of it is decreasing day by day on our planet. Only 1.5 billion people from 7.5 billion people living on the earth has an opportunity to use pure drinking water due to the poverty and low purchasing power. 2.4 million children die due to the diseases caused by the low-quality water. Approximately 2.5 billion people leave in the regions with the disastrous deficit of water usage. It is expected that this number will increase to 5.5 billion by 2025 and constitutes two-third of the world population. Georgia is rich with its water resources. The total annual flow of its rivers amounts to 65 800 million m3, while the total annual flow on the territory of Georgia is 56 500 million m3. There are 26,060 rivers in Georgia, the total length of which is 58 957 km. 99.4% of them are small rivers (the length shorter than 25 km). There are 555 rivers of the Black Sea basin and 528 rivers of Caspian Sea basin which are hydrologically studied [6].
Pure groundwater is the most valuable recourse and the most reliably protected source of drinking, high quality water. It represents the primary requirement of human life after the air and that’s why it is considered as unique resource, considering the amount of which Georgia is one of the richest countries. The natural pure water stock of the country amounts to approximately 18 000 million m$^3$. Total forecasted-exploitative stocks are approximately 10 600 million m$^3$. The huge part of the natural resources of the groundwater – 95% - consists of drinking waters – 571,7 m$^3$/sec or 49,4 million m$^3$/day, while permissible amount of water resources to exploit is 301 m$^3$/sec (26 million m$^3$/day), which is widely, but not equally spread on the whole territory of Georgia. 64,4% (362,5 m$^3$/sec) of the water resources come to the west Georgia, 24,1% (137,9 m$^3$/sec) to east Georgia and 12,5% (71,3 m$^3$/sec) - to south Georgia. Significant part of these waters is characterized by the very low content of the mineral salts (200-300 mg/liter).
Considering the daily physiological norm for the human (2-2.5 liters), mentioned resources give an ability to satisfy the world demand of the water – 17.5 billion liters of drinking water daily, in case of existing real opportunity of packaging and transportation without endangering its bio ecological environment.

If we conduct the calculations and assume that 1 person consumes 1.5 liter of water daily in average, number of consumers (L_d) is 110 million – considering that there are 7.5 billion inhabitants on the earth but not all the countries are situated on the shores, not every person has an ability to purchase a bottle of water and the part of the market is taken by other companies. Then total annual consumption of the water will be:

\[ V = V_l \times L_d \times T \]

where \( V \) – is the volume of the water consumed annually; \( V_l \) is the volume of the water consumed by a person on a daily basis; \( T \) is number of days in a year.

Assume we are using the 19-liter volume bottles for the transportation of water. Then the number of bottles necessary to carry the water (\( S_b \)) is:

\[ S_b = \frac{V}{19} = \frac{60 \times 225 \times 10^6}{19} = 3 \times 10^8 \text{ bottles} \]

Let’s choose the 40-foot container, which fits 620 units of 19 liter future near.

The market for bottled water has been estimated for 90 billion US dollars in 2007. North America turned out to be on the first place according to the volume – almost 100 liters of bottled water per inhabitant annually, while the figure is 10 times less in Asian countries. The volume of bottled-packaged water sold increased sharply in 2011 and reached 214 billion liters, which is equivalent to the 30.5 liters per person in the world. The bigger part of this volume sold – 171 billion liters, was the pure non-carbonated water. The market of South-East Asia became the most rapidly increasing and largest scale market. It ousted West Europe, which was absolute leader in terms of sales. Changes like this continue to happen: according to the estimations, the consumption of packaged water solely in India and China increased by more than 60% in 2010-2015.

The United States has actively got involved in the supply of clean drinking water to the countries of Asia. In order to exert influence on the market of water supply American companies are working on the projects, according to which the water will be supplied to the Arabic countries from American great lakes [7].

Thus the time of free water has ended. For example, 1 m3 of irrigation (not drinking) water costs 1.25 US dollars in Oman. In some countries the price of 1 liter of drinking water reaches 3 US dollars.

If we discuss the passed year 2019, the share of mineral and pure water trade in the foreign trade (export) of Georgia constituted 3.5% and takes 6th place in the production exported. This is quite low measure considering the existing resources, but it is quite real to increase those figures in case of active marketing campaign through the positioning of the health benefits of the Georgian water. In total, from the export of mineral and pure water Georgia received 133 570.7 million dollars in 2019, which is 21.2% higher than in 2018. Total US dollar volume of the exported mineral and pure water was 110 171.7 million in 2018. The largest amount of mineral and pure drinking water has been exported to Russia with the total volume of 95 605.5 tones, which amounts to 60 580.6 million US dollars.

### Table 2: The natural stock of groundwater according to regions

<table>
<thead>
<tr>
<th>Region</th>
<th>The natural stock of underground pure water; Million m³</th>
<th>Total forecast-exploitative stock; million m³</th>
<th>Underground pure drinking waters; m³/sec</th>
<th>Permissible exploitation amount of pure drinking water; m³/sec</th>
<th>West Georgia</th>
<th>East Georgia</th>
<th>South Georgia</th>
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<tr>
<td></td>
<td>Relative share of water resources; %</td>
<td>Amount of drinking water; m³/sec</td>
<td>Relative share of water resources; %</td>
<td>Amount of drinking water; m³/sec</td>
<td>Relative share of water resources; %</td>
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<tr>
<td>18 000</td>
<td>63.4</td>
<td>362.5</td>
<td>24.1</td>
<td>137.9</td>
<td>12.5</td>
<td>71.3</td>
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</table>

| **The table 2 shows the distribution of the natural stock of groundwater according to regions.**

bottles. Then the number of containers (\( S_{con} \)) which is necessary to carry annual volume of the water is:

\[ S_{con} = S_b \times N_{40} = \frac{60 \times 225 \times 10^6}{19} = 3 \times 10^8 \text{ bottles} \]

We choose container ship the volume of which is equivalent to 4 000 units of standard 40-foot containers. Annual number of trips for the ships is:

\[ S_{int} = S_{con} \times 1000 = 3 \times 10^8 \times 1000 = 3 \times 10^{11} \text{ trips} \]

The number of trips in a day is:

\[ S_d = \frac{S_{int}}{365} = \frac{3 \times 10^{11}}{365} = 8.2 \times 10^7 \text{ trips/day} \]

3. Conclusion

Although Georgia is not rich with such natural resources as oil and natural gas, but it actually can get a name of mineral and drinking water producer country on the work map due to the characteristics of its water. The data ambiguously makes it clear that the sector has a potential, though using the water resources will bring more considerable benefits to the economy of Georgia if the pace of development will increase in the direction of export production, as well as building hydro powers.

4. References

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1. Introduction

Road transport is an integral part of our lives. Whether we are driving a car, a motorcycle or a bicycle, are in a public transport or just pedestrians, we are all participants in traffic. Every day, we spend considerable time moving from one place to another. Crowding, traffic jams, blocked intersections, aggression, young rebels behind the wheel, careless pedestrians, noise pollution, illegally parked cars, all define contemporary traffic where no one seems to follow the rules. Unfortunately, all these problems translate in the very large number of road accidents. Of all transportation accidents, road accidents cause the most casualties each year.

2. The causes that generate road accidents

The influence of the road environment on traffic safety. The Road Environment - Man - Vehicle system is the conceptual framework in which road traffic, with all its components, must be understood and analyzed.

The totality of streets and spaces reserved for the pedestrian and vehicular traffic of a city constitutes the traffic network or the street network; the elements consist of bars (streets) and nodes (intersections, squares, centroid, etc.), to which are added the extended parking arrangements (parking lots, garages).

A very important index in establishing traffic networks is the percentage of land use of the total area of the traffic network in the entire area of the city. Statistically, such occupancy rates vary between 10% and over 40% of the city. Experience has shown that the ground occupancy of traffic networks of values close to 20% is reflected with satisfactory results in traffic, but this indicator also depends on the size of the city and some local conditions.

The different plan configurations of the traffic networks, in particular of the main road network, distinguish several types with common characteristics. Differentiations between types occur depending on the multitude of conditions that have influenced the structure of existing cities since the origins of their formation. Thus, sets of different types of street networks can be found in the same city, developed in different eras.

Regardless of the causes that generated them, there are two main categories of network types: geometric more or less rigid, and free.

From the point of view of traffic, each of these networks has positive and negative characteristics, so the inclusion in one of these types must result from comparative analyzes.

In general, for the development of modern traffic, the aim is to achieve clear networks of interzonal and external connections, as direct as possible and without embarrassing interference. Of course, the elements of the traffic network cannot and should not be identified with the traffic vectors of the zonal distribution, but they must satisfy them in the best conditions, in this sense, the configuration of the network, as a type, is not necessarily an essential condition., but it must still be taken into account which of the types would be most appropriate for local conditions and coordination with the provisions of the systematization of land use and traffic distribution, in the current and future traffic conditions.

The geometric elements characteristic of roads represent the totality of the component elements of a road in situation plan, longitudinal profile and transversal profile.

Studies conducted over time on road accidents by Kang.J. [1] highlighted a number of connections between the risk of their occurrence and the geometric elements of roads, drawing the following conclusions: the proportion of accidents is 1.5 to 4 times higher in curves than in alignment.

A number of authors have identified some of the risk factors in their studies. For example, they studied the perception of the credibility of the speed limit imposed in relation to certain characteristics of the road according to which the objective risk varies:

- curve: yes / no;
- road width: average / wider than average;
- viewing distance: less than average / average / higher than average;
- opening the scene (presence of objects that block the view);
- left / right vision;
- the presence of the bicycle lane;
- presence of traffic lights;
- trees left / right;
- vegetation on the left / right;
- traffic in the same direction / in the opposite direction [2].

The arrangement of many intersections is the apparent result of evolution over time.

By arranging the intersections, the aim is to allow the crossing of flows and changes of direction and direction, which are necessary to travel a route, minimizing the dangers of accidents and ensuring the best possible flow of traffic, with average speeds and flows, as close as possible to the design speeds and traffic capacities of the component streets of the route.

During the process of driving a vehicle, approximately 95% of the information that reaches the driver is perceived visually. The visual detection process is the only one in tracking the road, as well as the detection of obstacles and the interpretation of road
signs, light signals, markings or other signaling modes. Drivers do not have the ability to observe the road continuously. They blink, notice objects on the other side of the road, look in the rearview mirrors, read the car’s appliances, and talk to passengers in addition to other tasks. The process is therefore one of sampling [3].

In the case of developed countries, the road network is largely defined on the basis of the classification of roads in terms of the function they perform, with an emphasis on the ability to collect or transit traffic.

Traffic planning and infrastructure design have a particular impact on road safety, reflected for example both in the appearance of streets in residential areas for accidents involving pedestrians and in the case of an urban traffic network with a large number of intersections, which poses a danger, high accident due to the lack of separation of traffic of all categories of road users.

The correct location of traffic signs makes a considerable contribution to improving the safety and efficiency of the transmission network. They must be designed to convey clear and unambiguous messages to road users so that they can be understood quickly and easily. In developed economies, road signs comply with the regulations and standards in force to ensure their consistency across the country.

The quality of the road surface essentially influences the traffic conditions. The safe operation of the road is influenced by the way the road tire contact is made. The lack of permanent contact of the tires with the road reduces the possibilities of maneuvering and braking and can generate undesirable road events.

The roughness, flatness and impermeability of the road surface are absolutely indispensable, ensuring the comfort and safety of traffic.

Pits, veils, sills, sanded surfaces, damaged edges and poor sidewalks are just some of the factors involved in losing control of the vehicle and skidding.

There are no statistics on accidents caused by potholes, but it is believed to be the major cause of accidents that occur at high speeds, especially for two-wheeled vehicles. The pits are risky, on the one hand on impact, on the other hand when trying to avoid them.

Roughness. Roughness is the property of the road surface to show roughness. This ensures the stability of the vehicles in motion, by achieving the best possible grip between the tire and the track.

Flatness. Flatness is a characteristic of the track and represents its uniformity. Its quality can be affected by different types of cracks, deformations or disintegration problems.

Defects related to the flatness of the road surface directly influence the comfort level of the occupants of a vehicle, the cost of operating the road and can also have adverse effects on road safety.

Impermeability. Waterproofing is a qualitative parameter of the running surface and has a special importance on the behavior of the road structure in operation.

If the wear layer of the roadway does not ensure the impermeability of the road, water from rain or melting snow enters by infiltration into the layers of the road structure. In this situation, there are a number of deficiencies in each road layer, which is influenced by the presence of water in its material structure.

The traffic participant is the first link in the road safety chain. Whatever technical measures are taken, the effectiveness of road safety policy ultimately depends on the behavior of the traffic participant.

Worldwide, the human factor is responsible for 80-90% of road accidents. Starting from the premise that people are prone to commit various types of errors and that the human factor has a very important role in accidents, since the ‘80s, more and more efforts have been made to research and understand these factors.

Below is a list of the most common causes of fatal road accidents:

1. Inattention and daydreaming at the wheel - 62%
2. Use of mobile phone - 12%
3. Interest in an event, object, person from outside - 7%
4. Conversations with other occupants in traffic - 5%
5. Using or searching for an object in the car - 2%
6. Eating and drinking - 2%
7. Setting the volume and air conditioning - 2%
8. Use of other systems adjacent to the machine:
   - adjustment of side mirrors or seats - 1%
9. The movement of a pet or an insect in the habitat - 1%
10. Smoking - 1% [4].

All these are the basis for the formation of the most common causes of road accidents: excessive speed, failure to give priority, violation of pedestrian traffic rules, driving drunk vehicles.

In the hierarchy of causes of accidents with serious consequences, the second place in terms of frequency is not given priority. It has been observed that these accidents are mainly grouped in the area of intersections, as a result of:

- the inattention of the drivers when crossing the space for reading the regulatory indicators;
- failure to take into account the influence of meteorological factors on visibility and the optimal stopping distance;
- incorrect assessment of the speed and distance of vehicles on the priority road;
- incorrect assessment of the distance from the vehicle, which comes from the opposite direction caused by the rear uninsurance.

Research has shown that noise influences aggression, because it amplifies the intensity of the state that has already been caused:

- to some extent this can be seen as a result of the direct influence of noise on frustration. The connection between the noise level and the degree of aggression seems to be given by the level of control that the subject has over the noise. If the individual has no control over the duration or volume of an irritating noise, the level of aggression increases;
- noise also tends to cause stress and makes concentration much more difficult. The horn is so overused in traffic that it becomes almost more important than the brake or steering wheel of a car.

The car crowds pedestrians on sidewalks that are permanently reduced in area, reducing the possibility of socialization and perception of the urban environment. Thus, in modern cities, the car that was conceived as a fast means of movement violates the freedom and possibility of safe movement of pedestrians, especially in city centers.

According to the data on the distribution of accidents by vehicle type, we can see that the group with the highest number of accidents is that of cars. In conclusion, road safety measures to reduce accidents will apply mainly to, but not limited to, this category.

3. Studies conducted on Stefan cel Mare Street in the city of Chisinau Republic

The traffic intensity was analyzed on Stefan cel Mare Street in Chisinau, Republic of Moldova, depending on the time of day. We build a graph of the difference in traffic intensity during the day.

![Fig.1 Variation of traffic intensity during the day.](image-url)
Analyzing road accidents according to the time of day, we build another graph. [5]

![Graph showing the difference of road accidents during the day.]

The difference of road accidents during the day.

We make an analysis of these two graphs, we see that the intensity of traffic increases between 08:00-09:00 and 16:00-18:00, and the frequency of road accidents also increases between 08:00-09:00 and 16:00-18:00 which proves that it is a dependence of the frequency of road accidents on the intensity of traffic. The influence of noise pollution on Ștefan cel Mare și Sfânt Boulevard on the frequency of road accidents was established.

The measurements were performed with the sound level meter DT8852 on Ștefan cel Mare și Sfânt Boulevard on 13.04.2016, starting with 12:43 on Libertății Square and until 14:25 on Dimitrie Cantemir Square. The sound level meter DT8852 has been set to determine the level of continuous sound pressure weighted A on the edge of the roadway at a height of 1.2 m. From the curb upwards, setting the maximum sound level (L_max) on the streets:

1. Ciuflea (L_max) = 89.5 dB.
2. Ismail (L_max) = 91.0 dB.
3. Tighina (L_max) = 87.2 dB.
4. Armenească (L_max) = 88.9 dB
5. V.Alecsandri (L_max) = 87.4 dB
6. A. Pushkin (L_max) = 87.0 dB
7. Bănulescu Bodoni (L_max) = 94.0 dB, it is raining
8. D. Cantemir Square (L_max) = 91.2 dB, it is raining

In the measurement process, the maximum sound level was (L_max) = 99.0 dB, when the alarm was on. The values of the noise indicators (L_max), presented above can be represented graphically for each point where the measurements were made.

![Graph showing the sound level at the intersections on Ștefan cel Mare și Sfânt Boulevard.]

The sound level at the intersections on Ștefan cel Mare și Sfânt Boulevard.

Why is there a difference in sound level at different intersections? A study was made of the traffic intensity on all the intersections on Ștefan cel Mare și Sfânt Boulevard. Difference in traffic intensity at intersections. We compare these values and see that the noise intensity is higher at intersections where the traffic intensity is higher. So the size of the noise depends on the traffic. It was noticed that the biggest noise is the old trolleybuses and old buses.

From the graph shown in Figs. 3 results that on Ștefan cel Mare și Sfânt Boulevard, the admissible limits of the sound level during the day are: exceeded by 26dB, reason for which measures must be taken to reduce noise pollution.

4. Conclusions

Considering the increase, in recent years, of the degree of self-motorization, changes in the structure of public transport, increase of intercity commuting, it becomes clear that the existing road network (with insufficient technical parameters and traffic capacities) can no longer meet modern requirements. The situation is also complicated by the lack of alternative possibilities regarding the orientation of road connections, which causes the appearance in the central area of intra-urban transit flows in a volume of 50%. At the same time, the city center acts as a node in the structure of public transport, being the most important point of arrival and departure of passengers. It can be concluded that the main streets of the central area, destined for the connection with other urban territories, do not honor their tasks and need reconstruction with the conformity of the technical parameters to the normative ones.

In order to reduce noise pollution and to streamline road traffic on the traffic artery where the measurements were made, provision should be made for:

- introduction of new means of public transport;
- parallel use of green barriers and those built of special materials, noise screens;
- a less noisy road.

Through the consequences for the individual and the society, the analysis of the causes generating road accidents and especially the identification of the directions of action for the prevention of road accidents requires fundamental and experimental researches, to the development of which this work contributes. The situation of road accidents in Moldova, presented in this paper, emphasizes that research is needed to identify measures to improve road safety.

Bibliography

Investigation of the thermostatic system of high-voltage components of an electric vehicle in real time during the xil experiment

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Abstract: The automotive industry is facing new challenges in the electric vehicle segment. It is relevant to conduct joint research of various vehicle systems in a common virtual physical environment, which will allow combining a large number of test rigs located in different parts of the world. A common virtual physical environment, called X-in-the-loop, was developed, as a part of these studies. The work involves the joint connection and use of test rig for various purposes, software simulators, driving simulators, etc., to conduct a comprehensive study of the components and systems of electric vehicles in real time. The development of the thermostating system for high-voltage components is an urgent and important task when creating modern electric vehicles. A test rig was created at FSUE NAMI to study the operation of the thermostating system for high-voltage components of an electric vehicle’s traction drive. The test rig includes a physical simulation of high-voltage components of the traction drive of an electric vehicle from the point of view of temperature and hydraulic conditions of the components studied at other test rigs included in the XIL experiments. The scientific article presents the concept of a developed test rig. The article also describes the test modes that were necessary to conduct research on various components and systems of electric vehicles in various conditions. The article describes a method for controlling the actuators of the thermostating system and devices designed to reproduce the thermal and hydraulic characteristics of cooled objects (motor-wheels and inverters) in real time. A test rig for the study of the thermostating system of high-voltage components, modelling, prototyping and testing were carried out in the process of developing.

KEYWORDS: ELECTRIC VEHICLE, THERMOSTATING SYSTEM, ELECTRICAL COMPONENTS, INVERTER, ELECTRIC MOTOR, TEST RIG, VIRTUAL OBJECT, TESTING, XIL.

1. Introduction

The automotive industry is facing new challenges in the electric vehicle segment. Vehicle manufacturers around the world are trying to reduce costs and significantly reduce the development and testing time of vehicles. With an increase in the applied innovation, the number of required tests also increases, which leads to a rise in price and a significant increase in the terms of product development. Therefore, it is relevant to conduct joint (between different organizations) research of various vehicle systems in a common virtual physical environment, which will allow combining a large number of test rigs located in different parts of the world [1 - 3].

A common virtual physical environment, called X-in-the-loop, was developed, as a part of these studies. The work involves the joint connection and use of test rig for various purposes, software simulators, driving simulators, etc., to conduct a comprehensive study of the components and systems of electric vehicles in real time. The development of the thermostating system for high-voltage components is an urgent and important task when creating modern electric vehicles [4, 5].

2. The concept of the test rig

A test rig was created at FSUE NAMI to study the operation of the thermostating system for high-voltage components of an electric vehicle’s traction drive. The test rig includes a physical simulation of high-voltage components of the traction drive of an electric vehicle from the point of view of temperature and hydraulic conditions of the components studied at other test rigs included in the XIL experiments.

The conceptual scheme [6] of the test rig is shown in Figure 1.

Data exchange between test rigs takes place using VPN technology. The temperature control of the coolant inside devices simulating high-voltage components occurs by changing the flow rate of the fluid, as well as the flow of air passing through the heat exchanger used in the thermostating system, as well as by regulating the speed of rotation of the fan of the thermostating system [6].

The test rig has two independent control units - the control unit 19 controls the simulators of high-voltage components of the test rig and a group of fans that simulate the oncoming air flow and the control unit 20 of the thermostating system.

The control unit for simulating high-voltage components serves to control electric heaters installed in simulators 5 - 12, depending on the information received from foreign partners of the project on the power sold in electric motors and inverters. This unit is also responsible for simulating the speed of the incoming air flow and the ambient temperature, which are measured using an anemometer $Q$ and a temperature sensor $t_3$. The free air velocity is simulated by controlling the power of the fan group 1. To reduce the unevenness of the air flow after the fans 1, an equalizing grid is installed 2. The control unit also receives information about the volume flow rate of the coolant passing through the simulators using differential pressure gauges $dp$ and its temperature, by means of thermal resistance $t_1$. This information is transmitted through a VPN connection to foreign partners.

Figure 2 shows a functional electrical scheme of the test rig.

The thermostating system control unit 20 is responsible for controlling the actuators (water pumps) 13 - 16. The three-way valve 18 to maintain the set temperature on the simulating devices 5 - 12. The block analyses the signals received from temperature sensors $t_2$ and pressure sensors $p$. Based on this information, actuators are controlled. This solution provides the highest efficiency of the thermostating system.
as well as a quick response time to individually variable power parameters of each tandem of the electric motor and inverter. Radiator 3 is a tubular air-liquid radiator. This type of radiator is used in most designs of modern cars. The three-way valve 18 in this system is used to reduce the time that the temperature of the simulating devices reaches the optimum level. The expansion tank 17 serves to compensate for changes in the volume of fluid in the thermostating system associated with a wide range of the functioning of this system, as well as for degassing of the coolant.

2.1. Test rig operation modes

A set of tests was performed aiming at demonstration of flexibility and speed of the X-in-the-loop environment during the studies, as well as analysis of operation of specific systems of integrated vehicle system. The following operation modes of the test rigs were studied in real time [6]: 1) Mixed braking. 2) Mixed motion. 3) Integrated control of chassis. 4) Analysis of fault tolerance and reliability.

2.2. Electron architecture of test rig control

The electron architecture of test rig for studying thermostatic system of high-voltage components of electric vehicle traction drive is comprised of main control unit intended for control of operation of thermostatic system, load control units intended for control of simulated devices, and ventilator control unit [6].

3. Test rig development

In order to closely repeat the characteristics of real objects, and to reproduce the temperature characteristics of the coolant in particular, simulators of electrical components were developed: an electric motor and an inverter.

The design of the developed devices allows you to simulate coolant temperatures in the temperature range from -40°C to 70°C, at an ambient temperature that changes in the range from -40°C to 50°C. The electric motor simulator provides a power of 12.8 kW, and an inverter of 5.2 kW. A general view of the simulating devices is shown in Figure 3.

Figure 3 General view of simulating devices

The simulators of the electric motor and inverter are located in a protective frame and consist of a housing with built-in heating elements of the required power. The central opening of the case is selected so that the resulting internal volume is as close as possible to the volume of the cooling jacket of a real high-voltage device. The output nozzles in diameter correspond to real electric machines. The output nozzles in diameter correspond to real electric machines.

Figure 4 Pressure distribution over the volume of the electric motor cooling jacket at a fluid flow rate of 8 l / min and a temperature of -5 °C.

Figure 5 Pressure distribution over the volume of the inverter cooling jacket at a fluid flow rate of 8 l / min and a temperature of -5 °C.

Figures 6 and 7 show the pressure distribution in the cooling jackets of the motor and inverter simulators.

Figure 6 Pressure distribution over the volume of the cooling jacket of the electric motor simulator at a fluid flow rate of 8 l / min and a temperature of -5 °C.

Figure 7 Pressure distribution over the volume of the inverter simulator cooling jacket at a fluid flow rate of 8 l / min and a temperature of -5 °C.

These calculation results will be used for mathematical modeling and regulation of the thermostating system.

The test rig was designed to test, study and calibrate the thermostating system of the traction electrical components of a vehicle designed for use in various climatic conditions (from minus 40°C to 50°C).

The layout of the test rig was made taking into account the location of the units in a real vehicle. The height of the components relative to each other corresponds to the location in the car-analogue. Simulators-heaters are located respectively to the wheels of the vehicle, the tracing of the pipes of the thermostatic system is made as if laid in a car, taking into account the size of the track and the base of the vehicle. The general view of the test rig is shown in Figure 8, and the technical characteristics of the test rig are presented in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Technical characteristics of the test rig</th>
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</thead>
<tbody>
<tr>
<td><strong>Gross weight, kg</strong></td>
</tr>
<tr>
<td><strong>Overall dimensions, mm</strong></td>
</tr>
<tr>
<td><strong>Maximum power consumption, kW</strong></td>
</tr>
<tr>
<td><strong>Power of one heater-simulator of electric motor, kW</strong></td>
</tr>
<tr>
<td><strong>Power of one inverter heater-simulator, kW</strong></td>
</tr>
<tr>
<td><strong>The total power of free flow electric fans, kW</strong></td>
</tr>
<tr>
<td><strong>Electric fan power, kW</strong></td>
</tr>
<tr>
<td><strong>Range of working ambient temperatures, °C</strong></td>
</tr>
</tbody>
</table>
Fig. 8 General view of the test rig of the thermostating system of the traction components of a vehicle: 1 - frame of test rig; 2 - simulator of an electric motor; 3 - inverter simulator; 4 - fans, simulators of the incoming air flow; 5 - a casing of a free stream of air; 6 - control box for heating elements and a group of fans of the oncoming air flow; 7 - a radiator; 8 - radiator electric fan; 9 - expansion tank of thermostatic control system; 10 - three-way valve; 11 - electric pump (1 pump in tandem of an electric motor with an inverter); 12 - nozzles of a thermostating system; 13 - differential pressure sensors; 14 - sensors for measuring the temperature of the coolant; 15 - measuring collectors; 16 - control box for electrical components of the thermostating system.

4. Simulation

A mathematical model of the thermostating system in the Simulink software environment was developed in the process of work. A mathematical model is necessary to obtain a multifunctional tool designed to conduct research on the temperature control system, to connect a model of a power plant (or its parts) to the X-in-L system, and also to develop a control system for thermostatic control of power plant components [8 - 14].

Figure 9 shows the upper level of the developed Simulink model, on which its main subsystems are located.

Using the developed mathematical model, computational experiments were carried out in accordance with the following conditions:

- modeling is carried out using the temperature control system diagram shown in Figure 2.
- the electric vehicle’s driving mode is set by the WLTC driving cycle (World Harmonized Light Vehicles Test Cycle, regulated by Global Technical Regulation No. 15. This cycle is also used as the main test mode in the X-in-the-Loop environment, as well as in the works of participants in the European consortium.
- ambient temperature range in accordance with the project specification: from –40 °C to 50 °C with a number of intermediate values.

According to the results of computational experiments, the following characteristics of the compared circuits of thermostating system were evaluated:

- ensuring the required temperature regimes of the components of the power plant (the temperature of the coolant at the entrance to the cooling jacket: not more than 65 °C for the motor wheel and not more than 60 °C for the inverter, the minimum coolant flow rate: 8 l/min for the motor wheel and 5 l/min for the inverter) in a given range of ambient temperatures;
- qualitative and quantitative indicators of the functioning of the control algorithm of the temperature control system;
- energy efficiency provided by comparable circuits of the thermostating system.

Figure 10 shows the calculation results.

The developed model is universal and scalable, which allows it to be a tool for studying the characteristics of the thermostating system, developing a control unit for the thermostating system, and also be part of the virtual instrumentation of the X-in-th-Loop environment.

The computational experiments made it possible to conclude that the use of a combination of closed automatic control of thermostatic system pumps and control of the radiator fan allows optimal temperature conditions for the operation of power plant components at elevated ambient temperatures up to 50°C inclusive. Control of the coolant movement in the mains with the help of a three-way valve and regulation of the pumps allows ensuring the operation of the components of the power plant at negative temperatures up to – 40°C inclusive.
5. Conclusion

Currently, the test rig with a developed a thermostating system is being prepared (work is underway on the final assembly and debugging of operating modes) for research tests, which must confirm the effectiveness of the developed method of joint testing.

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6. References

Initial design of an internal combustion engine for a range extender unit for electric vehicles

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Abstract: The present paper is focusing on a basic research for an initial design of an internal combustion engine for use in a range extender unit for an electric vehicle. The paper introduces a short description of the power train concept as well some interesting points, problems and challenges during the design process of the internal combustion engine. Some of them are connected with a proper selection of the engine configuration (number of the cylinders, their configuration, etc.), a determination of the engine main parameters (bore and stroke) and how they affect the engine operation and performance. Different parametric models are used and some output results are presented.

Keywords: ELECTRIC VEHICLE, VEHICLE RANGE, RANGE EXTENDER, IC ENGINE DESIGN, BORE/STROKE RATIO

1. Introduction

Alternative fuel vehicles are growing in popularity these days, especially the battery electric vehicles (BEVs). The pure electric power train of vehicles appeared more than a century ago. Since then the available technologies, manufacturing processes and human knowledge have been changing incredibly. Thanks to these prerequisites, it is possible nowadays to create much better all-electric powered vehicles with significant enhancement in efficiency and performance.

The power train layout (configuration) of BEV with REM looks very similar to that one, which the series hybrid vehicles use. The main role of the range extender unit is to increase the vehicle travel range to an acceptable level when it is necessary. However, in most cases this device has to serve only as a safety measure, to remove the anxiety of staying broken down on road with a flat (discharged) battery.

2. Electric vehicle with Range Extender

Electric Vehicle Modelling and Simulation. Nowadays, in the automotive industry there are different simulation software products, which are used for convenient analyses of vehicles and their power trains (engines, transmissions, etc.) during the design process. For the next simulations, the package GT-SUITE from Gamma Technologies is used.

This paper presents a brief comparison between a traditional battery electric vehicle (BEV) and a modified electric vehicle equipped with a range extender. In that case, simple models are prepared for a simulation study and then properties of the vehicles are explored. To compare how the vehicles perform under different circumstances, basic simulation analyses are done in the conditions of two driving cycles - the old NEDC and the new WLTP.

Vehicle Simulation Model. As a representative example, a simple EV model is studied. The vehicle itself is equipped with a battery electric system and a single electric traction motor. The motion goes through a single drive shaft and a differential to the axles of the wheels. An external power source recharge the batteries, but a regenerative brake mode can be also present.

As a next step, the same EV power train configuration is transformed to a ReEV one. The additional REM unit includes models of an IC engine and an electric generator. This ReEV architecture is similar to the layout of the series hybrid vehicles. For simplicity, a single simulation model is used to perform all analyses for both vehicles. The vehicle parameters are modified for each type of vehicle, e.g. in the pure EV the IC engine is simply disconnected.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>BEV 60 Ah</th>
<th>BEV 94 Ah</th>
<th>REM 60 Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle weight [kg]</td>
<td>1270</td>
<td>1320</td>
<td>1390</td>
</tr>
<tr>
<td>Battery weight [kg]</td>
<td>230</td>
<td>280</td>
<td>230</td>
</tr>
<tr>
<td>REM weight [kg]</td>
<td>-</td>
<td>-</td>
<td>120</td>
</tr>
<tr>
<td>EM power [kW/rpm]</td>
<td>125/4800</td>
<td>125/4800</td>
<td>125/4800</td>
</tr>
</tbody>
</table>

Fig. 3. Some EVs Parameters

Three different configurations are reviewed: 1) an EV with 60 Ah battery, 2) the same EV with a REM unit and 3) the same EV with 94 Ah battery. Their analysis shows the differences in reachable electric range just by changing the size of the battery and the contribution of using a range extender instead of increasing the battery size. This quick study reveals also some preliminary parameters of the range extender unit.

Fig. 1. A Range Extender System with Twin Cylinder Boxer IC Engine from Robby Moto Engineering, Italy.

Fig. 2. A Range-Extended Electric Vehicle (ReEV).
Most of the important parameters are inspired from products available on the market, i.e. BMW i3 series EV. The EV simulation models are not calibrated in any way and the provided input data are roughly adjusted to correspond to BMW parameters. Fig. 4 presents the described simulation model in GT-SUITE.

Some results from EV simulations can be seen below. For simplicity, a single simulation model is used to perform all analyses. The vehicle parameters are modified for each case and in the pure EV the IC engine is disconnected.

**EV Simulation Results.** The overall EV range is estimated by performing the selected driving cycle a few times in a sequence until the battery is fully discharged. The results show that by increasing the capacity of the battery from 60 to 94 Ah, i.e. adding additional 50 kg of weight, the EV can drive 65/53 km more in the NEDC/WLTP accordingly (i.e. +53 % for both).

![Vehicle Simulation Model in GT-SUITE.](image)

**Fig. 4. A Vehicle Simulation Model in GT-SUITE.**

![Vehicle Electric Range.](image)

**Fig. 5. A Vehicle Electric Range.**

**ReEV Simulation Results.** One more important question appears here: what amount of power the IC engine in the range extender unit has to generate and of course, how the engine operating to be controlled: when to start and stop it to guarantee an appropriate optimal extension of the vehicle range. The preliminary results indicate that an engine with output power of around 20 kW to 30 kW has to be enough for ensuring an acceptable extension for the vehicle. For this model example, only one engine operating point is used (power of 20 kW). Clearly, it is meaningful to develop a more advanced control strategy with more than one operation points of the range extender.

Because at that moment the parameters and properties of the IC engine are completely unknown, the simulation model is simplified. The IC engine is represented in the model by simple mechanical components that simulate the function of the engine just by applying torque and speed to the rotating shaft. In the electric mode, the state of charge (SoC) of the battery is set to 100 %, i.e. fully charged. The simulation runs the vehicle in the specific driving cycle a few times until the battery is completely depleted (fully discharged). In the REx mode the range extender is started when a specific battery SoC is reached. The total vehicles range is presented below.

![Comparison of the Total Vehicle Range](image)

**Fig. 6. A Comparison of the Total Vehicle Range**

Right now, it is roughly known what amount of power is needed for an IC engine in a REx unit to prolong the EV range. In the model example, a 20 kW IC engine can roughly provide 50 % longer travel range in both NEDC (+93 km) and WLTP (+80 km) compared to BEV 94.

### 3. Internal Combustion Engine for EV Range Extender Unit

The REx unit has to satisfy different requirements. Most of them depend on the IC engine itself such as fuel consumption, efficiency, exhaust emissions, costs, assembly size and weight, NHV properties etc. Shortly, the IC engine in a REx unit has to be small, compact and efficient. A naturally aspirated (NS) spark ignition (SI) IC engine seems to be the most suitable for this application because of its simplicity and undemanding design.

At the beginning of the design process of a new reciprocating IC engine, there are four essential points, which need to be determined. They will significantly affect the engine design, size, performance and behaviour. They are as follows: the engine displacement volume needed to generate the required power, the number of the cylinders which the displacement volume will be divided to, the cylinder geometry (bore and stroke), and the engine (cylinders) configuration.

For an estimation of the IC engine displacement volume $V_e$, the engine can be considered as a positive displacement air pump. To produce a certain amount of work (power $P$ at a specific engine speed), the IC engine has to burn an appropriate quantity of fuel. To ensure a complete combustion of the fuel a sufficient amount of air has to enter into the engine. After a rough outline of the expected torque curve and prediction of the brake specific fuel consumption (BSFC), as well knowing the air to fuel ($A/F$) mass ratio, the needed mass airflow can be calculated as follows.

$$\dot{m}_{fuel} = \frac{P}{\text{BSFC}} \rightarrow \dot{m}_{air} = \frac{\dot{m}_{fuel}}{A/F} \rightarrow V_e = \frac{\dot{m}_{air}}{\rho_{air}} \left( \frac{A}{2} \right) \cdot \eta_{vol}$$

In our case, the objective is to propose a new NA spark ignition IC engine for an application in a REx unit for EVs. Let us state the IC engine has to deliver a power of 20 kW at 4000 rpm. It can be assumed the specific fuel consumption at that power could be around 250 g/(kW.h). In addition, an engine volumetric efficiency of around 90 % at that speed is supposed. The estimated displacement volume is calculated for these assumptions as 586 cm$^3$. A next critical issue to decide is how to divide the IC engine displacement volume, i.e. the number of cylinders and their orientation. The engine layout has serious impact to costs, complexity, components mass, engine speed, acting mechanical forces and their balancing, surface to volume ratio, losses etc.
An essential point to solve is the ratio of the cylinder bore (B) and the piston stroke (S). In theory, for a specific cylinder displacement, an endless number of bore to stroke (B/S) ratios is feasible. However, selecting the right B/S ratio will significantly affect the overall size and design of the engine (i.e. engine block length and height). Moreover, it has an essential impact on the engine performance, efficiency and losses.

**ICE Simulation Model.** A simple study (sensitivity analysis) can show the impact of the B/S ratio on the IC engine behaviour. For a better image, the IC engine displacement is maintained at a constant value and a few different B/S ratios are used. For this aim, a simple model of a twin-cylinder boxer IC engine in GT-SUITE is used for a parameters analysis. At this stage of the IC engine design, there are many unknown parameters and some assumptions are done. Some parameters of the IC engine that can also significantly affect the engine behaviour are considered and maintained similar done. Some parameters of the IC engine are presented.

**ICE Simulation Results.** Some output parameters of the IC engine, as the brake power produced at the specific speed, the brake fuel consumption and the volumetric efficiency at that speed are presented.

<table>
<thead>
<tr>
<th>B/S Ratio</th>
<th>Bore B [mm]</th>
<th>Stroke S [mm]</th>
<th>Displ. vol. [cm³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>60.7</td>
<td>101.2</td>
<td>585.7</td>
</tr>
<tr>
<td>0.7</td>
<td>63.9</td>
<td>91.3</td>
<td>585.6</td>
</tr>
<tr>
<td>0.8</td>
<td>66.8</td>
<td>83.5</td>
<td>585.6</td>
</tr>
<tr>
<td>0.9</td>
<td>69.5</td>
<td>77.2</td>
<td>585.6</td>
</tr>
<tr>
<td>1.0</td>
<td>72.0</td>
<td>72.0</td>
<td>586.3</td>
</tr>
<tr>
<td>1.1</td>
<td>74.3</td>
<td>67.6</td>
<td>585.6</td>
</tr>
<tr>
<td>1.2</td>
<td>76.5</td>
<td>63.8</td>
<td>585.6</td>
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<tr>
<td>1.3</td>
<td>78.6</td>
<td>60.4</td>
<td>585.6</td>
</tr>
<tr>
<td>1.4</td>
<td>80.5</td>
<td>57.5</td>
<td>585.6</td>
</tr>
</tbody>
</table>

Fig. 7. *An Overview of Bore/Stroke Ratios*

The cylinder bore specifies the size (diameter) of the intake and exhaust valves. That is why, the B/S ratio and the parameters of the valve train system have to be tuned together to optimize the cylinder charge exchange and thus, the engine performance. A larger value of B/S ratio, i.e. a larger cylinder bore, will make possible operating at higher engine speeds and together with larger valves (i.e. an optimized intake velocity) will ensure a higher power density. On the other hand, a smaller value of B/S ratio, i.e. a longer stroke, will allow locating the peak power at lower engine speeds.

The achievable engine compression ratio (CR) is also dependent on the B/S ratio, which specifies the volume of the cylinder and the combustion chamber. A higher CR is necessary to enhance the engine thermal (and fuel) efficiency. For a given displacement, it is not easy to reach a high CR. With a growing cylinder bore, the variants meet the power requirement. The maximal value of power occurs at B/S ratio 1.1 - 1.3. It is clear that the engine with higher B/S ratio performs better at this speed.

The pistons move in a reciprocating manner and continuously change their velocity and acceleration during the strokes. The piston velocity is zero at TDC, and the piston accelerates to its maximum velocity around the middle of the stroke, and then decelerates and stops at BDC at every stroke. The maximum values of the piston velocity and acceleration depend to the stroke length and the engine speed. A higher rate of acceleration causes higher mechanical stresses of the engine components. An effective method for stating the engine design limits is to define the mean (average) piston speed \( V_p = (\text{Stroke} \cdot \text{rpm})/30 \text{ [m/s]} \). The mean piston speed is one parameter that limits an engine structural design. A higher piston speed increases friction and wearing, but it increases also the load forces in the connecting rod. In some cases, it is possible to reduce the stress in the connecting rod by using of a longer connecting rod in a combination with a shorter and lighter piston. Fig. 9 shows a comparison of engine variants from this point of view.

![Fig. 9. A Mean Piston Speed at 4000 rpm](image)

Fig.10 presents the IC engine volumetric efficiency at defined speed. The results corresponds with the preliminary assumption made at the beginning of the IC engine design process.

![Fig. 10. A Cylinder Volumetric Efficiency at 4000 rpm, CR 12](image)

The B/S ratio affects significantly the heat transfer process in the cylinders and the combustion efficiency. For a number of reasons, the design and optimization of the combustion chamber with a rising bore diameter is getting more and more complicated. The B/S ratio has a major impact on the shape of the combustion chamber for a specific cylinder size. The rising bore diameter will cause a change of the aspect ratio of the combustion chamber to a shallow disc.

![Fig. 8. An Output Power at 4000 rpm, CR 12](image)
piston stroke shortens and the compression chamber height shortens also, and an interference of the valves and the piston crown can occur at TDC.

\[ \text{Compression Ratio} = \frac{\text{Volume}_{\text{max}}}{\text{Volume}_{\text{min}}} = \frac{V_{cc} + V_{cyl}}{V_{cc}} \]

**Fig. 11. A Compression Ratio for Equal Combustion Chamber Height**

The B/S ratio slightly affects the engine frictional losses. A larger B/S ratio means that a similar peak combustion pressure will act on an increased piston surface area and this will cause higher loads on engine components and bearings (Fig. 12). That is necessary to take into account during the design and optimization of all separate engine components. Higher loads will result in a need for larger bearings and higher hydrodynamic losses. The mass of the piston grows as a function of the bore and this will negatively affects the inertial forces, which also increases the loads. On the other hand, a longer piston stroke will result in a higher mean piston speed, which leads to an increase of friction between the piston and piston rings and the cylinder wall.

**Fig. 12. Force on piston vs. cylinder peak pressure at 4000 rpm, CR 12**

Fig. 13 shows the engine brake specific fuel consumption (BSFC) at the defined speed. It can be seen that the variants of an IC engine with B/S ratio of 1.0 to 1.3 have one of the best fuel economy.

**Fig. 13. Brake Specific Fuel Consumption at 4000 rpm, CR 12**

Also the values of the fuel consumption in the simulation are more optimistic than the preliminary expected value of 250 g/(kW.h).

### 4. Summary

This paper presents a brief outline of the problems connected to the design of range-extended electric vehicles. An initial study of vehicle properties shows a comparison of a traditional BEV and the same vehicle equipped with a REx unit to ensure an extension of the vehicle range. The results confirm the fact that the EVs with REx have a great potential and need a further research. In the Figure 14 one more challenge can be seen, i.e. the weight of the REx unit is also deciding (of course together with the solution price). Therefore, the main question is: is it worth going to a higher battery capacity or to a REx unit from this point of view (i.e. weight vs. price)?

**Fig. 14. BEV vs. ReEV Range Comparison**

A brief overview of some issues related to the IC engine design for REx units for EVs is presented here focusing on the main IC engine parameters (geometrical properties): the cylinder bore and the piston stroke. The research outlines some trends how the relation between these two parameters (B/S ratio) can affect the performance and behaviour of the engine. A basic review of a possible REx unit IC engine layout – a twin cylinder spark ignition boxer IC engine with displacement volume of 586 cm³ is presented and a preliminary simulation study has shown the sensitivity of the engine parameters and its performance to different B/S ratios.

In any case, a further study and optimisation of the IC engine parameters and its individual systems will give better advice which parameter values are better and more suitable. According to the noticeable at this design stage trends, most of the IC engine parameters are getting better with a higher value of B/S ratio. So a B/S ratio of around 1.1 - 1.2 could be recommended. A magic rule for a right selection of the parameters does not exist. The ratio between the cylinder bore and piston stroke of the IC engine depends on many different factors and of course, on the engine purpose. That is why the general knowledge and engineering experience have to be always supported additionally with parametric studies (simulations) and optimizations.

### 5. Reference

Reliability, safety and efficiency - challenges for transport infrastructures

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Abstract: Transport infrastructure brings together conventional groundwork and innovative technologies in order to improve various aspects of transport system management and control. It enables anticipatory maintenance, planning and scheduling, resource management and aims to improve reliability and safety, increased capacity and asset utilization, better energy efficiency and lower emissions, higher customer service levels and increased economic feasibility. Transport infrastructures have long service life and great costs of building, manning, operating and maintaining throughout their life. Innovation and technology shifts proved to be important factors determining great changes in infrastructure potential and even determine its obsolescence. It is regarded as a concern throughout infrastructure’s entire life cycle and reflects changes in expectation regarding performances in functioning, safety and environmental effects. Performance and failure are illustrated conceptually and represented in a simplified form considering the evolution of technology, the influence of innovation breeding new generation rail infrastructure, all the way through infrastructure’s service life. According to the identified particularities, recommendations are to be made in order to insure a best practice in lifecycle management and transport infrastructure renewal in the context of improved reliability, safety and efficiency.

Keywords: TRANSPORT INFRASTRUCTURE, RELIABILITY, SAFETY, EFFICIENCY, LIFECYCLE, OBSOLESCENCE

1. Transport infrastructures and their lifecycles

An unquestionable feature of transport infrastructures is the long service life. Even if some parts/components decrease their performance more rapidly, most transport infrastructures last for decades, some even for centuries (see Fig.1.1). Commonly, the lifespan of transport infrastructure is different than the physical life. The end of physical life is reached when parts/components are over their service life - a convenient number of years. In some cases, financial reasons, rather than those of a technical or organizational nature, are the source of this lifespan. It can be said that the attempt to determine a correct theoretical value, which would predict the physical life of an infrastructure, is irrelevant, that this may even be impossible, at least at the level of the entire specific transport infrastructure.

First of all, the premises from which the forecast starts, for example, the characteristics of transport infrastructure features, the maintenance operations that will be applied, the future atmospheric conditions, cannot be guaranteed for several decades. Second, infrastructures are very rarely completely taken out of service; this does not happen until an alternative infrastructure is available to provide the same services, possibly at lower costs, or until the service is no longer needed, i.e. the infrastructure is obsolete. Maintenance work may be negligible, but component repair and replacement work must be carried out when it can no longer be postponed. In the end, the expected increases in users will more than likely lead to a decrease in the level of intrinsic performance of the old infrastructure below an acceptable minimum and then to its consideration as exhausted.

In conclusion, the notion of design service life of an infrastructure is significant only if it is defined in the sense of obsolescence and can hardly be described in terms of intrinsic deterioration of performance. Therefore a function of user’s expectations must be included in the analysis [2]. The function Pd is known as „expectation function‖. The growth rate of this function of expectations can vary very rapidly, as shown in Fig. 1. 2.

Experience shows that expectations almost always have an increasing trend, but there is not much information either about the pace of growth or their consequences on the installation of physical life of an infrastructure. The decisions of designers and future infrastructure managers are based on the premise that performance at an appropriate level can be ensured for a certain service life - a convenient number of years. In some cases, financial reasons, rather than those of a technical or organizational nature, are the source of this lifespan. It can be said that the attempt to determine a correct theoretical value, which would predict the physical life of an infrastructure, is irrelevant, that this may even be impossible, at least at the level of the entire specific transport infrastructure.

Experience and testing are the two main sources of information on which the expectations on the service life of an infrastructure are based. Efforts to predict service life, as well as the form of function that describes performance deterioration, face a number of obstacles, including the limited ability to understand how failure occurs, uncertainties and factors influencing deterioration and lack of data are very complex issues of the problem. Among these aspects are the challenges of characterizing the service life for a facility, for the entire infrastructure or even for the entire system, as opposed to their repairable or replaceable elements.

In general, the experience already gained in good practice cases and the empirical data are still the main source of estimating the service life of an infrastructure. The decisions of designers and future infrastructure managers are based on the premise that performance at an appropriate level can be ensured for a certain service life - a convenient number of years. In some cases, financial reasons, rather than those of a technical or organizational nature, are the source of this lifespan. It can be said that the attempt to determine a correct theoretical value, which would predict the physical life of an infrastructure, is irrelevant, that this may even be impossible, at least at the level of the entire specific transport infrastructure.

Fig. 1.1 Main Transport Infrastructures Lifecycles

(source: data from Living Planet Report, 2006 and Summary result of second Eurostat questionnaire on CFC on public infrastructure, DOC.CFC 15, Eurostat, 2003 [1])

Fig. 1.2 Evolution of expectations over transport infrastructures

Expectations on transport infrastructure performance are rising, so the slope of the function curve must be greater than zero. Well-founded data for an analysis of this function are not easy to find, it is only known that the obsolescence of an infrastructure is determined by technological changes, new regulations, social, economic, user behavior and values, changes that are, as shown in the last decades, accelerated for periods of time comparable to the service life of the infrastructure.

Experience shows that expectations almost always have an increasing trend, but there is not much information either about the pace of growth or their consequences on the installation of
obsolescence of infrastructure. Direct observation provides some information about each of the four main sources that induce the moral degradation of infrastructure: technological, regulatory, socio economic and behavioral.

Of these, technological change follow-on new generation, intelligent infrastructure that brings together conventional groundwork and innovative technologies in order to improve various aspects of transport system management and control, can only be seen from a long-term perspective and it is observed that it takes longer and longer until an infrastructure is considered obsolete. This period of transition from one technology to another is not as slow as it used to as there is currently a major technological change in transport sector.

2. Performance and failure

2.1 Performance

Infrastructure performance is a concept widely examined over the years and therefore many perspectives concerning this concept emerged. Present paper refers to the model of describing performance proposed by Lemer [3, 4] and bases his assumption on the mathematical formalization presented in equation 2.1.

\[ P(S_j, D_j, t) \]  
(2.1)

Where:

- \( S_j \) represents the supply vector for an infrastructure facility \( j \) (in relation to different users: operators, individual users, neighbors of the infrastructure);
- \( D_j \) = the demand vector for an infrastructure facility \( j \) (in relation to different users: operators, individual users, neighbors of the infrastructure);
- \( t \) = time, measured from the commissioning of infrastructure

On general terms, supply vector, \( S_j \), is well described using a function that uses as variables the physical characteristics and operational characteristics of a given infrastructure, as in equation 2.1.

\[ S_j = S(X_j) \]  
(2.1)

\( X_j \) represents the physical characteristics and operational characteristics vector (for example: simple or double track, interlocking systems type, management system type, safety integrity level).

The service outputs that infrastructure provides can be quantified as positive: higher accessibility, mobility, safety, comfort reliability or as negative: higher noise level, pollution, disruption of wild life habitats.

The main measures of the performance function, \( P \), can be considered to be: reliability, safety and efficiency. Consequently, the specific criteria can be organized in three main groups: reliability criteria, safety criteria and efficiency criteria. Each group is multidimensional and the specific indexes varies with infrastructure’s location, features etc.

Reliability. On general terms, reliability is a probabilistic measure of rail transport infrastructure network that refers to specific infrastructure elements ability to fulfill their roles, not to fail or malfunction, during a specific period, given a set of performance guidelines. Even if some elements of transport infrastructure fail, the network should remain functional even if not so performant as before. There can be differentiated three types of reliability [5, 6]:

- Connectivity reliability – the probability that the nodal infrastructure remains connected through linear infrastructure (links) - there is still a path connecting the nodes even if a set of links do not fulfill their roles or have been cut off;
- Travel time reliability – the probability that a trip between an origin and a destination node can be completed within a given time period. The travel time can be affected by the increasing demand for rail services, straining the existing system and therefore requiring optimization of the existing passenger and freight schedules to achieve increased throughput on existing rail infrastructure;
- Capacity reliability – the probability that an infrastructure network can accomplish a given level of travel demand and the reserve capacity can accommodate the required demand for a specific capacity loss due to network degradation or obsolescence. Rail companies are increasing asset utilization and making significant investments in infrastructure to meet the capacity challenge.

Safety and Security. As rail network infrastructures become an even more attractive alternative to other modes of transportation, stricter requirements are being imposed on railroads to help ensure safety. Political scrutiny and regulatory oversight are increasing, with legislation enacted requiring positive train control (PTC) systems. Predictive maintenance and data analysis is being used for accident prevention.

Operational Efficiency. Aging rail systems limit the efficiency of resources and compromise reliability in established rail markets. New markets have the opportunity to adopt newer, more flexible technology infrastructures, advancing fast and leaving behind current practices. Many current intelligent transportation systems are old and complex, making the sharing of data difficult. They are also unable to cope with the scale of growth predicted over the next few years. Frequent network failures and systems components obsolescence can have a domino effect, significantly impacting customer satisfaction.

![Fig. 2.1 Transport infrastructure performance evolution](image-url)
A special attention to operational matters must be shown in the early stage after commissioning the infrastructure in order to reach the highest level of performance and to avoid the possibility of early manning problems that can influence performance.

Assuming that infrastructures performance level is reaching the optimum designed level, the new infrastructure will continue to function at this parameters, in a quasi-stable regime, for a long period of time, if maintained according to standard procedures. A slow but inevitable degradation sets up as years go by, reaching, at a certain moment an unacceptable performance level.

Planners and designers of infrastructure work with multiple criteria decision models trying to well balance reliability, safety and efficiency outputs in order to maximize performance for the entire infrastructure’s design life, as in equation 2.4.

\[ t \leq T^D, P(t) \geq P^F \]  

(2.4)

Where \( T^D \) represents the infrastructure’s design service life.

Maximum performance, in this context, denotes that level of service that insures reliability and safety at minimum acceptable cost, in other word, at the higher efficiency level. Considerations can be debated on this subject as different users consider that this minimum cost measure conveys in an unacceptable level of congestion, an unsafe service or other compromises.

2.2 Failure

Failure establishes when performance level drops below a threshold level considered by the decision makers to be unacceptable – infrastructure is either unable to fulfill its functions either shortly it will become unable, either is much too expensive to further operate it. The failure condition is described in equation 2.3:

\[ P(t) < P^F \]  

(2.3)

Where \( P^F \) represents the minimum infrastructure’s performance threshold level considered by the decision makers to be acceptable.

As for mechanical and electrical components, the failure behavior of infrastructure facilities can be described in terms of a bath-tub time-dependent failure (see Fig. 2.2). We can set the limits of three zones in this figure as those correspond to the young age, to the maturity and to old age, with decreasing, constant and increasing danger of collapse, respectively.

The effects of infrastructure components aging are compensated by maintenance actions, performed periodically, which reestablish the infrastructure performance level. In practice, during the interval between maintenances, the failure rate increases only slightly so that, to simplify the calculations, they are characterized by stepwise constant failure rates whose values are determined by imposing that the probabilities of failures within each maintenance period \([6]\). Even with maintenance counterbalancing its effects, the aging of some components is inevitable \([7, 8]\).

As shown in practice, the result of a repair action on an infrastructure component might not necessarily return it to an “as good as new” condition since it is likely to become more instable and susceptible to future failures \([9]\).

Negligence in respect to manning conditions of every infrastructure component and high solicitations of this components lead to an increased failure rate and therefore to a decreased performance level, resulting in a drawback of infrastructure’s design service life.

3. Obsolescence of transport infrastructures

User’s awareness, higher expectations due to innovation and technology shifts proved to be important factors determining great changes in infrastructure perceived performance and even determine its obsolescence. It is regarded as a concern throughout infrastructure’s entire lifecycle and reflects changes in expectation regarding performances in functioning, safety and environmental effects. From the point of view of railway infrastructure management the problem of obsolescence is becoming more and more acute. Obsolescence has the connotation of the loss in value of one or more infrastructure’s components, due not to its conditions or past operation history but to a change in the external scenario of technological evolution and marketing \([11]\).

Fig. 3.1 shows that many stakeholders cause or are affected by obsolescence. The transport infrastructure depends primarily on the fixed facilities, their components and on supporting tools used in design and management. It often uses contracted manufacturing and repair process capabilities, but is also driven by regulations and legislation.

The drawback of infrastructure’s design service life, below \( T^D \) (see Fig.2.1) is considered a failure both by infrastructure beneficiaries and administrators and only in very few cases large efforts of manning and maintenance can restore it to designed service life.

For simplification, in Fig. 3.2 is made the assumption that optimal and minimum accepted performance levels are stationary most of infrastructure’s lifespan. In practice one can rarely come across this type of behavior as user’s higher expectations evolve most of them due to development of new infrastructures and facilities, new emerging technologies, new standards (see Fig. 3.3).
If we refer to equation \( P(t)<P^T \), the infrastructure’s performance threshold minimum level can be described as in equation 3.1:

\[
P^T = P^T(E_k, t)
\]  

(3.1)

Where \( E_k \) represent exogenously and environment factors (new emerging technologies, economic and social environment, beneficiaries higher expectation, behavior changes) challenging infrastructure’s performance level.

\( t \) – time.

User’s higher expectation lids to a decrease in perceived performance level and finally to infrastructure obsolescence.

A good measure for obsolescence is the decrease in design service life. Obsolescence occurs when \( P^T \), performance threshold minimum level, increases rapidly due to exogenously and environment factors and the real lifespan goes well beyond optimum expected lifespan, characterized by an expected performance level at \( t_0 \) as in equation 3.2:

\[
E(P(t = t_0 / X_i, D_i, E_k)) < P^T (t = t_0 / E_k),
\]

for \( t_0 < T^0 \)

where \( t_0 \) is the starting moment from which infrastructure is considered obsolete.

The function \( P^T(E_k, t) \) is known as ‚expectation function‘. The growth rate of this function of expectations can vary very rapidly, as shown in Figure 3.3.

Standardization and regulatory actions are potential sources of both system functional (demand side) obsolescence and component (supply side) obsolescence. If transport infrastructure facilities are not compliant with a new standard, it can no longer be used or is subject to significant usage restrictions. Rules and mandates are regulatory instruments that impose new operational requirements or procedures. They may impose new functional requirements on infrastructure’s features, but require new equipment and installations [12].

The infrastructure’s obsolescence related with the change of regulations or standards can be represented in the form of a scale function (see Fig. 3.3), although these changes are often preceded by significant periods of time dedicated to public discussions and debates.

The overcoming of a new standard/given technology due to technical, legislative and/or marketing reasons typically leads to a decrease in value of the system which is not necessarily related to its past or current performance but can certainly influence its future life. Indeed, the availability on the market of improved components offers the enviable opportunity to plant managers of upgrading their system performance while rejuvenating the system itself [7].

**Fig 3.2 Higher user’s expectation effect on modification of infrastructure’s lifecycle**

**Fig 3.3 Change of regulations or standards effect on modification of infrastructure’s lifecycle**

However, obsolete infrastructures can still be used, but if they are not replaced or upgraded, they create a wide variety of inconveniences for users, managers and residents (e.g., loss of capacity, environmental degradation, very high operating and maintenance costs).

Other factors that can be included in the \( E_k \) vector of exogenous or environmental factors are: the level of economic development and industrialization, the location of the infrastructure, the availability of alternative infrastructures.

### 4. Conclusions

The evaluation of the transport infrastructures efficiency must be assessed at the global social level and reflect the interests of all those involved and affected by the transport process on the infrastructure: the interests of users, managers, operators and residents who feel the positive and negative external effects of system activity (see Tab 4.1). All these effects can be quantified by a generalized cost function that combines the monetary and non-monetary costs at global society level, costs are related to transport, but involves a lot of parameters that are difficult to estimate and which, in most cases, require simplifications [9].

For this reason, for synthetic assessments regarding the efficiency of transport infrastructures, no explicit calculations can be made, but instead, the use of quantitative and qualitative criteria and indicators is preferred. Based on this indicators, the achievements are compared with the previous ones, with those of similar systems, in order to guide the decisions regarding the technical, technological and organizational improvement. The complexity of some aspects regarding calculation of the transport efficiency led to the necessity of go into detail and structure a set of indicators of great variety some of them with a pronounced contradictory character.

**Table 4.1: Outputs of transport infrastructure performance assessment**

<table>
<thead>
<tr>
<th>Actors involved and affected by transport infrastructure performance assessment</th>
<th>Outputs of transport infrastructure performance assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users</td>
<td>Improved speed, availability and reliability of trips</td>
</tr>
<tr>
<td></td>
<td>Enhanced safety due to efficient maintenance and asset health monitoring.</td>
</tr>
</tbody>
</table>
The choice of the most appropriate reliability indicator must take into account considerations regarding simplicity, statistical stability and its importance in defining the functionality of the system. It must also be based on the types of technological disturbances and the correct assessment of their consequences. The calculation of reliability indicators for transport infrastructures does not present major methodological difficulties.

The choice of the efficiency criterion for transport infrastructure appraisal is a delicate issue and is equivalent to the correct formulation of the objectives and the vector of possible solutions [13]. The designers and managers of the transport infrastructures try, most of the times, to ensure those properties of the infrastructure for which the level of efficiency is the appropriate one. Excess supply over demand is generally accepted as a possible sideline of satisfaction for the expected future growth, as a safety factor for possible nonlinearities of demand or only as a higher level of quality offered beyond the functional minimum imposed by standards [14].

The operation of transport infrastructures is affected by random factors of internal and external nature, which can cause changes in the performance of a facility, of the entire infrastructure or even for the entire transport system as a whole.

That is why average values of the efficacy criterion must be used.

Further, if one tries to spread the analysis from efficiency to effectiveness, one will find that involved actors: transport infrastructure managers, operators, beneficiaries and infrastructure’s neighbors often pursue conflicting interests and this makes it necessary to specify some elements and requirements that are restrictive. The strategy is to ensure a “satisfactory” level rather than an optimum one. For example, the “capacity of a section of road artery” can only be a criterion of effectiveness accompanied by clarifications on the duration of the trip, the taxes collected, etc. “Travel time” or “journey time” (or the corresponding average speeds in a given relationship) could be relevant efficiency criteria for infrastructure users / beneficiaries.

In the best practice studies of restructuring / development of a transport infrastructure, the efficiency of various possible technical solutions can be estimated as follows: only equivalent solutions are retained for ranking in terms of meeting quantitative (e.g. capacity) and qualitative requirements (e.g. travel / transport duration), facilities for users, comfort, storage of goods). In this situation, the selection among given solutions, a choice can be made by comparing the equivalent expenses to ensure the desired level of imposed performance measures (e.g. capacity, reliability, safety).

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Analysis and prospects of cruise tourism in the east Black sea region: the case of Georgia

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Abstract: once a part of the Soviet Union, a backwater country, Georgia in a couple of years flips the script and rushes into tourism industry as one of the most popular emerging destinations on the Black Sea coast. With unprecedented numbers of tourists spotlighted by the leading international journals Georgia wins hearts of millions and becomes a revelation for the USA and Western EU countries. This paper assesses current situation in Batumi Port that serves small cruise ships and explores potentials of cruise tourism development based on statistics, industry experts and investors reviews. The article uses a mixed method, a combination of qualitative and quantitative data analysis.

The findings show how Black Sea region will benefit from country’s cruise tourism development.

Results of the study can be applied as basis for investment analysis of Georgian cruise industry.

KEY WORDS: CRUISE TOURISM; BLACK SEA REGION; GEORGIA; BATUMI PORT; CRUISE SHIP TERMINAL.

1. Introduction

The cruise industry went underwater after the novel coronavirus pandemic hit the world in March 2020. Some ships are still stuck in the middle of the oceans with passengers and crews onboard waiting for the ports to accept them. (April 2020) [3] Once a “phenomenon of our times”, a fairy tale on the water, an incredible business machine that multiplies ships sizes, numbers of passengers and profits exponentially, today is facing obscurity and unprecedented crisis. Functioning as a $46 trillion/year worth and 26 million profits exponentially, today is facing obscurity and unprecedented crisis. According to Cruise Lines International Association’s (CLIA) report “2020 State of the Cruise Industry Outlook” the cruise market has been expanding steadily since 2009. Above 15,000 travel agencies with 53,000 travel agent members earn a living from cruising. CLIA 2020 report suggests 82% of cruise passengers choose to cruise again. According to other statistics from CLIA report each year cruise industry pays out more than $50 trillion in salaries and wages to more than 1.17 million people, with total output of $150 trillion worldwide. Moreover, as CLIA points out a passenger spends in average about 100$ while visiting a port. Over 32 million passengers had been expected in 2020 before COVID-19 pandemic began. The tendency and yet undiscovered segments of the market stipulate the growth of the cruise tourism demand. The cruise industry grows for sure and keeps benefiting a lot of communities around the globe. While representing less than 1% of the global maritime community, the industry has already invested $22 milliard to new energy efficiency technologies and made cleaner fuels a top priority for cruise shipping industry, that makes it a leader in environmental sustainability. CLIA’s recent Environmental Technologies and Practice Report shows considerable progress in application of innovative practices, while the rest of shipping communities still searches for new way to be more efficient.[18]

Summing up all the statistics it becomes obvious that cruising industry is profitable for all the interested parties, governments and countries of visit.

In the current situation cruise industry is stuck in front of one major question:

- When will customers come back after the COVID-19 outbreak is over?

As Plymouth University professor Sheela Agarwal commented in BBC News article “Will we ever take cruise holidays again?” of April 9: “Tourists have very short memories.” “… Three months maximum, and they are back to normal.” [5] Reviewing the financial situation of such a giant as “Royal Caribbean” cruise company, comparing “then” and “now” Will Ashworth, a financial blogger at InvestorPlace stated that “I just don’t see people giving up cruising.”[6]

And later in the reply to Prof. Agarwal words, Will Ashworth assured the industry 100% to recover, as well as Royal Caribbean (NYSE:RCL) stock will reach $100 mark again. However, InvestorPlace contributor added that “it’s going to take many months for this to sort itself out”. (Apr 14, 2020) So it’s most likely to be as soon as travel restrictions are lifted.[6]

Meanwhile, notwithstanding pandemic conditions, damaging articles and the rest of tourism market taking unprecedented break from operation and acting pretty cautiously, some cruise companies have already announced the restart in May 2020.[8]

2. Preconditions Problem and means for resolving the

According to CLIA data (2018) Europe rates number two biggest cruise source market after the North America. Western Europe - 6,731,000 passengers; Eastern Europe - 213,000 passengers. As well as number two cruise destination worldwide, after the Caribbean- 17%.

As a part of Mediterranean cruise market Black Sea region (BSR) has all the support and potential to become new emerging destination for Europe. However, while the rest of the world suffers from the deep crisis due to well-known international events, BSR cruise shipping has been facing problems in the industry long before the pandemic.

The most famous, and perhaps the first foreign cruise ship in the Black Sea waters under the flag of the North American United States, visited the ports of Odessa and Yalta in August 1867, was called “Quaker City”. There were 55 American tourists onboard, including a journalist Samuel Langhorn Clemens, better known as the writer Mark Twain. That was the beginning of international cruise shipping on the Black Sea. However, Black Sea cruising didn’t get mass since then. Until the collapse of the Soviet Union, mainly Soviet cruise ships sailed in the Black Sea. Since the mid-1990s, various domestic shipping companies tried to revive cruise shipping in the region. Due to political and economic instability all the attempts were in vain. Black Sea cruising got a second wind in 2010-2011, when Italian cruise company MCS plot a route between Odessa and Venice. According to MedCruise previous president, Stavros Hatzakos (2014), the cruise traffic in the BSR between 2000-2015 was steadily growing. The number of calls at MedCruise member-ports located in Turkey, Georgia, Ukraine, Romania and Russia increased from 200 in 2009 to almost 450 in 2013. The tendency kept to be relative till “ship deployments were affected by the Ukraine unrest.” Passenger numbers (pax) also increased from around 110,000 in 2009 to almost 225,000 in 2013. [22]
In 2013, more than 400 cruise ships flying a foreign flag entered Istanbul and only 73 of them to the Black Sea. The main reason was the lack of infrastructure, inability to accept vessels longer than 200 m. [19]

The specifics of the Black Sea geography make BSR ports partners, not competitors: the more ships are attracted to the Black Sea region, the more benefits get each of the ports. Given this feature, in 2012 at one of the International Cruise Exhibitions the idea initiated a non-profit marketing project to promote the Black Sea cruise line as a unitary brand Cruise Black Sea. To promote this project was created an advisory group on infrastructure development of cruise tourist services in the Black Sea Region. [20] After a short promising 2 years of development BSR hits another political crisis, this time in Ukraine. Despite the significant amounts of money spent on development and promotion of cruise itineraries in the area, another BSR cruise industry recession has begun.

It is noteworthy that MedCruise President Airam Diaz Pastor in his speech during the meeting did not mention Batumi Port/Georgia as one of the BSR cruise ports. Here is the speech:

‘The launch of this Working Group will have a positive impact on the regional cruise sector and it will bring new opportunities to all MedCruise members from the Black Sea – Port of Odessa, Port of Varna, Port of Constantza, Port of Burgas, Port of Trabzon and Port of Istanbul - as well as the cruise-industry-related-companies that operate in the region.’

However, he announced his plan to conduct negotiations with the port of Batumi in the nearest future.[11]

As Diaz Pastor stated, all the mentioned ports have necessary infrastructure, and the cities themselves are interesting enough for tourists from the point of historical and cultural attractions.

So, the question is: why there are still no cruise ships calling Georgia since 2016?

According to Craig Turp, the editor of Emerging Europe: “Georgian tourism first took off in 2012, jumping from 2.8 million visitors to 4.4 million in the space of 12 months.” With its peak in 2017 “which really placed the country on the map” (7.5 million tourists) [1], Georgia hasn’t stopped since that.

For today Georgia is named “World’s greatest hidden travel gem” and ranks #1 in the top 30 emerging travel destinations on the planet for 2020. [2]

Still there are lots of properly undiscovered opportunities for tourism development in this country. One of them is cruise tourism potential of West Georgia.

As cruise market with its growing demand hunts for new interesting destinations, Georgia has all the advantageous variables to become a new cruise breakthrough. Some of them are:

- country’s rich history;
- attractive sights;
- favorable geographical location;
- good political relations with neighboring cruise countries;
- reasonable prices;
- and a vast variety of one-day tours.

There are 5 active seaports in Georgia: Poti, Batumi, Anaklia, Kulevi and Supsa. According to experts, Batumi port is the most promising one for cruise shipping development among them. [12]

Batumi - a subtropical port city rounded by mountains, rich in greenery, history and confessions, famous for delicious Adjarian cuisine and hospitable people. Also known as “ Las Vegas of the Black Sea” due to lots of legal gambling establishments. Batumi is the third largest city of Georgia and a capital of Autonomous Republic of Adjara. The city is considered to be a transportation hub between Europe and Asia. [15]

Batumi port is a multiterminal port (Oil terminal, Container and the railway ferry terminal, Dry Cargo Terminal, Marine Passenger Terminal) with annual revenue of $200-300 million. [16]

Passenger terminal is located in the very center of the city, at the beginning of the seaside boulevard. Terminal capacity is up to 180 000 passengers per year with two berths:
Department of Tourism and Resorts of Adjara Autonomous Republic commented on the situation and stated that cruise tourism development requires a number of issues to be settled by the government, including port modernization (access to larger ships), cooperation with Black Sea ports, optimization of harbor dues and improvement of port management. [17] According to the World Association for Waterborne Transport Infrastructure (PIANC) there are special requirements for cruise terminals. In compliance with “Guidelines For Cruise Terminals” presented to MedCruise General Assembly in 2016 the average LOA (length over all) has to be at least 300 m. [14] For today only 2 BSR ports have the requested infrastructure: Constantza (Romania) and Odessa (Ukraine). As it was mentioned previously, to organize a full-fledged round trip for an average size cruise liner we need at least 5 ports with LOA 300 m. Until then BSR is doomed to welcome only small cruise ships and suffer from periodic crises, that take place during last 20 years. In 2011 Royal Caribbean and Government of Adjara signed a memorandum of cooperation on the development of the new Batumi Cruise Terminal that would be able to accommodate all kind of cruise ships by 2015. However, the project was frozen due to internal political changes in Georgia. [21] MedCruise Black Sea Working Group was formed during General Assembly in Malta in May 2018 with 4 official port-members: Odessa, Burgas, Constantza and Varna. The group had several meetings in Odessa and Constantza in 2019. As a result, there were discussed a marketing strategy for the next 3 years and upcoming Seatrade Cruise Global 2019 exhibition in Miami, namely the Action Plan to be submitted there on how to return cruise tourism back to BSR. For now, 12 cruise lines are going to visit Odessa port this year: Olsen Cruise Lines, Azamara Club Cruises, Phoenix Reisen and others. Azamara and Crystal Cruises planning eight calls to Odessa in 2021 so far. Constantza has welcomed Amara in October 2019 and is expecting 9 more calls from 6 cruise lines in 2020. Burgas is preparing to host a MedCruise GA in 2021. [23] Notwithstanding the fact that Batumi seaport is not MedCruise member anymore, Georgia is going to benefit from Black Sea Working Group’s diligence anyway. After 4 years of absolute lull in cruise calls at Georgia, there are 2 Azamara ships calling at Batumi port in July and September this year (2020) and 5 more by Azamara, Crystal and Silver Cruises in 2021. [24] For analysis, of current cruise situation in the Black Sea Region was applied desk research using combination of qualitative and quantitative methods, as well as statistical and general analysis. Qualitative method was applied to process and evaluate experts’ interviews in industry journals, quantitative -to collect, analyze and compare parameters of cruise ships and terminals. Statistical and general analysis was made for getting a full picture of the situation. The purpose of the study was to examine Batumi seaport as a cruise terminal of BSR, identify current state, consider the problems, challenges and potentials of its development, to study available cruise infrastructure and make recommendations for country’s sustainable cruise tourism development.

3. Conclusion
The cruise tourism represents one of the fastest growing sectors of the tourism business. Industry has a need to develop new ports, discover new itineraries and to accommodate larger sizes of ships. It is important to understand how the development of cruise ports may impact local economy and country’s communities overall. Tourism made up 7.6% of total GDP of Georgia in 2018. According to The World Travel and Tourism Council (WTTC) 2018 report, direct contribution of travel and tourism to GDP in Georgia is anticipated to increase up to 10.5% by 2028. [25] It’s obvious, that tourism sector is more than important for Georgia. Engaging in cruise tourism will benefit local infrastructure, country’s economy and social life, as well as will attract foreign investments and reveal new opportunities for international cooperation. Main conditions for attraction of cruise lines to Georgia are:

- Favorable and goal-oriented cruise politics of government;
- Modernization of Batumi seaport. In order to be available for mass cruising and be able to welcome average size cruise ships, port has to meet technical requirements;
- As history has shown, political stability is vital for cruising shipment and development in country and in the whole region;
- Another key to success is internationally active policy. Membership in MedCruise became crucial and defining for its members.

And last but not the least, reasonable port charges. Batumi cruise terminal is an unprecedented opportunity to make Georgia a cruise country and place it on the map one more time. Cruise ships calls may multiply tourism incomes several times, increase urbanization rate in the city, attract new capitals, expand international inclusion and diverse transportation hub. As a maritime country Georgia has to consider global trends which emerge in BSR. The necessity to develop port infrastructure is defined by profitability of cruise market. Thus, Georgian government and business sector have to promote Batumi seaport as a promising European destination of cruise tourism. Development of cruise shipping will set off all the neighboring sectors, such as transportation, city tour business, catering, shops, touring companies, etc.) and ultimately will create new jobs and contribute to regional economy.

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**Abstract:** The shaft is a machine part that allows the movement (rotation) of the drive unit (motor) to be transmitted to the actuators of the machine. This movement is accompanied by friction, using various lubricants to reduce it. As the shaft may be discarded or leaked when rotating the shaft, the use of radial seals may be necessary. In general, they are intended to retain the lubricant in the bearing area on which the rotating shaft is mounted and to prevent contaminants entering from outside. The radial seals are made of an oil-resistant elastomer and there is a great constructive variety there. The research conducted in the specialized literature revealed that there is no approach to analyze the operating conditions of the rotary shaft and hence the choice of a suitable radial seal for it. The purpose of the report is to investigate the operating conditions of a radial seal for a rotating shaft and from there to select the appropriate seal design, specifying its mounting method for its proper functioning. As a result of the research conducted, the type of lubrication oil (grease), the speed of rotation of the shaft, the value of the pressure which the sealant must bear have the greatest influence on the choice of the suitable construction of the radial seal. The radial shaft seals are manufactured with sufficient enough precision, so their installation must be carried out with due care so that they can effectively fulfill the purpose described above without disrupting the operation of the rotating shaft. The work also provides specific recommendations for the installation of a gasket.

**Keywords:** CONDITIONS, CHOICE, RADIAL SEAL, POWER SHAFT.

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1. **Въведение**

Валът представлява машина част, която позволява предаването на движение (въртене) от задвижващия агрегат (двигател) към изпълнителните механизми на машината. При това движение валът трябва да изпълнява и редица функции – да поема определено натоварване по вид и големина, да осигурява определената скорост на въртене при минимално трение и други. В съвременното машиностроение за осигуряване на минимално трение се използват различни по вид и качество мажещи материали. Тъй като при въртенето на вала е възможно мажещият материал да бъде изхвърлен или да изтече с налага употребата на радиални уплътнители. Най-общо тяхното предназначение е да задържат мажещият материал в областта на лагерите, върху които е поставен въртящият се вал и да не се допусне навлизането на замърсители отвън. За изпълнение на тези изисквания конструцията им трябва да е с определена форма, като най-вече са необходими уплътняващи елементи с подходящ профил в зависимост от конкретните изисквания.

От направения литературен обзор се установи, че в недалечното минало конструираните на радиалните уплътнители за въртящи валове са представлявали метална вложка от мед (маниш – хромиран или не), чийто ръб се е притискал към вала посредством пружини пръстен (Фиг. 1) [4].

**Фиг. 1. Първоначална конструкция на радиален уплътнител за въртящ вал**

Недостатък на тази първоначална конструкция радиален уплътнител е, че е било необходимо прединост шлифоване от външната страна на металната вложка за по-лесно стопяване на уплътнителя. Освен това като материал медта не е могла да издържа дълго време на повишени температури при работата на вала, както и в агресивни среди.

**Фиг. 2. Съвременна конструкция на радиален уплътнител за въртящ вал**

1. **Метална вложка (Арматура)** – метален пръстен от стоманена ламарина, най-често с Г-образен профил;
2. **Еластомер,** състоящ се от три части :
   - **Оblastовка,** която обхваща директно металната вложка,
   - **Уплътняваща част**, чиято дължина позволява да се избегнат някои отклонения при въртенето на вала,
Уплътняващ ръб, който осигурява уплътняването чрез директен контакт на триене с вала. Наклонът на повърхностите на скосяванията е подобен така, че да се осигури уплътняване със сгъстяване бъгство на флуида, разположен от диска страна, показана със стрелка.

3. Притискаща пружина – състои се от пружинни спирали, притиснати една към друга и оформящи гнездото на уплътнителя, геометрия на вала, съосност и други за притискане в дефектите уплътнения фл уид, скоростта на въртящия се вал.

Съществува големо конструктивно многообразие на радиалните уплътнители от избори за разглеждане тип, който изисква да се направи анализ на конкретните условия на работа с цел да се подберат оптималната конструкция. Радиалните уплътнители за въртящи валове се изработват с достатъчно висока точност и прецизност, което изисква съответно монтажът им да се извърши с необходимо внимание, така че те да могат да изпълняват ефективно описаното по-горе предназначение без да се наруши работата на въртящия се вал.

От направленото проучване в специализираната литература[1,3,4] се установи, че липсва подход за анализ на условията на работа на въртящия се вал и оттам обоснован избор на подходящ радиален уплътнител за него.

Целта на предлагания доклад е да се изследват условията на работа на радиален уплътнител за въртящ се вал и оттам да се избере подходящата конструкция уплътнител от посочения тип като се конкретизира начина на монтиране с оглед правилното му функциониране.

2. Избор на радиален уплътнител за въртящ вал

За правилния избор на радиален уплътнител от посочения по-горе тип беше направен анализ на факторите, които оказват влияние и бяха проведени предварителни експериментални изследвания за установяване на степента на това влияние. Получените резултати показват, че най-силно върху избора на радиален уплътнител влияят условията на работа (вида на уплътняващия флуид, скоростта на въртящия се вал, налягането), както и условията, при които той ще функционира (гнездото на уплътнителя, геометрията на вала, съсност и други). Ето защо по-долу ще се представят подробно резултатите от тяхното изследване.

2.1. Изследване на условията на работа

2.1.1. В зависимост от флуида, който ще се уплътнява – в този случай влияние оказват:

- Металната вложка и пружината – за стандартните радиални уплътнители те трябва да са изработени от стомана, която да е устойчива на органични и химически разтворители, както и на всички други агресивни агенти, използвани в съвременната индустрия, предизвикващи ръжда, респ. корозия.

- Еластомер – от направените изследвания се установи, че най-подходящ за уплътнителите е каучукова смес на базата на нитрилен еластомер, който е устойчив на повечето използван масла и греси за машини. При анализа на условията на работа на един радиален уплътнител от еластомерен материал не е достатъчно да се вземат предвид само и единствено температурните граници, в този случай влияят и условията на работа. Еластомерните смеси са чувствителни само към високите температури, които ги въвеждат неизбежни предизвиквайки усукане и нарушаване на конструкцията на уплътнителя, но и към прекомерните студове, правещи ги тъй или по-чупливи.

Поради изброените по-горе причини особено внимание трябва да се обърне на температурата на уплътняващия ръб, влизащ в контакт с въртящия се вал. Под влияние на триеното той повишава температурата си, и то в много по-голяма степен от тази на околовния флуид. Например беше установено, че температурата на един радиален уплътнител, уплътняващ маслото в картера на двигател с вътрешно горене при голяма скорост на въртене на коловия вал (над 8 m/s), се повишава до около 500 °C в рамките на няколко минути работа, докато маслото, намиращо се около уплътнителя за същото време се затопли малко - само с няколко градуса. В този смисъл показанията на термометъра, измерващ температурата на маслото в картера не могат да се считат за определящ критерий за условията на работа на уплътнителя.

Препоръчваниятите работни температури от производителите на радиални уплътнители за въртящи валове [2] са от порядъка на -40°C до +80/+100°C за нитрилни каучукови еластомерни смеси, а за флуороредувиращи и флуоркарбонови – от -30°C до +130/+150°C.

2.1.2. Във функция на скоростта

Върху избора на подходящ радиален уплътнител големо влияние оказва и скоростта на въртящия се вал. На Фигура 3 е показана графично определената по експериментален път зависимост между линейната скорост (съответно броя завъртания в минута) на вала и неговия диаметър във функция на различните температури на работа на уплътнители. За еластомерни смеси за изработване на уплътнители във функция на скоростта на въртене на вала и диаметъра му при различни еластомерни смеси за изработване на уплътнители във въртящ еластомерен радиален уплътнител, въртейки се на до +40°C във вътрешно горене двигател с вътрешно горене.

2.1.3. Във функция на налягането

Ефективното налягане, на което един радиален уплътнител с подходящ материал за уплътненята на флуидите от двете му страни, като най-често от едната му страна флуидът е околните въздух. Това означава, че устната (виж Фиг.2) трябва да е разположена от страната с по-високо налягане на флуида. По принцип радиален уплътнител за въртящ вал от разглеждан тип се различава от уплътнители на няколко минути работа, докато маслото, намиращо се около уплътнителя за същото време се затопли малко - само с няколко градуса. В този смисъл показанията на термометъра, измерващ температурата на маслото в картера не могат да се считат за определящ критерий за условията на работа на уплътнителя.  

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Във функция на скоростта върху избора на подходящ радиален уплътнител току-що е показано графично определената по експериментален път зависимост между линейната скорост (съответно броя завъртания в минута) на вала и неговия диаметър във функция на различни еластомерни смеси за изработване на уплътнители – флуороредувираща, силиконова, полиакрилатна и нитрилна.

Фиг.3. Зависимост между скоростта на въртене на вала и диаметъра му при различни еластомерни смеси за изработване на уплътнители.
могат да понесат налягане средно до 3-4 bar, като към уплътнителя се добави и поддръжка (помощен) пръстен.

2.2. Условия за правилно функциониране

От направените изследвания се установи, че за правилното функциониране на радиалния уплътнител от особено значение са следните фактори:

2.2.1. Гнездо (легло) на радиалния уплътнител – то трябва да бъде изработено с подходящи за съответния уплътнител форма и грапавост на контактните повърхности.

Изискванията към формата на леглото на радиалния уплътнител са представени на Фигура 4.

Грапавостта на контактните повърхности е в зависимост от вида на радиалния уплътнител:
- За уплътнители с еластомерна облицовка (Фиг. 2) – $R_a = 1,6$ до $4 \mu m$;
- За уплътнители с външна метална вложка [2,4] – $R_a = 1,2$ до $2,5 \mu m$.

Фиг. 4. Изисквания към формата на гнездото на радиалния уплътнител

Липсата на входна фаска (скосяване) или такава с по-малки от необходимото размери може да доведе до:
- повреди по външната повърхност на уплътнителя;
- силно увеличаване на усилието за монтиране, което да провокира деформиране на металната вложка;
- неправилно аксиално позициониране на уплътнителя.

2.2.2. Вал – изисквания към него следните:
- препоръчителен допуск на диаметъра - h 11;
- грапавост на повърхнината - $R_a = 0,2$ до $0,5 \mu m$;
- Твърдост – 45 HRC при $V \leq 4 m/s$; 55 HRC при $V > 4 m/s$;
- Дебелина на закалената зона – $0,3 mm$ минимум;
- Отклонение от цилиндричност – $5 \mu m$.

Не се препоръчва покритие на повърхността на вала – хромиране и др.

2.2.3. Съвместимост – гнездото на радиалния уплътнител и валът трябва да бъдат центровани, т.е. осите им да се разминават по възможност минимално. В случаите, при които разминаването между оста на уплътнителя и тази на вала е значително, еластичността на каучуковата устна позволява монтажът в определени граници да се извърши без разделяване (т.н. „прозявка”).

На Фигура 5 са представени максимално допустимите отклонения от съвместимост във функция на диаметър на вала.

Фиг. 5. Максимално допустими отклонения от съвместимост в зависимост от диаметъра на вала

2.2.4. Радиално бие не – получава се когато геометричната ос на вала не съвпада точно с оста на въртене, което води до огъване на вала, а оттам и до по-силно или по-слабо съприкосновение между устната на уплътнителя и вала.

Максимално допустимото радиално бие в равнината на устната на уплътнителя във функция на скоростта на въртене на вала е показано графично на Фигура 6 за различни еластомерни смеси.

Фиг. 6. Максимално допустимо радиално бие във функция на диаметъра на вала за различни еластомерни смеси

2.2.5. Монтиране на радиален уплътнител в гнездото

Монтирането на радиалния уплътнител се явява твърде деликатна операция, което, ако не бъде изпълнено внимателно, може да компрометира ефикасността на един много добър по качество и не съвсем евтин като цена продукт. Затова при монтирането е необходимо да се спазват някои прости правила:
- Да се избягва нараняването на устната;
- Да се избягва нарушаване то на целостта на еластомерната облицовка по външния диаметър на уплътнителя;
- Да се обмаже със смазка предварително уплътняващият ръб, за да се избегне поврежданието му по време на първото старттиране на машината. Същото се отнася и за външния диаметър на уплътнителя.
Уплътнителя да е позициониран правилно.

При монтиране на радиалния уплътнител се препоръчва да се използват специализирани инструменти (Фиг. 7), които позволяват да бъдат изпълнени направените по-горе препоръки.

Фиг. 7. Конструкция на инструмента за монтиране на радиален уплътнител

2.2.6. Монтиране на радиален уплътнител върху вала

Монтирането върху вала може да се извърши по следните два начина:

- В посока обратна на отварянето на устната (Фиг. 8):
  - $\phi A < \phi$ на вътрешния диаметър на уплътнителя
  - $B$ – състояние на повърхнината без издатини и бразди. $R_a \leq 0,8 \mu m$.
  - В посока на отваряне на устната (Фиг. 9):

Фиг. 8. Монтиране в посока обратна на отварянето на устната

Фиг. 9. Монтиране в посока на отварянето на устната

Изискваната в този случай са следните:

- Уплътнителя да е позициониран правилно.

Производителите на радиални уплътнители предлагат съответна форма на вала, която предполага сравнително лесно и правилно монтиране. Конструкцията е представена на Фигура 10, като стойностите на размерите, закръгленията и грапавостта на повърхнините са дадени в съответните фирмени каталоги [2].

Фиг. 10. Конструкция на вала за монтиране на радиален уплътнител

3. Изводи

Анализирана е конструкцията на конкретно избран радиален уплътнител за въртящ вал с уплътняващ ръб, метална вложка и притискаща пружина.

В резултат от проведените експерименти се установи, че върху избора на радиален уплътнител за въртящ вал от избрания тип най-силно влияние оказват условията на работа - вида на уплътняващия флуид, скоростта на въртящия се вал, налягането, като те бяха изследвани подробно.

За правилния избор на радиален уплътнител се оказва, че влияят и условията на функционирането му – гнездото, в който той ще се монтира, геометрията на вала, съсъсността, радиалното биене, начините на монтиране на радиалния уплътнител към гнездото и съответно монтирането на вала към уплътнителя. Посочени са и конкретни стойности на грапавостта на контактните повърхнини, на скосяванията, закръгленията и наклоните и други геометрични параметри, получени в резултат на проведените изследвания.

Подходът за избор на посочения конкретен тип радиален уплътнител може да се използва и при други близки по конструкция уплътнители за въртящи валове.

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POSSIBILITIES FOR APPLYING ALTERNATIVE WAYS TO MEASURE THE SPEED THROUGH WATER

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Abstract. The well-known traditional ways of measure the speed of vessels by means of instruments immersed in water, the so-called logs prove to be inaccurate and unreliable due to various disturbances during the movement of the ship. Their operation involves various expensive installations and difficult maintenance. As a result of improvements in hardware and the development of image processing algorithms, the speed measurement has been made possible in recent years through radars operating in X-Band frequencies. The accuracy obtained is sufficiently high and appropriate when planning a ship’s voyage. This article highlights the benefits of measuring systems using radars operating in the X-band and their application capabilities.

Keywords: WAVE RADAR, SPEED THROUGH WATER, DOPPLER SHIFT, SPEEDLOG, SEA CURRENT, FUEL CONSUMPTION EXPENSES

1. Введение.

За измерване на повърхностните течения и спектъра на морските вълни, в края на миналия век са се използвали късовълнови радари. Едно основно предимство на такава система е възможността за свързване на различни конфигурации от приемни антени. Когато се работи с двубния масив, информацията за състоянието на морето може да бъде получена чрез спектрални ленти от втори ред. Предимство представлява гъвкавост в разпределителната способност между 0,3 и 1,2 km, вместо фиксираната разделителна способност от около 2 km. Това се постига чрез предаване на честотно модулирани непрекъснати вълни, вместо непрекъснати импулси. Техническият проект известен като WERA (Wellen Radar) претърпява трансформация и става допълнение към конвенционалните радари работещи в X-band (8-12 GHz). [1]

Точното измерване на скоростта на обект спрямо водата и морската повърхност в корабоплаването има много различни цели и приложения. Например: оптимизиране на разхода на корабно гориво, оценка на бързината на няколко възела на кораба, възможности за приложение на алтернативни начини за измерване на скоростта на кораба.

Допълнено до използване на радар на картина по избор, далеч от смущаващи обекти за определения обхват, може да се прилага подводен лаг или прибор на подобен принцип - допълващ радарна информация. Този прибор може да се прилага във всякакъв кораб, като използва ефекта на Доплер, като се определя скоростта спрямо водата и повърхностните течения със съответните допълващи радарни системи и алгоритми за генериране на точни данни за скоростта на кораба.

2. Решения за отчитане на скоростта спрямо водата

В резултат на подобрения и допълнение в хардуерата, заедно с прилагане на алгоритми и математически модели, скоростта спрямо водата и повърхностните течения могат да бъдат „измерени” чрез системи допълващи радарната картина. В този случай може да бъдат измерени, използвайки радарна картина по избор, дальеч от смущаващи структури и обекти, като са приложени вълните в близост до
корпуса на кораба. Решението може да се осъществи чрез приставка към наличното радарно оборудване [14]. Така измерването на скоростта спрямо водата (STW) ще бъде достоверно. Тези параметри са взаимосвързани при еднакви дълбочини, както са свързани и със скоростта спрямо земята получавана от глобалната система за позициониране (SOG от GPS)

\[ \vec{u}_{STW} = \vec{u}_{SOG} - \vec{U} \]  
(1)

cъдето \( \vec{U} \) е векторът на течението.

2.1. Технология и принципи използвани в приставката към радара

Полученото от морски навигационен радар изображение се дигитализира от т. нар приставка. Дигитализирани образи могат да бъдат получени и директно от радари с цифров изход, пример през интернет протокол, което елиминира нуждата от допълнителен хардуер за цифровизация. За да се получи оптимална работа, също се налага използване на нефилтриран сигнал, взет от краткопериодния режим на радара. В допълнение се отчита и скорост на вятъра от 2-3 m/s за да се регистрира обратното електромагнитно разсейване от водната повърхност. Дигиталните радарни изображения се подават на обработваща спектрална алгоритъм, който предоставя на потребителя стойностите за скоростта спрямо водата, вълнението и течението.

При конфигурирането на приложението следва да се дефинират няколко образни сектора на сканиране в декартова правоъгълна координатна система (вж. Фиг.1). Впоследствие се прилага тримерно бързо преобразуване на Фурие върху последователните правоъгълни области на сканиране, в резултат на което се получава картина на спектъра, съдържаща информация за наличната мощност на сигнала за различни вълнови числа и различни честоти. Теченията на морската повърхност и скоростта спрямо водата могат да се разгледат и съпоставят с теоретични модели в които има данни за стандартни навигационни измервания. Методът е известен отдавна и се базира на моделите на гравитационните вълни при липса на течение. Известна е следната дисперсионна връзка:

\[ \omega_0^2 = g|\vec{k}|\tanh(\vec{k}|\vec{d}|) \]  
(2)

Където \( \omega_0 \) е честотата на вълната, \( \vec{k} \) е векторът на вълновото число, \( \vec{d} \) е дълбочината на водната повърхност, \( g \) е гравитационното ускорение. Ако съществува течение \( \vec{U} \) относно радара, то наличие е допълнително изменение на честотата, което може да се разглежда като:

\[ \omega = \omega_0 + \vec{k}.\vec{U} \]  
(3)

2.2. Примери за приложение и резултати

Няколко пилотни системи на Wavex [13], [15] са били инсталирани на различни видове кораби с различни модели X-band радари. Надеждността и точността на измерените от радарите скорости спрямо водата могат да се разгледат и съпоставят с теоретични модели в които има данни за стандартни навигационни измервания. Примерите, които са посочени по-долу са получени в морски региони. Примерите, които са посочени по-долу са получени при навигация в различни морски региони. Примерите, които са посочени по-долу са получени при навигация в различни морски региони. Примерите, които са посочени по-долу са получени при навигация в различни морски региони. Примерите, които са посочени по-долу са получени при навигация в различни морски региони.
Акустичният лаг е модел JLN-550 доплеров лаг, производство на японската JRC [17], който представлява широкозаповеден прибор за измерване на скорост спрямо водата на плавателни съдове. Той е четири лъчев доплеров апарат излъчващ в две направления, с допълнителна възможност за отчитане на градус на завиване, работещ на 2 MHz. Информацията за скоростта по дължината се получава чрез VBV NMEA изречение (двойна земя/вода скорост). Това е компонентата, която е паралелна на движението на кораба. Въпреки се, че тя има положителни стойности, когато корабът се движи непреди относно водата. Моделът на Норшлф [18], осигурява данни за течениета на моретата в норвежкия шейлф. Моделът е създаден от норвежкия метеорологичен институт и включва протока Скагерак на югоизток, северната част на Северно море, шейлфът на запад от Баренцово море на север. Това представлява сериозна част от първата секция на разглежданата мрежа от Фиг. 2 (Section 1). Моделът осигурява данни с резолюция в хоризонтална посока 2.4 km през времепериод - 1 час. Данините са достатъчни от метеорологичния институт [19] във формат NetCDF. Данините от модела са за дълбочини до 5 m, тъй като се счита, че това е ефективно измерване на скоростта спрямо водата.

Данни от модела на норвежкия морски институт за североизточната част на Атлантически океан [20] осигуряват информация за повърхностните течения в тази част на водните пространства. Това може да се проследи във втората част на прехода от Фиг. 2 [Section 2]. Хидродинамичният модел на регионалната система за моделиране ROMS използва средна резолюция от 1.9 km и осигурява данни през период от 1 час. Данините са използвани за възприемане на Thredds и ERDDAP [21] и са в различни формати. Предишните данни са получени от норвежкия морски институт и обработени в MatLAB.

3. Статистика и времеви серии.

Данни за теченията от моделите са извлечени според маршрута показан на Фиг. 2, като са използвани времената и позицията на кораба с известна линейна интерполация. Това е отчасти подобно на извършеното в [14], когато се дефинира динамичен модел на приливите според маршрута на кораба. Точността на измерваната на скоростта спрямо водата е тясно свързана с точността на измерването на скоростта според (1). За удобство, както моделите, така и приставката WaveX към радарната система, осигуряват стойности за теченията, които могат да се разгледат като статистически (вж. Табл. 1.). Надължната компонента на скоростта спрямо водата получена от кораб се конвертира в надължна компонента на течението използвайки формулата (1).

С цел да се получат по-балансирани статистически данни, се прави допълнително осредняване. Така се изглаждат минималните времеви измервания на отчетите получени от различните източници. Измерените данни ще бъдат по-сравними с данните от моделите, преди да се представят статистически като резултати. За тази цел е приложен филтър от 40 мин средно, на отношение на времепериодните. Отчетено е средното и средно квадратично отклонение върху данните. [15]
Данните от радарно базираната система осредняват стойностите. Стойността на течението е в границите на 0 до 0.5 м/с последователно спрямо данните от моделите. Грешката за 0.5 m/s.
Измерванията от лага изглеждат със систематична грешка от 2.
1.
допълнително увеличаване на разхода с десетки тонове гориво измерване с традиционни лагове, могат да означават малките грешки в измерването, както се наблюдава при скорост спрямо водата е от съществено значение. Относително отчитайки дневната консумация на гориво, параметърът корпус. По отношение на оптимизирането на разхода на гориво, дистанция, встрани от водната среда близка до корабния скоростта спрямо водата следва да се изпълняват на достатъчна точност могат да бъдат избегнати. Измерванията на наслагване на шумове и високите разходи вследствие на дистанционно наблюдение, предизвикателствата свързани с традиционен доплеров лаг. С помощта на техника за определяне на скоростта спрямо водата. Експериментите, които са проведени с инсталирани приставки на Wavex, показват че измерванията са с достатъчна точност и съдържат по-малко шумове, отколкото стандартните измервания с традиционни доплеров лаг. С помощта на техника за дистанционно наблюдение, предизвикателствата свързани с налагане на шумове и високите разходи вследствие на неточност могат да бъдат избегнати. Измерванията на скоростта спрямо водата следва да се изпълняват на достатъчна дистанция, встари от водната среда близка до корабния корпус. По отношение на оптимизирането на разхода на гориво, отчитайки дневната консумация на гориво, параметърът скорост спрямо водата е от съществено значение. Относително малките грешки в измерването, както се наблюдава при измерване с традиционни лагове, могат да означават допълнително увеличаване на разхода с десетки тонове гориво на ден.

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Application of regression analysis on some thickness measurement data collected for inner bottom plates of aging bulk carriers

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Summary: In this article we analyzed real thickness measurement data collected on aged bulk carrier. Totally 25 aging bulk carriers were investigate under the 38 special ships surveys. As it is most important part of bulk carriers are fuel oil tanks, which can be located in different areas, in this article we analyze fuel oil tanks located in double bottom tanks. During exploitation life of ships there are lot of influenced factor as it is cargo operation, maintains, type of cargo, transport route and etc., which can accelerate corrosion and lead to different steal damage. From that reason it is important to analyze corrosion data in order to describe the expected corrosion. The aim of this article is to analysis totally 3136 thickness measurement data and find some correlation between the measured values and the time. It is clearly seen that the number of measurements increases with the time which can affect the results of the statistical analysis. Obtained statistical and graphical results show that the linear regression between statistical value and the Year parameter would be well appropriate to describe estimation model for inner bottom plates of bulk carriers.

KEY WORDS: BULK CARRIER; FUEL OIL TANKS; INNER BOTTOM PLATES; CORROSION; LINEAR REGRESSION

1. Introduction

Lot of research last few decades were related to bulk carriers and tankers, as a vessel affected with critical corrosion damages. Aggressive environment, specifics of trade routes, continual contact with salt water and atmosphere, cargo and ballast effects dry and wet ballast circles, ratio of ballast and cargo, frequencies of cargo loading/unloading operations, etc., often affected serious bulk carriers’ corrosion deteriorations [1, 2, 3, 4].

Numerous corrosion models have been developed to date for different structural areas and structural elements, as it is transversal bulkhead of bulk carriers [5], inner bottom plating [3, 6, 7] or all structural members (see Puik et al. [1, 8]). Most notable are those related to the consideration of historical data that testify to the constriction of structural elements during exploitation. From that reason, only huge data bases of aging bulk carrier can contribute to a better understanding of the corrosion process and to predict its rate over time. In that way, this article is the continuation of research aimed at understanding the corrosion of fuel tanks in in aging bulk carriers.

The research in this paper is a continuation of previous research of corrosion investigations on fuel oil tanks where is established different two and multi-parameter continuous distributions as it is normal, Weibull and logistic distributions which are best fitted distributions for the corrosion [3, 6].

This paper is organized as follows. Section 2 firstly gives a short description about input data and motivation for this investigation. Section 3 explain descriptive statistic for collecting data which are dedicated to corrosion wastage of inner bottom plates of aging bulk carriers [3, 6]. Chapter 4 presents regression analysis between statistical values and the time. Chapter 5 is dedicated to conclusion.

2. Input data

As it is mentioned earlier, large data base has been provided by the recognized ultrasonic measurements used from the INVAR-Ivosević Company (see Acknowledgement) during the last fifteen years [3, 6]. These data were collected through numerous standardized and very detailed measurements over almost all hull structure members of the group of analyzed aged bulk carriers. In spite previous research on aging bulk carriers are covered mostly on cargo holds and ballast tanks [5, 9, 10, 11], in this article, only bulk carriers’ fuel tanks have been analyzed. Despite the damaged of ships structure can be find due to general corrosion, pitting, fatigue and other reasons, but only general corrosion were analysed.

The total of 25 aging bulk carriers ranging from 5 to 25 years of age is investigated and 71 different fuel oil tanks were included in this research. Based on a clearly defined methodology and overall data collected, we consider in this paper a totally 3136 measuring data. Analyzed data of thickness measurement of inner bottom plating of fuel oil tanks are part of collecting data during 38 different special surveys which were conducted after 5, 10, 15, 20 or 25 years of exploitation life cycle.

Data were collected for vessels which had different age and some of vessels were analyzed few times during exploitation. The data is denoted by 1, which is the difference in thickness. The numbers of data related to the vessel’s age are showing in Table 1, where all are present thickness measurement data collected after 5, 10, 15, 20 and 25 year. Thickness measurement data were in range of 0 mm up to 6.7 mm of diminution.

<table>
<thead>
<tr>
<th>Age [year]</th>
<th>Number of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>230</td>
</tr>
<tr>
<td>10</td>
<td>266</td>
</tr>
<tr>
<td>15</td>
<td>526</td>
</tr>
<tr>
<td>20</td>
<td>908</td>
</tr>
<tr>
<td>25</td>
<td>1016</td>
</tr>
</tbody>
</table>

3 Descriptive statistics for the collected data

The distributions of the data are visualized in Fig.1 and 2. The x axis is the measured value, and the y axis is the count of a certain interval. It is clearly seen that the histogram is “moving” toward larger values by the time. Minitab 18 software was used for statistical, graphical and numerical results of analyzed data.
The distribution of the data is not well known and described. The distribution regarding the age factor were controlled for normal, lognormal, Weibull, exponential, logistic, smallest extreme values distributions and the data is not fitted. (In case of distributions related to positive numbers, the values were neglected from the data). Therefore the statistical parameters (such as mean, median, and so on) could describe the measurement values. Those statistical values are presented in Table 2.

### Statistical values of data collected (the data are in mm)

<table>
<thead>
<tr>
<th>Age [year]</th>
<th>Mean</th>
<th>StDev</th>
<th>CVariation</th>
<th>TRMean</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.109565</td>
<td>0.097545</td>
<td>89.02948</td>
<td>0.105825</td>
<td>3.280854</td>
<td>28.88383</td>
</tr>
<tr>
<td>10</td>
<td>0.38609</td>
<td>0.373553</td>
<td>96.7527</td>
<td>0.351667</td>
<td>1.44518</td>
<td>1.398052</td>
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<tr>
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<td>0.969358</td>
<td>68.17518</td>
<td>1.387131</td>
<td>0.199421</td>
<td>-1.03158</td>
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<td>1.273258</td>
<td>63.93518</td>
<td>1.954566</td>
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</tr>
<tr>
<td>25</td>
<td>3.28878</td>
<td>1.851659</td>
<td>56.30233</td>
<td>3.308425</td>
<td>-0.02964</td>
<td>-1.56701</td>
</tr>
</tbody>
</table>

**Figure 1:** Histogram for the vessels’ data grouped by the age

**Figure 2:** Histogram for the vessels’ data grouped by the age in separate diagrams
Above tables show the statistical values for the collected data where are [12]:

- **Mean**: The mean is the average of the data, which is the sum of all the observations divided by the number of observations. 
  \[ \bar{y} = \frac{\sum y_i}{n} \]

- **StDev**: The standard deviation is the most common measure of dispersion, or how spread out the data are about the mean. 
  \[ s = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n-1}} \]

- **CVariation**: The coefficient of variation (denoted as COV) is a measure of spread that describes the variation in the data relative to the mean.

- **TRMean**: The trimmed mean is the mean of the data, without the highest 5% and lowest 5% of the values.

- **Skewness**: Skewness is the extent to which the data are not symmetrical. 
  \[ \text{skewness} = \frac{\sum (x_i - \bar{y})^3}{s^3} \]
  (In case of normal distribution)

- **Kurtosis**: Kurtosis indicates how the tails of a distribution differ from the normal distribution.
  \[ \text{kurtosis} = \frac{\sum (x_i - \bar{y})^4}{s^4} \]

Above mentioned values are good in case of really or approximately normal distributed data. When the distribution is not known it is better to use the following statistics (Table 3):

### Table 3: Statistical values of data collected (the data in mm)

<table>
<thead>
<tr>
<th>Age [year]</th>
<th>Q1</th>
<th>Median</th>
<th>Q3</th>
<th>IQR</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
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</thead>
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<tr>
<td>5</td>
<td>0</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>0.1</td>
<td>0.2</td>
<td>0.5</td>
<td>0.4</td>
<td>0</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>15</td>
<td>0.4</td>
<td>1.5</td>
<td>2.2</td>
<td>1.8</td>
<td>0.1</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>20</td>
<td>1.1</td>
<td>1.8</td>
<td>3.1</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>1.5</td>
<td>3.2</td>
<td>5.2</td>
<td>3.7</td>
<td>0</td>
<td>6.7</td>
<td>6.7</td>
</tr>
</tbody>
</table>

In Table 3 we can see the statistical values for the collected data where are [12]:

- **Q1, Median and Q3** are the quartiles. Quartiles are the three values—the first quartile at 25% (Q1), the second quartile at 50% (Q2 or median), and the third quartile at 75% (Q3)—that divide a sample of ordered data into four equal parts.
  - The first quartile is the 25th percentile and indicates that 25% of the data are less than or equal to this value.
  - The median is determined by ranking the observations and finding the observation that are at the number \([N + 1] / 2\) in the ranked order. If the number of observations are even, then the median is the average value of the observations that are ranked at numbers \(N / 2\) and \([N / 2] + 1\).
  - The third quartile is the 75th percentile and indicates that 75% of the data are less than or equal to this value.

- **IQR**: The interquartile range (IQR) is the distance between the first quartile (Q1) and the third quartile (Q3). 50% of the data are within this range.

- **Minimum**: The minimum is the smallest data value.

- **Maximum**: The maximum is the largest data value.

- **Range**: The range is the difference between the largest and smallest data values in the sample. The range represents the interval that contains all the data values.

The boxplots with quartiles, minimum and maximum values are in Fig. 3. The lowest point is the minimum of the data set and the highest point is the maximum of the data set. The box is drawn from Q1 to Q3 with a horizontal line drawn in the middle to denote the median.

![Boxplot for the vessels’ data](image)

**Figure 3**: Boxplot for the vessels’ data
3. Regression between the statistical values and the time

Linear regressions are presented here between the statistical values (Mean, StDev, and so on) and the Year parameter. The following figures show connections between these variables. The goodness of fit is denoted by R-sq. The closer is the R-sq value to 100% the better the fitting. The equations are on the top of the graphs, and the green line is related to the 95% confidence interval for the equation. With the help of these equations the future behaviour of the vessels' data could be predicted, i.e. what will be in 30 years.

There are good linear regressions between Mean and Year, StDev and Year and TRMean and Year variables due to goodness of denoted R-sq is greater then 90%. The skewness values are moving toward 0 (which is the normal distribution case) by the time. The kurtosis values are quite different at 5 year, 10 year and in case of the other values.

Figure 4: Regressions for the Table 1
There are good linear regressions between quartiles and Year, IQR and Year and Range and Year variables. As we can see from Figure 5 almost all analyzed value of R-sq is greater than 93% of confidence what is mean excellent linear regression of all collected data from Table 3.

4. Conclusion

Motivated by previous research of author of this analyze regression model related only to inner bottom plates of aging bulk carriers. Precisely, in this article we analyze some empirical data collected on inner bottom plating, as a part of 71 fuel oil tanks of 25 aging bulk carriers. In order to predict future behaviour of the specific structural vessel’s data could be predicted. On that way, we can predict what will be in 30 years of vessel explanation.

Also, considering above analyzes we can compare any data in range of 5-25 years of exportation and consider intensity of corrosion of structural areas.

On that way, we can use different empirical data and larger set of measuring data in order to predict future condition of vessel in different structural elements or areas. This will be part of future research in this field.

Acknowledgement

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Experimental determination of parameters of dynamic systems of machine-tractor aggregates

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Abstract: The central moment with respect to the vertical axis OZ is determined in the paper. The tractor is suspended on two strings so that its center of mass is at an equal distance from them. Elastic and damping properties are determined by the dynamic test method by creating damping vibrations of a system with one degree of freedom.

KEY WORDS: TRACTOR, DYNAMIC SYSTEMS, AGGREGATE

1. Увод

В доклада се определя централният момент по отношение на вертикалната ос OZ. Тракторът е окачен на две струни, така че центърът му на маса да е на еднакво разстояние от тях.

Еластичните и амортизиращите свойства се определят от метода на динамичното изпитване чрез създаване на амортизационни вибрации на система с една степен на свобода.

За осигуряване на достоверност на резултатите от симулирането на динамичните процеси е необходимо да се разполага с полученi доста точно стойности на параметрите на динамичните системи и опитно проверени работоспособни модели на машинно-тракторните агрегати (МТА).

2. Изложение

При избора на метода на експерименталното определяне на масовите инерционни моменти на детайлите е необходимо да се изхожда от точността на получените резултати и простотата на техниката за осъществяване на метода.

По метода на физичното махало могат да се получат масовите инерционни моменти на колелата на трактора и маховиkey на двигателя, а по метода на еластичното окачване масовите инерционни моменти на корпуса на трактора относно надлъжната и напречната централни оси.

За определяне на централния масов инерционен момент спрямо вертикалната ос OZ, използването на горепоменатите методи е технически трудно. Затова се използва методът на торсионното махало. Тракторът се окачва на две струни така, че центърът на масите му да се намира на еднакво разстояние от тях (фиг. 1). Бълговото трептене на трактора относно оста затихва бавно, което осигурява точното измерване на периода на трептене.

Фиг. 1 Опитна уредба за определяне на масовия инерционен момент на трактора спрямо вертикалната ос.

Еластичните и демпфирациите свойства се определят по метода на динамичното изпитване [1, 4] чрез създаване на затихващи трептения на система с една степен на свобода. Схемата на опитната уредба е представена на фиг. 2 със стойка 1, около която трепти тракторът, повдигащото устройство 2, разделящото устройство 3 и измервателната система. Тя включва първичен преобразувател (ПП), за ускорение, виброусилвател (УС) и осцилограф (ОС).

Фиг. 2 Схема на определяне на коравината и демпферащия коефициент на предните (а) и задните (б) гуми

При опитното определяне на динамичните параметри на трансмисията, за осъществяване на свободните трептенения се блокира маховиkey на двигателя и едното от двете задвижващи колела. Към свободното колело се захранва лост с много голяма коравина със закрепени на другия край допълнителни тежести, които натоварват трансмисията и осигуряват линейни трептенения. Изпитването се провежда с различен брой тежести за всеки предавка на трактора.

За изследване силовото взаимодействие между трактора и навесната машина се провежда експеримент [3] с Трактор МТЗ-80 в режим на плавно положение на хидравличната система (фиг. 3). Тракторът е повдигнат на стойките 1 така, че колелата му да не контактуват с опорната повърхина. Работната машина е подпряна с пружината 2 в близост до долния окачен точка М на навесната система и извършва малки свободни затихващи трептенения.

Фиг. 3 Схема на експерименталната уредба...

За анализ на характера на трептящия процес е построен график на изменение на амплитудите на изследваните първи три периода в полулогаритмични координати, който показва нерегулярно разсеивание на енергията за всеки период [2]. Динамичната система има една степен на свобода (фиг. 4).
Фиг. 4 Схема на динамичната система.

Моделът на съпротивителните сили при едновременно наличие на вискозно и на сухо триене е представен в следния обобщен вид

\( R = -S(\dot{x}) + F\text{sign} (\dot{x}) , \)

където:

\( S = S_1 \frac{1 - \text{sign}(\dot{x})}{2} + S_2 \frac{1 + \text{sign}(\dot{x})}{2} \text{sign}(\dot{x}) \)

Е обобщената сила на анизотропно вискозно съпротивление, \( S_1 = -k_1 \dot{x}_1, S_2 = -k_2 \dot{x}_1, k_1 \) и \( k_2 \) – обобщени коефициенти на дисипация, приведени в точка \( K, \dot{x} \) – обобщена координата \( x_1 = x(l/l_1) \), \( l \) и \( l_1 \) – показаните на фиг. 4 линейни размери

Аналогично, за приведената в точка \( M \) обобщена сила на анизотропно сухо триене \( F \) е пренет вид:

\( F = -F_1 \frac{1 - \text{sign}(\dot{x})}{2} + F_2 \frac{1 + \text{sign}(\dot{x})}{2} \text{sign}(\dot{x}) \)

С компоненти мерките на \( F_1 \) и \( F_2 \).

Решаването на гореописаната задача за структурна и параметрична векторна идентификация на параметрите на съпротивлението в навесната система е основана на енергетична оценка на предлагените модели.

При относителна разлика 0,02% на енергията на дисипация между симулирания процес и процеса от експеримента за сухо триене в първия и втория полупериод се получават съответно силите \( F_1 = 179,8 \) N и \( F_2 = 11,7 \) N.

3. Заключение:

Структурната и параметрична векторна идентификация на параметрите на съпротивлението в навесната система е основана на енергетична оценка на предлагените модели.

Настоящото изследване води до следния извод: вискозния съпротивителен коефициент за двата полупериода е един и същ и е равен на \( k = 829,14 \) Ns/m

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Processes of Ukraine’s integration into the common aviation area

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Annotation. Aviation integration is seen as a process of rapprochement and unification in the air transport industry. Conducting a study of the common aviation area of the European Union. Today there is a common transport policy in the EU. Its goal is to provide market conditions and a competitive basis for airlines. The analysis of competition in the market of air transportation of Ukraine is carried out. The main flights passing through Ukraine are singled out. The shortcomings of Ukrainian airlines in the international market have been identified. It is concluded that the air transport industry in Ukraine is still underdeveloped. Ukraine’s accession to the Free Sky of Europe has advantages. Strategic directions of development of the air transportation market of Ukraine are determined.

KEYWORDS: COMMON AVIATION SPACE, AIRLINE, AIR TRANSPORTATION, DEVELOPMENT STRATEGIES, COMPETITIVENESS.

1. Introduction

International economic integration should be understood as a political and economic process of convergence and unification of states with their economic systems interconnected, joint economic policy and supranational political governance.

Nowadays, aviation integration is deemed to be a process of convergence and unification in the air transport industry, which includes the following: interconnected management systems, a joint policy and control. Pertaining to the international integration, general provisions are introduced for the countries interested in such integration, which allows management of aviation activities between these countries.

Air transportation in Ukraine has not been able to be referred to as a competitive market. The availability of healthy competition is obstructed by a certain monopoly taking place at the modern air transportation market in the country [1]. However, one of the most attractive features of the Ukrainian market for foreign investors and manufacturers is the transit location of Ukraine and necessary initial conditions for the creation of a new transport connection system that complies with the European standards.

The open skies agreement with the European Union (EU) opens new opportunities for the air transportation market in Ukraine, both for individual citizens and for the state as a whole. The interest of citizens is as follows: being provided with reasonably priced air services of high quality, increasing the profits of national companies and taxes to the budget, and enhancing the level of air transport safety.

The creation of a "free trade zone" leads to the enhancement of air transportation services and the liberalization of the national aviation market of Ukraine. Within the established Common Aviation Area of the European Union and the third countries involved, the air transportation markets of different countries are actually combined [2].

2. Characteristics of the Common Aviation Area of the European Union

Integration in the transport sector is carried out based on the principles of international economic law, as well as by means of introducing a common transport policy in the European Union, which reflects the supranational nature of European integration [3]. Legal support therefore comprises regulatory documents of EU authorities and international agreements between EU members and other countries.

The purpose of the EU’s common transport policy is to adopt and implement generally accepted rules for international transport to or from the territory of the Member States or for transit transport (Treaty on the Functioning of the European Union, Articles 90-100) [4]. The common transport policy also includes conditions for the provision of services by non-resident carriers, and measures to improve transport safety. The ultimate goal of the common transport policy is to create a common market in the field of transport services. The implementation of such a policy has a particular specificity related to the close interaction between international law and EU law, which provides for the participation of member states in international transport agreements.

In the field of air transport, there is a harmonious combination of international law and supranational levels of legal regulation. According to the tasks of ICAO, the key elements of legal regulation are the development and enhancement of activities in the field of civil aviation with a high level of aviation security, promoting the participation of states in international air transportation and the benefits associated with such participation.

Since 2011, a Joint Commission of the EU and ICAO has been active. This commission has already concluded a number of agreements on air flights and incidents. In 2013, a new aviation security program was agreed and added to the memorandum of cooperation. This program has determined important areas of cooperation, in particular, the exchange of information and funding of certain initiatives in this area.

EU legislation in the air transport sector is mainly based on regulations and structured in accordance with the tasks to be fulfilled. The main goal is to ensure proper market conditions and competitive principles for airlines, regulation of requirements for aircraft, conditions for transportation, safety assurance and other issues.

On 10 June 2013, the European Commission proposed a plan to accelerate the implementation of the Single European Sky project (SES-II+). This project is a set of measures to address the current situation concerning the state monopolies that are responsible for providing air navigation services, which, in turn, has caused a number of protests. Back in 2005, the EU Commission developed a roadmap for the implementation of foreign policy for air transport, which was based on the three following elements:

1. Gradual alignment of existing bilateral air service agreements with EU law. This is an outcome of the resolution made by the European Court of Justice, which states that the provisions on nationality in such agreements are illegal, but it is permissible for an EU carrier to conduct air transportation from its country to a third country.

2. The need to conclude aviation agreements with key strategic partners. The EU model tends to liberalize airline ownership and regulate security, competition and other issues that have not been regulated at the national level.

3. Creation of a common airspace with neighboring countries. Consistent alignment with the above-mentioned requirements of the EU aviation market provides financial and material support.

For Ukraine, "open skies" means the intensification of the process of the air transportations market development due to: update of airport infrastructure; establishment of high technical standards for airplanes and air services; security enhancement; modernization of air traffic control procedures; updating sectoral legislation, etc. In order to solve these problems, it is necessary to implement the provisions of the Concept for the development of the aviation complex and the development of programs for the period
up to 2020 and to ensure the safety of flights by improving the mechanisms of supervision and control of transport activities [5].

3. Analysis of competition in the air transportation market of Ukraine

In 2019, national air carriers attained an increase in the main economic indicators of the industry. 28 national air carriers operated in the market (Fig. 1), which performed 47.8 thousand commercial flights (compared to 46.2 thousand in 2018). 10 air carriers of those specified above have been engaged in passenger transportation [5].

At the same time, 93% of the total volumes are covered by the five national air carriers (see Table 1) that are the following: Ukraine International Airlines (UIA), Wind Rose, Azur Air Ukraine, Sky Up and Bukovyna. Traditionally, the largest passenger traffic was served by UIA [7].

### Table 1 Growth of passenger traffic of the top 5 airlines in 2018-2019

<table>
<thead>
<tr>
<th>Top air carriers in 2018</th>
<th>Growth of passenger traffic from 2017 to 2018, %</th>
<th>Top air carriers in 2019</th>
<th>Growth of passenger traffic from 2018 to 2019, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>UIA</td>
<td>16.5</td>
<td>UIA</td>
<td>8.1</td>
</tr>
<tr>
<td>Wind Rose</td>
<td>25</td>
<td>Azur Air Ukraine</td>
<td>33.6</td>
</tr>
<tr>
<td>Azur Air Ukraine</td>
<td>17</td>
<td>Wind Rose</td>
<td>19.7</td>
</tr>
<tr>
<td>Atlas jet Ukraine</td>
<td>74</td>
<td>Sky Up</td>
<td>Multiplied by 7</td>
</tr>
<tr>
<td>Bravo</td>
<td>50</td>
<td>Bravo</td>
<td>-</td>
</tr>
</tbody>
</table>

According to statistical indicators [7], the number of transported passengers increased by 986.9 thousand people in comparison with 2018 (Fig. 2).

Along with this, cargo volumes were increased by 688.5 thousand tons. Mail and cargo were transported by 18 Ukrainian air carriers, most of which were charter flights to other countries under UN humanitarian and peace programs, as well as under contracts with other customers. The majority of transportations (83%) were performed by Antonov, ZetAvia, Ukrainian Helicopters, Maximum Airlines and CAVOK Air.

During 2019, commercial flights of national and foreign air carriers were served by 20 Ukrainian airports and airfields. According to the statistics, the number of departing and arriving aircraft equaled 153.9 thousand units, which exceeds the number obtained in the previous year 2018 by 15.8 thousand units (Fig. 3). Passenger traffic through the airports of Ukraine increased by 27.6 percent and equaled 16498.9 thousand people.

### Fig. 2. The volume of passenger traffic in Ukraine in 2009-2019 (thousand people)

When visually assessing the real-time flight map (Fig. 4), it is possible to distinguish the main air routes passing through Ukraine, which, in turn, means the loss of Ukraine's benefits in the form of payment for flight performance through its airspace. When comparing foreign and Ukrainian air traffics, Ukraine has a much smaller one.

Factors leading to the bypass of Ukraine's airspace comprise the political situation in the country, the Crimea annexation and military conflict in its Eastern part. Hence, there are flight safety recommendations established by some international institutions and authorities of the European Union to bypass a certain part of airspace in Ukraine, using other routes, and the deterioration of the economic situation takes place in this regard.

The non-competitiveness of air transportation in Ukraine is due to the following factors:

1) UIA monopoly in the air transportation market;
2) Obstacles to the creation of a competitive environment by foreign companies in the air transportation market;
3) Long delay in signing the agreement on Common Aviation Area with the European Union;
4) The air fleet is morally obsolete;
5) The infrastructure of most airports is underdeveloped.
One of the significant problems of Ukrainian air carriers in the international air transportation market is unsatisfactory service. According to the British company named Skytrax, UIA was awarded 2 stars out of 5. The disadvantage is the inflated price factor, low quality of services provided and a number of other factors that sustain the low position of Ukrainian air carriers in international markets.

4. The current situation regarding the processes of Ukraine’s integration into the Common Aviation Area

Ukraine's air transport system is currently at the stage of integration into the European one. To implement the Single European Sky program, a number of measures have been taken to ensure compliance with Eurocontrol standards. Integration into the Common Aviation Area implies that the system of economic regulation of air transportation ought to be adapted in accordance with EU legislation, which is one of the priority areas [9].

The State Aviation Administration of Ukraine (SAAU), which reports to the Ministry of Infrastructure of Ukraine, monitors the aviation industry in Ukraine. SAAU is responsible for the implementation of aviation policy and the use of the country's airspace, oversees the safety of air traffic, the flight condition of aircraft, the proper condition of airfields, technical devices and other aviation facilities, manages and regulates the aviation security system.

Ukrainian aviation still has a number of aspects that need to be addressed. One of them is instability in the creation and implementation of state policy in the aviation industry. In this case, it is appropriate to propose the development of a comprehensive program pertaining to the preparation for the Agreement on the Common Aviation Area being concluded and entering into force. The agreement itself should describe a number of relevant issues to ensure compliance with Eurocontrol standards. Integration into the European Sky program, a number of measures have been taken to improve the image of Ukrainian air carriers in the European transportation market. Also, the unification of these air carriers can lead to the expansion of the route network by coordinating the flight schedules, combining different types of services, and increasing the number of routes to different countries.

Access to resource allocation among the air carriers participating in the alliance can reduce the cost of various services, including the maintenance and servicing of aircraft, the use of the services provided by handling companies, the establishment of joint systems for selling and booking tickets, and others.

5. Conclusions

The air transport industry in Ukraine is still underdeveloped in comparison with other countries, but there has been some improvement in recent years. However, Ukraine can efficiently apply its capabilities in the aviation industry, which is possible if there is some liberalization of access to the national market. Insufficient state support is a major factor among the political factors. There is no basic state policy for Ukrainian airlines in a difficult competitive environment. The weak point is also a discrepancy legislation of Ukraine in the field of air transport to international and European standards, including the International Civil Aviation Organization (ICAO), the European Union, the European Civil Aviation Conference (ECAC), and the European Organization for the Safety of Air Navigation (EUROCONTROL). Gradual displacement of a domestic air carrier to foreigners is due to weak state regulation of competition in the aviation market.

At the stage of Ukraine's integration into the Common Aviation Area, the issue of promotion competitiveness between national air carriers becomes extremely relevant. After all, when entering the market of European air carriers, the situation pertaining to competitiveness in the Ukrainian market can change exponentially. Therefore, in order to maintain Ukraine’s achievements in the international air transportation market, it is necessary to identify the main areas where the development of competitiveness between Ukrainian air carriers can be attained in the period of liberalization and integration.

Ukraine's accession to the Single European Sky has a number of benefits for both aviation infrastructure and citizens. The benefits anticipated as a result of this accession can be the following [12]:

1) Improving the level of service and increasing the level of flight safety;
2) The growth of supply in the market of air services, resulting in a possible reduction in air transportation prices;
3) Increasing the load of airports in Ukraine and further intensification of the development of "Boryspil" International Airport with its capabilities as a hub;
4) Improving methods of management and increasing the efficiency of Ukrainian air carriers;
5) Improving air connections between the Ukrainian regions and the European Union, which might lead to the emergence of new markets for national manufacturers, including those who represent the aviation industry;

6) Attaining an increase in foreign investment into airports, growth in the number of jobs related to both aviation and services, as well as an increase in the level of remuneration for aviation specialists.

Strategic directions of the development that the air transportation market of Ukraine ought to achieve can be considered as follows:

1) Improving the regulatory provision of air transport at the national level;
2) Increasing the level of air transport safety;
3) Attaining progress in air transportation and increasing the level of its accessibility for citizens;
4) Development of airports, liberalization of the aviation service market;
5) Increasing the number of multimodal transportations and high-speed ground transport connections between the airport and cities, improvement of logistics links and creation of logistics centers;
6) Improvement of air navigation systems;
7) Development of general aviation and unmanned systems;
8) Improvement of qualified training.

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