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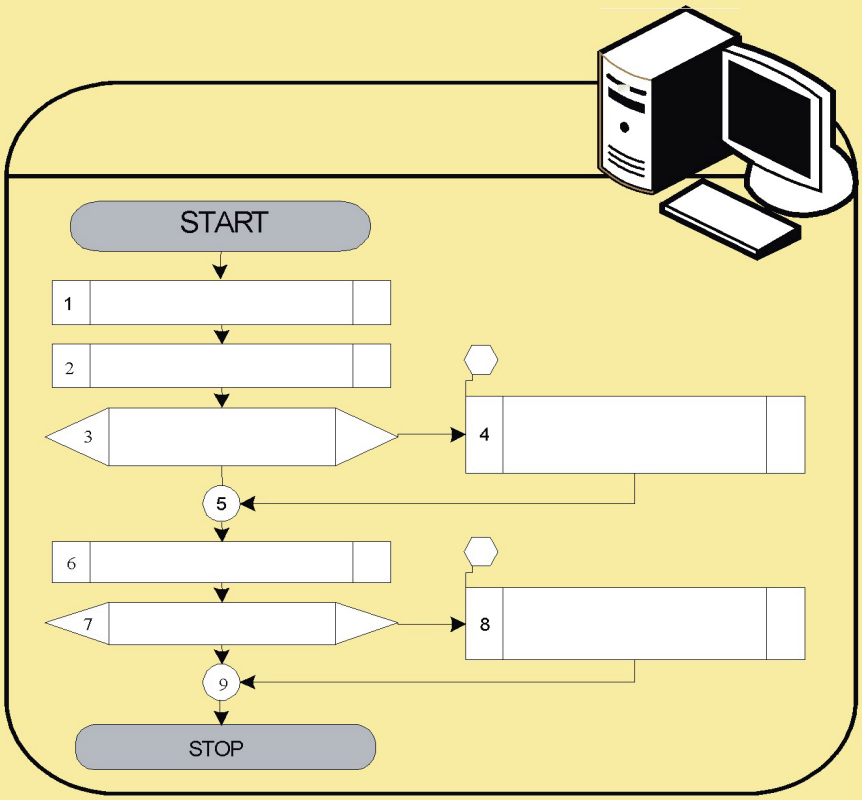

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CONTENTS

Paweł LONKWIC[*]

COMPUTER-AIDED PROJECT OF THE PROGRESSIVE GEARS INSTALLATION VALIDATION WORKSTATION

Abstract

In reply to the Polish market demand and the increase of competitiveness in the lifting sector the innovative construction of CHP 2000 type gear with changeable loading capacity configuration has been created. Computer-aided project of the workstation to validate the installation of a friction lift brake (the gear) in the production conditions is presented in the research study. The construction and the operation scheme of the lift braking system are described. Methodology of validation has been proposed at the stage of production on the basis of variability of the production demand for the presented model of the progressive gear.

1. INTRODUCTION

Presently, the professional literature regarding the aspects of the construction and operation of the braking systems and progressive gears does not focus much on that subject matter. In the publication [11] the authors touch the aspects connected with the impact of the wires weight, the wires which supply the lift cabin with power, as well as the carrying lines in the so called tall lifts working in tall over 40 floors buildings on the lift operation. In such lifts, a significant height of lifting is connected with the fact that it is necessary to use a leveling belt which compensates the weight of carrying lines and the power supply wires and in consequence the remaining subassys of the lift are not excessively loaded. The authors describe in a model way the behaviour of the leveling belt and the impact of the belt on the linear model of the lift operation. Moreover, they test the impact of the leveling belt horizontal dislocations on the system self-vibrations frequencies. The authors in the publication [2] deal with the aspects regarding

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the application of a reduction method to evaluate the lift operation dynamics. In the presented analyses the lift cabin model has been reduced to a flat system with one, vertical level of freedom. The authors used the presented reduction methodology to describe a specific mechanism of a cargo lift by describing the presented aspects in a mathematical way. Furthermore, the authors in their research study analyse what kind of results, parameters of the lift operation have the impact on the lift system accelerations characteristics.

In the publication [10] the authors focus on the aspects connected with the application of neuronal nets to analyze the lift operation vibrations due to the variable weight of the load which is carried. The applied neuronal nets were used by the authors to assess the vibrations symptoms as a result of which a part of the lift or the whole device damage could be detected. In the publications [1, 7] the authors describe the application of a finite elements method to evaluate the stiffness and resistance of the cabin frames construction in different types of the lifts also including the gears. The application of FEM method in the described aspects was used by the authors to optimize the carrying frame construction in the light of the frame construction section beams, to reduce its weight, to determine safety coefficients and on the basis of received results they made an attempt to determine places of the lift frame system which are sensitive to damage. The issues connected with the lift braking system dynamics, the analysis of applied materials influencing the comfort of operation as well as with the gears are touched also in the research studies [3, 4, 5, 6]. In those publications the authors focus among others on the braking system analysis. They compare the European manufacturers' gears construction and operation with the newly developed solution.

While analyzing the state of the existing knowledge regarding the subject matter the lack of information can be noticed especially in the international publications. Moreover, there is a shortage of research studies referring to the application of computer systems to aid the gears production processes as well as the systems supporting the supervision over the gears operation.

With respect to the increasing market demand for the progressive gears in different types of settings and in different quantities dependent on the market demand variability, it becomes purposeful to undertake the aspect regarding the application of the systems aiding the installation processes in the production facility. The variable configuration of the applied packets of Belleville springs requires constant monitoring of the proper gears installation what in the further operation of the lifting device is reflected in the proper operation and their reliability.

2. CONSTRUCTION AND OPERATION OF THE PROGRESSIVE GEAR

Recently developed construction of CHP 2000 type progressive gears was designed in order to be applied in the lifts with the nominal loading capacity from 8000 up to 20000 N, what constitutes approximately 75% of devices manufactured on the national market. Estimated yearly production of this type of gears with variable braking construction would be closed in the number of 2000 shipsets per year. Fig. 1 presents the progressive gear construction reflected in the form of a computer model.

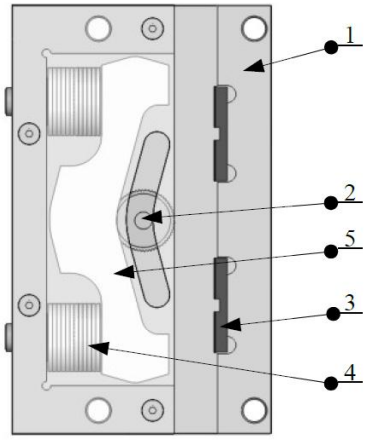

Fig. 1. Diagram of CHP2000 type progressive gears: 1 – a body, 2 – a braking roller, 3 – a braking plate, 4 – Belleville springs, 5 – a cam [5]

CHP 200 type gear consists of the body 1, where the cam 5 was located along which the braking roller 2 with knurled surface moves. Between the cam and the body the packets of Belleville springs 4 with variable configuration depending on a nominal loading capacity of the lift device were installed. During the operation the gear moves along the lift slide (pos. 6 in Fig. 2), which is placed in the gear body between the braking roller and the resistance plates 3 located in the opposite side of the Belleville springs packets.

The lift braking system together with the location of respective subassys coming into its construction are presented in Fig. 2.

The lift gear is located in the cabin frame 5 under the lift cabin. The lever 4 is mounted to the gear, its ends are connected with the speed limiter line 2. At the top part of the lifting shaft there is the speed limiter located which supervises the lift operation and at the bottom part of it there is a tensioning weight which is responsible for the proper speed limiter line stretching.

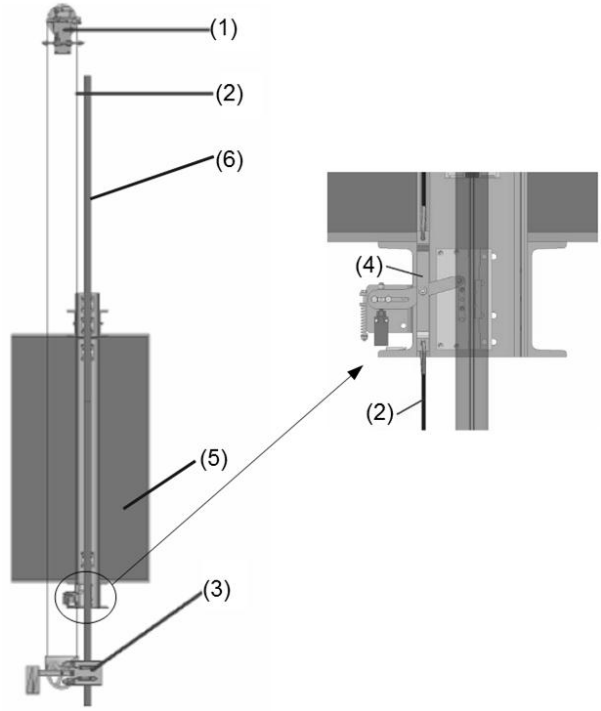

Fig. 2. The location of the braking system subassys of the friction gear, 1 – the speed limiter, 2 – the speed limiter line, 3 – a tensioning weight, 4 – a gear with a lever assy, 5 – the cabin with a frame, 6 – a guide [6]

The speed limiter initiates the braking process when the nominal speed of the lift cabin is increased by 0.3 m/s. Once the speed is exceeded the speed limiter is blocked and at the same time the line by properly selected friction coefficient is also blocked. During the lift cabin movement when the line is motionless the lever 4 is displaced in the opposite direction to the direction of the moving cabin and lifts the gear braking roller. The roller is pressed to the slide due to which the elastic deformation is created in the direction of the resistance plate which is placed on the other side of the Belleville springs packet causing the energy loss of the speeding up mass. The Belleville springs packet is responsible for the fact that changeable force is created. The force presses the roller to the guide and it depends on the mass which is carried in the cabin when the braking process is initiated.

3. MODEL OF THE GEAR BRAKING

The variable parameters, which influence the gear configuration, are as follows:
- The nominal speed v [m/s],
- Loading resulting from the lift construction F [N].

The construction of CHP 200 type gears was designed and initially tested for the nominal loading with the set-up from 8000 to 20000 N. On the basis of the above presented variables, in order to ensure the proper operation, the gears susceptible element is selected in such a way that skidding appearing during the braking is as gentle as possible. That is why, the nominal loading is a sum of a couple of mass parameters (changeable and constant) mainly influencing the selection of the susceptible element which causes the braking process. The mass parameters variability constitutes the Ist criterion to select the susceptible element of the gear to ensure proper reliability while the braking process takes place.

Thus, F nominal loading of the gears is defined by a mathematical relationship (1) [0]:

$$F = \sum P, K, D, Q \tag{1}$$

where: P – the cabin weight (a constant parameter) [N],
K – the cabin frame weight (a constant parameter) [N],
D – the cabin doors weight (a constant parameter) [N],
Q – nominal loading capacity (a variable parameter) [N].

The IInd criterion for the suitable configuration of the susceptible element selection is the right level of delay at the moment of braking. Bearing in mind the variability of Q loading which is placed in the lift cabin, the value of the force created during the braking process by the susceptible element must be within a tolerance of the system loading: with the loading capacity and without the loading capacity. During braking, the load which is inside the lift cabin as per the literature [8] should be subject to overloading within a range from 0.2, to 1 g, where "g" stands for the acceleration of gravity. That is why, the construction of a susceptible element of the gear should be matched in a such way that it is able to ensure average value of delay at the level of 0.6g during the braking process. With respect to the above, the braking force is described with a mathematical relationship (2) [5].

$$F = \frac{\text{Braking force}}{16} \tag{2}$$

While analyzing the empirical relationship (2), it should be noticed that the value of "braking force" which is supposed to be created by the gears during the emergency braking should be 16 times bigger than the value which is required to brake the cabin in movement.

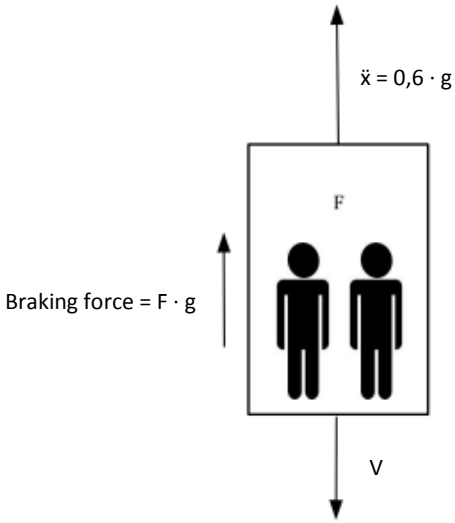

Fig. 3. The relationship between the speed, delay vectors and the braking force [3]

During the braking process, the value of braking force which is generated by the gear must defeat the weight of the whole system which loads the gears together with the loading capacity multiplied by the acceleration of gravity. The constant value, included in the empirical relationship (2) is the sum of accelerations of gravity value and the average value of braking delay 0.6 g which should be taken at the time of stopping the moving cabin system together with a changeable loading. The coefficient described in the relationship (2) is suitable for the value of gravity acceleration 10 m/s^2. Graphic relationship was presented in Fig. 3. It is the relationship between the v speed vectors, $\ddot{x}$ delay vectors and braking force.

However, bearing in mind complexity of the lift structure and changeability of the carried load weight as well as due to the variability of the system resulting from the lift operating conditions, in practice the Ist criterion is accepted to select susceptible elements in the gear.

4. METHODOLOGY OF THE INSTALLATION VALIDATION

CHP 2000 progressive gears construction was fully designed in SOLIDWORKS computer system and then it was pre-tested in the testing bench located in Lublin Factory of Passenger Lifts LIFT SERVICE S.A. The conducted tests aimed at determining whether a developed model of Belleville springs packet complies with the Ist criterion of the susceptible element selection or not. The performed tests gave the positive results. With respect to the above, as the next step the preparation of an effective system supporting the evaluation of the gear

installation correctness should take place. For that purpose within the cooperation with Department of Mechanics at Lublin University of Technology the project of the workstation was developed. Due to that project it will be possible to perform the validation process of the gears installation in the production conditions. The validation system task would confirm whether the manufactured gears comply with specific parameters determined in the purchase order or not.

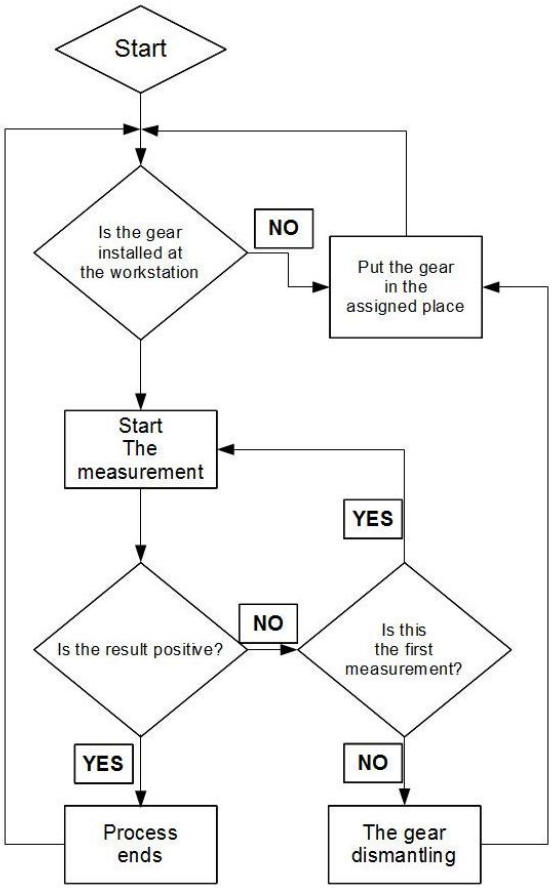

Fig. 4. The algorithm to control the validation workstation for the gears installation [9]

During the preparation of assumptions for the project the main attention was paid to the effective check of Belleville springs as the main susceptible element at the stage of the installation validation process. In order to ensure the correctness in the steps sequence during the validation, a block diagram was prepared. The block diagram is presented in Fig. 4. and it illustrates the methodology "step by step" of proceedings when the validation activities are conducted at the workstation.

In order to illustrate the validation of the gear installation at the production phase, Fig. 5 presents the project of the workstation to perform validation.

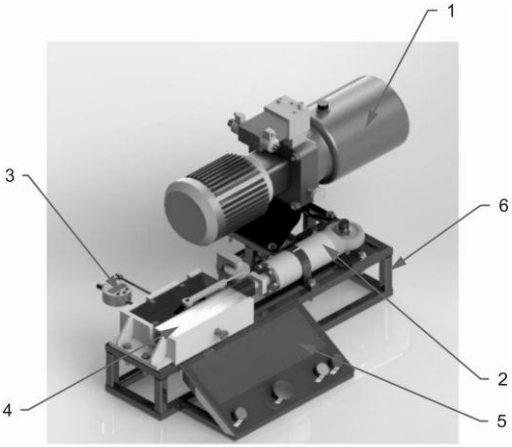

Fig. 5. The workstation to perform CH 2000 progressive gears installation validation [9]

The workstation designed in the computer consists of an engine with a pump 1, the engine drives a servomotor 2, a clockwork sensor 3, the validated gear 4, control desk 5 and the carrying frame 6. In order to perform proper validation of the gear installation, two basic indicators will be used: the pressure value read out from the manometer placed on the feeder and the value of the clockwork sensor deflection along which the Belleville springs responsible for the correct braking force will be located. Data received due to validation will be compared with the values of the gear carrying capacity set up at the beginning of the installation process [9].

5. CONCLUSIONS

In production processes of the elements responsible for safety, it is important to use diagnostic systems or systems validating the installation processes especially when the speed of production constantly increases. Direct advantages resulting from implementation of such a system in the company are the following:

- validation of the gears installation in the production without the need to check it on the object;
- the measurement of the carrying capacity directly after the installation;
- the execution of approximately 150 measurements without a need to retool the validation bench;
- the reduction of costs connected with missing parts;
- possibility to react on non-conformities immediately.

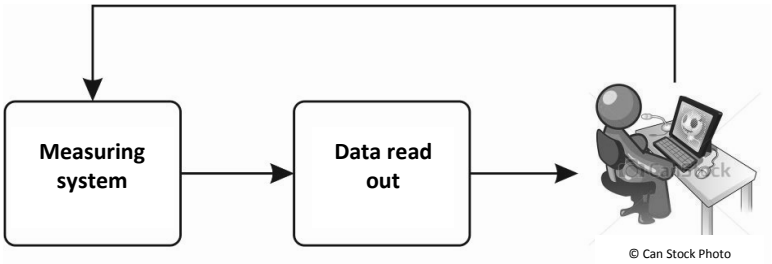

Fig. 6. A proposal of a decision making algorithm for the gears installation validation [source: own study]

The proposed system of the installation validation can be treated as the system of continuous supervision over the installed subassemblies (Fig. 6) as well as it can be correlated in its scope of work with the computer control system. Development of the field regarding decision making systems, validation and expert systems presently constitutes an important scientific subject. The product configuration changeability due to variability of the market demand constitutes a problem connected with the obstacles in the production cycle and leads to the process cost increase. With respect to the above, the implementation of such elements to the production processes allows us to reduce significant amounts of money connected with stoppages, defective production or storage of redundant subassemblies. The research study presents the project of a system which will provide a support not only to a decision but also thanks to the applicable system it will be possible to increase the production. When several pieces a day are manufactured the installation validation process is in the hands of the operator who has to decide on the classification of the item – "good/bad". Thanks to the implementation of the validation system there is a possibility to avoid not only a defective installation of susceptible elements but also to eliminate the remaining defects such as material defects. Such defects in a consequence of the installation validation can e.g. crack or deform what is unacceptable from safety point of view.

The presented system can be extended with strain gauge sensors which measure the gear stresses values caused by the braking force. Bearing in mind the above and the poor professional literature regarding the pertinent subject it seems purposeful to implement this validation system to production structures as well as to develop this field of interest.

THANKS

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computer linguistic system, texts analysis and synthesis, content system management

Victoria VYSOTSKA [*], *Lyubomyr CHYRUN* [**]

FEATURES OF THE CONTENT-ANALYSIS METHOD FOR TEXT CATEGORIZATION OF COMMERCIAL CONTENT IN PROCESSING ONLINE NEWSPAPER ARTICLES

Abstract

This paper presents the features of text categorization of commercial content in linguistic modelling. Description of syntax sentence modelling is applied to automate the processes of analysis and synthesis of texts in natural language for commercial content categorization. This article suggests methods of content analysis for online newspaper. The model describes the processing of information resources systems of content analysis and simplifies the technology of content management system automation. General problems of syntactical and semantic content analysis and functional services of content management system are analysed.

1. INFORMATION

The methods and tools development for automatic processing of text of commercial content in modern information technology are important and topical [1–5] (for example, systems of information retrieval, machine translation, semantic, statistical, optical and acoustic analysis and synthesis of speech, automated editing, knowledge extracting from the text content, text content abstracting and annotation, textual content indexing, training and didactic, linguistic buildings management, instrumental means of dictionaries conclusion of various types, etc.) [6–15]. Specialists actively seeking new models of description and methods for automatic processing of text content [2–4]. One of these methods is the development of general principles of lexicographic systems of syntactic type. It is important by these principles these systems construction of text content processing for specific languages [1, 5].

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In the last ten years humanity has implemented a significant step in developing and implementing new technologies. Development of technologies has given the opportunity to solve a lot of complex tasks, which touch humanity, but also generate new tasks, solution of which is difficult. One of these tasks is a task of content analysis. Methods and systems of content analysis are used in various areas of human activity (politics, sociology, history, philology, computer science, journalism, medicine, etc.) [1–5]. These systems are quite successful and do not require large funds and time to get the desired result. At the same time using this type product allows you to increase the level of success at 60 %. Basic system of content analysis includes the following features: quick information updates, searching for information on this resourse, collect data about the customers and potential customers, creating and editing surveys, analysis of resource visitations. If to automate system for the using information system of content analysis, the workload can be reduced, the time for processing and obtaining the necessary information can be also reduced, productivity of work system increases which leads to a decrease in expenses of money and time to get the desired result. Issue of the theme has been caused by increasing demands of the users of these systems and by the following factors: rapid growth in demand for reliable information, the necessity of forming plurals operational information as well as use for automatic filtering unwanted information [1–5].

2. RECENT RESEARCH AND PUBLICATIONS ANALYSIS

Any tools of syntactic analysis consists of two parts: a knowledge base about a particular natural language and algorithm of syntactic analysis (a set of standard operators of text content processing on this knowledge) [1–5]. The source of grammatical knowledge is data from morphological analysis and various filled tables of concepts and linguistic units [2]. They are the result of the empirical processing of textual content in natural language of experts in order to highlight the basic laws for syntactic analysis. Table-based of linguistic units constitute configurations or valences sets (syntactic and semantic-syntactic dependencies) [2]. This is a lexical units list/dictionaries as instructions for every of them all possible links with other units of expression in natural language [2, 5]. In implementing of the syntactic analysis should be achieved full independence of rules of tables data transform from their contents. This change of this content does not require algorithm restructuring.

The vocabulary V consists of finite not empty set of lexical units [2]. The expression on V is a finite-length string of lexical units with V. An empty string does not contain lexical items and is denoted by Λ. The set of all lexical units over V is denoted as V'. The language over V is a subset V'. The language displayed through the set of all lexical units of language or through definition

criteria, which should satisfy lexical items that belong to the language [2]. Another is one important method to set the language through the use of generative grammar. The grammar consists of a lexical units set of various types and the rules or productions set of expression constructing. Grammar has a vocabulary *V*, which is the set of lexical units for language expressions building. Some of lexical units of vocabulary (terminal) can not be replaced by other lexical units.

3. RESEARCH RESULTS ANALYSIS

Development of Internet technologies and its services gave the humanity access to virtually unlimited quantity of information but as often happens in these cases – there is a problem in reliability and efficiency. It is for that, because the information was efficient and trustworthy, technology of content analysis are implemented. The use of these technologies allows you to receive the information as a result of her functioning, provides an opportunity to interference in the system operation to increase the level of that system, the activity of the information resource and for popularity increase among the users. World's leading producers of processing information resources work actively in this direction such as Google, AIIM, CM Professionals organization, EMC, IBM, Microsoft alfresco, Open Text, Oracle, SAP.

Content analysis is a high-quality and quantitative method information studies, which is characterized by objectivity of conclusions and austerity of procedure and is in the quantitive treatment of results further interpretation [1]. Content Management System, CMS is a software for web-sites organization or other information resources in the Internet or computer networks [1]. Today there are hundreds of available CMS and due to the functionality they can be used in different areas. Despite the wide range of tool and technical facilities available at CMS properties for all content management systems are similar. The Web content management system (WCMS) is a software complex which provides functions of creating, editing, control and organization Web pages. WCMS is often used for blogs creation, personal web pages and online-shops and are intended for users, who are not familiar with programming [1].

The following analysis stages are identified [5]:

1. *Program preparation for the document analysis.* At this stage so-called empirical theory research is being formulated. That means in analysis preparation hypotheses, which are in the context of problems are being systematised and those are discarded these that are not exposed to the data information.
2. *Selection of analysis sources.* It is necessary to identify sources, which include materials and information.

3. *Analysis of empirical models, the selection* (human communication, choice of materials for different periods of time, the types of messages, type of selection).
4. *Development of the specific analysis methods.*
5. *Platane research, testing of methods reliability*.
6. *Collection of primary empirical information*.
7. *Quantitative processing of collected data*.
8. *Interpretation of results, research conclusions*.

4. METHODS OF CONTENT ANALYSIS

Content analysis is based on journalism and mass communication and uses equipment in the following empirical areas: psychiatry, psychology, history, anthropology, education, philology and literature analysis, linguistics. Overall, the methods of content analysis in these areas so or otherwise is connected with the use in the sociological research framework. Content analysis is rapidly developing today, it is associated with development of information and Internet technologies, where this method has found wide application.

While creating an effective information system significant attention should be given to content management, because content analysis is used in the content management systems for automation of work and lowers expenses of time and money. There are several stages in the content management such as: content analysis, the content processing and submission of content. For effective system work firstly, analyze the content, then process the relevant results and make conclusions and then work on the that content. And on the final step is the presentation of content. The following methods of content analysis are: comments analysis, rating evaluation, analysis of statistics and history [5].

Comments analysis is used for adjustment analysis of the system user's moods who write in its comments reviews about system advantages and disadvantages or for adjusting operational and liquid information.

Analysis of statistics and history is used for observation and result processing, which are used to determine information efficiency and liquidity. For example, if one of the articles was visited by 100 users and another by 1, then you can certainly say that the information is more efficient in first article than in the second [5].

Rating assessment is used to determine the rate the same articles and is conducted by the polls, the evaluation users, etc. (Fig. 1).

Graphic content analysis is caused by the fact that in most cases graphic information is absorbed users faster than text. This can be seen, for example, in the motion diagrams, charts and diagrams (in the form information will be assimilated slower). When applying content analysis text use appropriate methods, and in this case, use two types of analysis: a quantitative and qualitative.

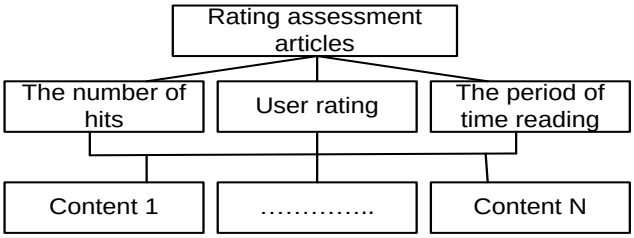

Fig. 1. Products rating assessment articles [source: own study]

A quantitative content analysis must include standardized procedures of counting allocated categories (table 1). For conclusions crucial role have quanti-tative values that are characterized by one or another category. Indicators may differ or, on the contrary, to be friends with an absolute value, which will be taken into consideration during interpretation processing results.

Tab. 1. Stages of quantitative content analysis

The stage	Stage characteristic
Allocation unit analysis	Conversion of linguistic unit in the form for processing.
Frequency units counting	Identify relationships between linguistic units.
Categorization	Determination of finite sets of redundant categories for obtaining quantitative data of their appearance.
Data mining	In-line detection content through multiple quantitative assessments of knowledge with further qualification of them as categories.
Interpretation of	Getting content and semantically- filled results using mathematical methods and semantic formers.

High-quality content-analysis aims to study text material deep and meaningful, as well as from the point of view of context in which the dedicated category (table 2). takes into account relationships of meaningful elements and their relative importance in the text structure. Depending on research tasks, high-quality content-analysis may be expanded with some quantitative content analysis elements [5].

Tab. 2. Stages of high-quality content-analysis

The stage	Stage characteristic
Wrapping text to blocks	Formation of integrated meaningful units for encoding and processing.
Reconstruction of flow content	The reconstruction of values, opinions, views and evidence each source text.
Conclusions formation	The generalizations through comparison of individual system values.

You can complicate the task, if put in as the precondition the allocation of substantial notional relation units of texts and then calculate the relative importance of the statements in comparison with other. In both cases the main part of calculations can be done with the use of computer programs [2]. The main stages of text information content-analysis:

1. *Determination of invistagated aggregate sources* or messages in accordance with the specified criteria, which corresponds to each message: the type of source (forum, e-mail, chat, online-newspaper, Internet); message types (article, electronic letter, banner, commentator); sides who take part in the communication process (the sender, the reciever, recipient); the messages size that they compare (the minimum amount of/length); frequency of messages apperance; distribution method; place of message distribution; time of the messages, etc.
2. *Forming a limited sample messages.*
3. *Identifying linguistic units of analysis*. There are strict requirements to a possible linguistic analysis unit: a big enough for interpretation importance; smallenough not to interpret many meanings; easily identified; the amount of units is large enough for the sample. In the case of the per unit analysis topics, take into account those rules: the theme does not go beyond the paragraph; a new topic is there when you change the theme, purpose, categories and persons, for which a topic is.
4. *Allocation of units calculation* which can coincide with meaningful units or have a specific character. In the first case, the analysis procedure is reduced to counting the frequency of the selected content items, in the other – a researcher from the analysed material and research purposes shows calculating units, which can be: physical text length; text area filled with informative units; number of lines (paragraphs, trademarks, text columns); the size and type of file, the amount of drawings with a content, plot, and so on. In some cases researchers use also other calculating elements. A fundamental value at this stage of content-analysis is a strict definition of its operators.
5. *Direct procedure for calculating* . In general terms, it is similar to standard methods of classification for selected groups of mathematical statistics and probability theory formulas. There are also special procedure about content-analysis counting.
6. *The received results interpretation to* a specific goals and tasks of research. At this stage characteristics of text are detected and evaluated and which allow to draw conclusions about what author wanted to emphasize/hide.

Content analysis – this is a high-quality and quantitative method to study the information, which is characterized by objectivity and strict procedures and is followed by the elaboration of quantative results interpretation. Because of significant step in developing and implementing new technologies mankind has

implemented in the last few decades, it created new tasks that are difficult to be solved. One of these tasks is to provide users with reliable and updated information. *Efficiency* – the information property, which means that gathering and processing of information follows the dynamics ofchanging the situation. *Reliability* – the property of information to be properly understood, the probability of no errors, unquestionable loyalty of the following information which takes a person. Thus, the reliability is not the same thing as the truth is. Details can be reliable or unreliable for those who perceive them, but not at all [5]. Content is the basis for online newspapers, where the user is looking for all the information he needs. That is why we need the information to be operational and available for the user. For example, if the text will have a large number of definitions and terms or formulas, it will be hard -readable and user will be uninterested in reading it. On the other hand, if the text will contain a large number of unnecessary information user will spend more time on reading. There is a need to solve actual scientific problems of automatic processing of online newspapers content to receive operational and available for the user information with information noise liquidation and less time needed on the formation process of the final data search result.

5. TEST REVIEW

Rating of the clauses is done with the help of 3 criteria. The amount of referencing, reading time, and custom views are taken into account. These criteria compose rating of the clauses (Fig. 2).

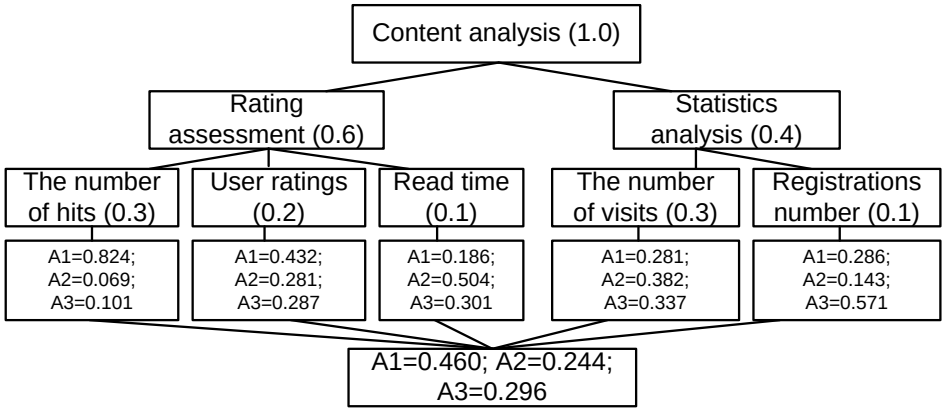

Fig. 2. Hierarchy of the choices for content analysis [source: own study]

Fig. 2 shows hierarchy of choices for content analysis. It consists of 3 levels: aim, criteria of 2 layers and alternatives. Congruous numbers of the fig 3 approve higher-priority elements of the hierarchy that are featured up with the help of MAI based on pairwise data comparisons on each layer related to elements of higher layer. The priorities of alternatives are calculated at the final stage by linear local priorities of all elements. Well-known higher layer criteria priorities pay the greatest attention to *Rating of the clauses* as it objectively reflects the quality of work. A statistic analysis criterion is less important because it doesn't reflect completely the quality of work. In the lower layer criteria attention is paid to *Amount of referencing* and visits that reflect users interest in a particular material. The next important criterion is a *Custom view* that shows the users' estimation for a specific material. The least vital criteria are *Reading time* and *Amount of signs up*. All the choices are figured separately due to each criteria. Due ot accounts it appears is the best for chosen criteria. An important factor for the functioning of the system is the availability of input data. Article is a journalistic or scientific work, which thoroughly and deeply, with scientific precision treats, interprets and summarizes the theoretical problem of social reality. Adding, editing and deleting of the articles is provided by an administrator. The source of information for articles are encyclopedias, periodicals, books, other articles, etc.. Another factor is the attendance of users. Users – are individuals who use information resource searching articles, reading them and voting? No user aspect impossible test quality content. Without user aspect, test content quality is impossible. There are two players in our system: *User* and *System manager*. 1st player is aimed for user modeling system as an individual. Player signs in / authorizes in the system, votes for the revised articles, reviews and searches for the articles. *System Manager* – is a person who analyzes and classifies information, adds edits and deletes articles, as well as performs other actions. He manages our system. Administration includes removal of incorrect articles and adding of new ones. *Sign in* option is used for registration of users in the system. *Authorization* option is used for user authentication. Usage of Authorization and *sign in* options expand the usage *statistic analysis*.

The object of *statistic analysis* is used for statistical estimation. Information is sent from the database in order to estimation. After the evaluation results are sent to the administrator object to this object could draw conclusions that would be needed to add new items or remove unwanted. After this procedure results are sent to the *system manager* so that he could conclude that what would be needed to add new items or remove unnecessary. System manager is the only person who can add or remove articles. After adding or deleting items the information is sent to display the latest and popular articles. Also, he checks for new articles, if the data was not sent. The result are new articles transmitted for publication. This object takes the output of new articles. This object performs publication of new items. On constructing cooperation graphs was held the determination of system objects, interaction analysis. Due to the graph there are 15 cocurrent flows.

Each flow put across items and informatiom from one object to another. Figure 3 shows working graph. It lets implement features of procedural synchro programming. Here you can see the system status after the user authentication. Fig. 3. shows that after the authorization user goes to browsing of the articles and the system shows him all the available items.

After the *browsing* the system shows user popular and latest articles. The user choose a specific item and the *choice of article* option helps to do that. After that the user goes to *Reading* option. This main option because here the user read the article and receive the information about the status of it. After the *reading* option the system goes into the following two statuses. These are *publication* status and *rating of the clauses*, that has 3 sub states. This is the *escape of amount of referencing* status. Here the information on the *amount of referencing* to this article is changed. The next step is is the *reading time change* status, where the time of reading the article is changed. The next one is *custom views* status where the the user rates for a particular article. These 3 statuses are used for the rating of the clauses. Afterthat the system goes to the *article shut-off*. This status is characterrized by the persistence of data and results. The system goes into the final state. Fig. 4 presents content analysis process.

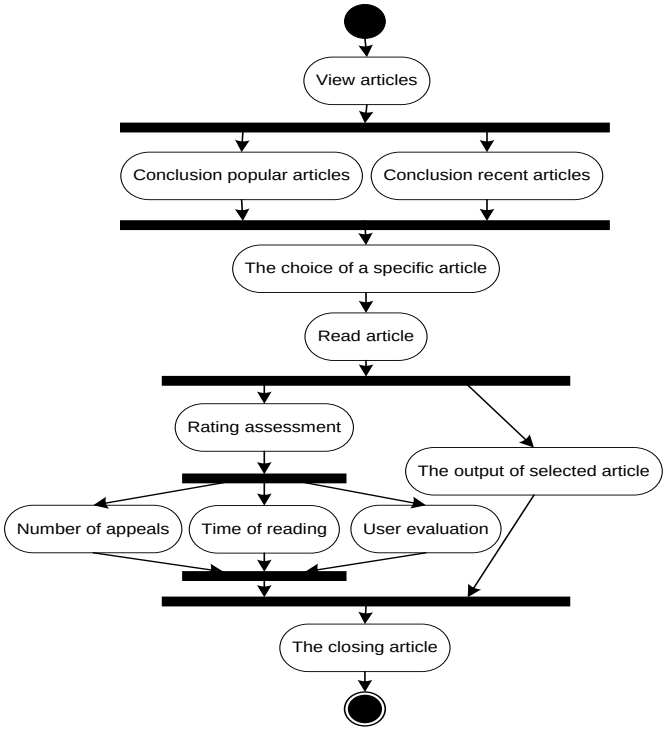

Fig. 3. Working graph [source: own study]

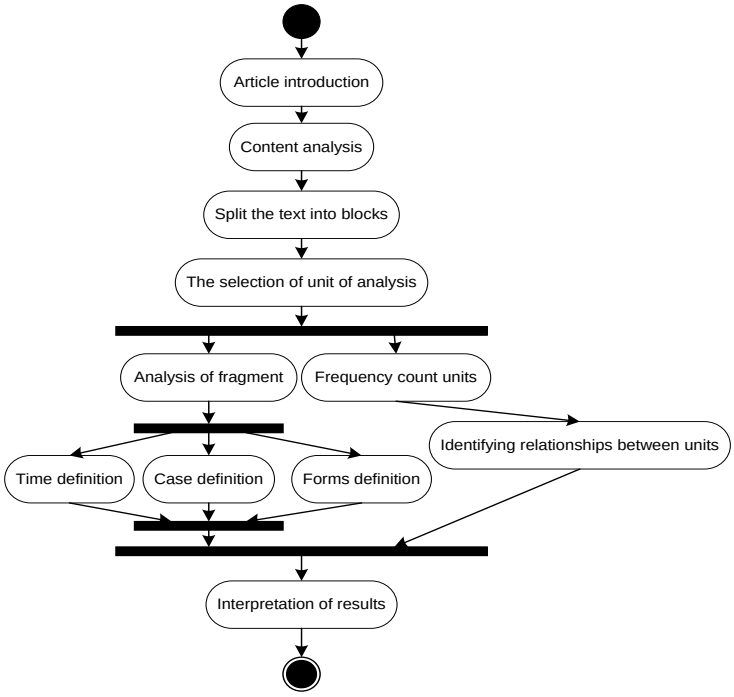

Fig. 4. Working graph of the content analysis [source: own study]

the publication of the article system enter *content analysis* status, after it goes to the next stage of *dividing the text into bodies*. Here the text is divided into items and the unit of analysis is identified. Farther fragment analysis is performed, counting of rate units, and identifying of relationships between linguistic units. After each option is held, the interpretation of the results of the content analysis is performed. Fig. 5 shows the working graph of the process of statistical analysis. Statistical analysis function after the system capture the data. One of the main options is *calculation of the amount of system users*. In addition. Amount of authentications and signs up are calculated. Then system calculates reading time of the articles and the average reading time. After all options are done, the treatment of statistical analysis is held.

The text realizes structural submitted activities through provides subject, object, process, purpose, means and results that appear in content, structural, functional and communicative criteria and parameters. The units of internal organization of the text structure are alphabet, vocabulary (paradigmatics), grammar (syntagmatic) paradigm, paradigmatic relations, syntagmatic relation, identification rules, expressions, unity between phrasal, fragments and blocks. On the compositional level are isolated sentences, paragraphs, sections, chapters, under the chapter, page etc. that (except the sentence) indirectly related to the internal structure because are not considered.

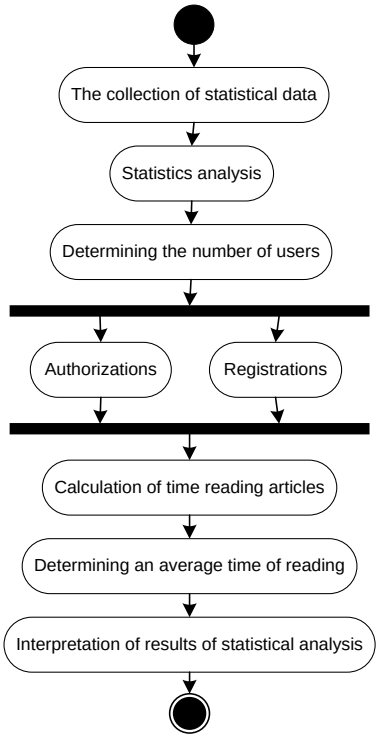

Fig. 5. Working graph of the statistical analysis [source: own study]

Content analysis for compliance thematic requests to $C_{Ct} = Categorization\left(KeyWords(C,U_K),U_{Ct}\right)$, where $KeyWords(C,U_K)$ is the keywords identify operator, *Categorization* is content categorize operator according to the keywords identified, U_K is keywords identify conditions set, U_{Ct} is categorization conditions set, C_{Ct} is rubrics relevant content set. Digest set C_D formed by such dependence as $C_D = BuDigest\left(C_{Ct},U_D\right)$, where *BuDigest* is digests forming operator, U_D is conditions set for the digests formation, C_{Ct} is rubrics relevant content set. With the help of a database (database for terms/morphemes and structural parts of speech) and defined rules of text analysis searching terms. Parsers operate in two stages: lexemes content identifying and a parsing tree creates (alg. 1).

Algorithm 1. Parser of textual commercial content.
Stage 1. Content C lexemes identification from set *V*.
Step 1. Terms string definition over *V* as a sentence.
Step 2. Nouns groups identification with bases dictionary V'.
Step 3. Verbs groups identification with bases dictionary V'.

Stage 2. Creating of a parsing tree from left to right. Each step of output is the deployment as one symbols of the previous string or it to others replacing, while other symbols are rewritten without change. It is obtained the component tree, or syntactic structure, if process of deployment, replacement or re-writing characters (*fathers*) connect lines directly with symbols that come out as a result of the deployment, replacement or re-writing (*descendants*).
Step 1. Nouns group deployment. Verbs group deployment.
Step 2. The implementation of syntactic categories of word forms.
Stage 3. The keywords set determination.
Step 1. The *Noun* terms determination (nouns, nouns word combinations or adjective with the noun) among the words set of commercial textual content.
Step 2. The *Unicity* uniqueness calculation for *Noun* terms.
Step 3. The *NumbSymb* value calculation (the characters number with no spaces) for *Noun* terms at *Unicity* ≥ 80.
Step 4. The *UseFrequency* value calculation (frequency of keywords using). The *UseFrequency* frequency for terms with *NumbSymb* ≤ 2000 is within the limits (6;8]%. Frequency for terms with *NumbSymb* ≥ 3000 is within the limits [2;4) %. Frequency for terms with $2000 >$ *NumbSymb* $<$ *3000* is within the limits [4;6]%.
Step 5. The values calculation of *BUseFrequency* (the frequency of keywords using at the beginning in the text), *IUseFrequency* (the frequency of keywords using in the middle of the text), *EUseFrequency* (the frequency of keywords using at the end in the text).
Step 6. Comparison of values *BUseFrequency*, *IUseFrequency* and *EUseFrequency* for priorities definition. Keywords with higher values *BUseFrequency* have higher priority than keywords with a higher value *IUseFrequency*.
Step 7. Keywords sorting according to their priorities.
Stage 4. The database filling of search image for content, i.e. attributes of *KeyWords* (keywords), *Unicity* (the keywords uniqueness ≥ 80), *Noun* (term), *NumbSymb* (the number of characters without spaces), *UseFrequency* (frequency of keywords using), *BUseFrequency* (frequency of keywords using at the beginning in the text), *IUseFrequency* (the frequency of keywords using in the middle of text), *EUseFrequency* (frequency of keywords using at the end in the text).

Based on the rules of generative grammar perform term correction under the rules of its use in context. The sentence define action limits of punctuation marks and links. The text semantics is due communicative task of information transfer. The textual structure is determined by internal organization of textual units and their relationship regularities. While parsing the text drawn in a data structure (eg. tree which corresponds the syntactic structure of the input sequence, and is best suited for further processing). After analysis textual block and term is synthesized a new term as a keyword of content topics by using base of terms and their morphemes. Next is synthesized terms for a new keyword formation by using base of structural parts of speech. The principle of keywords detection in content (terms) is based on Zipf's law. It is reduced to words choice with an average frequency of occurrence. The most used words are ignored through the stop-dictionaries.

And the rare words do not include text. According a meaningful analysis of the content corresponds to the process grammatical data extraction from the word by grapheme analysis and the results correction of morphological analysis through the grammatical context analysis of linguistic units (Alg. 2).

Algorithm 2. The textual commercial content categorization

Stage 1. The division of commercial content on the blocks.

Step 1. Block presentation to the input of tree construction with commercial content blocks.

Step 2. New block creation in the blocks table.

Step 3. The newline characters accumulation.

Step 4. Checking on point availability before a newline character. If there is, then go to step 5. If do not, then begin the sequence saving in the table, the new block parsing and transition to step 3.

Step 5. Checking on availability of the end in the text. If the end of the text is, then go to step 6. If do not, then start the accumulated sequence saved in the table, the new block parsing and transition to step 2.

Step 6. Blocks tree getting on the output as a table.

Stage 2. The block division on sentence with structure preservation.

Step 1. The input is a table of blocks. The sentences table creation with link for field *ID_section* of *n*-to-1 type of blocks table.

Step 2. A new sentence creation in sentences table.

Step 3. The symbols accumulation to point, semicolon or newline character.

Step 4. Checking on availability of cuts. If the cut exists, then go to step 5. If do not, then start the sequence saving in the table, a new sentence parsing and transition to step 2.

Step 5. Checking on availability of the end in the text block. If the end of the text exists, then go to step 6. If do not, then begin a sequence saving in the table, new sentences parsing and transition to step 2.

Step 6. The sentences tree getting on the output as a table.

Step 7. Checking for the end of the text. If the end of the text exists, then go to step 8. If do not, then start the new block parsing and transition to step 1.

Step 8. The sentences tree getting on the output in the form of tables.

Stage 3. The sentences division for lexemes with indication of belonging to sentences.

Step 1. The lexemes table formation based on the sentences table with fields of *ID_lexemes* (unique identifier), *ID_sentence* (number equal to the code of the sentence with lexeme), *Lexemes_number* (number equal to the lexemes number in the sentence), *Text* (lexeme text).

Step 2. A sentence presentation to the input from the sentences table for parsing on lexemes.

Step 3. A new lexeme creation in the lexemes table.

Step 4. The symbols accumulation to point, spaces or end of a sentence and the seving in the lexemes table.

Step 5. Checking for the end of the sentence. If yes, then go to step 6. If not then accumulated sequence saving in the table, new lexeme parsing and transition to step 3.
Step 6. Conducting parsing based on data obtained on the output (Alg. 1).
Step 7. Conducting morphological analysis based on data obtained at the output.
Stage 4. The topics determination for the commercial content.
Step 1. The hierarchical structure construction of properties for each lexical unit with text that includes grammatical and semantic information.
Step 2. The lexicon formation with a hierarchical organization of properties types, where each type-descendant inherits and overrides the ancestor properties.
Step 3. Unification as a basic mechanism for constructing syntactic structures.
Step 4. The *KeyWords* set identification for the commercial content (Alh.1).
Step 5. The values set definition as *TKeyWords* (thematic keywords in the *KeyWords* set for commercial content), *Topic* (the theme for commercial content) and *Category* (commercial content category).
Step 6. The values set definition as *FKeyWords* (the frequency of keywords using in the textual commercial content) and *QuantitaveryKey QuantitaveryTKey* (frequency of thematic keywords using in the textual commercial content).
Step 7. The values set definition as *Comparison* (the keyword using comparison with various topics). The values set calculation as *CofKeyWords* (coefficient of thematic content keywords), *Static* (coefficient of the statistical terms importance), *Addterm* (coefficient of the additional terms availability). Comparison of the content keywords set with the key concepts with topics. If there is a match, then go to step 9. If not, then go to step 8.
Step 8. A new category formation with a set of key concepts of the analyzed content.
Step 9. Assignment designated section of the analyzed commercial content.
Step 10. The values set calculation as *Location* (the coefficient of content location in the thematic section).
Stage 4. Filling the search images base for attributes as *Topic* (the theme of content), *Category* (content category), *Location* (the coefficient of content location in the thematic section), *CofKeyWords* (the coefficient of thematic keyword of textual content), *Static* (coefficient of statistical significance for terms), *Addterm* (the coefficient of the additional terms availability), *TKeyWords* (the thematic keywords), *FKeyWords* (the frequency of using keywords), *Comparison* (the keywords using comparison of the different themes), *QuantitaveryTKey* (frequency of thematic keywords using in the text of commercial content).

The process of categorization through automatic indexing component in commercial content is divided into sequential blocks: a morphological analysis, a syntactic analysis, a semantic and a syntactic analysis of the linguistic structures and meaningful writing variation in the textual content.

6. CONCLUSIONS

Content as articles is the base of online newspaper due to which the user is looking for the necessary information. Thanks to content analysis, the system owner can determine the reliability and efficiency of the information contained in the articles of online newspaper. With the help of this option you can determine the popularity of the newspaper and do some actions in order to augmenter number of users. General recommendations in architectural design of content analysis systems are developed which, however, differ from existing by more detailed stages and availability of information processing module resources, allowing an efficient and easy to handle information resources at system developer's stage.

In the thesis known methods and approaches to solving the problem of automatic processing of textual content and selected advantages and disadvantages of existing approaches and results in the field of the syntactic aspects of computational linguistics is considered.

In this paper the general conceptual framework of modeling inflectional processes of the text arrays creation is formed. The syntactic model and inflectional classification of lexical structure of sentences is proposed. Also in the theses lexicographical rules of syntactic type for automated processing of these sentences is developed.

The proposed technique allows to achieve the highest parameters of reliability in comparison with known analogues. They also demonstrate the high efficiency of applied applications in the linguistics construction of new information technologies and research inflectional effects in natural language. The work has practical value, since the proposed models and rules can effectively organize the process of creating a lexicographical systems of textual content processing of syntactic type.

The commercial content formation model implement in the form of content-monitoring complexes to content collection from data various sources and provide a content database according to the users information needs. As a result, content harvesting and primary processing its lead to a single format, classified according to the categories and he is credited tags with keywords.

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NUMERICAL ANALYSIS OF THE STRESS AND DISPLACEMENT LEVEL CAUSED BY AXIAL LOAD P=15000 N IN A CAR SCISSOR JACK BD-02B2

Abstract

The paper presents a numerical analysis of the stress levels occurring in the scissor jack BD-02B2. Model of scissor jack was prepared in an environment Catia V5R20. A simplified geometry for numerical calculation imported into the program Abaqus 6.10, in which the analysis was performed. FEM analysis was performed for the case when the scissor jack was at maximum lift height. Level occurring stress were compared with respect to the yield strength and tensile strength. The study also shows the level of displacements occurring under maximum load of the system. The results of numerical calculations have provided the necessary information concerning the degree of effort of mechanism. With the FEM analysis it was possible to determine the critical zones in the scissor jack.

1. INTRODUCTION

The scissor jacks are simple and basic mechanisms to operating at the car suspension. Thanks to them, it is possible to both independent replacement of worn suspension components, and repair of faults occurring in the suspension.

Cutting-edge research techniques strength of materials, provide analysis of mechanisms already working on the way their design. Finite element method allows to conduct numerical analysis designed components/mechanisms, already prior to them production. This method is beneficial to improve the properties of construction elements and also to reduce the applied load, which adversely affect long-term and correct operation of the system.

The paper analyzes the numerical level of displacements and stresses that occur in critical places the scissor jack.

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The aim of the numerical calculations was to determine the stress distribution in the model, for the vertical force P = 15000 N, which is the maximum load that can move the scissor jack. The resulting reduced stress distributions, consistent with the endurance hypothesis HMH (Huber-Mises-Hencky), were compared with the material properties of the jack. Numerical calculations were carried out to determine the strength of the mechanism.

In the literature reference [9, 10] the author deals with an introduction to the interface and a description of the program Abaqus and basic approach to design parts. The author also takes into account the approach to linear statics and to generate an appropriate mesh type to designed objects.

In the papers [4, 5] the authors deal with the presentation of a general approach to the problem of testing the strength of materials, through numerical modeling in Abaqus environment. The authors explain the idea of the work structure design based on the study of stability.

Through publications [11, 12, 13] it is possible to understand the Catia environment and the practical use of knowledge on how to design and generate simulation kinematic structure.

In references [2, 7, 8] the authors dealt with issues related to research vehicle lifts, which is the necessary basis for the development of the issues described in the present article. The publication [3] the author presents the problem of compression of thin-walled profiles are susceptible to loss of stability, which is close to a submitted article.

In [6] the authors take up the subject to generate 3D objects from 2D drawings prepared in order to increase the potential of construction work and to improve the design of machinery.

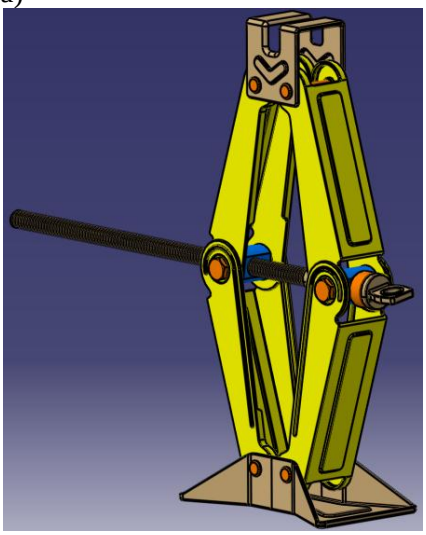
2. MATERIALS AND METHODS

The subject of research was scissor jack BD-02B2. The mechanism is dedicated to passenger vehicles with an unladen weight not exceeding 1500 kg.

In fact the lifting at the same time is one of the sides of car, so load is approximately only half the weight of the vehicle. Initial figure of model was designed in Catia V5R20 environment in which the simulation was also conducted kinematic, showing the correct operation of the jack and range of mobility. Numerical analysis was made using Abaqus 6.10. The mechanism was analyzed numerically, at maximum lift height of 345 mm.

The jack is designed on the basis of measurements taken on a real object. The spatial model designed in CATIA, and the actual form of the scissor jack, shown in Figure 1.

a)



b)

Fig. 1. Scissor jack: a) mechanism made in Catia v5,
b) the real form of mechanism [source: own research]

The object of research was characterized by a uniform material properties. The mechanism is designed in accordance with the characteristics of the structural steel C45.

The material of which made the scissor jack with its basic features of the material are shown in Table 1.

Tab. 1. Characteristics of the steel [1]

Material: Steel C45	
Young's Modulus [Mpa]	210000
Poisson's Ratio	0.3
Yield Strength [Mpa]	360
Tensile Strength [Mpa]	610

Numerical calculations were based solely on static calculations, so the mass of the mechanism were not taken into account. Any interactions prevailing in the system, were related only with contact on the tangential and normal direction with taking into account the coefficient of friction of 0.15.

The work of mechanism is performed by applying a vertical load to the crown, which acting in a downward direction in accordance with the X axis, and the mechanism undergoes axial compression.

Boundary conditions were associated with total restraint of base of the scissor jack, as well as the application of force concentrated at the reference point, which is coupled with the upper planes of the crown of scissor jack, through use coupling constraint in the interaction module, as shown in Figure 2.

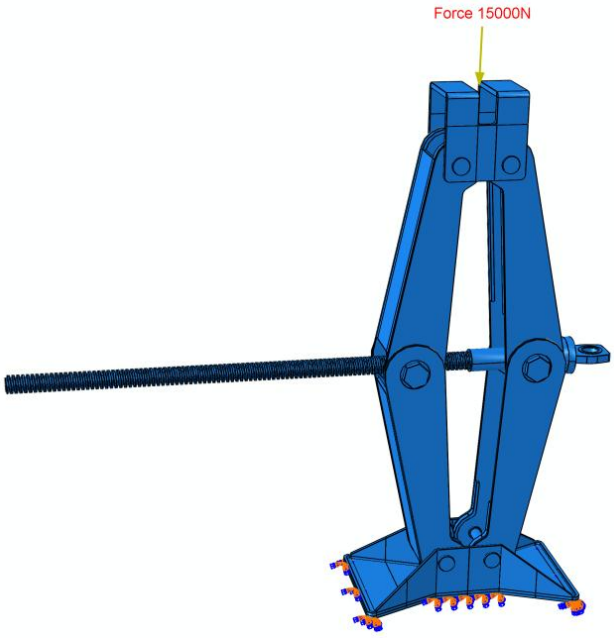


Fig. 2. Boundary conditions [source: own research]

Proper conduct numerical simulation was made possible by assigning appropriate FEM mesh model. For this aim was used a tetrahedral elements called C3D4 and eight-node elements C3D8R with a reduced number of points of integration. Reduced integration technique removes the problem of irregular form of the deformation of objects. Eliminated are the components of higher order polynomials, which is beneficial to improve the results of numerical analysis performed [14]. Finite element mesh was composed of more than 76000 items.

The bolt, nut and screw guide element, are part which have a tetragonal structure of mesh with a greater density, while all other components are assigned only type hexagonal type of mesh by using the appropriate partitioning methods. Visualization of the generated mesh is shown in Figure 3.

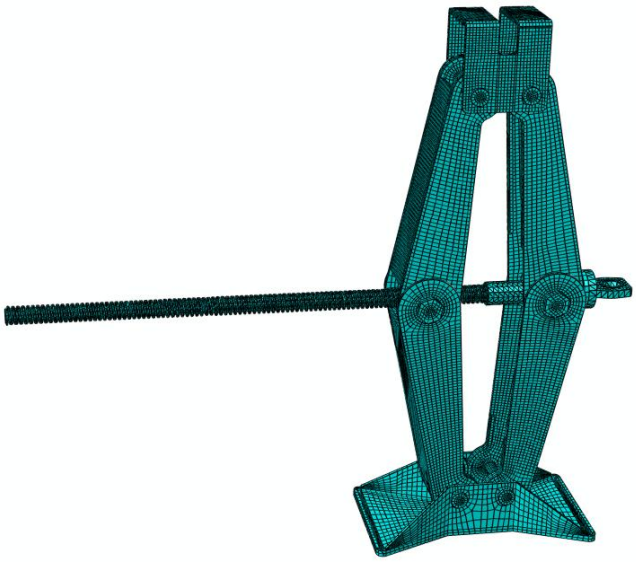


Fig. 3. The numerical model [source: own research]

3. RESULTS

FEM analysis made it possible to obtain a reduced stress distribution H-M-H in the investigated mechanism. The most loaded part of the mechanism is screw guide element, in which the stress level was about 504 MPa. The remainder of the mechanism to give the symmetric nature of stress distribution.

Analysis showed a lack of exceed of strength border components, so the system will not be exposed to permanent damage. The level of stresses and displacements shown in Figure 4.

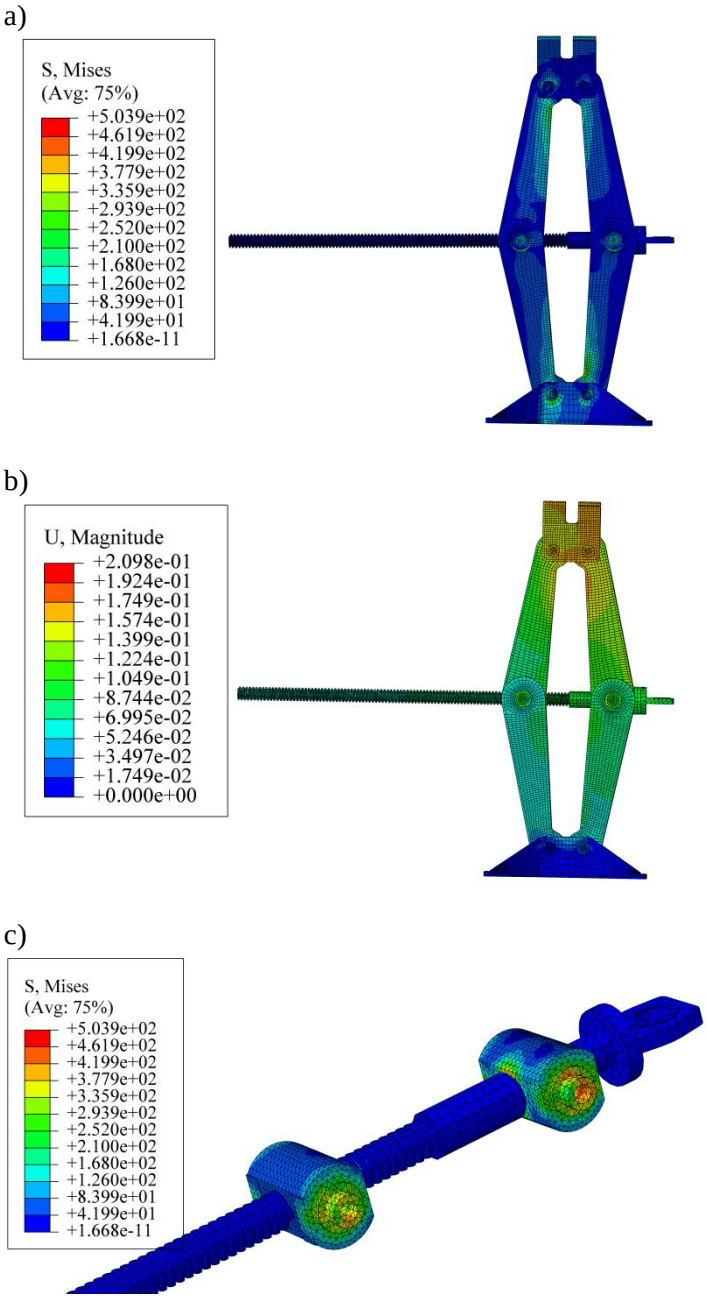


Fig. 4. The results of numerical analysis: a) stress distribution in scissor jack, b) displacements occurring levels, c) maximum stress level [source: own research]

Only the screw guide element and nut have a stress exceeding the yield strength. In these parts there was a maximum of stress concentration occurred at the connection of these elements with arms of the scissor jack as shown in Figure 4c.

The other components are not exposed to any loss of ductility. In fact, the emphasis generated by the weight of the vehicle, would be much lower, because is raised only a part of the vehicle, so the level of stress would have much less.

The paper presents the results of the analysis only with the maximum allowable load equal 15000 N and at maximum lift height equal to 345 mm. Any numerical calculation was carried out taking into account the issues of non-linear geometrically using the Newton-Raphson method.

4. CONCLUSIONS

On the basis of the numerical analysis can draw the following conclusions:

- analysis of the stress distribution allows to determine the sensitive zones of mechanisms, which have the greatest concentration of stress in the individual components and structural elements;
- FEM analysis results showed no cross the border strength of the material, confirming the correctness of the designed system;
- numerical research methods make it possible to further optimize the components in terms of reducing the concentration of stresses and strains.

In this study, showed no exceeding the maximum permissible strength of the material from which made the scissor jack. Only elements connecting the arms of scissor jack showed stress exceeding the yield strength at a given maximum emphasis.

Application of FEM to analyze the stress distribution in the mechanisms subjected to loads, allows to take stress and strain state of this type of construction, which nowadays is indispensable in engineering applications. Numerical analyzes are now an essential tool in the market when tested the strength of materials, so it is possible to prevent an unnecessary manufacturing errors.

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DESIGNING OF STRUCTURAL ONTOLOGICAL DATA SYSTEMS MODEL FOR MASH-UP INTEGRATION PROCESS

Abstract

This paper describes the construction of structural ontological data systems model in the process of data integration. The usage of ontologies in the context of improving the process of dynamic semantic data integration has been characterized. The algorithm of constructing of structural ontological data integrated systems model has been designed. This algorithm is based on the rules of using and application of ontological modeling. The algorithm as a sequence of five steps describing tasks for each of them has been presented.

1. INTRODUCTION

Today, in the active development of new and improved information technology era increases the need also of improving the technology and work with web-systems. Solution of this problem is the development of integration systems that use of Mash-Up technology. Mash-Up is an approach to application development that allows users to combine data from multiple sources into one integrated tool [1].

Mash-Up system work technology is to dynamically integrate data from different web-systems data sources. In order to integrate the some application to Mash-Up system, it is necessary first of all to know the structure of the application or system that is integrated. And knowing the structure of each input web-system we are faced with the task of creating of the common structural model of systems that are integrated.

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2. THE PROBLEM FORMULATION

Data sources can have different properties, essential for the choice of methods Mash-Up Data Integration – they can support the presentation of data in terms of a data model, can be static or dynamic, etc. Many sources of data integration can be homogeneous or heterogeneous with regard to the characteristics that respective of used integration level [1].

To ensure efficient search, web application must clearly understand the semantics of documents submitted in web. In this regard, one can observe the rapid growth and development of technologies Semantic Web, which is currently available. The W3C developed a concept based on the active use of metadata markup language XML, RDF language (Resource Definition Framework) and ontological approach. All the proposed tools allow data sharing and their reuse.

Existing methodologies and tools for building software systems are focused on well-structured problem with sufficiently formalized of subject areas and permanent local of knowledge source. So, the actual problem today is to develop mechanisms that can take into account the peculiarities of different input information systems, the knowledge specific required for the subject area forming and the distributed nature of their origin. In turn, the domain models must have of the internal mechanisms of domain model dynamic adaptation for the whole system lifetime.

Hence, the aim of this work are:

- to investigate the using of ontologies and ontological modeling principles in the context of the process improving of dynamic data semantic integration;
- to develop an algorithm of constructing of structural ontological data integrated systems model.

3. THE BASIC MATERIAL PRESENTATION

3.1. The usage of ontologies for data integration

One promising avenue of research is the use of ontologies for data integration task solving [3].

In [11] is the definition of information component ontological specification as a set of definitions and concepts and also rules (axioms), relating to definitions and concepts of the domain (application context).

The term “ontology” is now used in two contexts:

- philosophically: ontology is a system of categories used to consider taking into account the specific vision of the world [12];

– In the context of information systems, ontologies is formal description of the conventional understanding of some domain, through which people can communicate with a computer systems [12]. Software components use ontologies to interact with each other as part of an integrated system of heterogeneous resources. It is anticipated that ontology is independent of the domain representation language.

Data integration methods based on ontology has shown in practice to be effective, but building the ontology requires of expert knowledge in studies subject area and can take a significant amount of time [2, 3]. Therefore, an important task is to develop methods and algorithms for automating the process of building the ontology.

Ontological system built on the basis the following principles [3]:

– formalization, that is the description of objective reality elements using a single, strictly defined samples (terms, models, etc.);
– the using of a limited number of basic terms (entities) on which all other concepts construct;
– internal completeness;
– logical consistency.

Recently, more and more prevalent becomes use of ontologies for modeling of automated information systems domains [4, 5]. The most commonly such approach is used for intelligent systems [6], especially systems designed for the operation in the Internet. This is due to the fact that ontological model allows us to develop a metadata model, which greatly improves the system use of a wide range of users in terms of interaction organization, especially if that is dynamic Mashup system.

In general, formal presentation of data ontology is the following [8]:

$$O = \langle X, R, F \rangle \tag{1}$$

where: X – finite set of domain concepts with their properties (attributes),
R – finite set of relations (relationships, correlations) between concepts,
F – finite set of interpretation functions (restrictions, axioms) [8].

In accordance with the requirements of IDEF5 standard [9], the concepts are divided into classes and value classes. Relations between concepts are divided into classification relations (between classes and subclasses) and structural relations (links that describe the interaction of classes).

The authors of [10] define ontology as a cortege:

$$O = \langle C, I, R, T, V, \leq, \perp, \in, = \rangle \tag{2}$$

where: C – set of classes,
I – set of instances of classes,
R – set of relations,
T – set of data types,
V – set values (set C, I, R, T, V pairwise disjoint),
$\leq$ – relation to $(C \times C) \cup (R \times R) \cup (T \times T)$, called specialization,
$\perp$ – relation to $(C \times C) \cup (R \times R) \cup (T \times T)$, called exception,
$\in$ – relation to $(I \times C) \cup (V \times T)$, called realization (instantiate),
$=$ – relation to $I \times P \times \cup (I \cup V)$, called assignment.

Semantics of languages ontology are usually presented through models theory. In particular, it defines the interpretation function that maps each element of ontology at some particular set, called the interpretation domain.

The ontology interpretation (2) there are the couple $\langle I, D \rangle$, where D is the region of interpretation, and I – interpretation function such that:

$$\begin{gathered} \forall c \in C, I(C) \subseteq D \\ \forall r \in R, I(r) \subseteq D \times (D \cup V) \\ \forall i \in I, I(i) \subseteq D \\ \forall t \in T, I(t) \subseteq V \\ \forall v \in V, I(v) \subseteq V \end{gathered} \tag{3}$$

About contention expressed of the ontological language, saying that it is satisfied of interpretation, if interpretation agrees with this contention.

The interpretation for ontology (2) is model $m = \langle I, D \rangle$, satisfying all contentions ontology o: $\forall \sigma \in o, m \models \sigma$.

3.2. Designing of general structural ontological data systems model, as part of incoming information resources structure and content determining process

In [7] is described how to determine of the structure and content of incoming information resources to solve the problem of dynamic semantic data integration. This process, according to [7], consists of five steps:

1. Determining of the input data presentation form: structured data, semi-structured data or unstructured data.
2. Classification of input data according to the subject area with allocation and preservation of data semantics.
3. Allocation in the input information resource of the attributes set, that reflecting its main characteristics and aspects of that domain.
4. Setting clear boundaries and meet the basic restrictions related to the web-information input stream.
5. Formation of the input information resource model of general structure defined subject area.

Considering the problem which you need to solve in the second step when is the automatic information classification, we propose in first of the structure ontology automatically modeling of each of integrated applications. The system must perform this work after the sources selecting for Mashup. Due to the construction of the complete structural information meta-model that will combine all systems elements with their relationship we can thus carry out the procedure of input data classification, while retaining the semantics of the data. Thus, at this step, you need to solve the following problem:

1. Integrated system structural ontology. Retrieving information about the structure of each of integrated information systems in an ontological format.
2. The total structural ontology of all integrated systems. Combining the obtained structure ontologies in a general structural ontological information model.
3. The global integrated systems meta-model.

But only solving the first two problems can be fully automated, using the appropriate standard tools and technologies. But the implementation of the third task requires the participation of experts in web-systems integrating field and specialists of knowledge presentation in the form of ontologies. Therefore, an important task is to develop algorithms of designing of global meta-model of combined dynamic data set that has a general structure and unique content. According to solve this problem, we propose an algorithm of constructing of structural ontological data integrated systems model.

3.3. The algorithm of constructing of structural ontological data integrated systems model

In any web-system all information is stored in databases. There are relational databases. In relational databases information about the structure and relationships between the structural elements stored in data schemes, and these schemes must be obtained in the work of the algorithm. However, the scheme analysis can only to provide structural interoperability. To achieve semantic interoperability when data scheme extraction should also take into account of the semantic assignment of these elements, so we need to use domain ontology. This ontology for the resulting model will add connection between concepts in the subject area. Thus, each ontological model obtained from a system database will a subset of the domain ontology.

When building any algorithm, priority is to determine the input and output data. The input data for the algorithm constructing a structural ontological data integrated systems model are: structure schemas of integrated systems database and domain ontology.

Let O_G – general ontology schemas of all data of integrated systems:

$$O_G = \{O_i, O_D\} \tag{4}$$

where: O_i – ontology of structure of system,

O_D – domain ontology.

Domain ontology usually developed previously, with experts from the domain and specialist of knowledge presentation in the ontological format. The process of creating a model takes a long time, but it is necessary only at the initial stage of integration. With further addition of new systems operating in this area, the very ontology does not require additional changes.

For describing the work of algorithm of constructing of structural ontological data integrated systems model we introduce some notation concepts.

Let we have any system database schema: S.

$$S = \{T_1, ..., T_m\} \tag{5}$$

where: $T_1, ..., T_m$ – the system *S* database schema tables.

$$T_i = \{A_1, ..., A_k\} \qquad i = \overline{1, n} \tag{6}$$

where: $A_1, ..., A_k$ – database schema tables attributes.

$$R = \{R_1, ..., R_z\} \qquad i = \overline{1,n} \tag{7}$$

where: $R_1, ..., R_z$ – relationships between ontology concepts.

Algorithm of constructing of structural ontological data integrated systems model contains 6 steps:

1. Database structure presentation in RDF format (the consistent mapping *S* schema in RDF format).

$$T_i \to T(RDF)_i,\ A_j \to A(RDF)_j,\quad i = \overline{1,n},\ j = \overline{1,k}, \tag{8}$$

where: $T(RDF)_i$ – ontology concepts described by RDF,
$A(RDF)_j$ – ontology concepts properties.

2. Adding of semantic properties and ontology creating. This step is realized through the using of the procedure of identify the common features of database elements and adding of the links between them.
3. Adding the upper level ontology and domain ontology. We realize this step through OWL language, using the command owl: import. Due to the transitivity rule in RDF, additional ontologies expand the domains and add the new concepts and properties.
4. Checking of the created ontology. This step is realized by checking implementation and analysis as far as extracted ontology is "connectedness". That is, we check whether lack of nowhere semantic relations. If so, go to the fifth step – if not, go to the sixth step.
5. Editing of the extracted ontology using ontology editor (Protégé) and adding links between concepts. Then return to step 4.
6. Storing of the resulted common ontology structure in a file or metadata repository in RDF format.

The flowchart of the algorithm we are showing in Figure 1.

Let us consider the steps of the presented algorithm (fig. 1). In the first step is mapping of data scheme structural elements in RDF format. The main elements of the relational database to be displayed are tables and their attributes. Attributes (fields tables), also have of the important structural information, such as name and type of attribute. This information is obtained using SQL and foreign key mechanism.

When there is data schema analyzing, tables names are automatically the names of new classes, and tables fields names are properties associated with their class. Also, you can separately record of the information about a database

tables class RDF matching in a separate XML document or other key-value storage type. Since, according to the proposed method, each extracted proto-entity must have an identifier, the table being analyzed must have a primary key. In it absence, it is necessary to create during table processing. So, the unique proto-entity ID will compose with the table and the primary key.

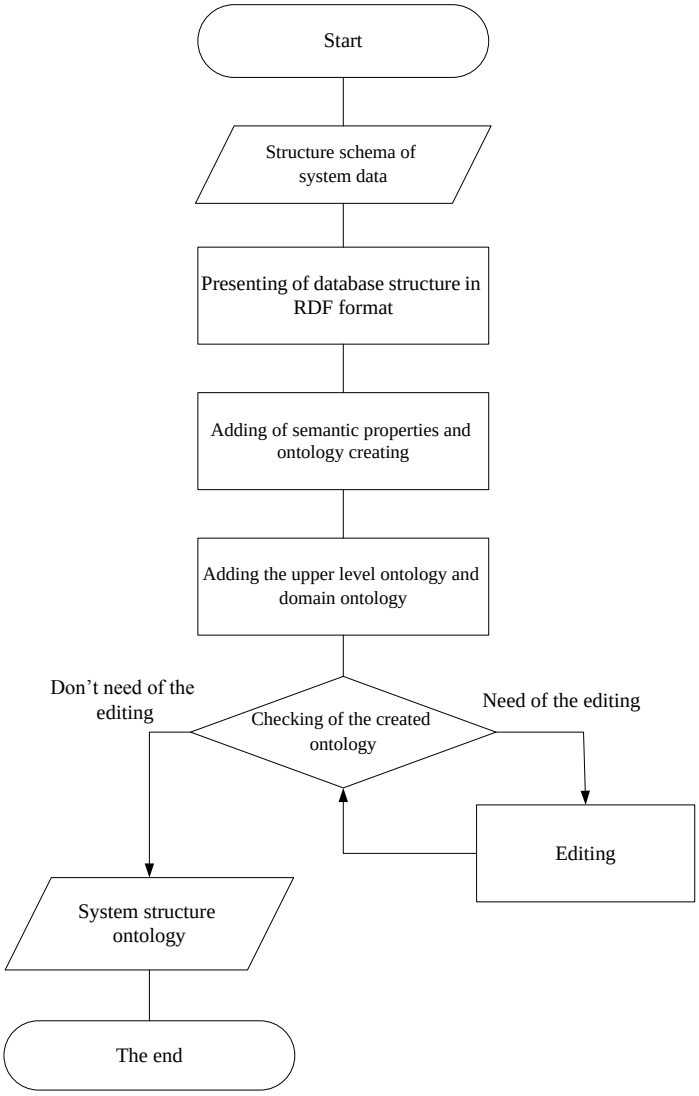

Fig. 1. The flowchart of the algorithm of constructing of structural ontological data integrated systems model [source: own study]

Suppose we have the following table:

Tab. 1. Table Product

Field name	Data type
ID	int
Name	varchar
Price	float
Quantity	int
Stock	int

Presented above table 1 matches to the following:

```
TABLE Product (
ID INT UNSIGNED NOT NULL AUTO_INCREMENT,
Name VARCHAR(20) NOT NULL,
Price FLOAT,
Quantity INT,
Stock INT,
PRIMARY KEY (ID)
);
```

For absolute identification when the table is displayed in the class, when the table fields names are converting in the class properties are transformed in the following way:

$$\mathrm{Pr}\,opertyOfClass = TableName + \_ + FieldName \tag{9}$$

Hence, a class that is a reflection of Product table is (according to the object-oriented programming notation):

```
class Product {
private int product_id;
private String product_name;
private double product_price;
private int product_quantity;
private int product_stock;
public String.getProduct_name () {
return product_name;
}
}
```

In this class is defined of the String.getProduct_name() method, which returns the name of the product. Also, we see that are transformed not only of the fields names in the table, but also their types. This is a very important task in the database schema analysis. Different systems may use completely different relational

database, which in turn can use various data types for the numbering of stored resources. Upon database structure extracting, you must also extract of the information about of the stored data types in its elements and describe them in RDF. Due to the fact that the RDF structure used for modeling is based first on the markup language XML, ontological properties described thus may have different XSD data types. XSD language is a standard language for describing XML documents. When is used XSD you can create a set of rules to be met XML document. This language has of a several primitive data types you can use to describe the item as in XML, and in RDF document. The result after the first step of the algorithm is an RDF-document contains statements that describe structural information from the database system schema. We show an example of RDF-document which have one class and meet our table Product, described above:

<sys:product>
a owl:Class;
rdfs:label "product"^^xsd:string.
<sys:product_id> a owl:DatatypeProperty;
rdfs:domain <sys:product>;
rdfs:label "ID"^^xsd:int.
<sys:product_name> a owl:DatatypeProperty;
rdfs:domain <sys:product>;
rdfs:label "Name"^^xsd:string.
<sys:product_price> a owl:DatatypeProperty;
rdfs:domain <sys:product>;
rdfs:label "Price"^^xsd:double.
<sys:product_quantity> a owl:DatatypeProperty;
rdfs:domain <sys:product>;
rdfs:label "Quantity"^^xsd:int.
<sys:product_stock> a owl:DatatypeProperty;
rdfs:domain <sys:product>;
rdfs:label "ProductStock"^^xsd:string.

The example shows how the fields of the table Product are transformed into owl: DatatypeProperty properties with XSD data types. Each property is associated with the sys: product class through rdfs: domain property.

In the second step of the algorithm is used of the procedure of the automatically determine of the common elements in the structure of integrated schemas and identify relationships between them. The main goal in the second step is to increase the number of semantic relations between the different systems ontologies within the overall global ontology. In other words, automatically analyzing of all the structural elements of each system can identify these items and add to them of the semantic property that will help tie them together. Thus, in the second step we need two problems solving: identification of common elements in the integrated schemas structure and adding of links between similar elements.

In [13] are discussed some annotative properties that represent of the classes and properties in general ontology and connect them with other objects in the model.

In the third step is the replenishment of the resulting ontology by the additional upper-level ontologies for the integrated ontological model getting. This replenishment carry, using the owl: import command, which is responsible for importing concepts and relations from external ontologies. Currently, there are much different domains ontology that contain of the different set of concepts and relationships between them. For example, there are ontologies describing of the relationships between people, ontologies describing of the bibliographic documents, etc. Importing such properties in the resulting structural ontological model, you can get information about the system not only within their domain, but also abroad. Thus, you can access even more options for automated logical decision making, due to the large amount of information objects within the ontological model.

The fourth step involves the checking of the created ontology to lack of relationships between ontology objects. Because in the third step execution during of the created ontology automated replenishment cannot always be found all relationships between the system elements and some links may be missed and not installed. Therefore, we must to do of the checking and if all is well, then go immediately to step six, if not – to step five.

The fifth step of the algorithm provides of the additional manually links establishing between objects ontology. Links can be established between ontologies integrated systems objects and between imported upper level ontologies and domain ontology. To implement this step, you must use the ontology editing software such as Protégé. In this step, we add of the necessary links manually to create a complete semantic model of the integrated systems.

And finally, in the sixth step is the getting of general ontology structure in the RDF form. The result can be written to a file or to a specialized data repository RDF. The resulting ontological model, in fact, is a conceptual part of the ontology. It contains concepts and links between them in integrated systems within a subject area in which they work, and the set of terms from other areas.

3. CONCLUSIONS

The usage of ontologies and ontological modeling principles in the context of improving the process of dynamic semantic data integration has been presented. The process of designing of the algorithm of constructing of structural ontological data integrated systems model has been described. The flowchart of the algorithm of constructing of structural ontological data integrated systems model and in detail each step of the algorithm has been considered.

On the basis the common global structure model getting as a result of the algorithm work we can get metadata of systems information resources. Using this approach can automatically to describe of the resources semantics at the very early stage of their receipt.

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3D scanning, reverse engineering, digital model, digitisation of museum objects

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SELECTED METHODS OF MAKING THREE-DIMENSIONAL VIRTUAL MODELS OF MUSEUM CERAMIC OBJECTS

Abstract

The paper presents available three-dimensional scanning technologies with a particular focus on the digitisation process of ceramic objects. Of the research carried out show that in digitising ceramic objects with concave ornamentation by the Roland PICZA LPX-600 scanner the method of scanning by planes should be used. While digitising such objects with the ZScanner ® 700 one should use the resolution of 0,4 mm. The paper also shows the suitability of reference imaging in recreating the shape of the object in constructing 3D models. This shape can be used in virtual assembly of the shells of broken ceramic vessels.

1.1. INTRODUCTION

Three-dimensional digitisations of objects from Polish museum collections have been made from the beginning of this century, e.g. by a team led by professor R. Sitnik, but they are still incidental activities. In the available literature one can find some suggestions formulated in relation to the three-dimensional scanning process, but they are more verbal in nature, and different authors are putting forward their own opinions. Kuśmidrowicz-Król [1] points out the fact that the technical aspects of the digitisation process not only require specialised equipment, but also a team of people well prepared to handle them. Issues concerning creation of low-budget jobs in 3D scanning and the training of people can be found in the works of Sansoni [2], Kęsik, Montusiewicz and Żyła [3, 4] and in Reznicek

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and Pavelka [5]. Pavlidis et al.' paper [6] presents a number of techniques of aquiring 3D images in the area of cultural heritage. In the book edited by Stanco, Battiato, Gallo [7] this subject is extended and completed, and Remondino's [8] paper reviews the actual optical 3D measurement sensors and 3D modelling techniques, with their limitations and potentialities, requirements and specifications.

Klak [9] describes the use of laser scanners for three-dimensional digitisation of museum objects, while Bunsch and Sitnik [10] devote more space to the advantages of scanning by using structured light, also discussing other non-contact scanning techniques. Skabek and Kowalski discuss the practical effects of applying selected scanner models using a laser beam in building 3D models [11], whereas Li, Luo and Zha [12] show practical realisations of 3D scanning. Kłos and Nowacki [13] discuss the practices that should be used in the process of 3D digitisation of museum collections. An original approach to creating cyber-archaeology is presented by Forte, Kurillo and Matlock [14], while Tyszczuk [15] considers his own ideas and practical solutions in this area.

The purpose of creating virtual 3D models of museum objects can be [15]: archiving the collected items to keep them as objects of cultural heritage, the ability to perform metric analyses of these objects, the ability to conduct comparative studies, including typological analyses, the use of models for the verification of the behaviour and determination of the authenticity of monuments, the ability to perform replicas of objects (rapid prototyping using 3D printing), reconstruction of destroyed or damaged items, as well as the possibility of using virtual assembly of fragmented objects, e.g. shells or ceramic sculptures. In addition, having digitised three-dimensional museum objects allows public access to virtual collections, which may contribute to the increased interest in specific museums and places where they are located.

The main problem addressed by the research team from the Department of Programming and Computer Graphics at the Institute of Computer Science, Technical University of Lublin, aims to develop algorithms and tools that will support virtual assembly of vessel shells found during archaeological excavations. The prepared technology will be tested among others on shards of vessels kept in the Alisher Navoiy Scientific-Experimental Museum-Laboratory of the Samarkand State University in the Uzbekistan. The created algorithms and prepared computer program will allow in the future to assemble these objects independently of where they might be kept. The presented phase of the study concerns the preparation of experimental material whose shape we know (creating three-dimensional digital records of the object as a whole and all its fragments when broken). In solving real-world problems we usually have shells that come from many dishes, whose shapes and sizes are not fully known, and in addition there is a deficit of the assembled components.

The aim of this work is to present the application of laser scanners Roland PICZA LPX-600 and ZScanner ® 700 in creating three-dimensional models

of complete ceramic objects and objects broken into parts and to determine their suitability to scan these types of exhibits. Digitisation was performed using equipment from the Department of Thermodynamics, Fluid Mechanics and Aviation Propulsion Systems, Faculty of Mechanical Engineering. Moreover, procedures for 3D modelling in AutoCAD 2013 are provided that can be used to perform a complete model of an object based on its reference photo and use it during the virtual assembly of digital shells.

2. DESCRIPTION OF MAKING DIGITAL THREE-DIMENSIONAL OBJECTS

2.1. Three-dimensional scanning

Currently, there are several methods that have found practical application in the creation of three-dimensional models of museum objects. These are the methods of digitisation which, through the use of reverse engineering, create a virtual image of the currently available real object as well as three-dimensional modeling, which can be done on the basis of the reference images of the object to which we do not have direct access (in the extreme case, the object may no longer exist). It is clear that only the reverse engineering methods allow us to create a faithful digital image of an existing object.

The existing methods of 3D digitisation can be divided into contact and non-contact scanning. Among the latter are distinguished [2, 16]:

- laser triangulation,
- photogrammetry (passive method),
- flight of the beam time method (used for large and very large objects),
- structured lighting method (used just as in laser triangulation method).

Because the study examined the usefulness of scanners using laser triangulation, only this method of digitisation will further be presented. The idea of laser scanning can be reduced to the principle of laser distance measurement from a point of known spatial coordinates for the points test and the designation of their position in the adopted system of spatial polar coordinates. This method utilises laser beams as points or lines, and its use is restricted to dispersion surfaces not exceeding two meters. When scanning surfaces which are transparent, reflective or refracting light, one should use a substance adhesively sticking to the surface and with light-scattering properties (talc, titanium oxide or acrylic medium). Once digitised, the object should be wiped or washed with water, which may be unacceptable for many works of art. One advantage of this method is the ability to digitise in daytime as the laser beam has a high energy efficiency. The measuring system of the scanner consists of: a low-power laser emitting orange-red or infrared light, a mirror allowing control of the direction of the laser beam and a high-resolution CCD sensor. During the scan, a camera

fitted with a filter transmitting only the laser light, record the place illuminated by the projected laser beam. Both cameras operate synchronously, i.e. to make a video recording, the laser beam must intersect on the scanned surface. Because they are positioned relative to each other at a distance and at an angle, it is not always possible to register the image from both cameras, and it is only possible to scan under this condition. The data on the geometry of the scanned object are obtained by calculating the most intensely illuminated points on the CCD and connecting them with information about the inclination of the mirror. As a result of this conversion a point cloud with coordinates (x, y, z) is obtained, which is a computer representation of the surface of the measured object.

To allow the scanning of an object it is placed on from every side on a computer controlled rotary table (in the case of stationary scanners) or, in the case of handheld scanners, the object placed on a stationary surface is scanned from every side. In the latter case it becomes necessary to place the object markers (tags affixed in the form of circles with a diameter of about 5 mm), which allow the moving scanner to locate reference points so that the obtained distance measurements could be related to points obtained earlier. Tyszczuk [15] believes that the laser light locally heats the surface of the scanned object, which can be dangerous for many objects requiring conservator's protection, but this finding is not supported by research.

Of the many data saving formats the one most commonly used in rapid prototyping methods are text files (extension *.txt*). The text file creates a point cloud which is a set of points with coordinates (x, y, z) and contains information about the intensity of the reflection. Most CAD software also provides the option to save in the *.stl* format, which is a triangulation (triangular) representation of the geometry of surfaces in three-dimensional space. Each area is divided into small triangles, and each vertex of the triangle is described by three points representing their location in relation to the coordinate axes. The resulting triangle mesh can also be saved in formats: *.igs*, *.dwg* and *.wrl*.

2.2. Three-dimensional modelling

A sample method of modelling the selected geometry using the scanning data obtained with a CAD program is shown in Figure 1.

After importing the data in the form of a point cloud (I) one should define an area for further processing (II) to eliminate unnecessary points created during the scan (which are erroneous data) from the object's surroundings. In the next step, based on the control points a polygon mesh (III) is generated as the image of the scanned geometry in the form of a NURBS surface (Non-Uniform Rational B-Spline). Only then can it be converted into a surface model (IV). Finally, it should be replaced it with a solid model by giving thickness to the existing surfaces (V), or in the case of closed surfaces by filling their interior. It is the solid model which most accurately reflects the virtual model of the scanned object.

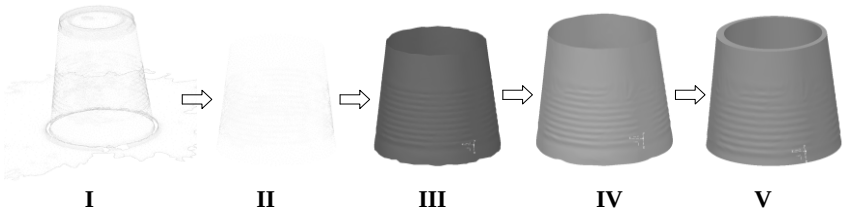

Fig. 1. A sample procedure for geometric modelling using the scanning data [source: own study]

For three-dimensional modelling of the actual exhibit, one can use the reference image of the same object. The basis for the selection of modelling tools is an analysis of the shape and geometrical properties of an object. One should find a plane of symmetry, the axes of symmetry, repetitive elements, their arrangement, rounded and chamfered areas. Such an analysis allows for proper selection of basic objects from which one can start modelling (so-called primitives) and tools for their conversion. More complicated objects are obtained by assembling elementary ones using Boolean operations (difference, sum, product) and locating the characteristic points of objects. Modern 3D modeling programs allow for the conversion of planar objects into solid ones, which greatly enhances the modelling techniques used and gives the designer more freedom of action and triggers his creativity. In this paper AutoCAD 2013 was used for the modelling process.

3. 3D DIGITISATION WITH LASER SCANNERS

3.1. Description of objects for digitisation

The selected objects are two jugs with significantly different shape, made of the same light diffusing material and coated in part with the same ornamentation. The jugs were formed manually as evidenced by a high degree of deviation of the actual cross sections obtained during the measurement of the adjacent circles. For example, the diameter of the foot of the jug shown in Figure 2 was 110 ± 0.1 mm, while the upper part from 110.9 to 120.3 mm. At this stage of the study the objective was the preparation of research material for testing algorithms supporting the virtual assembly of broken dishes. Scanning these vessels will give us their digital description when they were whole and after breaking. Information about the original shape and appearance of these vessels will facilitate the identification of shells and allocate them to a particular jug, while the identical ornamentation will make this process more difficult, especially when the broken fragments are not too large. Thus, the scanning process will include the digitisation of the vessel before and after the breakdown.

A B

Fig. 2. Jug scanning and modelling: A – jug 1, B – jug 2 [source: own study]

3.2. Scanning with the Roland PICZA LPX-600 scanner

Depending on your needs and the size of the scanned object two types of 3D scanning devices can be distinguished: portable (handheld) and stationary. Digitsed objects have been scanned using both the stationary and portable scanner. As a desktop scanner Roland PICZA 3D LPX-600 was used, which is shown in Figure 3 together with selected data in Table. 1.

Fig. 3. Roland PICZA 3D Laser Scanner LPX-600 [17]

Tab. 1. Detailed scanner Roland PICZA 3D Laser Scanner LPX-600 [17]

NAME	DESCRIPTION
Table size	Diameter 254 mm (10 in.)
Maximum scanning area	Plane scanning: Width 254 mm (10 in.), height 406,4 mm (16 in.) Rotary scanning: Diameter 254 mm (10 in.), height 406,4mm (16 in.)
Scanning pitch	Plane scanning: widthdirection 0,2 to 254 mm, heightdirection 0,2 to 406,4 mm. Rotary scanning: circumference 0,18 to 3.6 degrees, height direction 0,2 to 406,4 mm
Repeat accuracy	±0,05 mm (This figure reflects standard scanning conditions established by Roland DG)
Maximum table load weight	5 kg (11 lbs)
Laser	Wavelength: 645 to 660 nm Maximum output: less than 0,39 µW (maximum output of the laser light emitted inside housing is 0,1 mW)
Sensor	Non contact laser sensor
Scanning method	Spot-beam triangulation
Operating speed	Table rotation speed: 9 rpm, head rotation speed: 4,48 rpm, Maximum head movement speed: 37 mm/sec.
Interface	USB (compliant with Universal Serial Bus SpecificationRevision 1,1)

The Roland LPX-600 laser scanner is widely used in the trade by designers, artists, animators and game developers. They have thus the ability to scan objects to the computer in a highly automated manner. The user-friendly handling comes down to placing the object inside and setting the required scanning parameters. It does not call for any complicated setup or technical knowledge. Users enter only the required scanning resolution, area and mode (rotary or planar). Scans are performed automatically and unattended. The result of scanning are data in the form of a point cloud.

Scan files are further processed using programs such as CAD (Computer Aided Design). For this purpose, Roland offers an internal software package called EZ Studio, which creates an .stl format model. For more advanced work may require such software packages as Geometry Systems, Rapidform or Geomagic. These programs allow users to customise the scanning and processing of complex data to create animation formats.

Thanks to the movable head, the Roland PICZA 3D LPX-600 scanner allows two types of scanning techniques: rotary (rotary scanning) and planar (plane scanning), Figure 4. Rotary scanning is dedicated especially to objects that are nearly spherical or cylindrical and have smooth curves. In other cases, it is recommended to scan by planes. Using this technique, we have fewer constraints associated with the shape of objects.

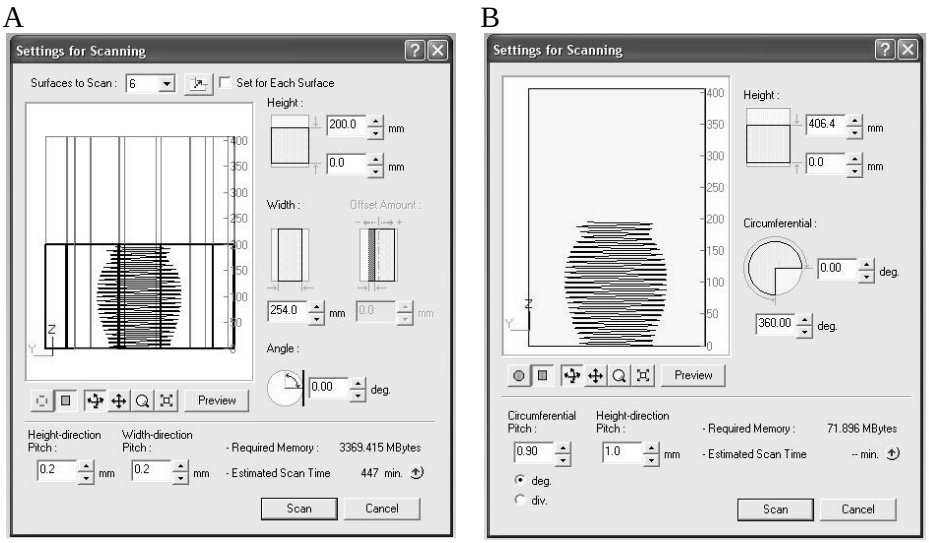

Fig. 4. Scanning settings: planes (A) and rotational (B) [source: own study]

When scanning by planes (Figure 4A), in the Surfaces to Scan field one enters the number of planes in which the object will be scanned; in the Angle field – the angle for the currently selected scan area; in the Height and Width fields the dimensions of the scanning area are introduced, regarding respectively the height and width (the scan area may also be implemented separately for each area). With specified settings a simplified preview of the print area is possible by clicking Preview. A more detailed look at the geometry is allowed by the features accessible through the icons placed under the preview window of the object being scanned.

Both scanning techniques allow to obtain a digital form of both the entire object and its separate fragments. In examining the usefulness of the Roland PICZA scanner in digitising museum objects a scan was performed of jug 1 of Figure 1 by using the two available techniques: rotating and planes.

Rotary scanning

The rotary scanning technique is made by introducing the digitisation accuracy of 0.4 mm. The image of the scanned fragment of the digitised jug (about 65% of the scanning process) is shown in Figure 5. The scanning time was about 85 minutes.

Analysis of the obtained digital image of a jug reveals that the scanning technique used is not appropriate, because the fragments in which the surface of the jug was covered with ornaments is discontinuous – the appearance of the effect of a "sieve". There are explicit see-through effects, with the peering blue background on which the digital recording is generated.

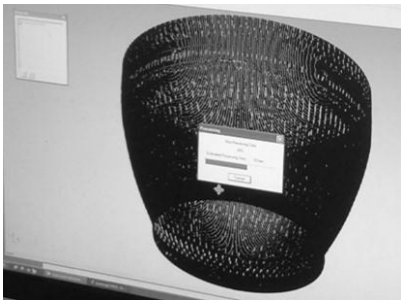

Fig. 5 is a partial view of the jug after scanning by the rotational technique [source: own study]

Scanning by planes

When scanning in this technique, six active surfaces were introduced. A jug surface was obtained consisting of six fragments shown in Figure 6. Because of the angle of covering the object with one plane and the number of planes, individual pieces overlap to form a continuous surface. This technique allows to scan the entire surface producing very well-mapped surface structures. Ornaments which decorated the jug are properly mapped and do not create holes, as was seen when scanning by rotation.

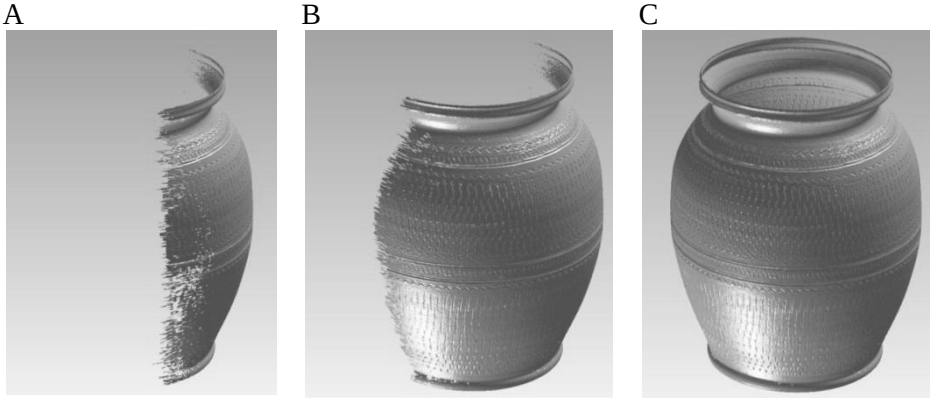

Fig. 6. View of the partial results of scanning jug 1: A – one plane, B – two planes, C – six planes (complete surface) [source: own study]

The quality of the scanned object is strictly dependent on, among others, the set accuracy of the scanning process. An important factor in the practice of digitisation is also the time of the process, which in turn is a function of the accuracy. For this reason, the scanning parameters are introduced individually for each object depending on the desired requirements. The Roland PICZA scanner

allows to scan with the accuracy of 0,2 mm with value gradation of 0.2 mm, both along the width and height. For estimated scan times a simulation of the digitisation process was done, changing the precision values of scanning. The experiment was performed while scanning jug 1, and the results are given in Table 2 and Figure 7. It was found that in scanning by planes an increase in the accuracy along the width does not affect the scanning time.

Tab. 2. Time values of scanning by six planes while changing process accuracy along the height coordinate [source: own study]

Lp.	Height [mm]	Width [mm]	Time [min]	Time shortening [%]
1.	0,2	0,2	437	-
2.	0,4	0,2	221	49
3.	0,6	0,2	148	33
4.	0,8	0,2	113	24
5.	1	0,2	91	19

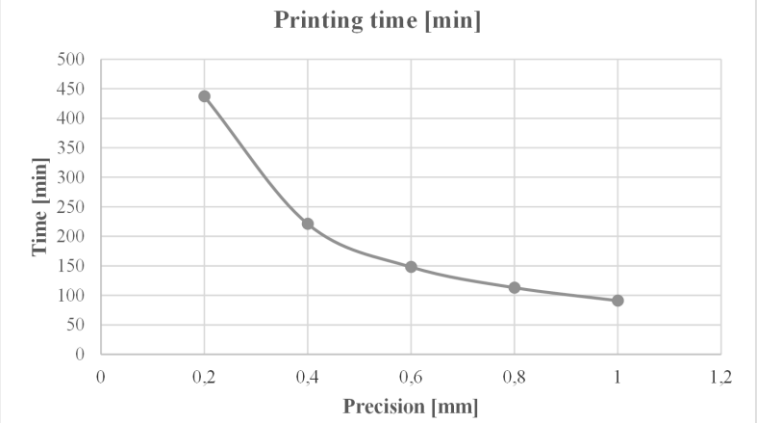

Fig. 7. Impact of accuracy on digitisation time in scanning by six planes along the height coordinate [source: own study]

A thorough analysis of the results of the simulated time values in scanning with six planes shows that halving the height accuracy from 0.2 mm to 0.4 mm reduces the time by 49%. Further reduction in the accuracy by the value of 0.2 mm (i.e. three times less than the initial value) shortens the time of digitisation threefold. Ultimately, the obtained results show that an n-fold decrease in accuracy reduces scanning time about n times. Thus the scanning duration with the accuracy of 1 mm is 90 minutes.

3.3. Scanning using a handheld scanner ZScanner ® 700

The ZScanner ® 700 shown in Figure 8A, the details of which are given in Table 3, is a handheld scanner. Using it requires sticking on the object markers enabling the automatic submission of individual scans. Thanks to these markers, after a change of the scan area (displacement of the device relative to the object), the scanner detects the positions relative to the previous surface. Markers are used normally in objects larger than the volume of the measuring scanner, Figure 8B.

A B

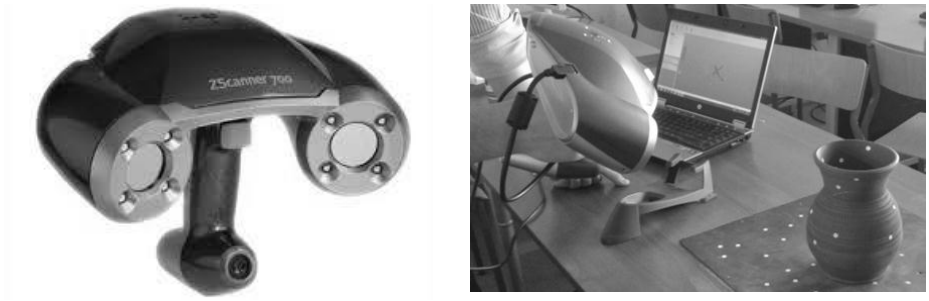

Fig. 8. The ZScanner ® 700: A – general view [18], B – the scanning process of jug 2 (cf. Fig. 1); visible white markers stuck to the object [source: own study]

Tab. 3. Details of the ZScanner ® 700 [18]

NAME	DESCRIPTION
Weight	1.3 kg
Dimensions	172x260x216 mm
Speed	18000 measurements/s
Laser class	II (safe for the eyes)
Cameras	3
Accuracy XY	50 μm
Resolution	0.1 mm in axis Z
Texture resolution	50 to 250 DPI
Depth of measurement	30 cm
Exported formats	*.DAE, .FBX, .MA, .OBJ, .PLY, .STL, .TXT, .WRL, .X3D, .X3DZ, .ZPR*
Certificate	CE
Data transfer	FireWire

A handheld scanner, due to its ability of movement relative to the object, allows one to scan the interior of an object so that the inner surface is generated. This capability significantly increases the use of this scanner compared to a desktop scanner and turns out to be very useful when scanning small items.

In examining the suitability of the ZScanner ® 700 to digitise exhibits, scans of jug 2 of Figure 1 were done, beginning with the digitisation of the entire object, and then after breaking it into eight parts, of the individual components, Figure 10. Breaking the jug results in several large components, some very small fragments and ceramic dust, whose total weight was about 5% of the weight of the complete jug (the total weight was 1176.9 g).

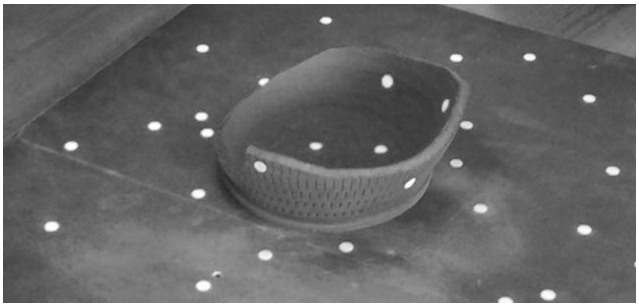

Fig. 10. Scanning the base of jug 2 by using the ZScanner ® 700 [source: own study]

The digitisation of the jug was made with the scanning accuracy set to 0.4 mm. Attempts to scan the sample were also conducted with the maximum accuracy of 0.2 mm, which, however, failed. The process of obtaining a digital fragment lasted a very long and the resulting image of the scanned area was characterised by a large discontinuity and was not fit for use.

Examples of the digital images of elements of jug 2 are shown in Figure 11. The drawing shows that the resulting scans show slight defects arising in the process of digitisation, which should be corrected during postprocessing.

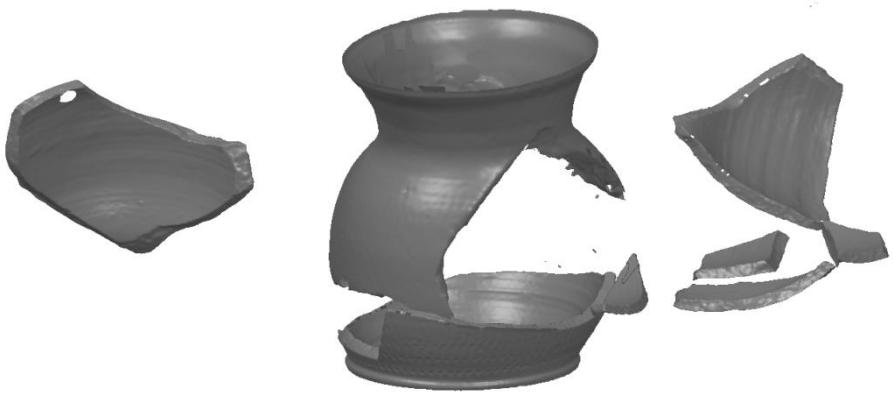

Fig. 11. View of scanned fragments of the broken jug 2 using ZScanner ® 700 and the process accuracy = 0.4 mm [source: own study]

4. 3D MODELING USING AutoCAD PROGRAM

The modelled jug 2 of Figure 1 is a rotating solid, so the best method of modelling it is plotting its left or right contour (for this purpose, spline objects were used) based on a reference photo and using the command to rotate this contour around the indicated axis (click Rotate around the Z axis 360 °). Thus, the outer surface of the jug was obtained. In practice, in modelling the external shape of the jug both contours were used, introducing other colours (purple and grey) for contrast. Since the jug was made by hand, the two contours are slightly different from each other. This is shown in Figure 12 by applying both modelled surfaces onto each other.

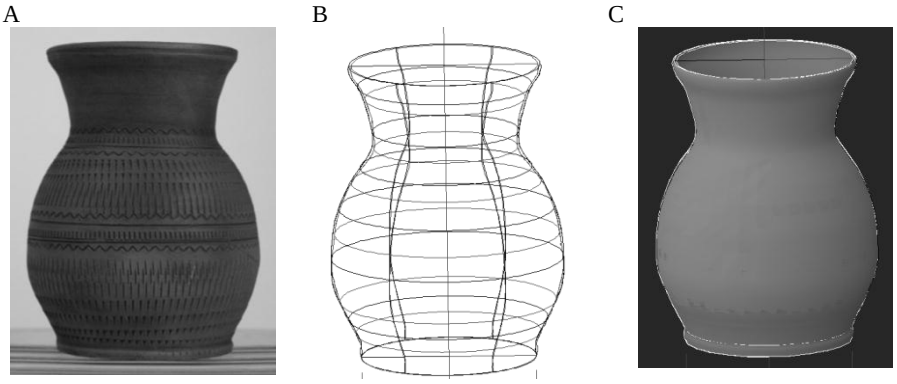

Fig. 12. Jug 2 and its model: A –reference image, surface models, B – overview edge, C – a conceptual overview [source: own study]

The colour penetration shown in the figure is due to a difference between the contours obtained by the outline of the left and right edges of the photographed jug. Obtaining a solid model was achieved by converting the surface model to a solid structure using the command Bold with the appropriate options and parameters, Figure 13.

Fig. 13. Fragment of a solid model of jug 2 [source: own study]

The presented modelling process does not afford ornamentation present on the surface of the jug in geometric form. In order to obtain a photorealistic visualisation one would have to map the model with the texture derived from a photo of the actual surface of the jug, and then perform the rendering.

The implementation of a virtual jug shows that the resulting model is only a digital approximation of the actual object, but may be useful in the process of virtually assembling the digitised items, because it can be placed in a three-dimensional scene and it shows the shape of the object.

5. SUMMARY AND CONCLUSIONS

Ceramic shells from excavations are objects that do not have sharp edges, but many small cavities. This causes that elements from the breakdown of a larger piece in time will not adhere to each other over the entire cross-sectional area of the shell. Thus, the requirements for the digitisation of such objects are characterised by a certain peculiarity, in which maximisation of the accuracy of the scan is not a priority. Generating large files would cause virtual assembly to require the use of equipment with large calculation capacities and would be very time-consuming.

From the work carried out it appears that:

1. The use of a desktop scanner Roland PICZA LPX-600 is justified in carrying out digitisation of complete objects, because the process is carried out automatically and does not absorb personnel time.
2. The stationary scanner is not suitable for scanning the shells of a broken jug (they form hypersurfaces) due to the continued coverage of their interiors. Obscured fragments will form breaks in the digital representation of the scanned surface.
3. In digitising by the Roland PICZA LPX-600 scanner, to obtain a correct image structure on the surface of an object, one should scan by planes and not by rotation.
4. Scanning with maximum accuracy takes too much time (over 400 min.) and the size of the files created varies from 30 to 140 MB, depending on the recording format.
5. The handheld ZScanner ® 700 is well suited for scanning the shells of a broken jug after introduction of the scanning accuracy of 0.4 mm. Then the digitisation process goes pretty quickly, and the resulting scan is characterised by good quality.
6. Creating AutoCAD digital models of complete vessels will be useful in the process of virtual assembly of elements created after their breaking. Saving the resulting files in various formats makes their use independent of the various programs for the treatment of three-dimensional objects.

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*enhanced numerical methods for gear life evaluation,
cylindrical toothed gear, accuracy deviations*

Myron CZERNIEC[*]

THE ACCURACY OF AN ACCELERATED METHOD FOR THE EVALUATION OF LIFE OF CYLINDRICAL GEARS WITH PROFILE CORRECTION

Abstract

This paper presents an accelerated method for the evaluation of life of cylindrical gears with profile correction. Compared to a more accurate solution based on the generalized method for evaluating the wear and life of cylindrical involute gears, the new method enables accelerating this process by over 16000 times. The method was used to estimate the life of a cylindrical spur gear depending on different ranges of blocks describing gear teeth meshing conditions (i.e. the number of gear revolutions). The accuracy of the results obtained thereby was examined, too. It has been found that when the range of a block is increased by 3000 times, the deviations of the numerical solution are below 0.5%.

1. INTRODUCTION

When designing gears, it is important from a practical point of view that their life be estimated along with their constructional parameters (including profile correction), operating parameters, wear and meshing conditions. The few evaluation methods which are reported in the literature [1, 2] are not suitable for this purpose. The estimation of wear and life of cylindrical involute gears is, however, possible using the new evaluation method [3–5] which was developed i.a. by the author of this paper.

Depending on service conditions, gears reach their allowable wear after a certain number of revolutions of the rack, ranging from hundreds of million up to several billion revolutions. As a result, the application of the generalized method to estimate gear life, including tooth wear perevery revolution of the rack, will require a significantly long computation time, too. In order to shorten the

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computation time to a significant extent, we every revolution of the rack, willrequire a significantly long computation time, too. In order to shorten the computation time to a significant extent, we developed an enhanced, accelerated method. Below, we present the results of gear life estimation by this method as well as the results concerning the accuracy of the method itself.

2. METHOD FOR ESTIMATING GEAR LIFE

As a result of gear teeth wear, the curvature radii ρ_{jh} of the their profiles increase; this, in turn, causes the initial maximum contact stresses $p_{jh\,max}$ to decrease, while the width of the contact areas $2b_{jh}$ increases. The contact stresses at wear are determined by the Hertz equations:

$$p_{jh\max} = 0,564\sqrt{N'/\theta\rho_{jh}}, \quad 2b_{jh} = 2,256\sqrt{\theta N'\rho_{jh}}, \tag{1}$$

where $j = 0,1,2,3,...,\ s$ are the contact points on the active face of the gear teeth; $j = 0,\ j = s$ are the first and last points of gear teeth engagement, respectively; $N' = N/l_{\min}w;\ N = T_{nom}K_g/r_{w1}\cos\alpha_w$ is the force acting in the engagement; $T_{nom} = 9550P/n_1$ is the rated torque; r_{w1} is the rolling radius of the pinion; α_w is the pressure angle of the corrected profile; P is the power on the drive shaft (pinion); n_1 is the number of revolutions of the drive shaft; K_g is the dynamic factor; $\theta = \left(1-\mu_1^2\right)/E_1 + \left(1-\mu_2^2\right)/E_2;\ E, \mu$ are the Young's modulus and the Poisson's ratio of the materials of gear teeth, respectively; $l_{\min}$ is the minimum length of the contact line; w is the number of engaged tooth pairs; $\rho_{jh} = \dfrac{\rho_{1jh}\rho_{2jh}}{\rho_{1jh}+\rho_{2jh}}$ is the reduced radius of curvature of the gear profile subjected to change due to wear, in a normal section; ρ_{1jh}, ρ_{jh} are the changeable radii of curvature of the pinion and gear tooth profiles, respectively.

The initial reduced radius of the curvature ρ_j of a cylindrical gear profile is:

$$\rho_j = \frac{\rho_{1j}\rho_{2j}}{\rho_{1j}+\rho_{2j}}, \tag{2}$$

where: ρ_{1j}, ρ_{2j} are the radii of curvature of the flank of unworn profiles of the pinion and the gear, respectively.

The formulas for calculating the radii of curvature of the corrected pinion and gear profiles of the cylindrical gear at j -th point of contact are [3–5]:

$$\rho_{1j} = \frac{\rho_{t1j}}{\cos\beta_b}, \quad \rho_{2j} = \frac{\rho_{t2j}}{\cos\beta_b}, \tag{3}$$

where: $\beta_b = arc\left(tg\beta\cos\alpha_t\right)$, $\alpha_t = arctg\left(\frac{tg\alpha}{\cos\beta}\right)$,

$\rho_{t1j} = r_{b1}tg\alpha_{t1j}$, $\rho_{t2j} = r_{w2}\sqrt{\left(r_{2j}/r_{w2}\right)^2 - \cos^2\alpha_w}$,

$\alpha_{t1j} = arctg\left(tg\alpha_{t10} + j\Delta\varphi\right)$, $\alpha_{t1s} = arctg\sqrt{\left(r_{1s}/r_{w1}\right)^2 - \cos^2\alpha_w}$,

$\alpha_{t2j} = \arccos\left[\left(r_{2w}/r_{2j}\right)\cos\alpha_w\right]$,

$r_{b1} = r_1\cos\alpha_t$, $r_1 = mz_1/2\cos\beta$, $r_{b2} = r_2\cos\alpha_t$, $r_2 = mz_2/2\cos\beta$,

$tg\alpha_{t10} = \left(1+u\right)tg\alpha_w - \frac{u}{\cos\alpha_w}\sqrt{\left(r_{20}/r_{w2}\right)^2 - \cos^2\alpha_w}$, $r_{a2} = r_2 + m$,

$r_{20} = r_{a2} - r$, $r = 0{,}2m$, $r_{1j} = r_{w1}\cos\alpha_w/\cos\alpha_{t1j}$,

$r_{2j} = \sqrt{a_w^2 + r_{1j}^2 - 2a_w r_{1j}\cos\left(\alpha_w - \alpha_{t1j}\right)}$, $a_W = \left(z_1 + z_2\right)m/2\cos\beta$;

where: r_1, r_2 are the radii of pitch circles of the pinion and the gear, respectively; r_{b1}, r_{b2} are the radii of base circles of the pinion and the gear, respectively; r_{a1}, r_{a2} are the radii of addendum circles of the pinion and the gear, respectively; r is the radius of the gear tooth fillet; u – is the gear ratio; $\Delta\varphi$ is the selected angle of revolution of the pinion from the point of initial contact (point 0) to point 1, and so on; $\alpha = 20^0$ is the angle of engagement; β is the pitch angle; m is the engagement module; z_1, z_2 denote the number of gear teeth; α_{10} is the angle of the first point on the contact line; α_{1s} is the angle indicating the location of the last point of engagement of the pinion teeth on the contact line; α_{20}, α_{2s} are the angles indicating the location of the first and last points of engagement of the gear teeth on the contact line.

The minimum length of the contact line is:

$$l_{\min} = \frac{b_W \varepsilon_\alpha}{\cos\beta_b}\left[1 - \frac{(1-n_\alpha)(1-n_\beta)}{\varepsilon_\alpha \varepsilon_\beta}\right] \text{ at } n_\alpha + n_\beta \rangle 1,$$

$$l_{\min} = \frac{b_W \varepsilon_\alpha}{\cos\beta_b}\left[1 - \frac{n_\alpha n_\beta}{\varepsilon_\alpha \varepsilon_\beta}\right] \text{ at } n_\alpha + n_\beta \le 1, \quad (4)$$

where: b_W is the width of the pinion; $\varepsilon_\alpha, \varepsilon_\beta$ are the coefficients describing the top and step-by-step overlaps of the gear; n_α, n_β are the fractional parts of the coefficients $\varepsilon_\alpha, \varepsilon_\beta$; $\varepsilon_\alpha = \frac{t_1 + t_2}{t_z}$, $\varepsilon_\beta = \frac{b_W \sin\beta}{\pi m}$, $\varepsilon_\gamma = \varepsilon_\alpha + \varepsilon_\beta$,

$t_1 = \frac{e_1}{\omega_1 r_{b1}}$, $t_2 = \frac{e_2}{\omega_1 r_{b1}}$, $t_z = \frac{2\pi}{z_1 \omega_1}$, $e_1 = \sqrt{r_{1s}^2 - r_{b1}^2} - r_1 \sin\alpha_t$,

$e_2 = \sqrt{r_{20}^2 - r_{b2}^2} - r_2 \sin\alpha_t$, $r_{1s} = r_{a1} - r$, $r_{a1} = r_1 + m$; ω_1 is the angular velocity of the pinion.

In addition, we must include the variations in the radii of gear teeth tips along with the profile correction:

$$r_{a1} = r_1 + (1 + x_1)m, \quad r_{a2} = r_2 + (1 + x_2)m \quad (5)$$

where: $x_1 = -x_2$ are the addendum correction coefficients; for this kind of profile correction: $r_{w1} = r_1, r_{w2} = r_2, \alpha_w = \alpha_t$.

The angles of transition from a double tooth engagement ($\Delta\varphi_{1F_2}$) to a single tooth engagement and, again, to a double tooth engagement ($\Delta\varphi_{1F_1}$) in the profile-corrected cylindrical helical gear are determined from:

$$\Delta\varphi_{1F_2} = \varphi_{10} - \varphi_{1F_2}, \; \Delta\varphi_{1F_1} = \varphi_{10} + \varphi_{1F_1} \quad (6)$$

where $\varphi_{1F_2} = \tan\alpha_{F_2} - \tan\alpha_w$, $\varphi_{1F_1} = \tan\alpha_{F_1} - \tan\alpha_w$, $\varphi_{10} = \tan\alpha_{t10} - \tan\alpha_w$;

$\tan\alpha_{F_2} = \frac{r_{w1}\sin\alpha_w - (p_b - e_1) + 0.5 n_\beta p_b}{r_1 \cos\alpha}$, $\tan\alpha_{F_1} = \frac{r_{w1}\sin\alpha_w - (p_b - e_2) - 0.5 n_\beta p_b}{r_1 \cos\alpha}$;

$p_b = \pi m \cos\alpha_w / \cos\beta$ denotes the tooth pitch; $e_1 = \sqrt{r_{1s}^2 - r_{b1}^2} - r_{w1}\sin\alpha_w$,

$e_2 = \sqrt{r_{20}^2 - r_{b2}^2} - r_{w2}\sin\alpha_w$.

The angles $\Delta\varphi_{1E}$ of teeth exit from the mesh are determined similarly to the above method, namely:

$$\Delta\varphi_{1E} = \varphi_{10} + \varphi_{1E} \tag{7}$$

where: $\varphi_{1E} = \tan\alpha_E - \tan\alpha_w$, $\alpha_E = \arccos(r_{b1} / r_{1s})$.

To shorten the computation time, we developed a method based on blocks. With this method, the variations in profile curvature radii, maximum contact stresses and contact area width are not determined per every gear revolution (gear teeth engagement); instead, these parameters can be computed following a certain number of revolutions (block of interaction). In every following block, these variations are taken into account in accordance with Equation (8); having determined the value of ρ_{kjh}, we can move on to compute required parameters and linear tooth wear.

The variable radii of curvature ρ_{kjh} are calculated by the formula [5]:

$$\rho_{kjh} = \rho_{kj} + E_k \sum_{B_1}^{B_{\max}} D_{kjB} K_{kjB}^{-1}, \; k = 1; 2 \tag{8}$$

where: k = 1; 2 are the numbers of the gears (1 – pinion, 2 – gear); B denotes the number of gear revolutions (i.e. the block range of teeth interaction) when the contact conditions are maintained constant; the range of a block can be selected in the following way: B = 1 revolution (accurate solution), $B = n_1$ (rev/min), $B = n_1$ (rev/hr), $B = n_1$ (revolutions per 10 hours), and so on; B_1 and $B_{\max}$ are the first and last computational blocks, respectively; E_k is the dimensionless constant which depends on the maximum allowable gear tooth wear h_{k*}; $D_{kjB} = K_{kjB}^2$ denotes the constant, i.e. the value which remains the same in one block, but changes in every other block.

The variation in the gear tooth profile curvature due to wear for every single block of interaction is:

$$K_{kjB} = 8\sum^{B} h'_{kjn} / l_{kj}^2, \tag{9}$$

where $n = n_k$ = 1, 2, 3, ... denotes the number of gear revolutions.

A single linear wear h'_{kjn} of the teeth at any *j*-th point of their profile is calculated after every block of revolutions in the time t'_{jh}; importantly, this value cannot be accumulated. The width of the contact area $2b_{jh}$ is measured at the revolution $n_k - 1$ or at the block $B - 1$ according to (1). Hence

$$h'_{kjn} = \frac{v_j t'_{jh} (fp_{jh\max})^{m_k}}{C_k (0.35R_m)^{m_k}} \tag{10}$$

where; $v_j = v$ denotes the sliding velocity at the *j*-th point of the tooth profile; $t'_{jh} = 2b_{jh} / v_0$ denotes the time of wear in the course of motion at the j-th point of contact along the tooth by the width of the contact zone $2b_{jh}$; $v_0 = \omega_1 r_1 \sin\alpha_t$ denotes the velocity of motion at the contact point along the tooth profile; f is the sliding friction factor; R_m is the immediate tensile strength of the material; C_k, m_k are the characteristics of wear resistance of the gear materials determined in accordance with the methodology given in [3], based on the results of experimental tribological tests.

The sliding velocity of the teeth in mesh is calculated as:

$$v_j = \omega_1 r_{b1} \left(tg\alpha_{t1j} - tg\alpha_{t2j} \right). \tag{11}$$

The length of the chord which replaces the involute between the points $j - 1$, $j + 1$ is expressed as:

$$l_{kj} = 2\rho_{kjh} \sin\varepsilon_{kjh} = \text{const}, \tag{12}$$

where $\varepsilon_{kjh} = S_{kj} / \rho_{kjh}$ describes the angle between the points j and j +1; $S_{kj} = \left| \frac{mz_k}{4} \left(\frac{1}{\cos^2 \alpha_{kj}} - \frac{1}{\cos^2 \alpha_{k,j+1}} \right) \cos\alpha \right|$ denotes the length of the involute between the points j, j + 1; α_j, α_{j+1} are the angles of engagement at selected involute points $j, j + 1$ [6] .

Hence, following each interaction or interaction block, all computational parameters will be changed, i.e. h_{1j}, h_{2j}, ρ_{1jh}, ρ_{2jh}, ρ_{jh}, $p_{jh\max}$, $2b_{jh}$, t'_{jh}.

For a given number of the revolutions n_{1s} of the pinion and the revolutions n_{2s} of the gear, and their corresponding number of blocks, the cumulative wear h_{1jn} and wear h_{2jn} at the *j*-points of contact are expressed as:

$$h_{1jn} = \sum_{1}^{n_{1s}} h_{1jB}\,, \qquad h_{2jn} = \sum_{1}^{n_{2s}} h_{2jB}\,, \tag{13}$$

where $n_{2s} = n_{1s} / u$; $h_{kjB} = \sum h'_{kj}$ denotes the gear tooth wear per every block

The gear life t_{min} for the number of revolutions n_{1s} or n_{2s} is defined as:

$$t_{\min} = n_{1s} / 60 n_1 = n_{2s} / 60 n_2\,. \tag{14}$$

3. NUMERICAL SOLUTION

The input data included: $z_1 = 20$; $z_2 = 80$; $m = 3$ mm; $u = 4$; $n_1 = 700$ rpm; $P = 6$ kW; $f = 0{,}05$; $b = 30$ mm; $\beta = 0^0$; K_g = 1,6. The following materials were used: the pinion was made of 38HMJA nitrided steel with 58 HRC; R_m = 1040 MPa, C_1 = 3,5⊙10^6, m_1 = 2; the gear was made of 40H steel after bulk heat treatment with 53 HRC, $R_m = 981$ MPa, $C_2 = 0.17 \odot 10^6$, $m_2 = 2.5$; $E = 2.1 \odot 10^5$ MPa, $\mu = 0{,}3$. The lubricant was engine oil containing an anti-wear additive with a kinematic viscosity of $\nu_{+50^\circ} \approx 15$ cSt; $h_{k*} = 0.5$ mm; step $\Delta\varphi = 4^0$. The correction coefficients and geometrical parameters of the gear were as follows: $x_1 = -x_2 = 0$; 0,2; 0,4; 0,6; a_w = 150 mm. The blocks had the following ranges: $B =$ 750 revolutions, $B =$ 42000 revolutions, $B = 84000$ revolutions, $B =$ 420000 revolutions and $B =$ 2100000 revolutions.

When solving the problem, the following conditions are taken into account: the teeth are in double-single-double engagement; the dynamic character of work is defined by the dynamic factor K_g ; the process is conducted under boundary lubrication conditions.

The minimum life is defined as the shortest value of the teeth life t_j at particular *j*-points of their profiles.

The results of the solution for a cylindrical spur gear with profile correction (P–O) are given in the table.

Tab. 1. Results of the solution

x_1, (-x_2)	B, rev					δ, %
	700	42000	84000	420000	2100000	
0	17608	17612	17616	17640	17660	0.30
0.2	28497	28500	28504	28520	28600	0.36
0.4	34266	34268	32272	32280	34400	0.39
0.6	31050	31052	31056	31080	31200	0.48

Note: $\delta = B_{max} / B_{min}$ denotes the deviation of gear life .

It was found that the deviation δ of the computational accuracy in the range between $t_{2100000}$ and t_{700} is negligible (not higher than 0.5%) for the selected range of the correction coefficients $x_1 = -x_2$. The computation time τ for the block B = 2100000 revolutions compared to B = 700 revolutions is shorter by about 2720 times. Fig. 1 shows the computation time for selected interaction block ranges (solid line) obtained using a standard personal computer.

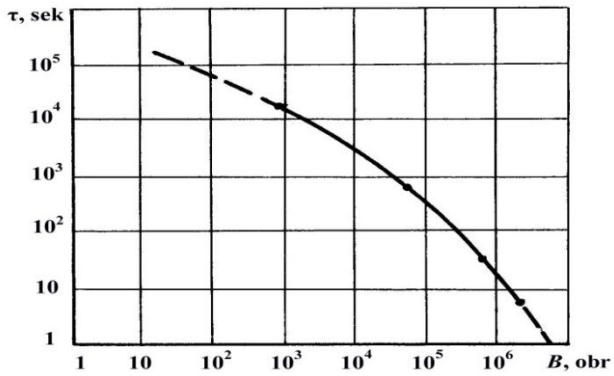

Fig. 1. Effect of block ranges on computation time [source: own study]

4. CONCLUSION

In conclusion, it has been found that increasing the block range by 3000 times, i.e. from 700 revolutions (1 min per pinion) to 2100000 revolutions (50 hrs), practically does not affect the accuracy of the results, despite the fact that the computation time is much shorter.

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Larysa VDOVYCHENKO[*]

THE ANALYSIS OF THE IMPACT OF THE REGULATORY COMPONENT ON BUSINESS ENVIRONMENT IN UKRAINE

Abstract

To analyze the impact of the normative regulatory sphere on business environment in Ukraine in order to identify shortcomings of the existing mechanism of the regulatory activities and prospects of its improvement on the current stage of economic development. To prove the feasibility of studies towards the formation mechanism of information relations in the regulatory activity.

1. INTRODUCTION

The worldwide experience suggests that better when the decisive factor of economic development of the society is not an authoritarian activity of the outstanding personality – a man-leader, but the creation of a system of organizational and legal conditions for decision-making in public administration streamlined, almost «automatic» mode. System methodology of the implementation of the regulatory activities in Ukraine is the organization of a regime providing preparation, adoption and implementation of regulations (normative acts aimed at the regulation of economic and administrative relations) of the legislative, executive and local governments, institutions, organizations and their officials whose authority is to adopt regulations (RA) defined by applicable law, the quality and effectiveness in controlling of the national economy.

One reason for the current situation in Ukraine on the regulatory activities is that most economic studies [1; 2] limit the scope of the scientific interest stage of the regulations, that their impact on the economy remain unnoticed stages of preparation and adoption of these acts. Because of the theoretical and methodological base that makes it possible to investigate the mechanism of the regulatory activities from the standpoint of economics is underdeveloped.

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2. PURPOSE OF THE ARTICLE

To analyze the impact of the normative regulatory sphere on business environment in Ukraine in order to identify shortcomings of the existing mechanism of the regulatory activities and prospects of its improvement on the current stage of economic development.

3. MAIN MATERIAL

Ukrainian law «About the principles of state regulatory policy in the field of economic activity» (hereinafter – Law) [3] is defined nine compulsory procedural steps of the regulatory activities. The first stage is the definition of the problem, which is expected to be solved by adopting certain RA, collection, compilation, analysis and systematization of the information available on this issue. The second phase is planning the preparation of the project of RA. The third phase is reasoning of RA, preparing its regulatory impact analysis (expert conclusion). The fourth stage is the development of the project RA and realization of basic tracking (to the effective date) of this project. The fifth stage is the proclamation of the report, project RA and its regulatory impact analysis (expert conclusion). The sixth stage is the work with the concerned subjects of the regulatory activity (receiving of the comments and suggestions for open discussion of the project RA). The seventh stage is the approval of the competent authority on the projects RA of legislative and governmental authority or relevant responsible standing committee of the state authority or responsible organizational unit of the executive authority (the executive office) of local council on the implementation of the regulatory policy for projects RA of the local governments. The eighth step is the adoption and official proclamation of RA. The ninth stage is the repeat (one year after the entry into force RA) and periodic (every three years) tracking of the effectiveness (achieving goals) RA and if it is necessary to review.

These procedural steps must comply with the principles of regulatory policy: expediency – a reasonable need for state regulation of the economy in order to solve the existing problems; adequacy – conformity of the forms an levels of the state regulation of the economy need to resolve existing problems and market requirements, taking into account all reasonable alternatives; efficiency – to ensure that the result of RA has maximum possible and positive results due to the minimum required expenditure of resources entities, the citizens (regulated entities) and the state; balance – ensuring regulatory balance of interests of the subjects and the state; predictability – a sequence of the regulatory, compliance with its public policy objectives and plans of preparation of the projects RA, which allows regulated entities to plan their activities; transparency and consideration of public opinion, to be open to regulated entities actions of government national economies (regulatory authorities) at all stages of their regulatory activities, needs

to review by the regulatory authorities initiatives comments and suggestions provided in the manner prescribed by law regulated entities, commitment and timely taken note of RA to regulated entities, informing them of the regulatory activities [3]. Thus, the meaning of regulation is to ensure respect for and protection of socially important interests of such activities.

Although the general principles of law created by constructing the system of the regulatory activities by the established range of economic subjects, unfortunately, the possibility of such a potentially powerful law into practice is not full, because there are unresolved issues that are in low quality of the implementing such a desired system in the ongoing activities of the regulators. This conclusion is supported by the data presented in Tab. 1.

Tab. 1. Indicators, characterizing the mechanism of the regulatory activities in Ukraine in 2012–2013 r. (summarized by the author on the basis of [4])

Indicators	2013	2012	Changes (+, -) in 2013 compared to 2012, %	Source
The number of developed and submitted for approval to the competent authority projects RA central authorities (CA), un.	2515	1792	+28,8	State Service of Ukraine on controlling the regulatory policy and developing of the enterprise [4]
The number of developed and submitted for approval to the competent authority projects RA local authorities (LA), un.	226	89	+60,6	
The total number of developed and submitted for approval to the competent authority projects RA CA and LA, un.	2841	1881	+33,8	
The number of failures of the authorized body on developed and submitted for approval of projects RA CA, un.	628	376	+40,1	
The number of failures of the authorized body on developed and submitted for approval of projects RA LA, un.	102	36	+64,7	
The total number of failures of the authorized body for developed and submitted for approval of projects RA CA and LA, un.	730	412	+43,6	
The number of projects agreed by the authorized body RA developed by CA, un.	1987	1416	+28,8	
The number of projects agreed by the authorized body RA developed by LA, un.	124	53	+57,3	

The total number of agreed projects of the authorized body RA developed by CA and LA, un.	2111	1469	+30,4	
The number of completed CA and LA measures for planning the preparation of RA, un.	1306	1185	+9,3	
The number of completed CA and LA measures for disclosure in the regulatory activities, un.	2432	1693	+30,4	
The number of submitted comments and suggestions of the regulated entities of projects RA, un.	938	282	+69,9	
The number of RA, which measures about tracking their effectiveness, un.	1226	817	+66,6	
The share of failures of the authorized body for developed and submitted for approval of projects RA CA and LA in the total number of developed and submitted CEB and MOVV for approval by the competent authority projects RA,%	25,7	21,9	+3,8	Author's development
The share of the number of planned projects RA CA and LA in the total number of developed and submitted CA and LA for approval by the competent authority projects RA,%	45,9 at optimum 100	78,1 at optimum 100	-32,2	
The share of the number of information disclosed in the regulatory activities in the total number of developed and submitted CA and LA for approval by the competent authority projects RA,%	85,6 at optimum 100	89,9 at optimum 100	-4,3	
The share of the number of RA, which measures about tracking their results, the total number of developed and submitted CA and LA for approval by the competent authority projects RA, %	43,2 at optimum 100	43,4 at optimum 100	-0,2	

In addition, the analysis of changes in terms of the mechanism of the state regulatory activities in Ukraine in 2013 allows the author to make the following conclusions:

1. There is a growth of the regulatory activity of CA and LA 33,8%.
2. The increase of the proportion of failures of the authorized body for developed and submitted for approval of projects RA CA and LA in the total number of developed and submitted CA and LA for approval by the competent authority projects RA 3,8%.

3. The decrease of not reaching 100%, as provided by law, the level of the implementation of CA and LA action by planning activities for drafting RA (-32,2%).
4. The decrease of the level of the implementation of CA and LA measures for disclosure in the regulatory activities (-4,3%), which also is not good [3] 100% level, while increasing requests of the regulated subjects with comments and suggestions projects RA CA and LA to 69,9%.
5. The decrease of the optimal level of 100% [3] level of performance CA and LA measures to monitor the impact of RA (-0,2%).

The idicators, which are given above and the conclusions, which are made on the basis of their findings, suggest low controllability of outcomes of the government regulation in Ukraine spheres of economic activity of the national economy on the part of the authorized body, so also of the initiators of the introduction of such regulations.

Thus, the ordering mechanism of the regulatory activities is incomplete and lead to the formal implementation of the regulatory legislation, making unreasonable or inefficient RA.

Given this, there is a need for a new qualitative level of understanding of evaluating the effectiveness of the implementation of its actors (government, business and citizens) of the regulatory activities and find effective evaluation technologies in the interaction of these actors in addressing RA, which affect on the development of social and economic processes in Ukraine.

Category of the entrepreneurship has always been the most vulnerable to a number of external stimuli, including the regulatory component to create the conditions for its operation. The criteria of the development and success of the state in shaping regulatory policy by the state is the number of applicants to do business. Consider and analyze for years 2004–2014 information on the number of adopted legal acts (RegAct) regulating the business environment in Ukraine and quantitative status of state registration (registered number, the number of subjects who discontinued business and the number of subjects not suspended) in Ukraine (Fig. 1).

Since the beginning of the laws of the regulatory policies implemented in phases: the first phase (2004–2011) – deregulation (detection and simplify the regulation of economic activity); the second phase (2012–2014 (till now) – improving the quality of regulations (development of efficient and low-cost qualified regulations of the economic activity, improvements of the regulatory activities and access to adjustments), the third stage (not implemented) – regulatory management (management of the regulatory effects, establishing aof the frameworks and improving of the regulatory flexibility) [7].

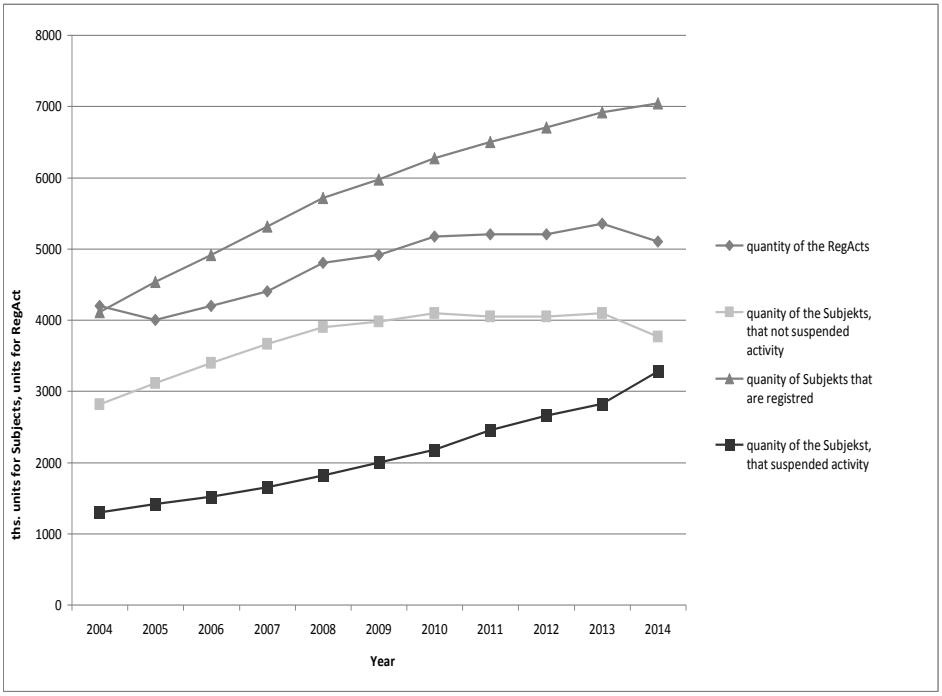

Fig. 1. Dynamics of changes in the number of RegAct governing the business environment in Ukraine and quantitative status of the state registration of business entities (collect by the author and based on [5; 6])

In view of Fig. 1 it can be argued that the first and the second stages of the regulatory policy in Ukraine, which took place in periods characterized by the development of national economy: 2004–2008 - before the crisis; 2008–2014 (until today) – post-crisis period, there is a dynamic relationship of the number of RegAct, regulating the business environment in 2004–2014, the number of subjects is not terminated and the number of subjects that ceased business in these periods.

The unidirectional relationship of the dynamics number of RegAc is graphically depicted in Fig. 1, regulating the business environment in 2004–2014, the number of subjects is not suspended and diverging from the number of subjects who discontinued business, can be explained by the fact that every year the becoming business environment in Ukraine recorded its qualitative transformation of the crystallization of the market environment through consolidation in certain market niches permanent market participants. This means that the subjects are established on the national market with strong economic ties to the modern economic system of Ukraine. That existing mechanisms for the interaction between economic markets are gradually becoming established. But existing normative regulatory sphere, which positively affects on the activity of economic subjects - not suspended subjects (see Fig. 1), makes it impossible to enter the

domestic market by new subjects (see ibid.), that is contribute to an increased number of market subjects, why any state doesn't win (shortfall in budgets of different levels of taxes and duties of such subjects) or citizens don't win too (increase through the established mechanism of competition in the areas of economic activity of the national economy consumer spending).

As a result of correlation analysis of the indicators given above for the entire study period 2004-2014 found that the correlation coefficient figure of RegAct, regulating the business environment in 2004-2014., and the number of subjects is still running 0,89, and the number of RegAce, and the number of subjects which discontinued the enterprise in 2004-2014 – 0,86. Thus, the impact of the normative regulatory environment for quantitative performance of businesses is significant. The estimated coefficients of the determination of these parameters (0,79 and 0,74) show that the pace of business activity subjects up to 80% depends on a statutory regulatory field of the financial and organizational conditions for the functioning of economic sectors of the national economy, and the fate of other factors (solvency of the population, economic globalization, etc.) account for 21–25%.

4. CONCLUSIONS

Thus, at the current stage of the economic development of Ukraine state regulation of the economic activity sectors of the national economy is not to abolish existing legal acts on the entreprise and making new documents, but in finding the effective technologies with the relationship between the process of the regulatory activities in the modernization of existing Ukraine model mechanism of the regulatory activities or in other words: the construction of the mechanism of informational relationship of the subjects in the regulatory activity.

The important thing is the methodology of selection tools and levers of the mechanism of information relations in the regulatory activity. Methodological basis of this mechanism is situational and systemic approaches. Methodology mechanism of information relations in the regulatory activities should be based on the use of dependency that has already developed, taking into account characteristics of the processes taking place, eliminating contradictions.

It is important to emphasize in the conceptual aspect that the information relationships in the regulatory activity requires formation (development) or improvement. You should distinguished formation (development) mechanism of its improvement. The improvement means the improving of individual elements or characteristics of the current system or its components, which should lead to increased efficiency of the system. Therefore, the formation (development) mechanism should be seen as a process of gradual transition from the current state to another, better. Moreover, the characteristic transformation occurring in the functioning of the whole or regulation as a process; qualitatively new elements are introduced to encourage respond in some way other components of the system [8].

Considering the dynamic object, on which the state regulation of the economy is directed (the process of the regulatory activities), the formation (development) of the mechanism of information relations in the regulatory activities directly related to its improvement, that is about the same time, that further actualizes the subject of our research.

The main driving forces on the formation (development) of the mechanism of information relations in the regulatory activity at the present stage of socio-economic development and the creation of an information society in Ukraine are:

1) the natural opportunities for growth and development of the mechanism of information relations in the field of the regulatory activity, since this mechanism is yet at the stage of development and is being tested;
2) the specificity of the regulatory activity that requires the creation and formation of the mechanism of multilateral relations of business information;
3) the environmental conditions that are constantly changing;
4) the achievement of the international experience and the search associated with it and the introduction of new instruments of the state regulation of information relations in the regulatory activities that have proven its effectiveness in the international practice.

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energetic efficiency, biofuel production, energetic plantations, EROEI

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EFFECTS OF FIELD'S TOPOLOGY ON ENERGETIC EFFICIENCY OF RAPESEED PLANTATION FOR BIOFUEL PRODUCTION

Abstract

The model, developed earlier, have been designed to the studies of energy gain in the biofuels production, as compared to the sum of energy inputs on various production steps, and in processes enabling biomass conversion to energy. The present paper shows application of that model towards estimation of the contribution of energy used for commuting between agricultural production sites for a chosen example of plantation's topological characteristics. Algorithm for computations is elaborated, and numerical example is shown. The sizes of the fields as well as distances between them determine the amount of energy spend for the agricultural work in addition to the tillage technologies being applied.

1. INTRODUCTION

Problems connected with the use of various types of biomass as the source of energy are widely discussed in literature [1–6]. Among others, the energy balance consisting of energy inputs to the biofuel production as compared to the energy gain was also considered [7–9]. Some of the papers have taken into account also transportation terms [9, 10] as well as embedded energy content in agricultural machines and transportation means. Tis matter was also discussed in earlier papers written by present Authors [11–13], but in the actual analysis it was temporarily neglected. In earlier papers, mentioned above, present Authors have published a theoretical model of energetic efficiency of agricultural plantation designed for production of biomass for biofuels. The model includes the most important contributions to energy efficiency, and permits calculations for any

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practical situation, as well as analysis of some dependencies. Although transporttation terms corresponding to commuting between fields, and between fields and external sites e.g. industrial ones, have been incorporated in the above model – general conclusions are possible only in limited scope, and conclusion was made that particular solutions have to be established for clearly specified field topologies. This task, based upon computer simulation, is a subject of the present work.

The aim of the present work is to estimate effects of energy inputs into subsidiary processes enabling production e.g. agricultural operations, transportation of machinery, and goods between fields as well as from the fields to the external industrial sites, on the energy efficiency of plantation (practically defined in analogous manner as EROEI).

2. THE METHOD

An algorithm for numerical computations have been elaborated and implementted as well as computations were performed under specific assumptions with respect to plantation's topology. The program is quite general and "elastic" enabling computations for different topologies. Fig. 1 presents a flow chart of the program involving one agrotechnical operation subsequently for all fields considered. (index *n* numbers the fields, while index *k* numbers the subsequent days (when it is relevant – it is assumed that working time cannot exceed t_{max}. When t_{max} is reached work is terminated for the particular day, and machines drive to the base, and return next day, the corresponding route is added to the distance D_{out}). In the present computations we have adopted 5 identical fields, and operations performed in identical configurations of the machines, maximum working time is specified as t_{max}=10h. Consequently, the values of the total distances driven, as well as energy spend for all operations, both depend upon a number of operations. The results presented in the tables 1–11, and figures 1–4 concern only one agrotechnical operation, therefore:

$$\eta_1 = \frac{E_{bio}}{(E_{out}+E_{agr})_1} \tag{1}$$

where: η_1 – is efficiency for one operation,
E_{bio} – is energy obtained in form of biofuel,
E_{agr} – is energy used for agricultural operation 1,
E_{out} – is energy spend for driving outside the fields associated with operation this particular operation.

Since it is assumed that all operations are performed in identical manner, the global energy efficiency for all *I* operations can be obtained as follows:

$$\eta_{tot} = \frac{E_{bio}}{\sum_{i=1}^{I}\left(E_{out}+E_{agr}\right)_i} \tag{2}$$

Therefore the efficiency for all *I* operations equals:

$$\eta_{tot}=\eta_i/I \tag{3}$$

In general, algorithm permits computations to be performed for linear structure of the production system with the topology of the fields shown on Fig. 2. The algorithm can be easily modified to be used for other structures e.g. star-like, etc. It represents a number of fields separated by some distances from each other, and separated from the main base. Dimensions of the fields, as well as distances between them are being introduced as primary data. Also the width of strip of land being elaborated during single ride, and velocity of the machine, is given for each of the agricultural operations.

As it was mentioned earlier the daily allowed distance, is computed as the product of allowed working time, t_{max}, and velocity of the machine. The t_{max} was assumed 10 hours, and velocity 6 km/h.

Energies consumed are computed basing on the distance driven and fuel consumption. Energy obtained from the field is estimated on the basis of crop yield from the unit area of field and fuel yield from the unit of mass of the crop.

At this stage of calculations the fuel yield is taken as an industrial average without distinguishing processing technology. Two values of the biofuel yield obtained from rapeseed grain related to the unit area of plantation (ha = hm^2) were accepted: a very small one that equals to 380 l/ hm^2, and much higher amounting to 1500 hm^2, which correspond to very efficient plantation. Values of energy required for agricultural operation, E_{agr}, as well as values of energy needed for transportation between fields, E_{out}, were computed using the values of average fuel consumption equal C=0,3 dm^3/km, and low caloric value of the fuel equal W_{fuel}=36MJ/dm^3.

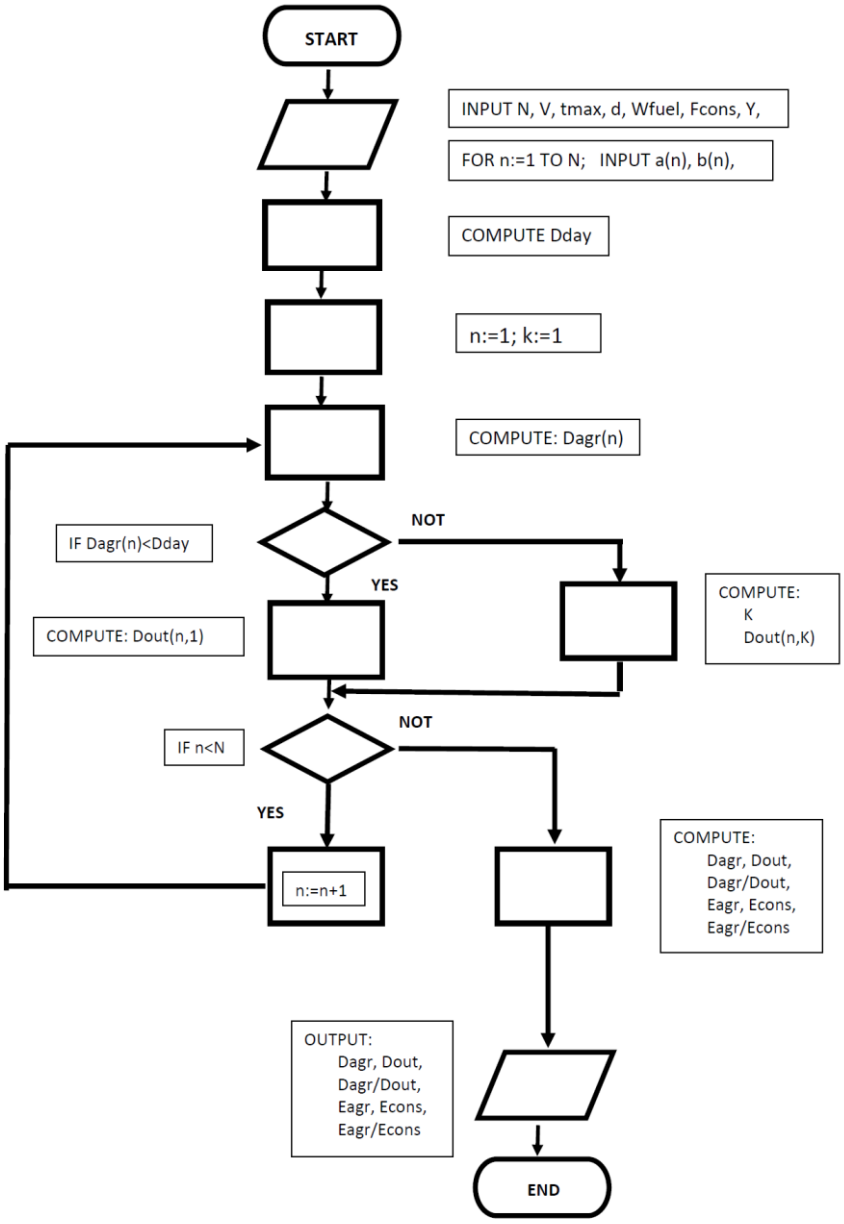

Fig. 1. Flow chart of computation algorithm for one operation [source: own study]

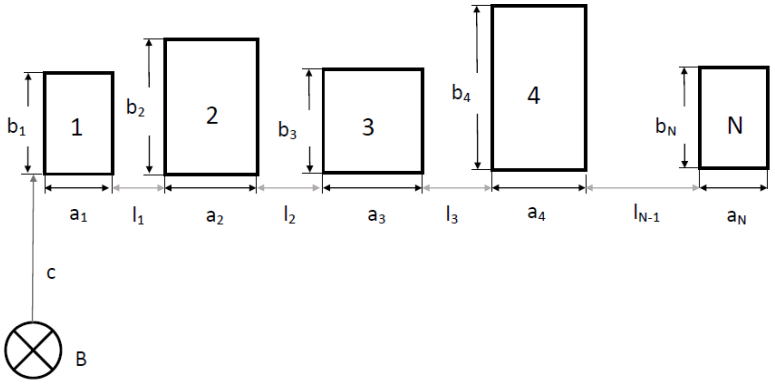

Fig 2. Field's topology (symbols denoting distances are indicated) [source: own study]

Computations were performed for the example consisting rapeseed plantation built of five fields of equal area, separated by equal distances. Several cases of plantation sizes and distances were considered. The initial data for computations are presented in Table 1.

Tab. 1. Values of parameters taken into computations [source: own study]

v= 6 km/h t_{max}=10 h						
$1 \leq i \leq n$ $a_i = b_i$						
n=5	a_i= 0,1 km			a_i = 0,5 km		
n=5	b_i= 0,1 km			b_i = 0,5 km		
c [km]=	1	5	10	1	5	10
l [km] =	0,2	0,2	0,2	0,2	0,2	0,2
l [km] =	0,4	0,4	0,4	0,4	0,4	0,4
l [km] =	0,6	0,6	0,6	0,6	0,6	0,6
l [km] =	1	1	1	1	1	1

3. RESULTS FOR RAPESEED PLANTATION

Results of computations indicate that obviously the distance driven on the fields depends upon the area of the field and the width of operation strip. The total distance, D_{agr}, driven on the fields for the case of field's area A=0,01 km^2, and strip width 4m equals to 12,5 km, while for the strip width 0,5m equals to 100 km. Similar calculation for the individual field size equal to 0,25 km^2 gives the total distance, D_{agr} , equal to 312,5 km for the strip width 4 m, and 2500 km for the strip width 0,5 m. It is clearly seen that the choice of working equipment seriously affects the driven distance.

Table 2. presents results of computations of distance outside of the fields D_{out} for the system of 5 identical fields, each of surface area, A, separated from themselves by a distance, *l*, and separated by the distance, *c*, from the base to the first field, and for working width equal to d = 4m. Two plantations are compared with sizes of individual fields each equal to 0,01 km^2 (1 hectare), and 0,25 km^2 (25 hectares).

The distances outside of the field obviously increase when the distances separating fields increase. It is also visible that those distances depend upon the size of the field. This dependence results of the need to return to the base after the allowed working time is reached, and next day drive again to the point where work stopped day before.

Tab. 2. Values D_{out} (in km) for the case when working width is d = 4m [source: own study]

A_i[km^2]=	0,01			0,25		
c = / *l* [km]	1	5	10	1	5	10
0,2	2,6	6,6	11,6	17,7	43,3	75,3
0,4	3,2	7,2	12,2	20,0	45,6	77,6
0,6	3,8	7,8	12,8	22,4	47,9	79,9
1	5	9	14	27	52,6	84,6

Fig 1. shows the ratio of distances driven inside and outside of the plantation composed of 0,01 km^2 (1 hectare) fields for the case when operation width was assumed 4 m as function of the distances between fields and upon the distance between the base and the first field. The ratio $\underline{D_{out}}/\underline{D_{agr}}$ assumes values between about 0.2 and 1.12, being affected by both distance between fields and the distance from the base. The later seems to show more pronounced effect.

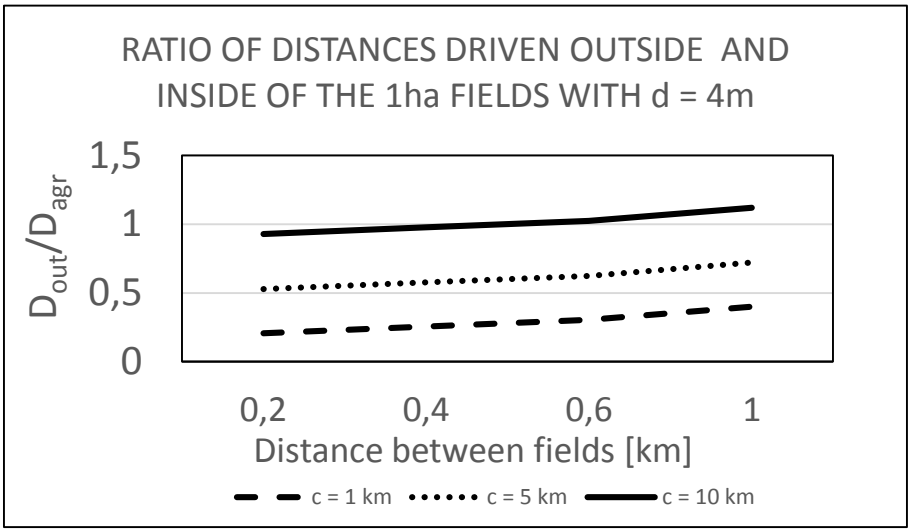

Fig. 1. Computed ratio of distances driven outside and inside of the plantation in the case when operation width was assumed 4 m [source: own study]

Similar results for the individual field size equal to 0,25 km^2 (25 hectare) are shown in fig. 2. In this case the values of the ratio $\underline{D_{out}/D_{agr}}$ are between 0,057 and 0,271. These values are smaller than previous ones, and do not exceed value of one. In this case there are also slightly dependent upon distances between fields, and rather stronger depend upon the distance between base and the first field.

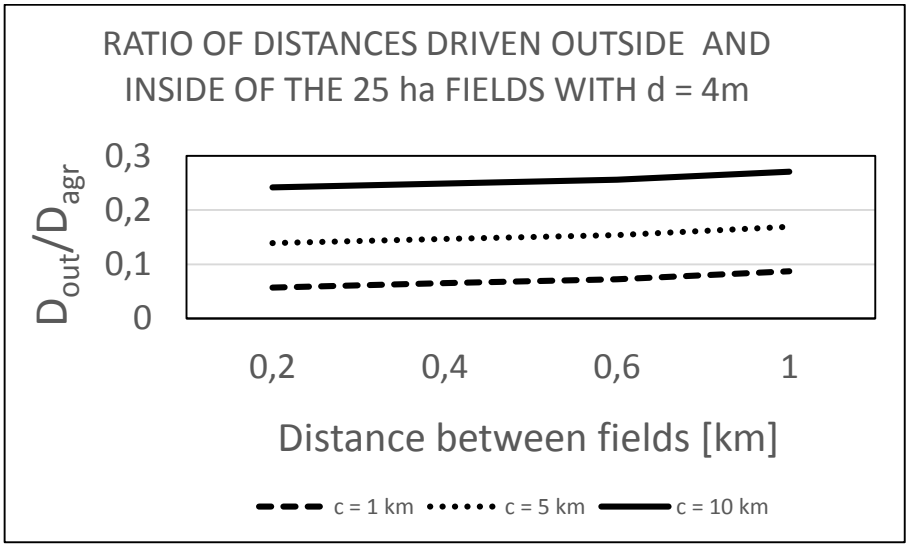

Fig. 2. Computed ratio of distances driven outside and inside of the plantation [source: own study]

Table 3. in turn, presents results for the case when the working width is 0.5 m. It is clearly seen that bigger field area contributes to substantial increase of D_{out}. The distances driven outside the larger fields are much higher than those for the small field area.

Tab. 3. Values D_{out} for the case when working width is d = 0,5m [source: own study]

A_i[km^2]=	0,01			0,25		
c = / l [km]	1	5	10	1	5	10
0,2	2,4	6,4	11,4	92,2	234,6	412,6
0,4	2,8	6,8	11,8	103,3	245,7	423,7
0,6	3,2	7,2	12,2	114,3	256,7	434,7
1	4	8	13	136,5	278,9	456,9

Such an increase of D_{out} with the increase of field area results of the necessity of return to the base after daily allowed working time is reached. The plots of D_{out}/D_{agr} presented in fig 3 and fig. 4 show similar shape of dependencies (a slight increase with the distance between fields, as well as an increase with increasing distance from the base). In this case there is no substantial difference beteween the values observed for different sizes of individual fields in the plantation. The values of $D_{out}/D_{agr,}$ in both cases are smaller than one. This result is mostly due to the high distance driven on the field when the working width is small (0,5m) – with respect to which the distances outside the fields do not contribute too much.

The most important question in this work concerns the amount of energy consumed during agricultural, and transportation operations as compared to the amount of energy obtained in the form of biofuel. Obviously, the amount of energy spend during plants cultivation depends upon the distance driven in, and outside the fields. Consequently it depends on the same factors as the distances driven. The amount of energy obtained from the field is easy to estimate from the crop yield (and also depends upon efficiency of the industrial system, which is not analysed in the paper), for which, two limiting values are accepted. Values of energy consumption by various machines, as well as possible field yields are taken from literature and practical sources of information [14–17]. An estimate of energy spend on driving the distances outside the fields for the case when working width is 4m, is given in Table 4.

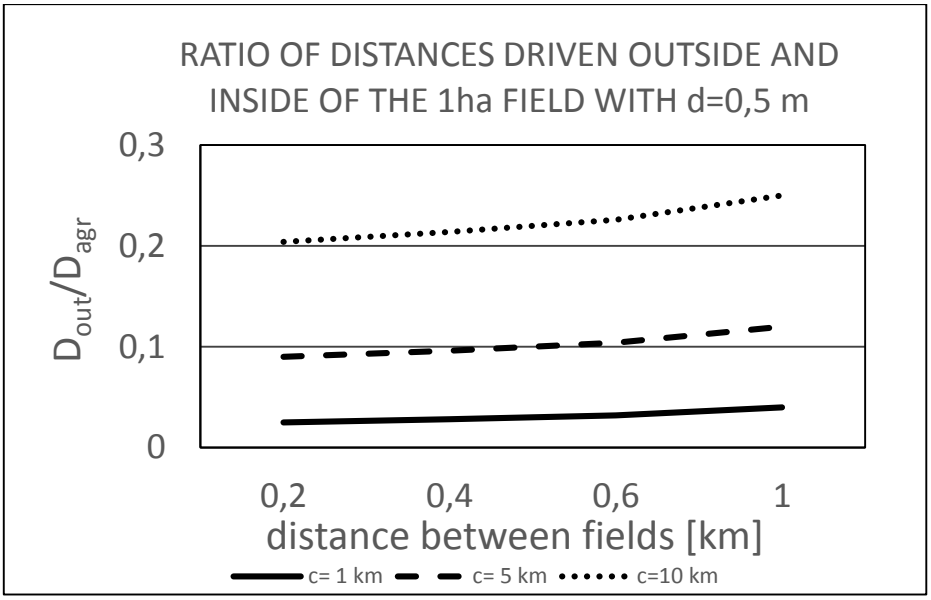

Fig. 3. Computed ratio of distances driven outside and inside of the 1hm^{2}field in the case when operation width was assumed 0,5 m [source: own study]

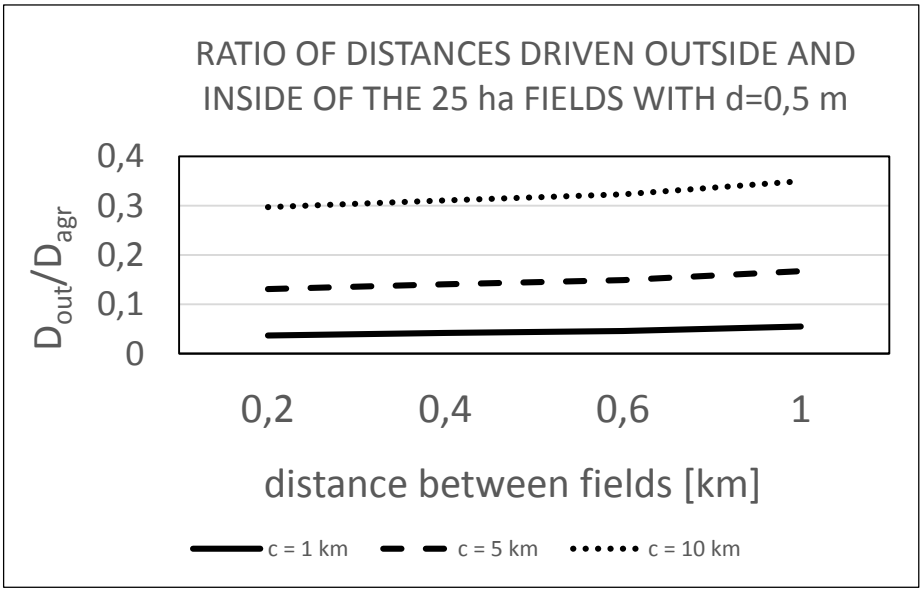

Fig. 4. Computed ratio of distances driven outside and inside of the 25hm^{2}field in the case when operation width was assumed 0,5 m [source: own study]

Tab. 4. Energy, E_{out} [MJ], spend for movements outside for the case when working width is d = 4m [source: own study]

A =	0,01			0,25		
c = / l [km]	1	5	10	1	5	10
0,2	28,1	71,3	125,3	191,4	467,9	813,4
0,4	34,6	77,8	131,8	216,4	492,9	838,5
0,6	41,1	84,2	138,2	241,5	517,9	863,6
1	54	97,2	151,2	291,6	568,1	913,7

It is seen, that the energy, E_{out}, spend outside the fields depends on both distances, *l* – between fields, and *c*- distance from the base, and first of all depends upon the size of fields. Again, this later dependence can be rationalized as the result of returns after the allowed working time is reached.

Similar results for the working width equal to 0,5m are presented in Table 5. For both sizes of plantation the energy spend outside of the fields depends on the distances between fields and the distance from the base. The biggest effect is, however, produced by field's size, which again can be interpreter as being due to returns after daily allowed working time limit is reached. The number of days, and consequently the number of returns is much higher when narrow strip is elaborated – what substantially increases the distance driven outside the fields.

Tab. 5. Energy, E_{out} [MJ], spend for movements outside of the fields for the case when working width is d = 0,5m [source: own study]

A =	0,01			0,25		
c = / l [km]	1	5	10	1	5	10
0,2	25,9	69,1	123,1	995,5	2533,5	4455,9
0,4	30,2	73,4	127,4	1115,2	2653,1	4575,5
0,6	34,6	77,8	131,8	1234,9	2772,8	4695,2
1	43,2	86,4	140,4	1474,2	3012,1	4934,5

Tables 6 and 7 give the sum of energy spend during operating on the field and energy spend during driving outside fields. Values presented in Table 6 show not very strong dependence upon the distance between fields, *l*, as well as upon the distance, *c*. Important difference is visible when values for small plantation is compared to values for large one. The later values are much higher. This difference is much more pronounced in the case of the narrow width of working strip (table 7).

Basing on the values presented in above tables the energetic efficiency for individual agro-technical operation is computed according to eq. 1.

Tab. 6. Sum of energies, E_{out} and E_{agr}, spend for individual agrotechnical operation for the case when working width is d = 4m [source: own study]

A =	0,01			0,25		
c = / l [km]	1	5	10	1	5	10
0,2	164	207	261	3567	3843	4189
0,4	170	213	267	3592	3868	4214
0,6	177	220	274	3617	3893	4239
1	189	233	287	3667	3944	4289

Tab. 7. Sum of energies, Eout and Eagr, spend for individual agrotechnical operation for the case when working width is d = 0,5m [source: own study]

A =	0,01			0,25		
c = / l [km]	1	5	10	1	5	10
0,2	1106	1150	1204	27996	29534	31456
0,4	1111	1154	1208	28116	29654	31576
0,6	1115	1158	1212	28235	29773	31696
1	1124	1167	1221	28475	30013	31935

Tab. 8. Ratio of energy contained in biofuel to the sum of energies, E_{out} and E_{agr}, spend for individual agrotechnical operation for the case when working width is d = 4m. The case of field yield 380 dcm^3/hm^2 [source: own study]

A =	0,01			0,25		
c = / l[km]	1	5	10	1	5	10
0,2	403	318,7	252,6	460,7	427,6	392,3
0,4	387,6	308,9	246,4	457,5	424,8	390
0,6	373,4	299,8	240,6	454,4	422,1	387,7
1	347,8	283,1	229,7	448,2	416,7	383,2

Tab. 9. Ratio of energy contained in biofuel to the sum of energies, E_{out} and E_{agr}, spend for individual agrotechnical operation for the case when working width is d = 0,5m. The case of field yield 380 dm^3/hm^2 [source: own study]

A =	0,01			0,25		
c = / l [km]	1	5	10	1	5	10
0,2	59,5	57,2	54,7	58,7	55,7	52,3
0,4	59,2	57	54,5	58,5	55,5	52,1
0,6	59	56,8	54,3	58,2	55,2	51,9
1	58,6	56,4	53,9	57,8	54,8	51,5

In these computations two values of energy yield from plantation, E_{bio}, are taken into account. Those are 380 dcm^3/hm^2 and 1500 $dcm^3/hm^{2.}$. Results for the case of low yield of plantation are presented in Tables: 8 and 9 giving data computed for working width 4m and 0,5m correspondingly. The resulting η_1 values vary from about 230 to about 460 for various combinations of parameters in the case of 4m wide working strip. Similar results for the case of 0.5m strip width give much lower values between about 54 and about 60.

Tab. 10. Ratio of energy contained in biofuel to the sum of energies, E_{out} and E_{agr}, spend for individual agrotechnical operation for the case when working width is d = 4m. The case of field yield 1500 dcm^3/hm^2 [source: own study]

A =	0,01			0,25		
c = / l [km]	1	5	10	1	5	10
0,2	1591	1258	997	1819	1688	1549
0,4	1530	1220	973	1806	1677	1540
0,6	1474	1184	950	1794	1666	1531
1	1373	1118	907	1769	1645	1513

Values of η_1 obtained for the other extreme case, of high crop yield equal to 1500 dcm^3/hm^2, and working width equal to 4 m, as indicated in Table 10, vary from around 900 to around 1800, depending on plantation structure (fields sizes, and distances between them). Corresponding values of efficiency η_1 are bigger for larger fields. As it is seen in Table 11, the values of efficiency for the case of working width 0,5m are much smaller than those for 4m operation width, and also the differences between different field's sizes, and inter-field distances are much less pronounced.

Tab. 11. Ratio of energy contained in biofuel to the sum of energies, E_{out} and E_{agr}, spend for individual agrotechnical operation for the case when working width is d = 0,5m. The case of field yield 1500 dcm^3/hm^2 [source: own study]

A=	0,01			0,25		
c = / l [km]	1	5	10	1	5	10
0,2	235	226	216	232	220	207
0,4	234	225	215	231	219	206
0,6	233	225	215	230	218	205
1	231	223	213	228	217	204

It was mentioned earlier that computations performed according to eq. 1 give the values of efficiency, η_1 ,corresponding to full yield of fuel, but only one agro-technical operation performed during cultivation of plants. It is never the case in real situations. Usually several tillage operations are necessary. Each of operations might require assumption of different conditions concerning e.g. working width, fuel consumption etc. For the case of simplicity, in the present paper, it was assumed that the same conditions are applied in all operations. Therefore eq. 3 could be used for estimation of final result. The examples of results of computations of energy efficiency, η, as function of a number of operations, for both cases, of field's yields, and for chosen sets of parameters of operations are given in Tables 12 and 13. Obviously results presented in those tables are smaller than those given in previous tables. Evidently the yield of plantation contributes very strongly to the efficiency. The higher the crop yield, the higher is the efficiency η. An increase of the number of operations evidently decreases efficiency. Strong effect is also shown by a decrease of technological parameter, e.g. width of working strip (determining machine's productivity), which also causes a decrease of efficiency. Characteristics of the plantation also play a role in defining efficiency. Factors, like field size, distances between fields or distance from the base show evident (10% to 40%), but less pronounced effects than the above mentioned (crop yield and productivity of the machinery).

Tab. 12. Comparison of the ratio of energy contained in biofuel to the sum of energies, E_{out} and E_{agr}, as a function of the number of operations, for the case when working width is d = 4m, and field yields 380 dcm^3/hm^2 and 1500 dcm^3/hm^2 [source: own study]

Strip width= 4 m	**Field yield = 380**					
A=	0,01			0,25		
c=	1	5	10	1	5	10
l [km]=0,2	403	318,7	252,6	460,7	427,6	392,3
Number of operations						
2	202	160	127	231	214	197
3	135	107	85	154	143	131
4	101	80	64	116	107	99
5	81	64	51	93	86	79
Strip width= 4 m	**Field yield = 1500**					
A=	0,01			0,25		
c=	1	5	10	1	5	10
l [km]=0,2	1591	1258	997	1819	1688	1549
Numer of operations						
2	796	629	629	910	844	775
3	531	420	420	607	563	517
4	398	315	315	455	422	388
5	319	252	252	364	338	310

Tab. 13. Comparison of the ratio of energy contained in biofuel to the sum of energies, E_{out} and E_{agr}, as a function of the number of operations, for the case when working width is d = 0,5m, and field yields 380 dcm^3/hm^2 and 1500 dcm^3/hm^2 [source: own study]

Strip width= 0,5 m	**Field yield = 380**					
A=	0,01			0,25		
l [km]/c=	1	5	10	1	5	10
0,2	59,5	57,2	54,7	58,7	55,7	52,3
Number of operations						
2	30	29	28	30	28	27
3	20	20	19	20	19	18
4	15	15	14	15	14	14
5	12	12	11	12	12	11
Strip width= 0,5 m	**Field yield = 1500**					
A=	0,01			0,25		
l [km]/c=	1	5	10	1	5	10
0,2	235	226	216	232	220	207
Number of operations						
2	118	113	108	116	110	104
3	79	76	72	78	74	69
4	59	57	54	58	55	52
5	47	46	44	47	44	42

4. CONCLUSIONS

Presented result show that amount of energy obtained from biofuel might substantially exceed the sum of energy, which is needed as inputs to facilitate processes of biomass production and conversion to energy. The effectiveness of the biofuel production system is defined as a ratio of energy obtained in form of biofuel to the sum of energy inputs in all subsidiary processes enabling biomass production and its conversion to the biofuel. The present work is confined to the investigation of agricultural subsystem, while the industrial one is considered as constant represented by industrial average. According to the model presented, this effectiveness varies from 10-th to several hundreds depending on various characteristics of the system and ongoing processes. Among those characteristics the main effect is shown by productivity of agricultural machines, and the biofuel yield from the unit of plantation. Although the dependence between biofuel yield and types of agricultural operations might exist, but the data are scarce, and consequently it rather requires further studies. Therefore in this work two extreme values were accepted for computations, giving chance to estimate limiting values characterizing the effect. Variation of the other parameters, characterizing the structure of plantation (in this case assumed as linear one) affect the resulting effectiveness in the range of 10% to 40%. depending on the actual case. One of the phenomena that play substantial role is the dependence of the total distance driven outside of the fields upon the size of the fields, and operational width. This dependence results on the assumption that machines return to the base after allowable working time is reached. The other assumption concerning organization of the work e.g. machines remain on the field, and only people are transported to the base, would bring somehow different results. The expected differences should not be extremely large, since they would be a part of those effects estimated here as being between 10% to 40%. Also changing the structure of plantation to e.g. star-like could bring some differences in the results. Consequently, optimization of the agricultural part of biofuel production system should first of all include proper choice of performance of machinery, assuring as high as possible specific yield of the fields as well as reasonable engineering of work organization and transportation of goods. Some other aspects like industrial sub-system itself and coupling between agricultural and industrial subsystems will be the topic of separated studies.

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“Ghostwriting” and “guest authorship”

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