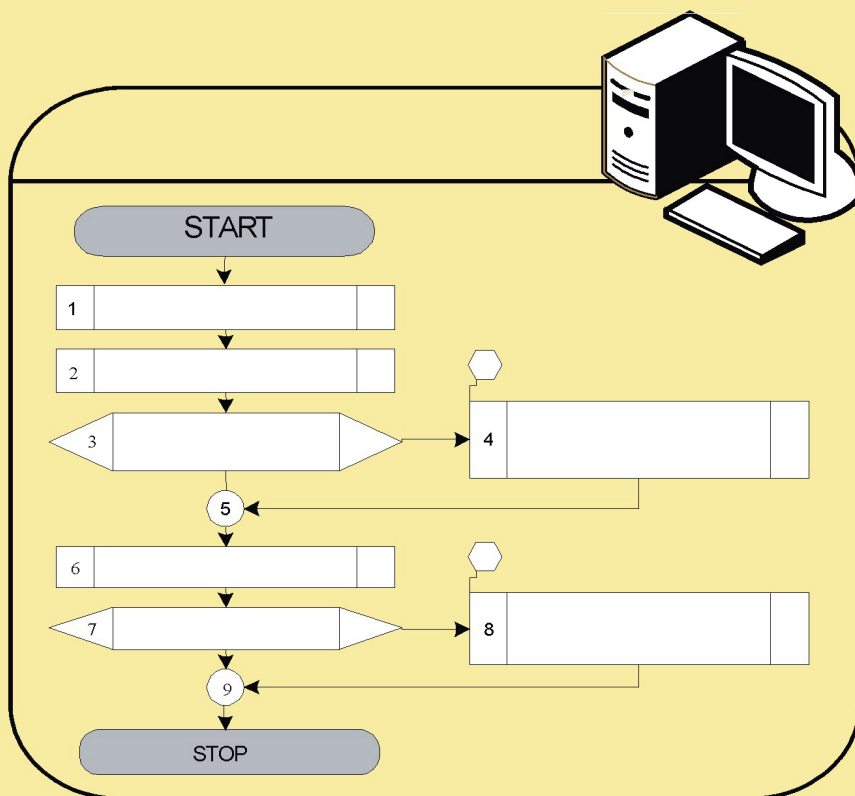


APPLIED COMPUTER SCIENCE

Vol. 10, No. 2, 2014



LUBLIN UNIVERSITY OF TECHNOLOGY

INSTITUTE OF TECHNOLOGICAL SYSTEMS OF INFORMATION

Scientific Board

Antoni Świć

Chair of Scientific Board

Lublin University of Technology, Poland

Zbigniew Banaszak

Deputy Chair of Scientific Board

Warsaw University of Technology, Poland

Józef Matuszek

Deputy Chair of Scientific Board

University of Bielsko-Biala, Poland

María del Carmen Alarcón del Amo

Universidad de Castilla-La Mancha, Albacete, Spain

Josef Basl

University of Economics, Czech Republic

Grzegorz Bocewicz

Koszalin University of Technology, Poland

Krzysztof Bzdrya

Koszalin University of Technology, Poland

María Cordente Rodriguez

Universidad CEU - San Pablo, Spain

Milan Gregor

University of Žilina, Slovakia

Mikuláš Hajduk

Technical University of Kosice, Slovakia

Henning Heuer

Technische Universität Dresden, Germany

Alexandr Jakimovic

Minsk State University of Technology, Byelorussia

José Mondéjar Jiménez

Universidad de Castilla-La Mancha, Cuenca, Spain

Martin Krajčovič

University of Žilina, Slovakia

Grzegorz Kłosowski

Lublin University of Technology, Poland

Emil Manoach

Bulgarian Academy of Science, Bulgaria

Egon Müller

Chemnitz University of Technology, Germany

Janusz Mleczko

University of Bielsko-Biala, Poland

Aleksander Moczala

University of Bielsko-Biala, Poland

Izabela Nielsen

Aalborg University, Denmark

Bogdan Palczewskij

Lutsk State University of Technology, Ukraine

Dariusz Plinta

University of Bielsko-Biala, Poland

Maria Reyes González

University of Alicante, Spain

Carlota Lorenzo Romero

Universidad de Castilla-La Mancha, Albacete, Spain

Jiri Tupa

Westbohemian University Pilsen, Czech Republic

Ali Türkyilmaz

Fatih University, Turkey

Walter Terkaj

National Research Council, Italy

Editorial Board:	Arkadiusz Gola (Editor-in-Chief, Secretary of the Scientific Board) Jakub Szabelski (Editorial secretary) Dariusz Wołos (Editorial secretary) Lukasz Sobaszek (DTP specialist) Daniel Gaska (Webmaster)
Redaction Board:	Bożena Skołud - Computer Science in Production Engineering (Subject Redactor) Zbigniew Pastuszak - Computer Science in Economy and Management (Subject Redactor) Marek Janczarek - Computer Science in Technology (Subject Redactor) Alex Bodnar - English Instructor at Kyushu University, Japan (Language Redactor) Paweł Zaprawa (Statistical Redactor)
Publisher:	Institute of Technological Systems of Information, Lublin University of Technology
Editorial Office:	„Applied Computer Science” Editorial Office 20-618 Lublin, ul. Nadbystrzycka 36, Poland Tel.: (+48 81) 538 44 83 Fax.: (+48 81) 538 46 81 e-mail: acs@pollub.pl www.acs.pollub.pl
Circulation:	100 copies (the digital version is available at the journal's website: www.acs.pollub.pl and at Digital Library of Lublin University of Technology: www.bc.pollub.pl)

APPLIED COMPUTER SCIENCE

The Journal is a peer-reviewed, international, multidisciplinary journal covering a broad spectrum of topics of computer application in production engineering, technology, management and economy.

The main purpose of Applied Computer Science is to publish the results of cutting-edge research advancing the concepts, theories and implementation of novel solutions in computer technology. Papers presenting original research results related to applications of computer technology in production engineering, management, economy and technology are welcomed.

We welcome original papers written in English. The Journal also publishes technical briefs, discussions of previously published papers, book reviews, and editorials. Especially we welcome papers which deals with the problem of computer applications in such areas as:

- manufacturing,
- engineering,
- technology,
- designing,
- organization,
- management,
- economics,
- innovations,
- competitiveness,
- quality and costs.

The Journal is published quarterly and is indexed in BazTech. Publication in Applied Computer Science is free of charge. Letters to the Editor-in-Chief or Editorial Secretary are highly encouraged.

CONTENTS

Andriy BERKO, Victoria VYSOTSKA, Lyubomyr CHYRUN FEATURES OF INFORMATION RESOURCES PROCESSING IN ELECTRONIC CONTENT COMMERCE.....	5
Radosław WICHNIAREK, Filip GÓRSKI, Wiesław KUCZKO APPLICATION OF ADDITIVE TECHNOLOGY OF FUSED DEPOSITION MODELING FOR MANUFACTURING SMALL SERIES OF ELASTIC MODELS.....	20
Svetlana RATNER, Pavel RATNER INTERACTIVE CALCULATOR FOR ASSESSMENT OF THE STRUCTURE OF ENERGY CONSUMPTION.....	32
Arkadiusz GOLA, Łukasz SOBASZEK IMPLEMENTATION OF MS ACCESS SOFTWARE FOR CASING-CLASS MANUFACTURING FEATURES SAVING.....	44
Natalya SHAKHOVSKA, Roman NOHA THE SYSTEM DEVELOPING OF FORMING RESEARCH SCHOOLS BASIS OF PUBLICATION ELEMENTS ANALYSIS.....	57
Olga ORYNYCZ, Andrzej WASIAK EFFECTS OF TILLAGE TECHNOLOGY ON ENERGETIC EFFICIENCY OF RAPESEED PLANTATION FOR BIOFUEL PRODUCTION.....	67

Andriy BERKO^{}, Victoria VYSOTSKA^{**}, Lyubomyr CHYRUN^{***}*

FEATURES OF INFORMATION RESOURCES PROCESSING IN ELECTRONIC CONTENT COMMERCE

Abstract

Some solutions of main problems of content e-commerce and content management services are described in the paper. Content lifecycle model in electronic commerce systems is considered. The model gives an opportunity to create effective tolls of information resources processing in electronic commerce systems and to implement the subsystem of commercial content formation, management and support.

1. INFORMATION

The electronic content commerce systems (ECCS) creation and implementation is one of the important areas of e-business development. A characteristic of such systems is the automatic processing of information resources. This helps to increase content sales volumes for a regular user, the active involvement of potential users and the boundaries expansion of the target audience [1-2]. In particular, the principles and technologies of electronic content commerce are used actively in the systems creation for on-line/off-line sales and content analysis/exchange/saving, cloud storage/computing, online shop [2]. The problems of electronic content commerce systems design, development, implementation and maintenance are topical. This is in view to such factors as the active development of research in the e-business area, the theoretical justification lack of standardized methods and need for the software unification of information resources processing in such systems [1-2,9-19].

^{*} Environment and Ecosystems Department, Lviv Polytechnic National University,
S. Bandery Str., 12, Lviv, 79013, UKRAINE, +38 (032) 258-91-82, berkoandriy@yandex.ua

^{**} Information Systems and Networks Department, Lviv Polytechnic National University,
S. Bandery Str., 12, Lviv, 79013, UKRAINE, +38 (032) 258-26-38, victana@bk.ru

^{***} Software Department, Lviv Polytechnic National University, S. Bandery Str., 12, Lviv, 79013,
UKRAINE, +38 (032) 258-25-78, chyrunlv@mail.ru

Regularly appear the new approaches and solutions to this problem, but the important issue is the discrepancy between the known methods and means of information resources processing and principles of electronic content commerce systems building. There are lack of general approaches of ECCS creation and standardized methods of information resources processing in these systems [2]. Specialists in ECCS designing, implementation and deployment have to deal with different processes of information resources processing. They contribute an increase of content sales volumes for a regular user, the active involvement of potential users and the boundaries expansion of the target audience [1-2,4].

2. THE ANALYTICAL PROCESSES OF COMMERCIAL CONTENT PROCESSING

2.1. Set-theoretic model of electronic content commerce systems

The main processes of information resources processing in electronic content commerce systems are the content formation, management and support (Fig. 1). Their scheme of connections is the following: *content formation* → *content management* → *content support*.

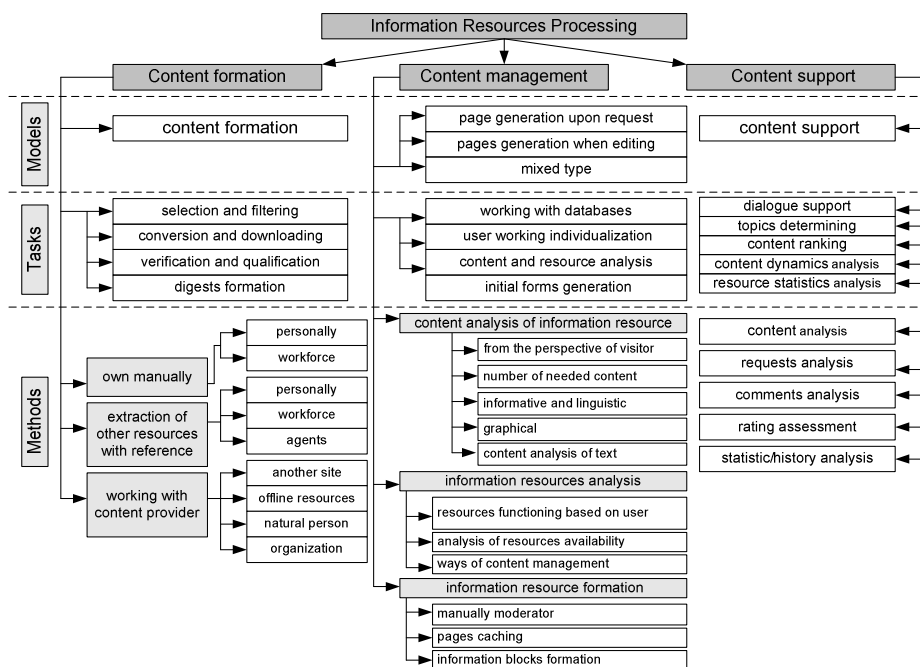


Fig. 1. Features of the information resources processing in electronic content commerce systems [source: own study]

Functioning of electronic content commerce systems is described by the following scheme of the main components links in this system:

- 1) for the process of an information resource formation: *content* → *commercial content formation* → *commercial content database* → *commercial content management* → *information resource of system*,
- 2) for the formation process of answers to a user's query: *user's query* → *commercial content management* → *information resource of system* → *commercial content support* → *system user database*,
- 3) for the formation process of the system working report to moderator: *a moderator request* → *commercial content support* → *users system database* → *commercial content management* → *report to moderator*,
- 4) for the moderation process of internal system parameters: *a moderator request* → *commercial content formation* → *commercial content support* → *rules database* → *commercial content management* → *results*.

Set-theoretic model of electronic content commerce systems is described as:

$$S = \langle X, Q, \text{Formation}, H, C, V, \text{Management}, \text{Support}, Z, T, Y \rangle, \quad (1)$$

where: $X = \{x_1, x_2, \dots, x_{n_x}\}$ – set of input data $x_i \in X$ from different sources at $i = \overline{1, n_x}$,

$Q = \{q_1, q_2, \dots, q_{n_q}\}$ – set by user requests $q_d \in Q$ at $d = \overline{1, n_q}$,

Formation – the operator of a commercial content formation,

$H = \{h_1, h_2, \dots, h_{n_h}\}$ – set of $h_k \in H$ internal parameters in the S system at $k = \overline{1, n_h}$,

$C = \{c_1, c_2, \dots, c_{n_c}\}$ – commercial content set $c_r \in C$ at $r = \overline{1, n_c}$,

$V = \{v_1, v_2, \dots, v_{n_v}\}$ – the influence parameters set $v_l \in V$ of the external environment on the S system at $l = \overline{1, n_v}$,

Management – the operator of commercial content management,

Support – operator of commercial content support,

$Z = \{z_1, z_2, \dots, z_{n_z}\}$ – pages set $z_w \in Z$ of information resource in the S system at $w = \overline{1, n_z}$,

$T = \{t_1, t_2, \dots, t_{n_t}\}$ – transaction time $t_p \in T$ of information resource processing in the S system at $p = \overline{1, n_t}$,

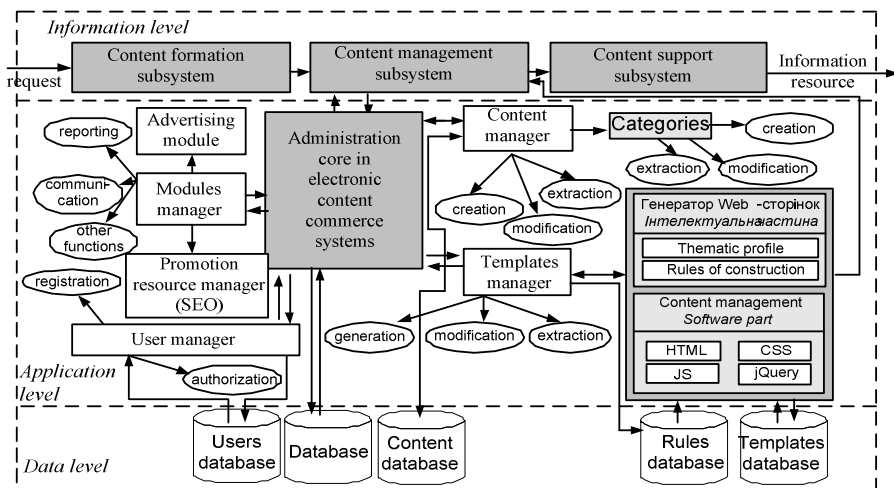


Fig. 3. The structure of electronic content commerce systems [source: own study]

Classical mathematical apparatus and distribution tools are not able to adequately reflect the content array analysis of fixed size and navigation to it [3-4, 6-8]. ECCS architecture has the hierarchy levels. They provide an independence of stored data on the programs that use them. Also they provide an opportunity of the system development without the existing applications destruction. In Fig. 4 is presented scheme of information resources processing in ECCS, and in Fig. 5 – stages of the commercial content formation in these systems. ECCS work based on the following scheme: *Content Manager* → *Editing Subsystem* → *Database* → *Core* → *User*.

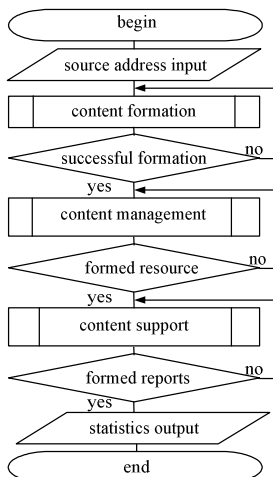


Fig. 4. Process of information resources – processing [source: own study]

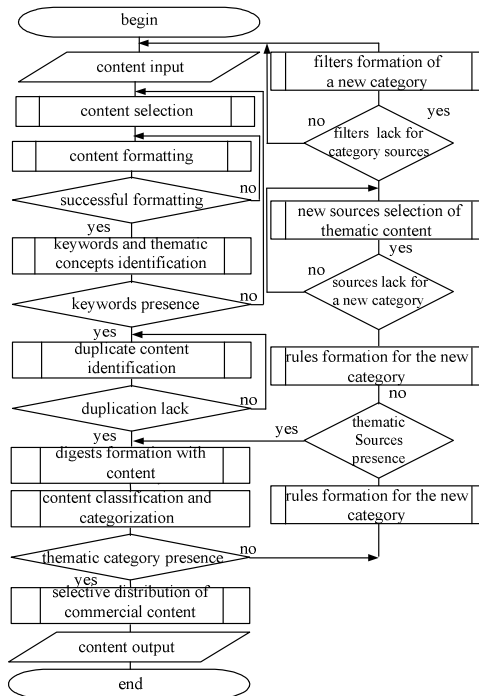


Fig. 5. Process of information resources – formation [source: own study]

When ECSS core creating are used an object-oriented models and abstract objects with properties/methods (Fig. 6). The interaction with the main objects of the system core implements through encapsulation. For this purpose in class implements the interface methods designed for manipulating within the object of the data/properties.

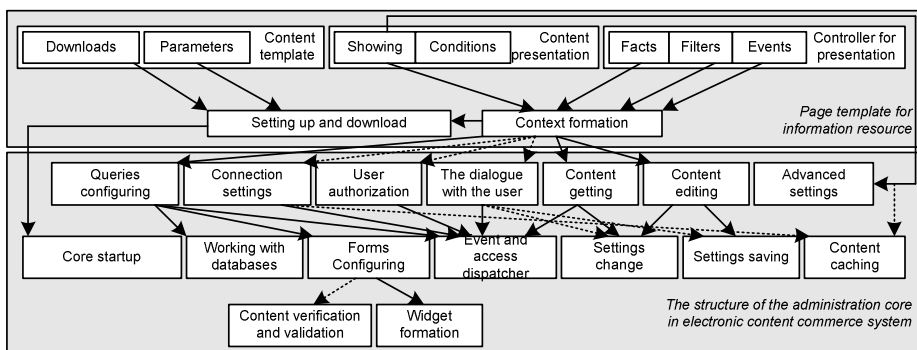


Fig. 6. The structure diagram of electronic content commerce systems [source: own study]

The process of information resources processing in ECCS is the content formation, management and support (Fig. 7).

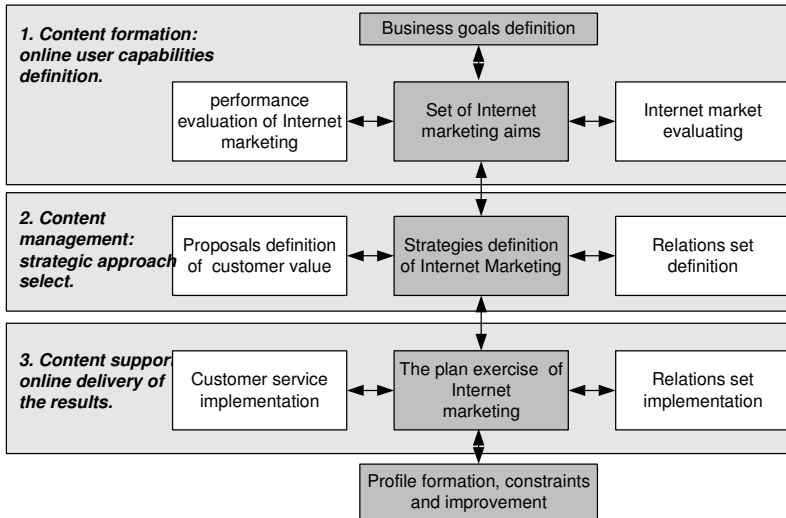


Fig. 7. Basic processes of information resources processing [source: own study]

The obtained data taken into account when an information resource creating or updating and the ECCS architecture improvement. Earlier moderator is independently searched and worked out needed content: content collection from different sources of data, content analysis and filtering, commercial content formation as the final product according to individualized data from system user. The process implementation of information resources processing in ECCS allows facilitating of moderator work by automating the content gathering from sources, content analysis and filtering.

2.3. Commercial content formation

The content formation consists of several stages: *moderator* → *content creating* → *database* → *content systematization* → *database* → *content distributing* → *editor or information resource (source)* → *content gathering* → *database* → *content systematization* → *database* → *content distribution* → *moderator*. This is realized in the form of content monitoring and database creation according to the information needs of consumers (Fig. 8).

Content leads to a common format after its gathering and primary processing. This is classified according to the specified classifier, including categories. And Content is attributed descriptors, including keywords.

When using online marketing for content systematization stages are provided constant updating of available data in databases, effective concurrent access of many users to the database, convenient means of the desired content finding.

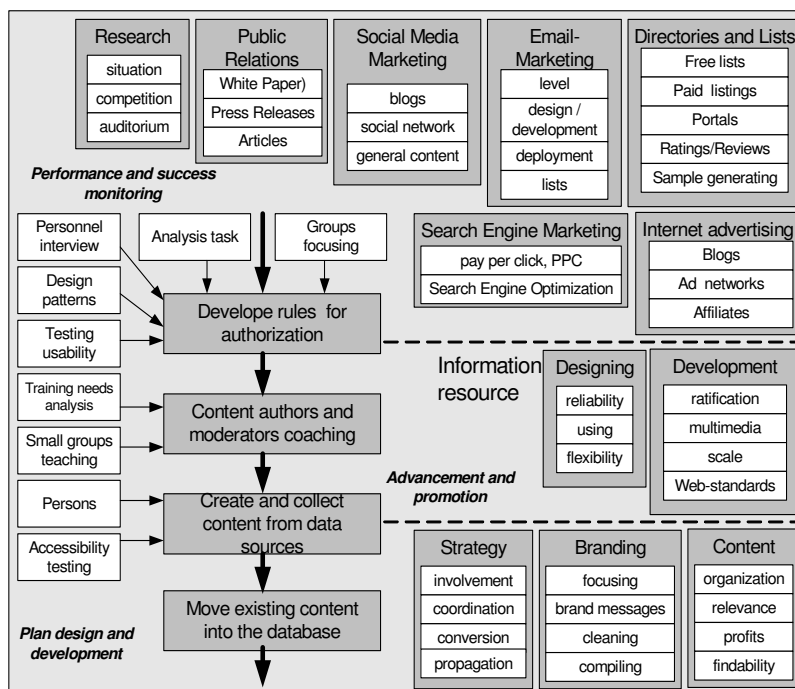


Fig. 8. Methods of content gathering/creation and marketing [source: own study]

The division into stages of the commercial content formation in the ECCS increases efficiency in the system administration, is provides economy of resources, Internet traffic and users anonymous, auto scanning of data sources.

2.4. Commercial content management

Content management of information resource and visitors (Fig. 9), their modelling is a quantitative research process of the individual thematic areas dynamics and technical analysis of information resource.

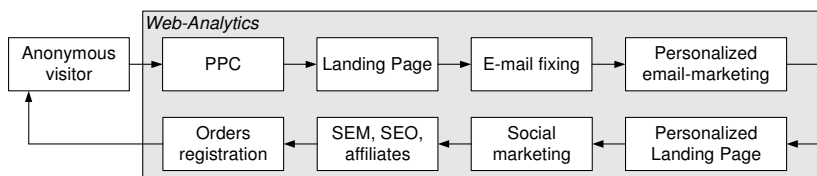


Fig. 9. Scheme of visiting analysis process of information resource [source: own study]

Content management process consists of several stages (Fig. 10): *the user → content processing → database → content analysis → database → content presentation → user*.

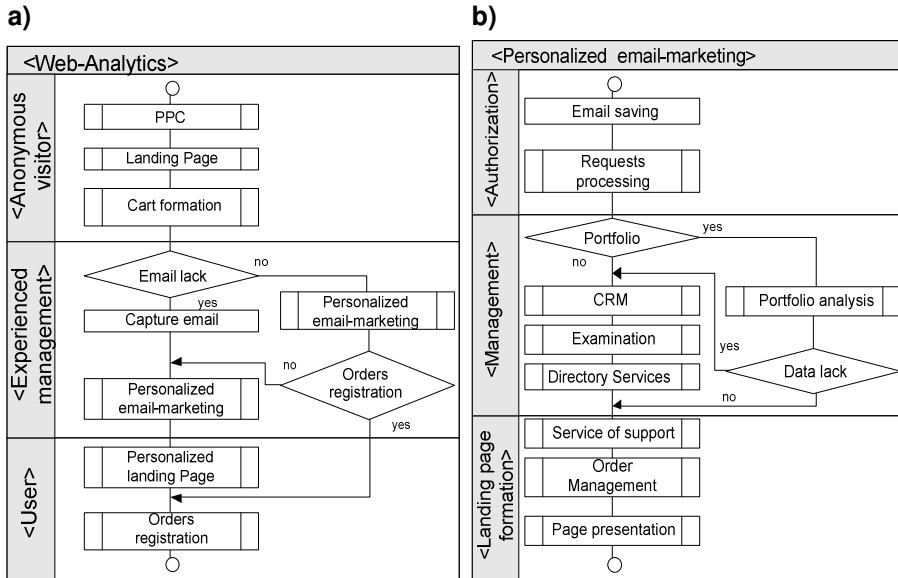


Fig. 10. Content analysis scheme of a) visitors and b) an information resource [source: own study]

Results analysis of the content management affects the speed thematic areas and content space development. Stable static relationships between content indicate a correlation between themes, the effectiveness of links to sources publishing, earlier citation, and republications others. Mechanisms, based on the generalized method of cluster analysis, identify content in the flow that forms the around a new thematic areas. Cluster analysis, fractals and self-similar processes theory in their correct application assess quantitatively the communication degree in thematic content streams. Operational analysis of visitor's content contributes to the implementation the content management process using pages generation through information blocks. It is divided into types: content, on last accessed, and combined.

2.5. Commercial content support

The content support process is operational stages of commercial content generalization, moderation and structuring (Fig. 11), i.e. *user → content structuring → database → content moderation → database → content generalization → moderator*. With the content support subsystem ECCS has

the following features: commercial content rankings formation; information portraits formation of permanent user in ECCS; characteristics analysis (comments, reviews, suggestions, etc.) on the commercial content of by the user in ECCS; information collection, storage and processing about the needs of the end/ potential user in ECCS and content consumer; a information portrait formation of content flows.

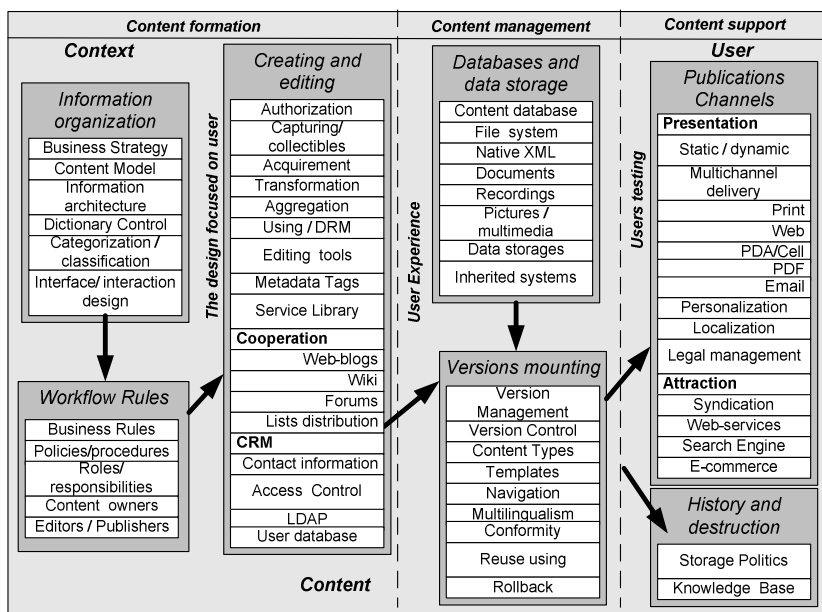


Fig. 11. Subsystems of content formation, management and support [source: own study]

The electronic content commerce systems greatly facilitate the work of moderator in the commercial content formation, management and support (Fig. 12). It has the following main stages of content processing of information resources.

1. Content gathering from different data sources.
2. Created and/or collected content filtration.
3. Content analysis (keywords identification, classification, digests formation).
4. Obtained data analysis for the moderator attention concentration on necessary issues. Data preparation for operational work with them.
5. Needs analysis of permanent and potential users of system.
6. End product formation according to the analyzed data and the needs of potential/regular users.
7. The list updating of data sources by users' queries analyzing.
8. Filter rules and dictionaries updating by content analysis.
9. New thematic categories identification for content flow.

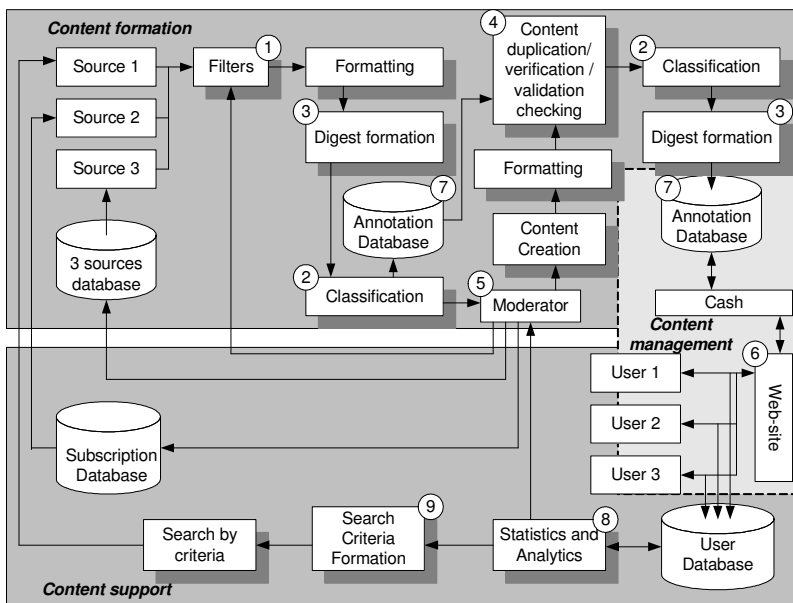


Fig. 12. Scheme of subsystems interaction of information resources processing [source: own study]

In Fig. 13 provides for a developed methods classification of information resources processing in ECCS with a detailed list of the implemented stages of commercial content formation, management and support of in these systems.

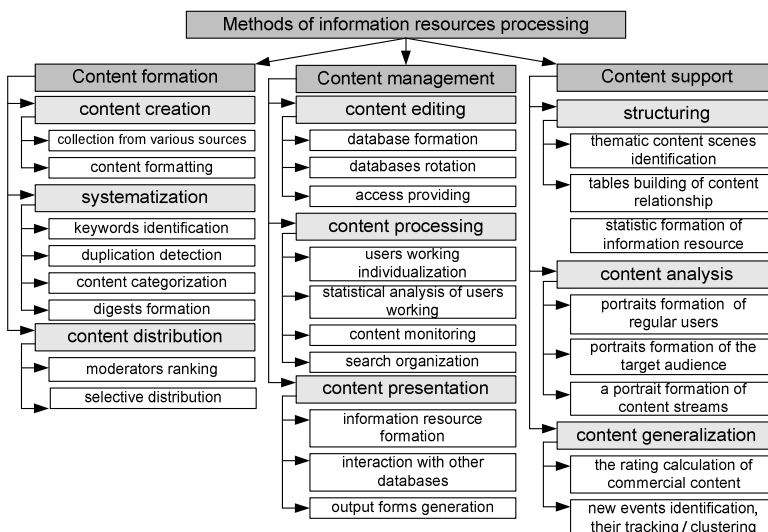


Fig. 13. Methods of information resources processing in electronic content commerce systems [source: own study]

Developed methods of information resources processing in ECCS make it possible to generate requirements for routines of information resources processing.

2.5. Content analysis of information resources

The modernity feature is the constant growth of content production rate. This process is objective and positive, but there was a problem: progress in the content production leads to a decrease in the general level of the potential user awareness. Increase in volumes content leads to the impossibility of his immediate processing. Moreover content distribution speed arise specific problems number (table 1).

Tab. 1. The main negative factors in the commercial content formation

Name	Rationale	Decision
Information noise	Content array structuring.	Filters, content monitoring, site analysis, content analysis.
Parasitic content	Appearances as applications.	Filters, content monitoring, content analysis.
Content irrelevance	User needs inconsistency.	Creation of annotated database, search pattern of initial content and their clustering, content analysis.
Content duplication	Duplication in sources.	Content analysis, scanners and filters based on statistics and criteria.
Navigating through the content stream	Rapid growth of the content volume and distribution.	Site analysis, filters, content monitoring, content analysis.
Search redundancy	Duplication and irrelevance.	Annotated search, content analysis and abstracting.

Negative factors in the commercial content formation make it difficult to find the necessary data when different sources scanning. The increase in volumes and relevance/dynamics variable of content streams (permanent regular and non regular updates) leads to duplication, information noise and results redundancy of content search. Large dynamic content streams coverage and generalization that continuously generate Internet sources requires new methods/approaches of search as a content monitoring (Fig. 14). Input information for content-monitoring is the text in natural language as a sequence of characters, output information – a table of partition, sentences and lexemes of analyzed text. Content monitoring is software tool of finding automation of the most important components in the content flow. This is an informative analysis of content flow in order to constantly obtain of the required qualitative/quantitative cuts over the advance not defined period of time.

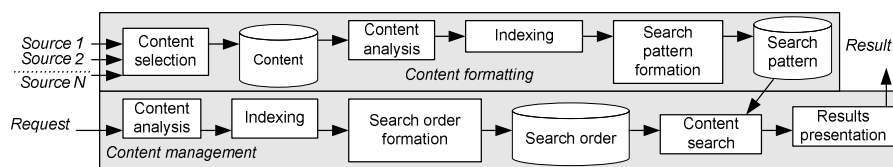


Fig. 14. Block diagram of the content monitoring process of the commercial content formation in the electronic content commerce systems [source: own study]

As part of the content monitoring is the content search and content analysis of the text. Content analysis is designed to search content in a data array by semantic linguistic units (Alg. 1). The account unit is a quantitative measure of the analysis unit. It allows symbol appearance frequency (regularity) registering of analysis category in text (number of specific words, or its combinations, lines, characters, pages, paragraphs, copyright pages, text area, etc.).

Algorithm 1. Commercial textual content analysis.

Stage 1. Criteria set determination for commercial textual content.

Step 1. Criteria set formation as the source type (forum, email, online newspaper, chat, and online magazine), type content (article, email, banner, comments), communication participants (sender, recipient, moderator).

Step 2. Content size (minimum volume or length), occurrence frequency, and distribution method/space and appearance time determination.

Step 3. Content stream filtration by generated set of criteria and the identified relevancy content storing.

Stage 2. Content analytic selection. The content sample formation on the criteria's of the limited sample from a larger array.

Stage 3. Meaningful units identification of commercial text content analysis (word combination, phrases, sentences, theme, idea, author, character, and social situation, the text part that is clustered content by analysis categories). Requirements for the linguistic unit selection of the analysis: large enough for values interpretation, small enough so as not to interpret many values, is easily identified, the units number is large enough for the sample conducting.

Stage 4. Account units bold of textual content analysis.

Step 1. If the account units are the same as analysis units, then find the occurrence frequency of the selected content unit, otherwise go to step 2.

Step 2. Moderator on the basis analyzed content offers account units, for example, the text length, text area, filled with meaningful units, the lines number (paragraph, symbols, marks, columns of text), the file size/type, the pictures number with a particular content/storyline and more.

Stage 5. Meaningful analytic units comparison with the unit account.

Step 1. Units classification by groups with scales evaluation of meaningful categories in total text. Classifier is a common table, which consolidated all categories of analysis and units analysis. It is fixed categories expression units.

Step 2. Statistical calculations are for content understandability and attractiveness identification.

Stage 6. The tool development of content analysis.

Step 1. Coded protocol of content creates for compact representation of data and rapid comparison of the different content analysis results.

Step 2. Content protocol is filled properties (author, publication time, volume, etc.).

Step 3. Commercial content protocol is filled analysis its results (number of usage for specific units of analysis and conclusions regarding the analysis categories). Each content protocol is filled based on data collection of all his registration cards.

Stage 7. It is content analysis table development. Table type is defined in a form of analytic coordinated and subordinated categories system: each category (issue) provides a features number (responses), which quantifies the textual content.

Stage 8. The coding matrix development for content analysis.

Step 1. If the sample size is ≥ 100 units, then is analyzed a set of matrix sheets, else perform step 2.

Step 2. If the sample size is <100 units, then is carried out a two-dimensional analysis. In this case, for the each content is formed coding matrix.

Stage 9. The text analysis is conducted by the created coding matrix.

Stage 10. Results are interpretation. The content characteristics identify and evaluate based on a statistical set of calculated coefficients for a certain period of time on specified category. This includes all extracted textual fragments; conclusions do not rely on some results and accounted for all without exception.

The content analysis using in data Internet sources monitoring automates the process of the most important components finding in the content flow based on the data selection from these sources. This eliminates content duplication, information noise, parasitic content search results redundancy and more. This method is used in subsequent stages of the commercial content formation for more accurate relevant results – a unique commercial content creation that is in demand among ECCS users.

3. CONCLUSIONS

From the perspective of systemic approach, is conducted the principles applying of information resources processing in ECCS for content lifecycle implementation, that enabled to develop methods for the commercial content formation, management and support. It is developed an integrated method of commercial content formation for the time and resources reduction of content production. This makes it possible to create a means of information resources processing and implement subsystem of automatically generated content.

In this paper is created operational method of commercial content management for the time and resources reduction of content sales, which makes it possible to implement commercial content management subsystem.

It is implemented a comprehensive method of commercial content support for the time and resource reduction of the target audience analysis in ECCS, which makes it possible to develop a commercial content support subsystem.

REFERENCES

- [1] BEREZA A., KOZAK I., LEVCHEV F.: *Elektronna komertsiya* (in Ukraine). KNEU, Kyiv, 2002.
- [2] BERKO A., VYSOTSKA V., PASICHNYK V.: *Systemy elektronnoyi kontent-komertsii* (in Ukraine). NULP, Lviv, 2009.
- [3] BOLSHAKOVA E., LANDE D., NOSKOV A., KLYSHINSKY E., PESKOVA O., YAGUNOVA E.: *Avtomaticheskaya obrabotka tekstov na estestvennom yazyke I kompyuternaya lingvistika*. (in Russian). MIEM, Moskva, 2011.
- [4] BRAYCHEVSKY S., LANDE D.: *Sovremennye informatsionnye potoki* (in Ukraine). Nauchno-tehnicheskaya informatsiya, no. 11, 2005, pp. 21-33.
- [5] CLIFTON B.: *Google Analytics: professionalny analiz poseschaemosti web-saytov* (in Russian). Vilyams, Moskva, 2009.
- [6] KORNEEV V., GAREEV A., VASYUTIN S., FREIHAM V.: *Bazy dannyh. Intellektualnaya obrabotka informatsii* (in Russian). Nolidzh, Moskva, 2000.
- [7] LANDE D., FURASHEV V., BRAYCHEVSKY S., GRIGOREV O.: *Osnovy modelirovaniya i otsenki elektronnyh informatsionnyh potokov* (in Ukraine). Inzhiniring, Kyiv, 2006.
- [8] PASICHNYK V., SCHERBYNA J., VYSOTSKA V., SHESTAKEVYCH T.: *Matematychna lnhvistyka* (in Ukraine). "Novyy Svit – 2000", Lviv, 2012.
- [9] BOIKO B.: *Content Management Bible* (in USA). Hoboken, 2004.
- [10] CM LIFECYCLE POSTER: *Content Management Professionals* (in USA). Retrieved 20, 2010. (<http://www.cmprosold.org/resources/poster>)
- [11] DOYLE B.: *Seven Stages of the CM Lifecycle* (in USA). EcontentMag.com, 2010. (www.econtentmag.com/Articles/ArticleReader.aspx?ArticleID=13554&AuthorID=155)
- [12] HACKOS J.: *Content Management for Dynamic Web Delivery* (in USA). NJ: Wiley, Hoboken, 2002.
- [13] HALVERSON K.: *Content Strategy for the Web* (in USA). Reading, Mass: New Riders Press, 2009.
- [14] MCGOVERN G., NORTON R.: *Content Critical* (in USA). Upper Saddle River, NJ: FT Press, 2001.
- [15] MCKEEVER S.: *Understanding Web content management systems: evolution, lifecycle and market* (in USA). Industrial Management & Data Systems (MCB UP), 103 (9), 2003, pp. 686–692.
- [16] NAKANO R.: *Web content management: a collaborative approach* (in USA). Boston, Addison Wesley Professional, 2002.
- [17] PAPKA R.: *On-line News Event Detection, Clustering, and Tracking* (in USA). Ph. D. Thesis, University of Massachusetts at Amherst, September, 1999.
- [18] WOODS R.: *Defining a Model for Content Governance*. 2010. (www.contentmanager.net/magazine/article_785_defining_a_model_for_content_governance.html)
- [19] ROCKLEY A.: *Managing Enterprise Content: A Unified Content Strategy* (in USA). Reading, Mass: New Riders Press, 2002.

Radosław WICHNIAREK^{}, Filip GÓRSKI^{**}, Wiesław KUCZKO^{***}*

APPLICATION OF ADDITIVE TECHNOLOGY OF FUSED DEPOSITION MODELING FOR MANUFACTURING SMALL SERIES OF ELASTIC MODELS

Abstract

The paper presents an application of additive method of Fused Deposition Modeling for manufacturing of small series of elastic models. Additive FDM technology is used to produce a casting mould for multiple use. Process of manufacturing of small series of products consists in casting a two-component silicone rubber degassed using vacuum chamber into a multiple use mould. The paper shows the course of the process and related problems on the example of industrial product – a cylindrical seal. The casting mould was produced out of ABS material using BST 1200 machine, whereas casted elastic models were made out of XTX 45 silicone rubber.

1. INTRODUCTION

1.1. Basic information

Additive Manufacturing Technologies (AMTs, also known as 3D printing techniques) allow to manufacture physical, three-dimensional models, prototypes and also some products or parts directly from their digital representation [8]. There are three main groups of applications of these technologies – Rapid Prototyping, Rapid Manufacturing and Rapid Tooling [2,10].

^{*} Poznań University of Technology, Chair of Management and Production Engineering, Piotrowo 3 Str, PL-60-965 Poznań, radoslaw.wichniarek@doctorate.put.poznan.pl

^{**} Poznań University of Technology, Chair of Management and Production Engineering, Piotrowo 3 Str, PL-60-965 Poznań, filip.gorski@doctorate.put.poznan.pl

^{***} Poznań University of Technology, Chair of Management and Production Engineering, Piotrowo 3 Str, PL-60-965 Poznań, wieslaw.kuczko@doctorate.put.poznan.pl

Rapid manufacturing of small series of finished products is often based upon the Vacuum Casting technology – a process complementary to additive technologies [9]. This technology allows to effectively create copies of elements manufactured by additive technologies, using chemically hardened resins as a build material, usually for thorough testing and evaluation of prototyped elements [3]. Molds for this method are manufactured using two component silicone rubbers vulcanizing in the room temperature and the casting material – two component resin – is usually composed in a way to mimic properties of various plastics. Both mold manufacturing and subsequent casting (the mold can be used many times depending on the geometry and conditions, but never more than for approx. 100 castings) requires degassing of the liquid material using a vacuum chamber [7].

The Vacuum Casting method is efficient and popular, but it has certain limitations – there is no possibility of manufacturing elements with elastic properties [12]. This paper presents a new process (designed and tested by the authors) of manufacturing short series of elastic products. The process is based on principles of the VC method, using the silicone rubber (similar in properties to some widely used elastomers) as a build material. A casting mold for this process is manufactured using one of the additive technologies – namely Fused Deposition Modeling.

1.2. Place and subject of the practical studies

Research of the process of manufacturing short series of elastic products using FDM method was conducted in the Laboratory of Rapid Manufacturing, localized in the Chair of Production Engineering and Management of Faculty of Mechanical Engineering at Poznań University of Technology. As a base model for process development and tests, a seal of cylindrical shape was selected (Figure 1).

Process of manufacturing of short series of products out of elastic material using the described process consists of the following stages:

- design and manufacturing of the reusable casting mold out of the ABS material, using additive technology – Fused Deposition Modeling,
- casting in the manufactured mold using additive silicone vulcanizing in the room temperature as a build material,
- finishing and evaluation of the obtained castings.

As the additive FDM technology is in this case used to manufacture tooling for the casting process, this application of AMTs should be considered as the Rapid Tooling.

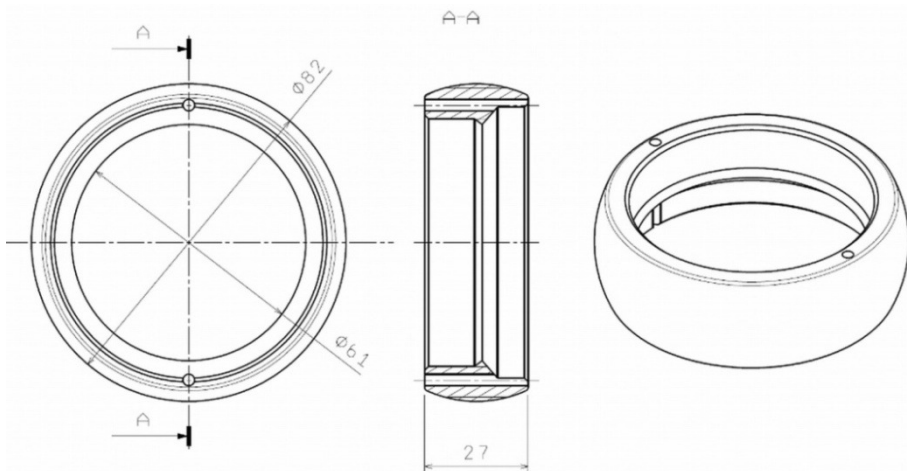


Fig. 1. Model of a seal selected for the study [source: own study]

2. PREPARATION OF THE CASTING MOLD – 3D PRINTING USING FDM TECHNOLOGY

2.1. Characteristics of the FDM technology

Physical prototype creation using layered deposition of thermoplastic materials is one of the most widely used AMTs in the industry. Fused Deposition Modeling is the widely acknowledged name of this method (fig. 2) [1]. It consists in deposition of the plasticized material through a special, two-nozzle head, positioned in two axes, X and Y. The support of some kind must also be created, because there are no natural supports and the created model is not stiff enough during manufacturing – it could deform under the gravity force if there were no supports. Build and support materials are supplied to the head in form of wire from the spool and they are heated inside. During single layer creation, the head moves in XY plane and deposits the material according to the cross-section profile. After one layer is completed, the model table moves down in the Z axis, value of the coordinate being equal to single layer thickness. After the thermoplastic material from the head is placed on the table, it momentarily solidifies, joining with the previous layer [8].

As in almost every other additive manufacturing technology, models are created on the basis of the CAD geometry in form of the triangle mesh (STL file format), imported to the software which controls the machine realizing the FDM process [11].

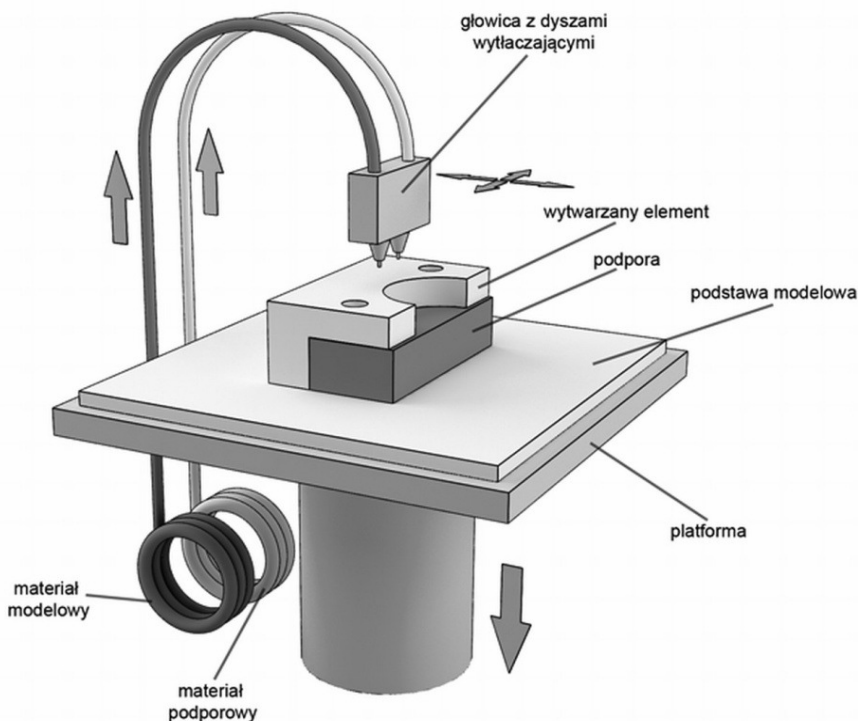


Fig. 2. Scheme of the FDM method [source: own study]

As a build material, usually the ABS material is used (ABS stands for acrylonitrile butadiene styrene), other thermoplastics can be used too. Support material type depends on method of the support removal (mechanically – by force or chemically – by dissolving the support in the liquid solution).

The Laboratory of the Rapid Manufacturing is equipped with the Dimension BST 1200 machine, manufactured by the company Stratasys. ABS material is used for both model and support, the support is removed mechanically. The machine allows to build models with maximum base size of 254 mm x 254 mm and maximum height of 305 mm. Models of larger size can be built by joining the smaller models, e.g. by gluing them together.

Models manufactured using the FDM method are ready for use immediately after the support is removed. They have good mechanical properties, but their visual quality is mostly poor due to so-called staircase effect (which occurs in each layered manufacturing technology) [4]. To obtain models with high visual quality, post-processing is required – processes like sanding, grinding, drilling or painting can be applied to the FDM model to improve its quality and functionality.

Prototypes manufactured using FDM technology are used mostly as visual and functional prototypes. Apart from the prototyping, the ABS models manufactured additively can be also used as patterns for the Vacuum Casting process [6]. The process of elastic model manufacturing presented in the next part of this paper can be treated as an inversion of the classic Vacuum Casting method – ABS model is used as a mold, while the silicone is used as a build material.

2.2. Manufacturing of the casting mold using the FDM process

Casting mold for manufacturing of the seal models was created directly from the CAD model. The first stage of preparation of the mold was therefore a creation of such model. It was made in the CATIA v5 CAD system, basing on the CAD model of the manufactured element – the seal. Shape of the mold cavity was created using Boolean operations (subtraction of solids representing the outer frame of the mold and shape of the model – fig. 3). Additionally, holes were added for fixing elements and a simple gating system was designed (consisting of pouring cup and gas vents). The whole mold was divided into two halves.

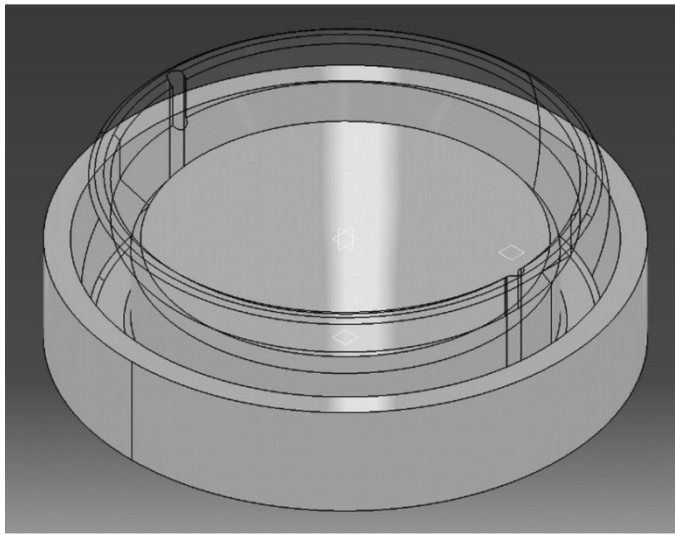


Fig. 3. CAD model of one half of the casting mould [source: own study]

On the basis of the solid model of two halves of the mold, triangle meshes were created and saved to STL files. These files were then imported to the control software of the BST 1200 machine. Then, NC programs containing information about paths of the head in subsequent layers were automatically generated and sent to the machine. After manufacturing of both mold halves, the post processing was performed. It consisted in removal of the support material, insertion of some fixing elements (namely, steel pins) and drilling

of small gas vents (it is not possible to plan these holes in the CAD model, as their diameter is very small – the same as the width of the single thread of material, so they would not be manufactured during the additive process). Finished mold parts are shown in the fig. 4.



Fig. 4. Halves of the casting mold produced using FDM technology [source: own study]

3. CASTING OF THE ELASTIC MODELS

3.1. Material characterization of the XTX 45 silicone

XTX 45 silicone belongs to a group of silicone rubbers vulcanizing in the room temperature (no necessity of heating). It is a two component material – the basis is a liquid material of very high viscosity. To obtain a solid elastomer, the base needs to be mixed with the catalyst in 10:1 proportion. Working time of the mixture in room temperature is 90 minutes since the mixing is complete (in higher ambient temperatures this time is shortened and in lower – lengthened) and hardening time is about 15 hours (it is also dependent on the ambient temperature). Properties of the silicone are presented in the table 1.

After hardening, a material from the elastomer group is obtained. Mechanical properties of the XTX 45 silicone in the solid form (after hardening) are good enough to use it for the planned task.

Tab. 1. Properties of XTX 45 silicone used during the study

Property name	Value
Mixture proportion	10 : 1
Part A color (base)	Translucent
Part B color (catalyst)	Translucent
Part A viscosity	70000 cPs
Part B viscosity	90 cPs
Mixture viscosity	35000 cPs
Density	1,12 kg / dm ³
Working time at 23°C	90 min.
Hardening time at 23°C	15 h
Shore A hardness after 24 h	43 ± 2 Shore A
Tensile strength	6,5 ± 0,5 N/mm ²
Elongation at break	400 ± 20%
Shear resistance	> 20 N/mm

3.2. Course of the casting process

The actual process of casting of elastic models using XTX 45 silicone consists of several basic stages.

The first stage is preparation of the mold for casting (fig. 5). The following actions need to be performed:

- cleaning of the mold cavity,
- insertion of the fixing elements (pins),
- tight connection of two mold halves in a temporary way (to ensure the possibility of getting the model out of the mold without damaging it),
- insertion of the external gating system elements,
- placement of the mold in a way to ensure difference of height levels of gating system entry point and exit (entry point should be placed on a lower level than the exit point).

The second stage of the process is material preparation. Applied silicone consists of two components – the base and the catalyst. Preparation of the material requires performing of the following actions:

- calculation of material quantity necessary for the task,
- weighing the proper amounts of the base and the catalyst,
- mixing the base with the catalyst and optionally with some dyes, if a certain color of the finished element is required,
- degassing of the silicone by placing it in the vacuum for about one minute.

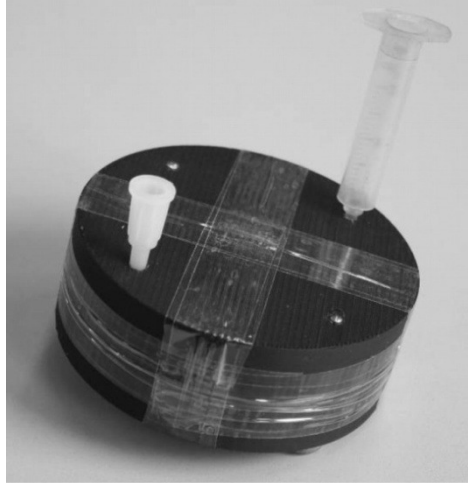


Fig. 5. ABS casting mould ready for casting [source: own study]

The last stage was performed using the MCP 4/01 HEK vacuum chamber (fig. 6). It is noteworthy that it is not entirely necessary to degas the silicone (especially when manufacturing very small elements), but models manufactured without degassing are characterized with presence of the air bubbles in large portion of the casting volume, which decreases the level of product mechanical properties in a significant way. During degassing the silicone should be placed in a vessel of volume at least twice as large as the base volume of the raw, liquid material – air bubbles running out of the material cause a significant, yet temporary increase in volume of the material.



Fig. 6. Vacuum chamber MCP 4/01 used for silicone degassing [source: own study]

The next stage is pouring the material into the mold. Filling the previously prepared casting mold with degassed silicone can be carried out gravitationally (in case of larger molds), but for more rapid and accurate filling of the mold cavity, pressure casting was used. The pressure was exerted by manual pressing of the material feeder (fig. 7). Value of the pressure and character of its variations during the mold cavity filling have no observable effects on quality and properties of obtained models.

The mold is entirely filled when the liquid material appears in the exit point of the gating system, assuming that there is a visible height difference between the pouring cup and the exit point.



Fig. 7. Pouring the silicone into the mould [source: own study]

After the silicone is hardened (solidification is usually complete after 12-15 hours), the mold can be opened and the model can be taken out (fig. 8). During mold disassembly it is important to remember that the silicone precisely fills the mold cavity, including all sub-cavities, even of a very small size. In case of the mold created using FDM technology, where the staircase effect is very distinct and mold surface is not smooth, the silicone model will require considerably high strength to divide it from the mold surface. It is therefore important to perform this process carefully, especially when using metal tools, to leave both the model and the mold intact (with no damage).

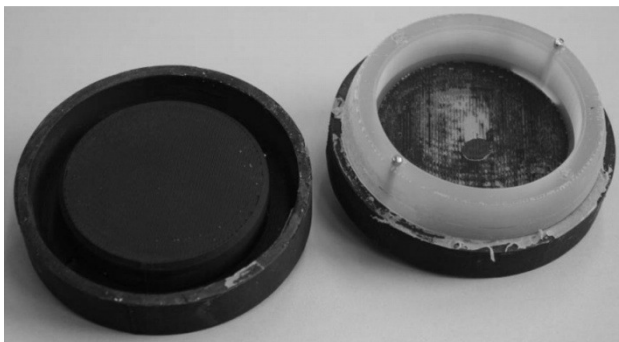


Fig. 8. Hardened model ready to be taken out of the mould [source: own study]

Directly after removal of the elastic model from the mold, it should be evaluated, especially concerning occurrence of the casting defects. The most frequently occurring defect in this type of models is presence of air bubbles and pockets (similar as shrink cavities in metal castings), appearing as a result of insufficient degassing of the raw material (fig. 9). Air pockets – if they are present – are usually located deep inside the model volume (as opposed to these appearing in resin models manufactured using classic approach to Vacuum Casting technology) and they have no impact on its shape and dimensional accuracy. Still, these flaws usually disqualify the product, especially when they have considerably large volume, as they impair the mechanical properties of the product.

Applied additive silicone does not present any visible shrinkage, which means that there are no possibilities of its compensation, neither on the design stage, nor during the manufacturing process.

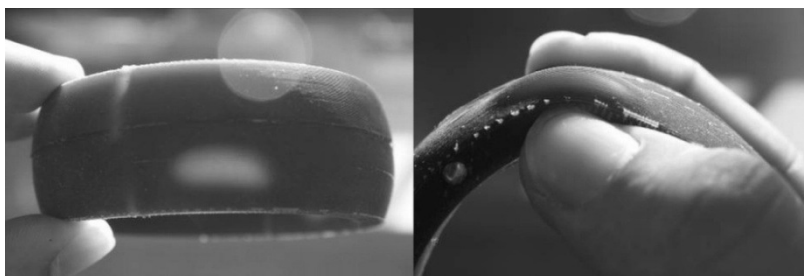


Fig. 9. Flaws occurring in silicone models – air pockets [source: own study]

The model removed from the mold is not a finished product yet – all the casting technologies make use of some type of post processing (the finishing). In this case it consists mostly in cleaning the model and removing the rest of the gating system and traces of mold division line. It is usually done using cutting tools or machining (fig. 10).

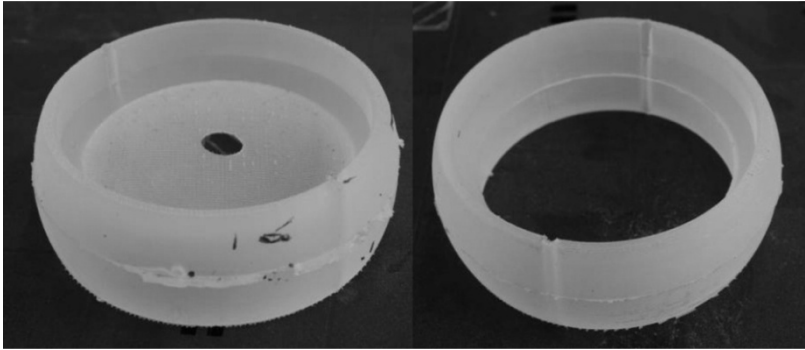


Fig. 10. Model taken out of the mould (on the left) and after post processing (on the right) [source: own study]

4. CONCLUSIONS, SUMMARY

Basing on the course and results of the casting of short series of elastic products in ABS molds, the following conclusions can be drawn:

- Applied silicone precisely fills the mold cavity, accurately representing all the surfaces (despite low castability in liquid form), so in case of surfaces that are irregular, uneven or with pockets, holes etc., there are problems with disassembling two mold halves and removing the product. These problems can be avoided by applying appropriate finishing treatment of the mold cavity (e.g. grinding).
- Silicone adheres to the mold surface strongly, so apart from appropriate surface finishing, the mold cavity should also be covered with a dedicated separator. It is well advised especially for models with more complex shapes.
- During the casting process, the ABS mold is subjected to mechanical wear (especially as a result of applying certain forces during model removal), so number of models obtained from one mold is limited – it would be advisable to further study the influence of the model geometry complexity and casting process course on the level of the mechanical wear of the mold, to be able to estimate the maximum number of pieces obtained from the given mold.
- Unlike during the regular Vacuum Casting process, the mold is not translucent, so it is not possible to determine the locations of air pockets before the model is removed from the mold – this is a clear disadvantage of using the FDM-produced molds.
- Thanks to using model material of elastic properties, the mold does not need to have any drafts or other special features to facilitate the model removal.

- Silicone does not present any visible shrinkage, so there is no need to compensate it.
- Defects in form of air bubbles and pockets can be easily avoided by thorough degassing of the base material.

To sum up, it can be stated that manufacturing products out of elastic materials using casting process in ABS molds prepared using additive FDM technology is quite possible, as long as proper process conditions are maintained. Appearing problems (defects, troubles with mold disassembly) can be solved by taking appropriate actions – modification of the mold, more thorough degassing or application of separators. It can also be said that amount of work needed to achieve satisfying results for this method is not high. A disadvantage of this process which may increase the cost of its possible implementation is necessity of applying the vacuum chamber to degas the base material. Still, described process remains one of the fastest and cheapest ways of producing short series of fully functional elastic products.

REFERENCES

- [1] BELLINI A., GUCERI S.: *Mechanical characterization of parts fabricated using fused deposition modeling*. Rapid Prototyping Journal, vol. 9, 2003.
- [2] HULL C., et al.: *Rapid prototyping: current technology and future potential*. Rapid Prototyping Journal, vol. 1 no. 1, pp. 11-19, 1995.
- [3] KAI C. C., HOWE C. T., HOE E. K.: *Integrating Rapid Prototyping and Tooling with Vacuum Casting for Connectors*. International Journal of Advanced Manufacturing Technology. Springer, vol. 14, 617-623, 1998.
- [4] KONIECZNY R.: *Projektowanie z wykorzystaniem narzędzi Rapid Prototyping*, Mechanik, t.76, nr 12, 2003.
- [5] KUCZKO E., et al.: *Choosing optimal rapid manufacturing process for thin-walled products using expert algorithm*. Journal of Industrial Engineering and Management, vol. 3, no. 2, 2010.
- [6] LEE C.W., et al.: *Rapid investment casting: direct and indirect approaches via fused deposition modeling*. International Journal of Advanced Manufacturing Technology. Springer, vol. 23, 2003, pp. 93-101.
- [7] MAIS G., DUCHSCHERER F.: *Vacuum casting - development stage of a special-purpose method*. Kunststoffe, German plastics, vol. 81, 1999, pp. 14-16.
- [8] PAJĄK E., et al.: *Techniki przyrostowe i wirtualna rzeczywistość w procesach przygotowania produkcji*. Agencja Reklamowo-Promocyjna „Promocja 21”, Poznań 2011.
- [9] PHAM D. T., DIMOV S., LACAN F.: *Selective laser sintering: applications and technological capabilities*. Proc Instn Mech Engrs, vol. 213 Part B, 1999, pp. 435.
- [10] ROSOCHOWSKI A., MATUSZAK A.: *Rapid tooling: the state of the art*. Journal of Materials Processing Technology, 106 (1-3), pp. 191-198, 2000.
- [11] WEISS E., et al.: *Accuracy of parts manufactured by rapid prototyping technology*. 7th International Conference of DAAAM Baltic Industrial Engineering, Tallinn, Estonia, 2010.
- [12] WEISS E., WARACZYŃSKI B.: *Zastosowanie Technologii Vacuum Casting do wytwarzania prototypów funkcjonalnych*. Zeszyty Naukowe Politechniki Poznańskiej, no. 5, 2007.

Svetlana RATNER*, Pavel RATNER**

INTERACTIVE CALCULATOR FOR ASSESSMENT OF THE STRUCTURE OF ENERGY CONSUMPTION

Abstract

In this paper we present a simple interactive calculator, which can be used in individual flats and houses, office buildings and educational institutes such as colleges and schools, for assessment of electricity use by different categories of equipment. The user indicates only type of equipment and its approximate time of work. The program outputs the structure of energy consumption in graphic format. The results of test procedures and the ways for improvement of the program are discussed.

1. INTRODUCTION

Insufficient energy supply is a problem faced by many countries, and energy efficiency improvement is identified as the quickest and most effective solution to this problem. Many energy efficiency projects are therefore initiated to reach various energy saving targets [1]. Nowadays Russian government pays a lot of attention to solutions of the high energy intensive production system in the country, inherited from the Soviet times. In November 2009 Russian parliament adopted the law “On energy saving and energy efficiency”, which established specific obligations of the federal government to co-finance the programs of Russian regions on energy efficiency. Financing of regional energy efficiency programs from the federal budget began in 2011. During 2011-2013, 66 out of 80 Russian regions were funded with 1.667 million rubles (about 40 million euro) in total, but only 18% of them have achieved expected economical results. Almost 30% of the regions were financed by the federal government only once (in 2011) and then their spending were considered ineffective.

* Institute of Control Science, Russian Academy of Science, 65 Profsoyuznaya st.
Moscow 117997, Russia, +79453348910, lanarat@gmail.com

** Plekhanov Russian University of Economics (Krasnodar branch), 23 Sadovaya st.,
Krasnodar 350002, +78612011071, ratner_p.d@gmail.com

According to our previous study [2-3] the key factors of low efficiency of regional energy saving programs is the lack of approved standards and algorithms in the area of energy audit. In practice, both technical and economical parameters of energy audit fluctuate in a very large range. It's due not only to different complexity of the audit (the number of surveyed buildings, the number of observed parameters etc.), but also the immaturity of the market. In some regions with monopolistic market of energy service the audit for a company costs much more than paying bills for electricity and heat. For example, in Yamal-Nenets Autonomous Okrug the average cost of energy audit contract in 2011 was 185 million rubles (about 4.4 million euro) [4], while in Lipetskaya Oblast only 200 000 rubles (4800 euro).

In this situation most of the small and middle-size companies as well as government organizations are getting more and more interested in some "do-it-yourself" tools that can help to make very first steps in introduction of energy management systems and reduce the cost of professional energy audit. Especially strong need for energy audit in public sector is explained by the fact that in many regions local laws oblige state-financed organizations to reduce energy consumption by 3% every year at least during 5 years [5].

It is also well known that private consumption, especially energy consumption, is one of the largest demand classes in most economies, and is therefore responsible for a major fraction of global emissions [6]. New energy efficient home appliances can significantly reduce the energy consumption, however, the extent to which the theoretical reduction potential can be realized highly depends on individual decision processes. General population in Russia on its own has not yet embraced energy efficiency as a social value, therefore not many people are interested to invest in increasing energy efficiency of their homes and, therefore, to use algorithms for home energy audit suggested by well-known western companies such as Energy Star and others. Besides the fact that the majority of Russian urban population live in big apartment houses, managed by municipal companies and don't have much opportunities to save energy, except reduction of personal electricity use. But in some regions tariffs on electricity for population already grew to the level that makes energy saving economically reasonable.

In this paper we present a simple interactive calculator (hereinafter EnergyCalc) which can be used in educational institutes such as colleges and schools, office buildings as well as individual flats and houses for assessment of electricity use by different categories of equipment. The user indicates only type of equipment and its approximate time of work. The program outputs the structure of energy consumption in graphic format and some recommendation on how to reduce the most costly item of expenditure. The EnergyCalc is realized in the C++ programming language, following the C++98 standard. It is available for personal computers running the Microsoft Windows or the GNU/Linux operating systems.

The structure of the paper is following: in Section 2 we discuss the formulation of the problem, the methods of gathering information for in-build database in the program and describe the algorithm of calculation. In Section 3 we present the design of EnergyCalc program and describe its realization. Section 4 is devoted to discussion of the results of the tests made for the case of individual apartment, office of the middle-size company and typical public school. In Conclusions we make a short summary of main results and introduce some way for improvement of the interactive EnergyCalc.

2. THE PROBLEM OF ENERGY CONSUMPTION STRUCTURE MONITORING

According to the standard ISO 50001 “Energy Management System” adopted in Russia at the end of 2012 the first step of developing energy-saving strategy is the energy survey. While a professional energy audit is the best way to determine the potential ways for reduction of energy consumption and the necessary part of the certification process, one can conduct their own simple but diligent research and spot many problems in the use of electrical equipment. The information about total electricity consumption in most cases is available because the majority of offices and homes are equipped with individual electricity meters, but the structure of energy consumption is unclear. The main problem for the average user is the lack of information about how powerful different types of office and home equipment are. In this situation users often start to save energy by ineffective methods and very soon give up.

The structure of energy consumption in offices and individual homes varies a lot. Thus, on fig. 1-2 we can see two electricity consumption structures of the same-sized families living in the same city and in similar homes. While one of the biggest parts in energy consumption for both families is a refrigerator, other “energy eaters” differ. For the first family they are lighting and TV, for the second family – electric stove, washing machine and dishwasher.

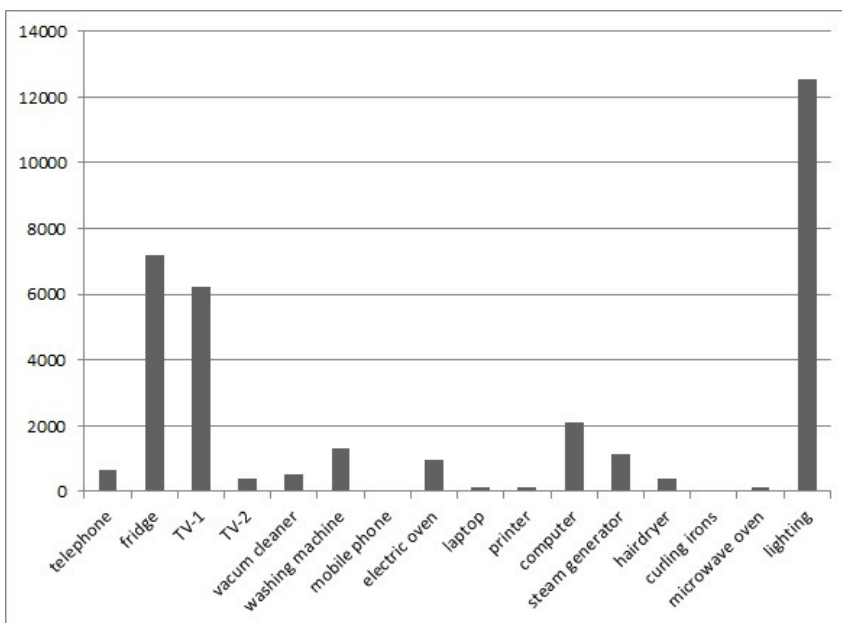


Fig.1. Weekly energy consumption structure: family 1
(Krasnodar city, 3 persons, 100 sq.m home) [source: authors own studies]

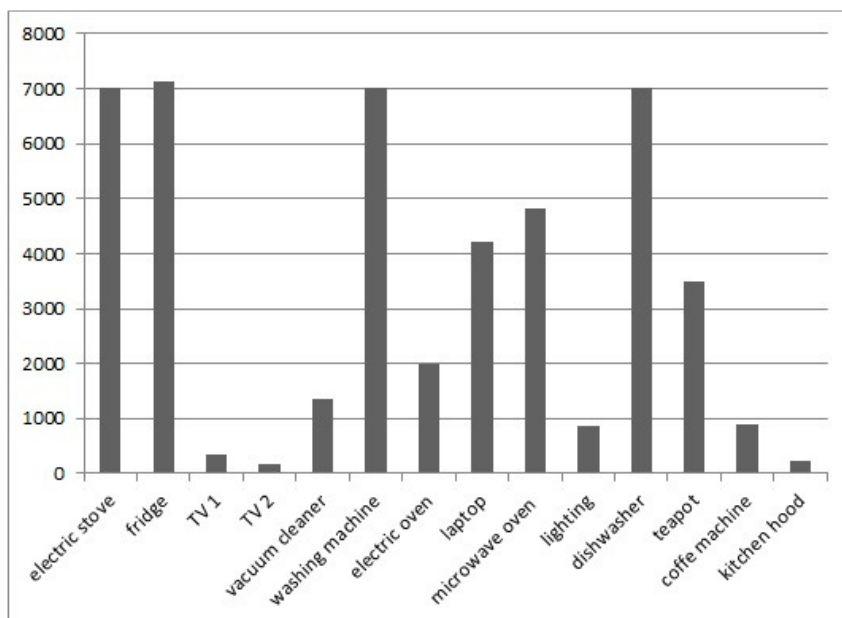


Fig. 2. Weekly energy consumption structure: family 2
(Krasnodar city, 3 persons, 100 sq.m home) [source: authors own studies]

The similar difference can be seen in the energy structures of offices. The main reason for this variation is not only different life style of the people and different commercial activities of the companies, but also the attitude towards energy efficiency and income level. Low energy prices cause the lack of incentives to improve energy efficiency for wealthy people and companies. The level of energy efficiency of household and office equipment has practically no effect on the price, therefore the majority of the buyers do not pay much attention to energy efficiency indicators and tend to choose more powerful and functional home and office appliances. Permanent growth of prosperity of the middle class Russians is primarily reflected in the acquisition of durable goods, including a variety of new types of household and office equipment.

Nowadays the study of the influence of the demographic, socioeconomic, and housing characteristics variation in household energy consumption became very popular in different countries (see, for example [7-10]), but still not in Russian economic literature. Therefore it was not possible to rely on results of previous studies and it was necessary to select a new way to investigate the structure of energy consumption of the households.

With this in mind we have abandoned the idea of using the typical structure of energy consumption as a pattern of the EnergyCalc and have used instead a case-study method for gathering the information about the possible set of home and office appliances. According to [11], a case study is an empirical enquiry that investigates a phenomenon in a real life context. In order to avoid volunteer bias in residential energy efficiency studies, we have used the results of [12] and provided volunteers with a short questionnaire that takes at most 1 minute to complete before the study about their intentions to enroll. A case-study was conducted for 7 households, 4 offices of SMEs and two public high schools in Krasnodar city, Krasnodar region, Russia. The following information at each object was collected:

- list of appliances,
- appliances' brand and year of manufacture,
- users' satisfaction with the quality (including energy efficiency) of appliances and their plans to purchase new kinds of equipment.

Then the information about appliances' energy consumption was collected from the sites of most popular Russian Internet stores and the official sites of equipment's manufacturers. For majority of appliances energy consumption is measured as power (Wt); for washing machines and dishwashers the energy consumption for the cycle was measured. If the energy consumption of appliance depends on the class of energy efficiency or on the presence some special functions, several modification of the same appliance were indicated in the list. All collected information was presented in the form of database, which later on will be built-in inside of EnergyCalc.

The process of calculation the energy consumption was organized as it is presented in the table below.

Tab. 1. Methods of energy consumption structure assessments

Object	Input parameters	Data base parameter	Calculation formula
Home and office appliances, except washing machines and dishwashers	Time of use (hours in a week), class of energy efficiency (if possible)	Power, Wt	Time×Power
Washing machines and dishwashers	The number of uses in a week	Energy consumption for a cycle (ECC), Wt	Number×ECC
Lighting in the public high schools (class-rooms)	The number of class-rooms, the time of lighting	Average energy consumption (AEC) for lighting a class-room	Number×Time×AEC
Lighting in the public high schools (halls)	The floor area of halls, the time of lighting	Average energy consumption (AEC) for lighting a sq.meter	Area×Time×AEC
Running the average school kitchen	The number of days in a week than the kitchen works	Average daily energy consumption (ADEC)	Number×ADEC

As seen from the table, the structure of the energy consumption in private apartment and office is calculated by multiplying the operation time of each device on its output. The algorithm for public high schools is slightly different, because the main part of the school building usually is occupied by the typical school classrooms with the same lighting systems, what can be used as a measureable unit in the process of energy consumption evaluation. Another measurable unit in school's energy consumption can be a school kitchen, which has standard equipment, purchased by municipalities at the same manufacture through tender system (most of the public schools in big cities have about 1 thousand students of different age from 6 to 17 and cook a standard lunch set for all students every day, except Saturdays and Sundays). Halls and gyms in school also have standards of lightings on one square meter and usually are equipped with the fluorescent lighting. The parameters of all other appliances in a school building such as air conditioning, computers, projectors, musical equipment, interactive whiteboards, plasma screens and others are included in build-in database. Their energy consumption is calculated similar to the case of office and apartment.

Proposed way of estimation the structure of energy consumption is simple for the user, because all he needs is to monitor the time of different equipment operation for several days (about a week). Then the user can run the EnergyCalc,

get the structure of energy consumption and the estimation of total electricity spending, which one can compare with the meter's records. If the calculated and actual readings vary greatly, it may indicate that the user does not take into account some items of equipment or underestimates the time of their use. If the readings are the same, the user can analyze the real energy consumption structure and select the most reasonable ways to optimize it.

3. CODE AND DESIGN

The EnergyCalc program is realized in the C++ programming language, following the C++98 standard. It is currently available for personal computers running the Microsoft Windows or the GNU/Linux operating systems. However, there are builds of the program possible for other operating systems, such as Apple OS X, as well as a mobile version for Android and iOS. EnergyCalc uses the Qt libraries (version 5.2.0) and was created using the Qt Creator development environment, which is part of the Qt project. The program provides a user interface in two languages, English and Russian.

The main program window is a selection dialog, which provides buttons to choose the environment energy calculations should be performed within, such as home, office or public school (fig.3). This is necessary due to the different types of electrical appliances typically used within these environments and therefore different measureable units.

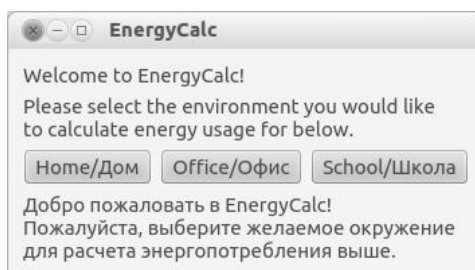


Fig. 3. Selection dialog [source: authors own studies]

After the desired environment has been selected, the program will attempt to read the data for this environment's typical appliances from files in its' directory. If this succeeds, the user should be presented with a dialog similar to the one below (fig.4).

Data Entry/Ввод данных

Please enter the following data for all the electrical appliances you use.
 Leave the fields of the appliances you do not use as-is.
 If the appliance doesn't have any known energy classes for it, the class dropdown will be empty.

Пожалуйста, введите следующие данные для всех электроприборов, которыми вы пользуетесь.
 Если вы не используете какой-то из указанных приборов, оставьте его поля как есть.
 Список энерго-классов будет пуст, если для конкретного типа прибора они неизвестны.

Name/Название	Class/Класс	Usage time/Время работы	
3-D телевизор/3DTV			h/ч
Вытяжка/Draught			h/ч
Кондиционер/Air Condition	A		h/ч
Кофеварка/Coffee machine			h/ч
Мини-посудомоечная маш			cycles/циклы
Мини-стиральная машина			h/ч
Музыкальный центр/Music			h/ч
Ноутбук/Laptop			h/ч
Стационарный компьютер			h/ч
Телевизор/TV set			h/ч
Фен/Hairdryer			h/ч
Холодильник/Refrigerator			h/ч

Calculate/Произвести расчет

Fig. 4. Input window [source: authors own studies]

Here, user should specify how many hours in a selected time period (usually week, but it also can be day or month) he uses specific appliances presented in the list. For some appliances (e.g. hairdryers), it may be more convenient to specify the time in minutes, in that case, the user can modify the right-most column to specify that he wants to input minutes rather than hours for those appliances. Also for some appliances such as washing machines or dish washers user specify the number of uses in the monitoring period.

If known, energy-saving classes may also be specified. However, this isn't possible for all appliances. For those which have no known energy saving classes, this place in the list will be empty.

As soon as user specifies the operating times for all the appliances, he clicks the Calculate button below the table. The program will then sort all electrical appliances by the amount of electrical power consumption, and output the result in number and graphic formats (fig.5).

Note, that in some situations, such as a failed installation, accidental installation to a system-only directory, or accidental deletion or damage of the programs' data files (having the ".energy" file extension), the program may fail to load information required to allow data entry for some or all types of environments. A program reinstallation should fix the issue. In case this happens, an error dialog will be shown.

energycalc				
	Appliance/Прибор	Energy consumption/Энергопотребление	%	
1	Электродуховка/Electric oven	69720	38.85%	
2	Электроплита/Electric cooker	69720	38.85%	
3	Холодильник/Refridigerator	28560	15.91%	
4	Электрочайник/Electric teapot	7000	3.90%	
5	Ноутбук/Laptop	3900	2.17%	
6	Вытяжка/Draught	550	0.31%	
7	Музыкальный центр/Music centre	30	0.02%	

Fig. 5. Output window [source: authors own studies]

4. TESTING PROCEDURES AND RESULTS

Testing procedures were conducted on the same objects as case-study. The main purpose of testing the EnergyCalc was to determine how the number of appliances and their year of production as well as the duration of monitoring period affect the accuracy of calculation of total electricity consumption. For this calculated results were compared with the meter's records. Another purpose of testing was to determine how easy the user can get input parameters and to what extent he is satisfied with results of monitoring experiment. The responders have estimated these two parameters in Likert scale from 1 to 5 (1 – not satisfied at all/ very difficult; 5 – totally satisfied/ very simple) [13]. The tests' results are presented in the table below.

Tab. 2. The results of testing procedures

Object	The number of appliances (measurable units)*	Average time of operation (year)	Duration of monitoring, days	Mistake, % (the difference in calculated and real readings)
Household 1	17	3	7	5%
Household 2	13	4	7	5%
Household 3	18	2	7	7%
Household 4	18	4	7	5%
Household 5	19	3	11	9%
Household 6	19	3	7	5%
Household 7	20	2	10	10%
Office 1	17	7	14	10%
Office 2	10	5	7	11%
Office 3	17	7	7	13%
Office 4	12	5	7	9%
School 1	20	3	5	15%
School 2	20	4	10	10%

* All appliances of the same kind such as lamps, computers or laptops of the same power were considered as one measurable unit

Analyzing the data at the table, we can see that the lowest level of mistake is achieved in households. However, neither the number of appliances under monitoring, nor their year of production or time of observation did not significantly affect the accuracy of the results.

The level of mistake for offices is almost twice higher, which can be explained by insufficient quality of monitoring procedure (not all types of devices and their differences in power are included in the list), but also by the fact that not all the energy consumption issues came to the attention of persons, who conducted monitoring.

There is not enough data to do some statistically proved conclusions about the accuracy of calculation for public schools, but it seems that the longer duration of monitoring cause better results.

The level of satisfaction with results and evaluation of simplicity of monitoring are presented on figure 6. It is interesting, that the level of satisfaction has a negative correlation with the accuracy of calculation. It happens mostly because owners (or managers) of complicated objects for monitoring such as SMEs offices and public schools are more interested in some tools that are quite simple in operating and can give them a glimpse which investment decision will be more effective for energy saving.

Most of responders also have noted that the process of monitoring helped them to realize how much they can improve their daily patterns of energy consumption; some decided to switch to use of energy saving light bulbs and others – to use day/night tariff meters. One office manager has observed unrecorded electricity consumption. Another firm started to consider implementing environmental standards and motivating workers with pro-social preferences, because they have found that “green employees” report a significantly higher perception of usefulness and equitable recognition at work during experiment (that fully correspond to the results of the study [14]).

These results of testing process show that participating in energy efficiency studies can be considered as a high influencing social interaction which helps to form of consumer perceptions and preferences for pro-environmental technologies [15].

Test procedures were helpful as well in terms of gathering user feedback for further improvement of the program. Thus, some users noted that they prefer to use similar program on their mobile phones.

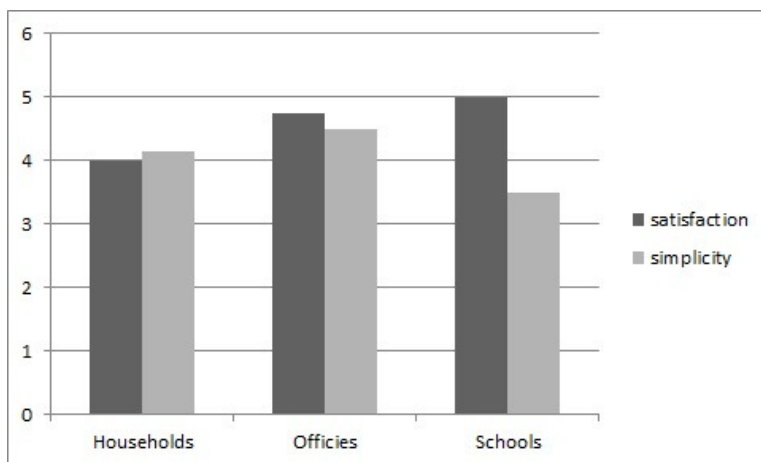


Fig. 6. Opinions of the respondents on satisfaction and simplicity with results of monitoring procedure [source: authors own studies]

Based on the results of test procedures it was decided to present the calculator for home and office in a form of mobile application. Current version of the program will be supplemented with practical recommendations on energy saving and put to one of the regional Internet portals on energy efficiency as open access software. It will not only give advantages in distributing the program, but will also (in case the user's consent) help to collect statistics on the energy consumption structure of households and offices. The use of the Calculator at the regional level will help to gather statistical data that can supplement and clarify the results of studies conducted by government agencies, which sometimes use outdated methods of data collection that do not meet the requirements of modern realities [16].

5. CONCLUSIONS

Resent significant increase in electricity tariffs and the growing popularity of energy-saving technologies in Russia initiate the interest to the problem of energy consumption monitoring. While a professional energy audit currently is very expensive, owners of small and middle-sized companies as well as regular householders demonstrate a high level of interest to use some “do-it-yourself” tools that can help to make very first steps in introduction of energy management systems and reduce the cost of professional energy audit.

By the use of presented EnergyCalc one can calculate the structure of energy consumption of a household, office or typical public school and see it both in graphic and number formats. Testing procedures helped to figure out that the lowest level of mistake is achieved in households (average 7%), while

the level of mistake for offices is almost twice higher. The results of monitoring for public school have the mistake about 15%, but they can be improved with increase of time for monitoring.

Test procedures were helpful in terms of gathering user feedback for further improvement of the program. Based on their results it was decided to present the calculator for home and office in a form of mobile application

REFERENCES

- [1] XIAOHUA XIA, JIANGFENG ZHANG.: *Mathematical description for the measurement and verification of energy efficiency improvement*. Applied Energy, Vol. 111, 2013, pp. 247-256.
- [2] RATNER S.: *The implementation of state policy in the field of energy efficiency*. Economic Analysis: Theory and Practice, No. 29, 2013, pp. 21-28. (in Russian)
- [3] RATNER S., IOSIFOVA L.: *Evaluating the effectiveness of regional energy efficiency programs (the case of Krasnodar region)*. Regional Economy: Theory and Practice, No. 35, 2013, pp.43-49. (in Russian)
- [4] Official site of energy audit: [electronic resource]. (<http://www.energo116.ru>) [date of access: 21.12.2013]
- [5] Russian Federation Government Decree of October 21, 2011 No. 1843 -r on the distribution of subsidies granted in 2011 from the federal budget of the Russian Federation to co-finance expenditure commitments associated with the implementation of regional programs in the field of energy conservation and energy efficiency.
- [6] GROGER M., SCHMID V., BRUCKNER T.: *Lifestyles and Their Impact on Energy-Related Investments Decisions*. Low Carbon Economy, No. 2, 2011, pp. 107-114.
- [7] VALENZUELA C., VALENCIA A., WHITE S., JORDAN J. A., CANO S., KEATING J., NAGORSKI J., POTTER L. B.: *An analysis of monthly household energy consumption among single-family residences in Texas, 2010*. Energy Policy, Vol. 69, 2014, pp. 263-272.
- [8] CHOONGWAN KOO, TAEHOON HONG, MINHYUN LEE, HYO SEON PARK.: *Development of a new energy efficiency rating system for existing residential buildings*. Energy Policy. Vol. 68, 2014, pp. 218-231.
- [9] IN-AE YEO, SEONG-HWAN YOON, JURNG-JAE YEE.: *Development of an urban energy demand forecasting system to support environmentally friendly urban planning*. Applied Energy, Vol. 110, 2013, pp. 304-317.
- [10] BOTETZAGIAS I., MALESIOS C., POULOU D.: *Electricity curtailment behaviors in Greek households: Different behaviors, different predictors*. Energy Policy, Vol.69, 2014, pp. 415-424.
- [11] YIN R.: *A case study research: Design and Methods*. Thousand Oaks, CA: Sage, 2002.
- [12] DAVIS, A.L, KRISHNAMURTI, T.: *The problems and solutions of predicting participation in energy efficiency programs*. Applied Energy, Vol. 111, 2013, pp. 277-287.
- [13] ALLEN E., SEAMAN C.: *Likert Scales and Data Analyses*. Quality Progress, 2007, pp. 64-65.
- [14] LANFRANCHI J., PEKOVIC S.: *How green is my firm? Workers' attitudes and behaviors towards job in environmentally-related firms*. Ecological Economics, Vol. 100, April 2014, pp. 16-29.
- [15] AXSEN J., ORLEBAR C., SKIPPON S.: *Social influence and consumer preference formation for pro-environmental technology: The case of a U.K. workplace electric-vehicle study*. Ecological Economics, Vol. 95, 2013, pp. 96-107.
- [16] FOULDS C., POWELL J.: *Using the Homes Energy Efficiency Database as a research resource for residential insulation improvements*. Energy Policy, Vol. 69, 2014, pp. 57-72.

Arkadiusz GOLA*, Łukasz SOBASZEK**

IMPLEMENTATION OF MS ACCESS SOFTWARE FOR CASING-CLASS MANUFACTURING FEATURES SAVING

Abstract

Manufacturing features are widely accepted as a means for the CAD, CAPP and CAM systems and their integration. Despite high number of works in this area, the investigations on the methods on manufacturing features saving are still limited and many results are not suitable for manufacturing systems design purposes. The paper presents possibility of using the MS Access software for saving and management of constructional data of casing-class parts. Therefore, the method of representation and saving casing-class constructional knowledge was developed. The proposed method is based on application of the design feature technique.

1. INTRODUCTION

The increase of global competitiveness, motivates manufacturers to realize their processes in more and more efficient way. On the other hand individualization and complexity of manufactured products caused the complexity of production preparation and management. In consequence, these challenges are the main cause of permanent development in such areas as production preparation processes and realization of production processes. The manufacturing process planning is one of the most important action in the domain of both technical production preparation [1,2] and manufacturing systems design [3,4].

Manufacturing feature technology is the subject of many works. Especially high number of works deals with the algorithm for feature recognition [5,6,7]. Despite underlining the significance of the manufacturing features in CAD/CAPP integration [8,9,10] or detailed descriptions of applications

* Lublin University of Technology, Department of Enterprise Organization,
ul. Nadbystrzycka 38, 20-618 Lublin, Poland, e-mail: a.gola@pollub.pl, tel. +48 81 538 44 83

** Lublin University of Technology, Institute of Technological Systems of Information,
ul. Nadbystrzycka 36, 20-618 Lublin, Poland, e-mail: l.sobaszek@pollub.pl, tel. +48 81 538 45 85

of manufacturing features in different manufacturing process planning activities [11,12,13], there are only works about the logic structure of the database used for a the storage and processing of manufacturing features [14,15].

Databases significantly influence the application of computer techniques. To make database software useful for manufacturing features storage the proper method of representation and saving constructional data is necessary. This paper presents the conception of method of representation and saving constructional knowledge about casing-class parts using the MS Access system. This solution was successfully implemented for computer aided machine-tool selection for flexible manufacturing systems [16-21].

2. METHOD OF REPRESENTATION OF CONSTURCTIONAL FEATURES

In this work the concept of '*construction*' word is understood in accordance with definition presented by J. Dietrych [22]. Following to this definition, '*construction is a configuration of features and different states of a part*'. Determination of construction depends on assigning of part's states. Construction is determined by defined constructional features. Identification of constructional feature depends on selection of constructional structure and configuration of dimensions what can be presented as below:

$$C = f(\Pi; Y), \quad (1)$$

where: C – constructional feature,
 Π – constructional shape of part,
 Y – configuration of dimensions.

According to J. Dietrych's definition, constructional shape of part is quality constructional property, while configuration of dimensions is a way of identification constructional features. Simultaneously, only construction determines permissible decomposition identified using a configuration of dimensions. Formal representation of W dimension as an element of configuration of dimensions can be submitted as below:

$$W = N + T, \quad (2)$$

where:
 N – rated dimension,
 T – tolerance of dimension.

After analyzing traditional constructional and technological documentation of casing-class parts and also available in literature solutions concerning with designing of technological data base and data management, the method of representation and saving constructional data was developed. This method was based on three-levels data base what was shown in fig. 1.

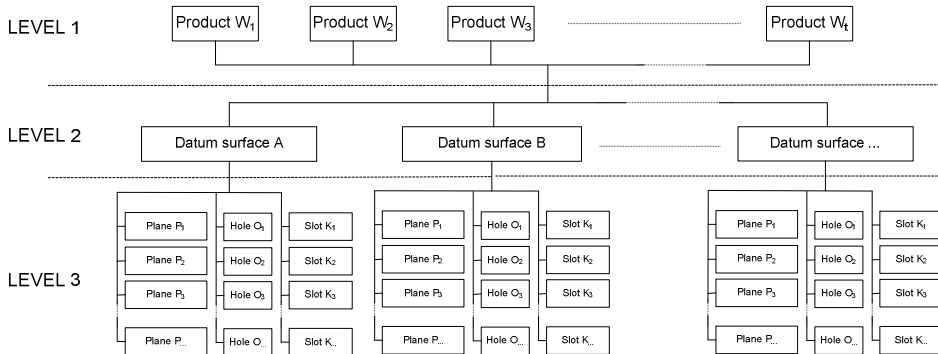


Fig. 1. Structure of database for saving data on casing-class products to be machined in a FMS [source: own study]

From Level 1 the user can input data of informative character and define the product to be machined in the FMS. In particular, the input data will include such items as:

- the name of the product,
- product's symbol,
- overall dimensions of the semi-finished product (including distances required for fixing the product on a machining palette or in a fixture),
- weight of the semi-finished product,
- assumed annual production program for the part.

Level 2 is used to define the datum surfaces for the machining of the part. The datum surface is taken as an actual or a virtual plane within the machining space, defined in terms of position, permitting precise parameterization of coordinates of features involved in the machining process of a specific product. A uniform system of classification of machining datum has been developed for the purposes of description of datum surfaces when machining parts.

Level 3 of the database is used to define the consecutive features to be machined, with relation to specific products from the casing class. In particular, there is a possibility to define three basic types of machined features – planes, holes, or slots.

2.1. Classification of the basic datum surfaces for the machining of the casing-class part

To make an automatic verification of machining specified part on specified machine tool possible it is necessary to simultaneously define both the position of the part and position of all objects to be machined in the machining space of the machine tool. But it is also important to define not only position but also side from with the machining process will be realized.

Casing-class parts are objects which have three-dimensional character, and machining process for these parts can be realized in flexible manufacturing system after fixing them on the technological (or machining) pallet. In order to realize proper description of basic datum surface for the machining of the part the literal-numerical system was taken. This system allows for determination of datum surface and coordinates of basic point which is characteristic for the position of basic datum surface for the machining (fig. 2).

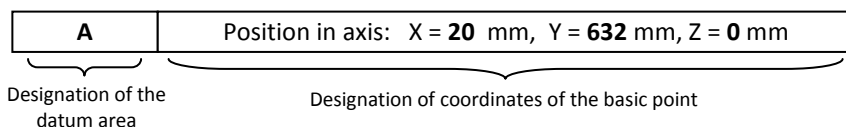


Fig. 2. An example of designation of basic datum surface for machining [source: own study]

The system of classification of datum surface for machining was based on five basic datum surfaces for machining designated using the symbols as below (fig. 3):

- A – basic datum surface for machining (cutting plane) parallel to the surface of technological pallet,
- B – basic datum surface for machining (cutting plane) perpendicular to the surface and parallel to one of longer edge of technological pallet
- C,D,E – basic datum surface for machining (cutting plane) perpendicular to the surface of technological pallet turned in accordance with the direction of clock-hand moving adequately for an angle 90°, 180° and 270° in relation to defined B basic datum surface.

In case of existing additional datum surfaces for machining placed into specified angle in accordance with the location of basic datum surface for machining the destination has the literal-numerical character. Letters indicate basic datum surfaces which are the basis for determination of placement and number which determines the angle of cutting-plane location in accordance with basic surfaces (for example: designation AE 30 determines basic datum surface placed between cutting planes A and E slanting into angle 30° in according to basic datum surface for machining A – fig. 4).

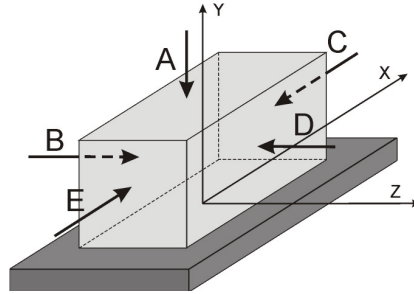


Fig. 3. Literal denotation of basic datum surface for machining [source: own study]

In order to define in an unequivocal way the basic datum surface for machining in machine-tool's machining space it is needed to define coordinates of location any basic point on the plane in according to co-ordinate system with origin of coordinates in the middle of front plane of technological pallet on which the object to be machined is fixed (fig. 4).

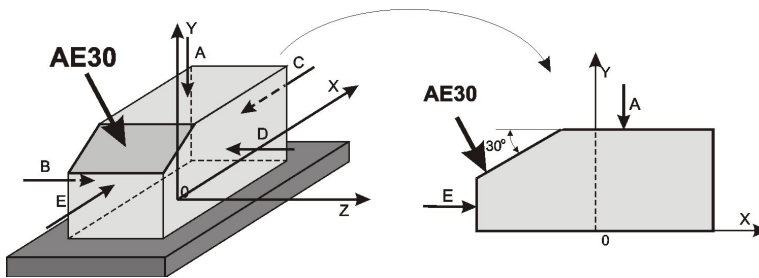


Fig. 4. An example of indicating the basic datum surface for machining located with the angle 30° in relation to A and B basic datum surface [source: own study]

2.2. Saving constructional knowledge about parts to be machined

Defining the basic datum surface for machining according to the classification gives possibility to define datum surface for machining in machine tool's machining space and determines the cutting plane of reference for each object intended to be machined in specified part. Analysis of features of casing class parts allows to specificate three elementary objects which are machined in this type of parts:

- Planes,
- Holes,
- Slots.

Planes are the most often machined to obtain surface's roughness or flatness imposed by the constructor. It is possible to distinguish two types of planes: internal (grooves) or external (shelves), for which are defined: coordinates of machining range in X and Y axis (in local co-ordinate system on the basic datum surface for machining in relation to placement of basic point), value of withdrawal from basic datum surface for machining, roughness of butting and/or lateral face (for grooves) and also different information concerning with the machined surface (for example: flatness deviation).

Holes can be divided in cylindrical hole (straight forward) and conical (convergent). In case of holes defined parameters are: coordinates of hole centre, its dimensions (diameter or diameters, angle of inclination), roughness parameters, deviations of position and dimension, information about its materiality, thread, machining depth and others.

The characteristic type of object which can be found in casing-class parts are slots completed for fixing with using o-rings. These objects, performed most often by the milling or reaming are some kind a special type of "cut-outs" performed in machined earlier holes. For slot-type objects defined parameters are: coordinates of slot centre, width and diameter of slot, value of withdrawal from basic datum surface for machining, value of roughness of cylindrical and frontal surfaces of slot and other values connected with the object (for example: deviations of position and dimension).

All of presented above objects are defined individually and independently apart from each other and each of these is identified using the unrepeatable symbol given by the user in the moment of input the object into database. In case of complex holes (with cylindrical or conical spot facing) they are decomposed into elementary elements (cylindrical or conical hole) where each one is defined separately.

For unequivocal determination of orientation in machine tools machining space, it is necessary to define coordinates in relation to connected with the object basic datum surface for machining. Coordinates of position of characteristic point (or characteristic points) – i.e. center of the hole or the slot are determined in two-dimensional local co-ordinate systems. One is the plane which is overlapping with basic datum surface for machining where its center is overlapping with the basic point of datum surface for machining (fig. 5).

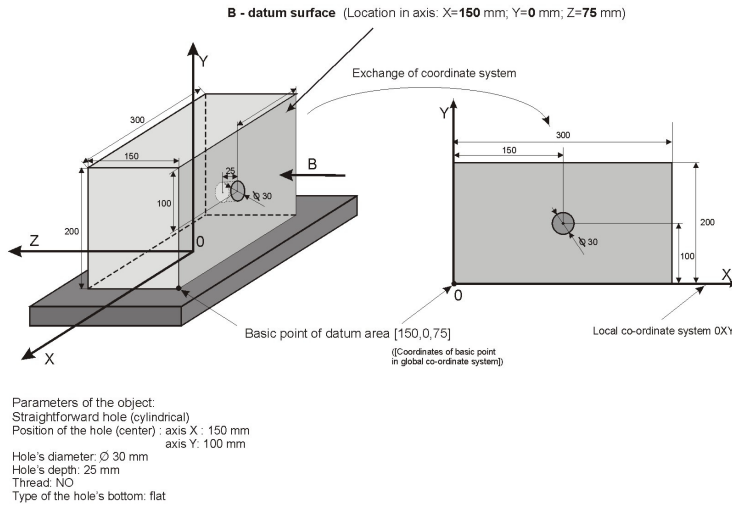


Fig. 5. An example saving data about location and parameters of selected cylindrical hole-type object [source: own study]

3. SAVING CONSTRUCTIONAL DATA ABOUT CASING-CLASS PARTS USING MS ACCESS SOFTWARE

The database where manufacturing features of parts intended to be machined in FMS are gathered using MS Access system and in this article the database is presented as a part of the system <<OPTSELECT>> which allows for computer aided machine tools selection for casing-class flexible manufacturing system. Its starting, which allows to input constructional data, is realized from the main form of program by trusting the bottom “Data input about parts to be machined in FMS” – fig. 6.

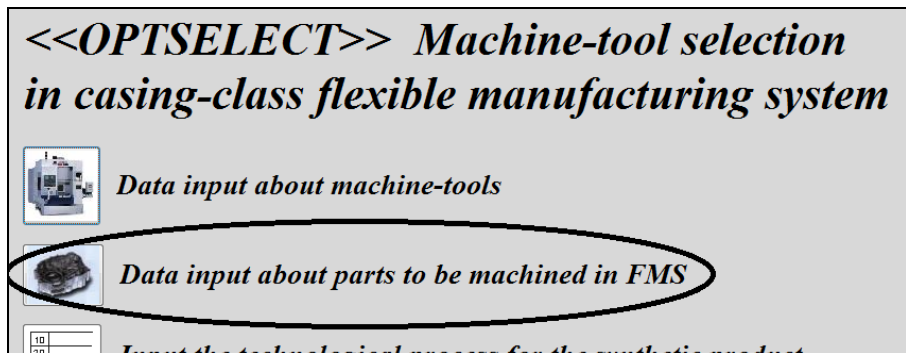


Fig. 6. Starting the constructional features database [source: own study]

Database where the saving process of constructional features of parts to be machined in flexible manufacturing system has three-levels structure according to brief foredesign presented in section 2 (fig. 1). Starting the database causes opening the main form of data base, which gives possibility to input data of informational sense which define the part to be machined in FMS – fig. 7.

Catalogue of casing-class parts to be machined in FMS

Identification number: 1

Part's catalogue number: 419-40-1002

Name of the part: Cylinder block

Overall dimensions of semi-finished product

Length (L):	712	mm
Width (B):	243	mm
Height (H):	712	mm

Distance needed to fix a semi-finished product

In axis of the product's length:	76	mm
In axis of the product's width:	307	mm
In axis of the product's height:	178	mm

Weight of semi-finished product: 91 kg

Annual production programme: 760 pieces

Fig. 7. Main form to input data about parts to be machined in FMS [source: own study]

Using the form presented above, the user has also possibility to define all necessary basic datum surfaces for machining in case of consecutive parts moved into system – fig. 8.

Catalogue of casing-class parts to be machined in FMS

Weight of semi-finished product: 91 kg

Annual production programme: 760 pieces

Basic datum surfaces of the part:

Symbol of datum surface:	In X axis:	In Y axis:	In Z axis:	
A	0 mm	832 mm	0 mm	Go to the datum surface form
AB45	0 mm	476 mm	0 mm	Go to the datum surface form
B	167 mm	476 mm	0 mm	Go to the datum surface form
C				
D				
E				

Location of basic point:
(In relation to the center of the pallet)

Remarks:

Fig. 8. The form for defining datum surfaces for machining [source: own study]

Defining individual objects intended to be machined into a part is possible after opening the datum surface for machining form (button “Go to the datum surface form”) and pressing the button “Add a new machining object” – fig. 9.

Datum surface

Identifier of the basic datum surface 1
(Generated automatically)

Symbol of the datum surface: AB45

Position of basic point
(in relation to the center of the pallet)

In X axis: 0 mm

In Y axis: 832 mm

In Z axis: 0 mm

Add a new machining object

Save and exit


Exit without saving


Close


Fig. 9. Adding a new machining object [source: own study]

When choose the defined object (fig. 10) the user takes advantage of proper appearing form (which is characteristic for particular object) input parameters connected with defined object. The fragment of an example object (cylindrical hole) was presented in fig. 11.


Type of an object

Plane

Hole

Slot

Type of a hole

Cylindrical hole (straight forward)


Conical hole (convergent)

Fig. 10. Following steps in defining the object to be machined [source: own study]

Cylindrical hole

Define the basic datum surface for the hole:
(choice from the list)
 B: Location in axes: X: 0 mm, Y: 476 mm, Z: 0 mm

Symbol of the hole: **03**

Coordinates of the hole's location:

In X axis: 66,25 mm

In Y axis: 333,2 mm

☐ Input tolerance for hole's location

Hole's diameter: \varnothing 13,50 mm

☐ Input tolerance for hole's diameter

Type of a hole:

☐ Arterial

☒ With defined depth

Głębokość otworu (L):
(from the datum surface) 17 mm

Is the hole threaded?:

☒ YES

☐ NO

Type of a thread 3/4" - 10UNC - 2B

Thread's depth (S):

☐ The same as the hole's depth

☒ Defined depth: 48 mm

Type of the hole's bottom:

☐ Flat

☒ Conical An angle of the hole's bottom: 112 °

Preview:

Roughness designation:

☐ Roughness of forehead surface: Ra

☐ Roughness of cylindrical surface: Ra

☐ Roughness of a thread: Ra

**Fig. 11. The form of saving data about the object
 (an example of cylindrical hole) [source: own study]**

Information about loaded parts, basic datum surfaces for machining and objects can be chosen both from the level of form and the table, where the data are saved. Passing between separate forms is possible thanks to navigational buttons located on each of the form. From the level of particular form it is possible to check each time all connected objects (for example: part and defined basic datum surfaces, or the basic datum surface for machining and connected objects).

All constructional data about parts to be machined are saved in 10 connected tables. Detailed specification and relation between them were presented in fig. 12.

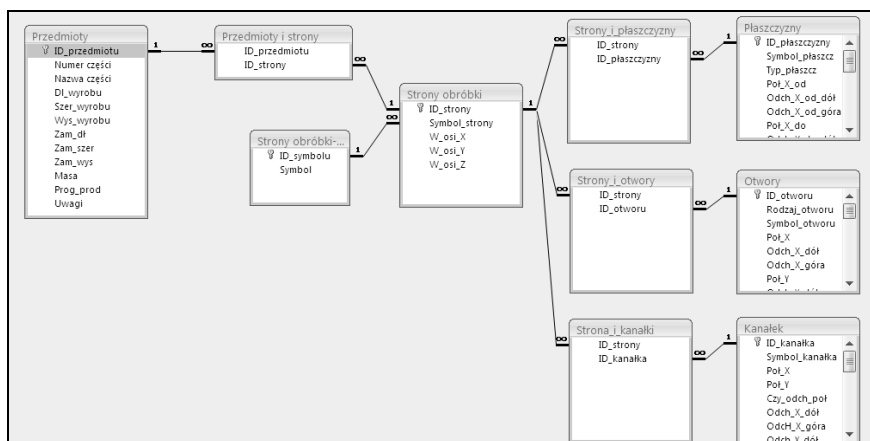


Fig. 11. Tables and relations between tables in database about parts [source: own study]

4. CONCLUSIONS

One of the fundamental tasks when design and develop software which helps the human to realize any activity is to guarantee possibility of simple and fast input appropriate data and in such way that it would be possible to select, look over and verify them. In order to make it possible one often has to develop the conception of gathering information is structuralized way, that gives further possibility to fast access to their source and fast processing of them.

This kind of problem is possibility of saving technical knowledge (constructional and technological) about parts to be machined in manufacturing system in such way that make possible the optimal selection of machine tools used for their processing. In this article the method of representation and saving constructional data about casing-class parts was presented. This method was submitted in context of problem of machine tools selection in flexible manufacturing system. The presented method allows for relatively fast and simple “transfer” data recorded as traditional constructional and technological documentation to computer software which helps the designer to select the FMS machine tools subsystem.

The presented method was based on three-levels data base which allows for saving constructional parameters and in different module – technological knowledge. This conception was implemented in the surface of MS Access database software and is an integral module of <<OPTSELECT>> program which is dedicated for casing-class flexible manufacturing system machine tool subsystem selection. The method can be moreover used in an independent way both for different task where the computer saving and registering technical documentation is necessary and also in different user applications.

REFERENCES

- [1] CIURANA J., GARCIA-ROMEU M.L., FERRER I., CASADESUS M.: *A model for integration process planning and production planning and control in machining process*. Robotics and Computer-Integrated Manufacturing, vol. 24, no. 4, 2008, pp. 532-544.
- [2] PHANDEN R.K., JAIN A., VERMA R.: *Integration of process planning and scheduling: a state-of-the-art review*. International Journal of Computer Integrated Manufacturing, vol. 24, no. 6, 2011, pp. 517-534.
- [3] GOLA A.: *Economical Aspects of Manufacturing Systems Design*. Actual Problems of Economics, vol. 156, no. 6, 2014, pp. 205-212.
- [4] TOLIO T. (ed.): *Design of Flexible Production Systems*. Methodologies and Tools, Springer-Verlag, Berlin Heidelberg, 2009.
- [5] BABIC B., NESIC N., MILKOVIC Z.: *A review of automated feature recognition with rule-based pattern recognition*. Computers in Industry, vol. 59, no. 4, 2008, pp. 321-337.
- [6] LIU X.J., NI Z.H., CHENG Y.L., LIU J.F.: *Machining feature recognition method for machining process facing plate parts*. Computer Integrated Manufacturing Systems, vol. 19, no. 12, 2013, pp. 3130-3138.
- [7] SHANTHAKUMAR A., SUMMERS J. D.: *Design enabler to recognize duplicate geometries in CAD assemblies*. Computer-Aided Design and Applications, vol. 10, no. 6, pp. 889-904.
- [8] NIKIEL G.: *Computer-aided CNC programming for the machining of non-typical parts*. Advances in Manufacturing Science and Technology, vol. 31, no. 4, 2007, pp. 21-36.
- [9] GRABOWIK C., KALINOWSKI K., MONICA Z.: *Integration of the CAD/CAPP/PPC*. Journal of Materials Processing Technology, 164-165, 2005, pp. 1358-1368.
- [10] GRABOWIK C., KALINOWSKI K.: *Object-Oriented Models in an Integration of CAD/CAPP/CAP Systems* [in:] Corchado E., Kurzyński M., Woźniak M. (ed.): Hybrid Artificial Intelligent Systems, Springer, 2011, pp. 405-412.
- [11] STRYCZEK R.: *A hybrid approach for manufacturability analysis*. Advances in Manufacturing Science and Technology, vol. 35, no. 3, 2011, pp. 55-70.
- [12] GRABOWIK C., KALINOWSKI K.: *The Hybrid Method of Knowledge Representation in a CAPP Knowledge Based System* [in:] Corchado E., Snasel V., Abraham A., Woźniak M., Grana M., Sung-Bae C. (ed.): Hybrid Artificial Intelligent Systems, Springer, 2012, pp. 284-295.
- [13] HOQUE A.S.M., SZECSI T.: *Designing using manufacturing feature library*. Journal of Materials Processing Technology, vol. 201, 2008, pp. 204-208.
- [14] GRABOWIK C., KNOSALA R.: *The method of knowledge representation for a CAPP system*. Journal of Materials Processing Technology, vol. 133, 2003, pp. 90-98.
- [15] POBOŻNIAK J.: *Logic Level of Workpiece Object Database Oriented on Manufacturing Features*. Advances in Manufacturing Science and Technology, vol. 36, no. 1, 2012, pp. 19-25.
- [16] GOLA A., ŚWIĆ A.: *Computer Aided FMS Machine Tools Subsystem Selection – Conception of Methodology*. Applied Computer Science, vol. 5, no. 1, 2009, pp. 27-39.
- [17] GOLA A., ŚWIĆ A.: *Brief Preliminary Design for a Method of FMS Machine Tools Subsystem Selection*. PAMM, vol. 9, no. 1, 2010, pp. 663-664.
- [18] ŚWIĆ A., GOLA A.: *Elements of Design of Production Systems – Methodology of Machine Tool Selection in Casing-Class FMS*. Management and Production Engineering Review, vol. 1, no. 2, 2010, pp. 73-81.
- [19] GOLA A., MONTUSIEWICZ J., ŚWIĆ A.: *Computer Aided FMS machine tools subsystem selection using the Evolutionary System of Multicriteria Analysis*. Applied Computer Science, vol. 7, no. 1, 2011, pp. 18-29.

- [20] GOLA A., ŚWIĆ A.: *Computer-Aided Machine Tool Selection for Focused Flexibility Manufacturing Systems Using Economical Criteria*. Actual Problems of Economics, vol. 124, no. 10, 2011, pp. 383-389.
- [21] GOLA A., ŚWIĆ A., KRAMAR V.: *A multiple-criteria approach to machine-tool selection for focused flexibility manufacturing systems*. Management and Production Engineering Review, vol. 2, no. 4, 2011, pp. 21-32.
- [22] DIETRICH J.: *System i konstrukcja*. WNT, Warszawa 1985.

Natalya SHAKHOVSKA^{*}, Roman NOHA^{**}

THE SYSTEM DEVELOPING OF FORMING RESEARCH SCHOOLS BASIS OF PUBLICATION ELEMENTS ANALYSIS

Abstract

In this paper the method of research publications elements analysis that is determining common qualities of research publications and their clustering as an instrument of selecting and sorting out the information about research schools has been introduced. In module structuring documents transmitted there are tape that indicates the address of the file. Depending on where the file is, it can be a path to a file on the local disk or URL on the Internet.

1. INTRODUCTION

Scientific direction is an area of scientific research team to address some significant fundamental problems. School Science is a Research team, which aims at addressing scientific field.

Abstracting is the process of obtaining information of primary importance from one or several sources in order to create a shorter version of it to meet the requirements of some users or tasks [1,2].

Among the segmental items of scientific publications the following ones can be defined: the author, the research institution, the subject, and the keywords. It is determining of these 4 elements that gives the possibility of faster content searching as well as text and structured information integrating. The process of abstracting is divided into three phases: analysis of the source text, identify specific fragments and the formation of appropriate conclusion. Most current work focused around technology developed referencing one document [1].

^{*} Lviv Polytechnic National University, Ukraine, 79013, Lviv, Bandera str., 28a, natalya233@gmail.com

^{**} Lviv Polytechnic National University, Ukraine, 79013, Lviv, Bandera str., 28a, rnoha@gmail.com

The method involves compiling quotes emphasis on the selection of characteristic fragments (usually sentences). This method of mapping phrase patterns allocated blocks biggest lexical and statistical relevance. Creating a final document in this case is merging aggregation of selected fragments.

Most methods used linear model weights. The basis of the analytical phase of this model is the procedure for appointing weights for each block of text according to characteristics such as the location of the block in the original frequency of appearance in the text, the frequency of use of key sentences, as well as indicators of statistical significance. The sum of individual weights are usually determined after further modifications according to specific configuration parameters associated with each weight, gives the total weight of the entire block of text [2,5,6].

2. THE PROBLEM FORMULATION

Among the available methods for the analysis of scientific publications is to develop ontologies. The important role in the analysis of the set of text documents and Internet there is playing World Wide Web. The ontologies usage for searching allows the user to formulate a query at a higher level of abstraction than is possible when searching for keywords.

Let us consider the examples of systems using ontologies for the Internet [4]. Observer (<http://siul02.si.ehu.es/~jirgbd/OBSERVER>). This system provides an approach using the many existing ontologies to access heterogeneous, distributed and independently of developed repositories of data. The implementation of this approach is the ideology broker ontology domains. It is assumed that there is a lot of pre-existing ontologies domains; user optionally can build new terms for a specific ontology. User formulates a query certain language in terms of one or more ontologies and broker “seeking” relevant information resources, performing broadcast request in appropriate ontologies and, if necessary, and a combination of multiple ontologies for a precise answer to the request [7,9].

OntoSeek is designed to retrieve information from the context of online “yellow pages” directories and products. The system can handle both homogeneous and heterogeneous catalogs of products. For exact fixing of context this system can be applied to interactive approach where user progressively refines the meaning of key words with linguistic database. OntoSeek a centralized server that hosts the database of lexical conceptual graphs known system resources, but create the graphs client.

The approach used in OntoSeek is different from the approach used in the model W3C Resource Description Framework (W3C RDF, Netlogon! Unacceptable Object hyperlinks. In the RDF description of the data structure (ie, schema data as <subject, predicate, object>) object is added in HTML/XML document and it is not stored separately. There are no additional conditions on the semantic consistency RDF requires.

WordNet is a linguistic database consisting of sensitive groups of words equivalent in meaning. WordNet is both lexical dictionary (created for several European languages), and ontology that reflects relationships between words in the dictionary. Description resource is implemented as a lexical conceptual graph, where peaks correspond to words, and referred to the arc present the semantic relations between words (eg, relations of “part” or “subclass”, etc.). Names of vertices and arcs are also taken from WordNet when you create a conceptual graph of a particular resource. Finding resources is relevant to a user query. This process based on a comparison of ontologies (lexical conceptual graphs) of these resources. For resources selection that relevant to a user query WordNet performs comparison of conceptual graph queries from existing resources conceptual graphs or parts of graphs.

Ontological approach is famous to search for papers specific scientific school. However there is small number of Ukrainian language ontologies. Therefore, we can use the ontological search on the next stages constructing a system analysis of the scientific schools.

As you can see, nearly all of these areas there are scientific investigations. But these non-integrated work, do not provide a single processing and rigidly attached to the data model that is completely unacceptable in the context of data space. Therefore, the problem of formalization of data space is important.

3. MAIN PART

3.1. The method of research school clustering

Uploading the data, analysis and selection of the publications elements are the necessary steps to acquire information needed from the content for its further processing. Suppose there is a certain publication P .

We will analyse the document, which consists of name T , keywords K , author A , main part M , literature L [3]:

$$D = \{T, K, A, M, L\} \quad (1)$$

Defining elements of the document is based on the allocation of such features text: location in the document; location of a paragraph (left, right, centered); type of writing (bold, italic, underline, normal); character recognition.

For the task of bringing to the final ranking factor “information novelty” use the following method:

1. Let we have two sets of sentences $B = \emptyset$ and $A = \{A_i | i = 1, 2, \dots, N\}$, N is count of sentences in text. For every sentence A_i the usefulness $P(i)_i$ set $q_i : P(i)_i = q_i, i = 1, 2, \dots, N$.
2. The sentences from set A sort Descending $P(i)_i$.
3. If A_i has the biggest $P(i)_i$, we take it in B . The usefulness for sentences in A set $s P(i) = P(i) / kq_i$, where $k > 0$ is a factor clipping similar sentences.
4. Is A empty? If NOT, go to 1.

After publication abstracting the expected material's "characteristics" have been obtained. After the data have been analyzed and the necessary information has been received the research publication clustering can operate. Clustering is the automatic partition of the elements of a certain set into groups. It can be achieved by using the k-nearest neighbor algorithm. The k-nearest neighbor algorithm consists of several steps.

1. Setting up the number of neighbors – k [7,8,10,11].
Since the features of clustering (author, research institution, subject, keywords) have not been arranged properly the d-isolated points matrix is to be applied:

$$l(X.x, Y.x) = \begin{cases} 1, X.x = Y.x \\ 0, X.x \neq Y.x \end{cases} \quad (2)$$

$$d(X, X_i) = \sum_i^p l(X.A_i, Y.A_i) + \sum_j^r l(X.D_j, Y.D_j) + \sum_t^w l(X.B_t, Y.B_t) + l(X.C, Y.C) \quad (3)$$

where: p – number of authors of both of the publications,
 r – total number of keywords, w is a total number of scientific institutions,
 $X.A_i$ – the author with number i for scientific publication X etc.

2. Determining the k – nearest neighbors for every object. Object X_i is considered to be the nearest neighbor for X if $d(X_i, X) = \max_i d(X_i, X)$, $i = \overline{1, N}$, where N is the number of publications.
3. Object X is defined to be of the same type as most of his nearest k neighbors. If the object is not registered in any of the clusters loose bounds between the object and the clusters are being searched for.

If the value of distance between the objects X and X_i is smaller than one third of its maximum number they are loosely bound:

$$d_s(X, X_i) \leq \frac{\max d(X, X_i)}{3} \quad (4)$$

Having a loose bound allows to use the common quality definition method in the title of the publication.

Suppose there are certain titles $C1$, $C2$, $C3$. For example:

$C1 = \text{«Searching and saving information with the help of the web search engine »}.$

$C2 = \text{«Review and saving files in the file System »}.$

$C3 = \text{«Searching for information in the World Wide Web»}.$

Let the titles be divided into 2 parts: right and left using the symmetric division in length. Suppose that the left part is more valuable in terms of its informative importance than the right half. The subjects are to be divided right and left and the common qualities are to be picked out. Words such as «and, so» should be ignored. Words with capital letters should not be ignored because there may be cases of it functioning as abbreviation. In addition the endings of the words should be cut-off. The result is:

$$\begin{aligned} C1l=C3l &= \text{«searching, information»}, \\ C1l=C2l &= \text{«saving»}. \end{aligned}$$

The created between the publications in which more than half of the words in the left column match is called the strong bound. Since $C1l$ and $C3l$ have 2 common names in their titles there is supposed to be strong relation between the publications $P1$ and $P3$. Therefore the titles $C1l$ and $C2l$ have a loose bound in their titles.

Such bounds between the titles can be applied for additional bound loading between the publications which in its turn may influence the process of decision making which of the existing scientific schools the research publication refers to or if it is to be left for creating a new school.

For estimating of classifier k -NN quality there is used indicator of the probability of correct classification: TP (true positive) – number of documents with true classified, FP (false positive) – error of 2 range (count of documents, which are incorrect been in cluster); FN (false negative) – error of 1 range (count of documents, which must be in cluster, but they are not here); TN (true negative) – count of documents, which not belong to the cluster. Values TP and TN evaluate by formula:

$$\begin{aligned} TP &= Np - FN \\ TN &= Nn - FP \end{aligned} \quad (5)$$

where: Np – count of documents, which clustered without error and Nn is count of documents which clustered with error.

Next we norm values TN , TN , FN , FP :

$$\begin{aligned} nFN &= \frac{FN}{Np} * 100\%; nFP = \frac{FP}{Nn} * 100\%, \\ nTN &= \frac{TN}{Nn} * 100\%; nTP = \frac{TP}{Np} * 100\%. \end{aligned} \quad (6)$$

Also we estimate the quality of document clustering. We use such metrics:

- Recall: $\frac{|D_{rel} \cap D_{retr}|}{|D_{retr}|}$,
- Precision: $\frac{|D_{rel} \cap D_{retr}|}{|D_{rel}|}$,
- Fall-out: $\frac{|D_{nrel} \cap D_{retr}|}{|D_{nrel}|}$,

where: D_{rel} – the set of relevant documents in cluster,

D_{nrel} – the set of not relevant documents in cluster (error in clusterization),

D_{retr} – the set of relevant documents in another clusters.

3.2. APPROBATION

The first stage of implementation is to design a database (DB). At the stage of system analysis we found the essence of which exist in the subject area, and identified their attributes. All entities in varying degrees are reflected in the designed database. Let us describe the purpose of the database relations:

- 1) Sentence contains the information of all sentences in the publication. This entity has the following attributes: SentenceID, WordsWeight (Weight of words), Format (Format), Place (Place), Sum (amount).
- 2) Keywords (Key words) contains all the keywords in the text. This entity has the following attributes: WordID, Word (word), Frequency (Frequency), Place (Place), Format (Format), UserWeight (weight user), Sum (amount).

- 3) Words-Sentence contains the relationship between words and sentences in the text. This entity has the following attributes: ID, WordID, SentenceID. Designed database has entity StopWords, which has a purely official character, has the following attributes: ID, Word (fig. 1).

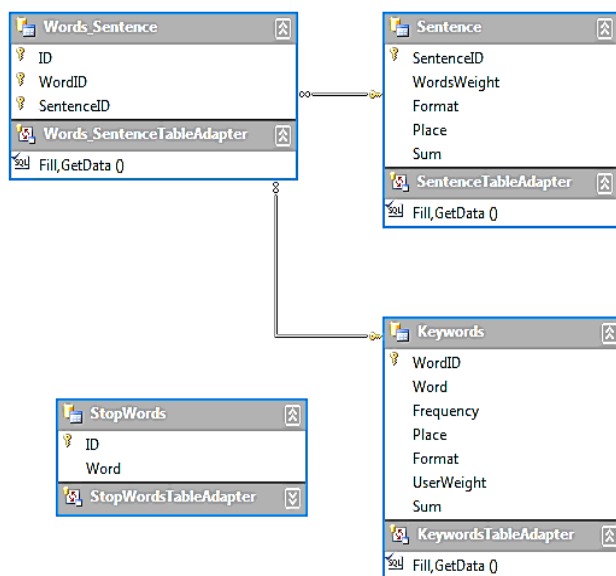


Fig. 1 The database schema [source: own study]

The database is implemented in SQL Server 2005 database that allows you to use a large arsenal of ready-made solutions for data analysis and texts.

To take into account effects associated with differences subjective knowledge receiver and transmitter in communication processes, which are the consequences of different amounts of knowledge in software, there is used thesaurus model that relates the semantic properties of information the user with the ability to perceive information. Updating a document in the system is due to its analysis. As the documents differ both in format and content, it provides the ability to replenish empowerment for disassembly. In module structuring documents transmitted there are tape that indicates the address of the file. Depending on where the file is, it can be a path to a file on the local disk or URL on the Internet. To describe the metadata is recommended to apply a basic set of elements of Dublin Core. The concept of metadata is used in many communities, including governments, libraries, educational institutions and commercial companies. So, it will be easier to integrate the system with other. This document is of a hierarchical structure that contains metadata for all sections regardless of the depth of nesting and all resources such as images and tables.

For approbation we analyzed 208 scientific publications and have result of publication clustering (table 1).

Tab. 1. Result of publication clustering

<i>Relation database</i>	Count
Lviv Politechnic National University	42
Kharkiv national university of radioelectronics	42
Ternopil State University	27
<i>Cloud computing</i>	Count
National Technical University of Ukraine :KPI	45
National Aerospace University	32
Lviv Politechnic National University	28

The interface of developed system is given belong.

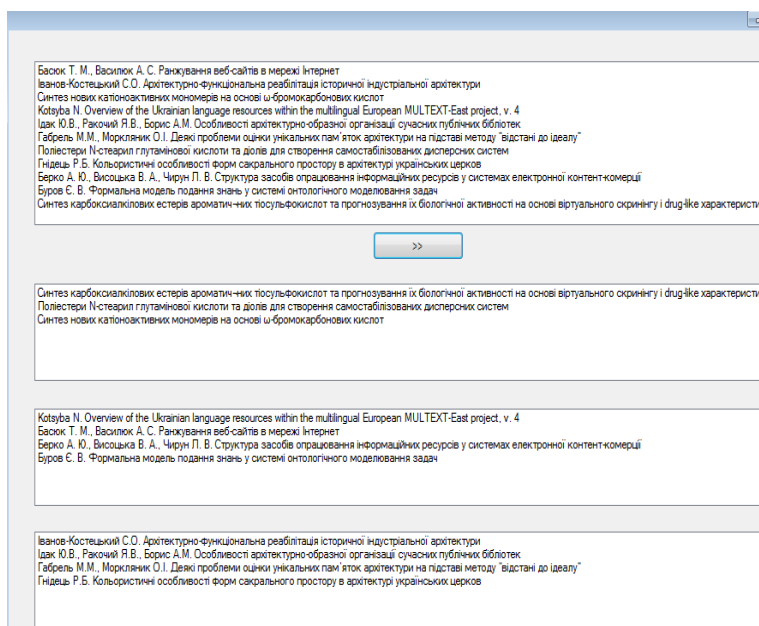


Fig. 2. Result of clustering [source: own study]

There is presented the result of scientific school clustering. In the first window the list of publications is given. After that we can see 3 schools consists of publications with similar keyword.

4. CONCLUSIONS

In this paper the method of research publications elements analysis that is determining common qualities of research publications and their clustering as an instrument of selecting and sorting out the information about research schools has been introduced. Depending on where the file is, it can be a path to a file on the local disk or URL on the Internet. There is described the method, which analyses the document. Clustering is used to sort out the information about scientific schools. The method of finding the bound between the research publication and the research school it refers to has been developed.

The document consists of name, keywords, author, main part, literature. Defining elements of the document is based on the allocation of such features text: location in the document; location of a paragraph; type of writing; character recognition. The sum of the individual weights of words and sentences tend to be determined after further modification according to specific settings associated with each weight, gives the total weight of the sentence. The sum of individual weights are usually determined after further modifications according to specific configuration parameters associated with each weight, gives the total weight of the entire block of text.

The algorithm to create a database publishing features is introduced. The architecture of scientific school forming system is described. In this paper there is described the purpose of the database relations. The database is implemented in SQL Server 2005. The business-part of the analyzer for data retrieval and for data finding is described.

Our experimental results demonstrate the efficiency of the proposed algorithm.

REFERENCES

- [1] BRANDOW R., MITZE K., AND RAU L. F.: *Automatic condensation of electronic publications by sentence selection*. Information Processing and Management, 31 (5), 1995, pp. 675-685.
- [2] SOLTON J.: *Dynamic library – information systems*. M: the World, 1979.
- [3] SHAKHOVSKA N., NOHA R.: *One method of analysis of research publications' elements*. MEST Journal, 15 01, 2(1), 2014, pp. 94-102.
- [4] SALTON G. et al.: *Automatic Text Structuring and Summarization*. Information Processing & Management, vol. 33, no. 2, 1997, pp.193-207.
- [5] RADEV D. R., MCKEOWN K. R.: *Generating Natural Language Summaries from Multiple Online Sources*. Computational Linguistics, vol. 24, no. 3, 1998, pp. 469-500.
- [6] CARBONELL J.G., GOLDSTEIN J. G.: *The Use of MMR, Diversity-Based Reranking for Reordering Documents and Producing Summaries*. Proc. 21st Int'l ACM SIGIR Conf. Research and Development in Information Retrieval, ACM Press, New York, 1998, pp. 335-336.
- [7] SHI ZHONG: *Efficient Online Spherical K-means Clustering*. Proc. IEEE Int. Joint Conf. Neural Networks (IJCNN 2005), Montreal, Canada, 2005, pp. 3180-3185.

- [8] HOU, JUN, NAYAK, RICHI: *The heterogeneous cluster ensemble method using hubness for clustering text documents*. Lecture Notes in Computer Science [Web Information Systems Engineering - WISE 2013: 14th International Conference, Nanjing, China, Proceedings, Part I], 2013, pp. 102-110.
- [9] STREHL A., GHOSH J.: *Cluster ensembles – a knowledge reuse framework for combining partitions*. Journal of Machine Learning Research, no. 3, 2002, pp. 583-617.
- [10] STREHL A., GHOSH J., MOONE R. J.: *Impact of similarity measures on web-page clustering*. AAAI Workshop on AI for Web Search, 2002, pp. 58-64.
- [11] KARYPIS G.: *CLUTO - a clustering toolkit*. Dept. of Computer Science, University of Minnesota, 2002. (<http://www-users.cs.umn.edu/karypis/cluto>)

Olga ORYNYCZ*, Andrzej WASIAK**

EFFECTS OF TILLAGE TECHNOLOGY ON ENERGETIC EFFICIENCY OF RAPESEED PLANTATION FOR BIOFUEL PRODUCTION

Abstract

Biofuel production, as well as any other production processes, involves a number of conversion steps each of those is connected with unavoidable consumption of energy. Since biofuels are intended to replace fossil fuels it is important that the sum of energy inputs into subsequent technological steps does not exceed the energy output from the system. Basing on theoretical model derived recently by present authors, energy requirements for several agricultural technologies are computed, and used for estimation of energetic efficiency of rapeseed plantations dedicated for biodiesel fuel production. The effects of technological choices on energetic efficiency of plantations are demonstrated basing on numerical computations performed using realistic data.

1. INTRODUCTION

Needs to mitigate carbon dioxide emission to atmosphere, and therefore to decrease danger of global warming, drives contemporary fuel production technology into search for various alternative energy sources that would effectively replace fossil fuels [1]. The other reason for such search is expectation of an exhaust of fossil fuels resources, especially that of petroleum, which

* Białystok University of Technology, 15-351 Białystok, Wiejska Str. 45A,
tel. 85-746-9842, e-mail: a.wasiak@pb.edu.pl

** Białystok University of Technology, 15-351 Białystok, Wiejska Str. 45A,
tel. 85-746-9844, e-mail: o.orynycz@pb.edu.pl

The research have been performed under financial support from Białystok University of Technology. Statutory Research Project WZ/S/1/2012.

should be replaced by other resources in order to maintain sustainability of economical development. Problems connected with the use of various types of biomass as the source of energy are widely discussed in literature [2-7]. In several recent sources a large variety of agricultural technologies has been presented [8-12]. Recently published handbook [13] presents several technological data of a number of agricultural machines including the fuel consumption. Differences in available tillage methods lead to very diversified energy consumption in different sets of operation being performed. This leads to the conclusion that energetic efficiency of plantations using different technologies might substantially differ. Since several economical instruments, e.g. “green certificates” or “Renewable Energy Certificates”, increase financial profitability of investments into biofuel plantations, the attention paid to the technological sense of particular solution might be decreased, and some important factors might be overlooked. It is therefore important to investigate how various technical effects play role in determination of energetic efficiency of any technical solution being undertaken.

The present authors [14] have recently 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 practical situation, as well as analysis of some dependencies.

The aim of the present work is to estimate effects of the choice of agricultural technology on the energy efficiency of plantation (practically defined in analogous manner as EROEI).

2. THE MODEL

Biofuel production, as well as any other production processes, involves a number of conversion steps, and a number of necessary operations. Each of the steps is connected with unavoidable consumption of energy. The energetic efficiency of plantation, can be defined as a ratio of total energy produced to the sum of energy inputs. On the side of outputs it can be expressed in terms of crop yield, caloric values and mass fractions of crop components used for biofuel production. Fuel consumption and caloric values of the fuel used in subsequent agricultural operations, as well as transportation distances and fuel consumption during transportation of goods (production means and products) between fields used in production and also during transport to customers, and its caloric value, as well as energy embodied in production means – determine energy inputs to the production system. Embodied energies (amounts of energy used for production of a particular good – the idea generalized to the notion of emergy contained in corresponding technical means (like fertilizer or e.g. insecticide or in machines) [15]. Consequently energetic efficiency can be expressed as:

$$\varepsilon = \frac{E_{bio}}{E_{ex}+E_{tr}+E_{emb}} \quad (1)$$

where: E_{bio} – is energy obtained from the field,
 E_{ex} – is energy expended on tillage operations,
 E_{tr} – is energy consumed for transportation outside of fields,
 E_{emb} – is a fraction of embodied energy contained in production means,
that is spend during tillage operations and transport.

The contributing energies are further expressed as follows – at first energy obtained from the plantation equals:

$$E_{bio} = A \times M_{crop} (c_f, c_w, c_{cp}, \dots) \times \gamma \times \sum_{k=1}^n \alpha_k \times W_{bio,k} \quad (2)$$

where: A – plantation area,
 $M_{crop} (c_f, c_w, c_{cp}, \dots)$ – crop yield dependent upon concentrations:
 c_f – fertilizer, c_w – water, c_{cp} – crop protection means, maintained during cultivation. This dependence should be estimated on the basis of empirical field studies.
 γ – general mass fraction of biofuel in the crop,
 α_k – mass fraction of k species of biofuel,
 $W_{bio,k}$ – low caloric value of k -species of biofuel.

The other term is the energy consumed on the field during agro-technical operations:

$$E_{ex,agr} = W_{fuel} A \times \sum_{i=1}^m \left[\frac{\omega_i}{d_i} \right] + \sum_{i=1}^m \sum_{k=1}^K \gamma_k \times Em_{ik} \quad (3)$$

where: ω_i – the fuel consumption per unit of the distance passed during the individual agro-technical process,
 d_i – width of the land strip operated in the single course of i -th operation
 W_{fuel} – the low caloric value of the fuel used for operations (might be fossil fuel or biofuel),
 m – the number of the agro-technical operations (in each one of the operations the width of the worked field, d_i , and the consumption of fuel, ω_i , can be different).
 γ_k – is a fraction of embodied energy contained in one of the, k technical means employed at i -th operation (machines, fertilizers, etc.). It may be estimated e.g. as ratio of the time of particular operation to the total expected life time of particular equipment.
 Em_k – is embodied energy contained in k -th technical mean.

The last term concerns transportation of goods (including crops) outside of the field. This term is especially important for big plantations that have to be arranged in several fields separated sometimes by quite long distances. Contribution of transport is also significant when crops have to be transported through long distance to industrial facilities for processing. It is expressed as:

$$E_{tr} = \sum_{p=1}^P L_p \times \{\beta_p \times W_{fuel,tr} + Emt_p\} \quad (4)$$

where:

- L_p – distance driven outside of the field in p -th route,
- β_p – fuel consumption during p route,
- $W_{fuel,tr}$ – low caloric value of the fuel used in transport,
- Emt_p – fraction of embodied energy of a given transportation mean corresponding to the unit of distance driven.

Another factor, do not expressed explicitly in above formulas, however possible to be included in numerical computations, may concern dependence of fuel consumption upon caloric value of the fuel. Such dependence should be determined empirically, and will be very much dependent upon the equipment being used. It is therefore difficult to include it in a general form.

The model described above does not contain any specific assumptions concerning type of plants being cultivated, therefore it is general, and applicable to any plantation. Only substituting specific numerical values corresponding to particular plant limits conclusions to efficiency of plantation of this specific plant.

3. RAPESEED PLANTATIONS

As mentioned earlier there exist several technologies of rapeseed cultivation for biofuel. In the present paper three different approaches will be presented. The first one is a traditional tillage system, while the last is a direct seeding being extremely simplified way of cultivation. This simplified cultivation method, after initially lower yield, is expected to give approximately the same yield as traditional method after the technology is implemented in full. Each of the approaches involve several variants exhibiting different requirements with respect to energy input.

The first method includes ploughing, and some other agro-technical operations and eventually forecrops.

In the other strategy ploughing, and agro-technical operations are evidently reduced., while direct seeding do not contain ploughing and other operations are reduced. Fig. 1 and 2 show consumption of diesel oil in some variants of traditional and direct seeding methods.

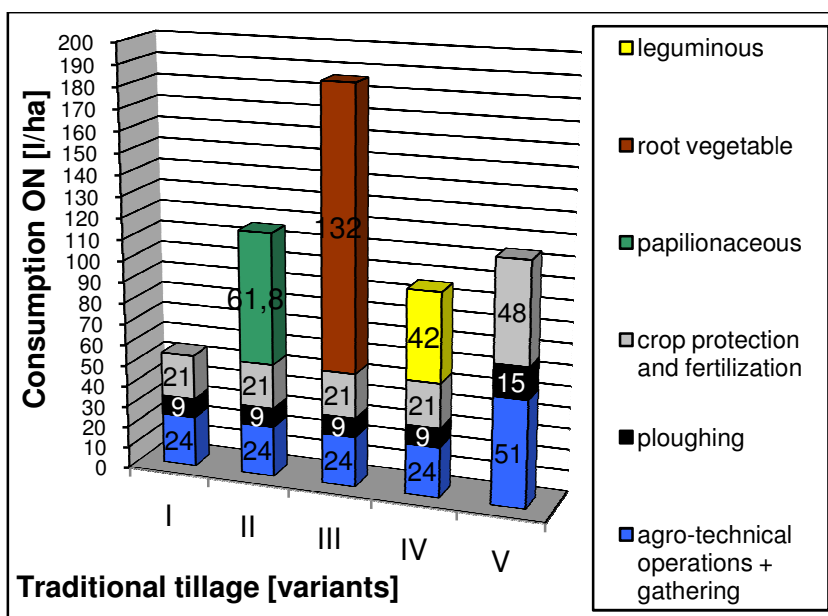


Fig. 1. Consumption of fuel on a hectare of plantation during traditional tillage with various forecrops [source: own study]

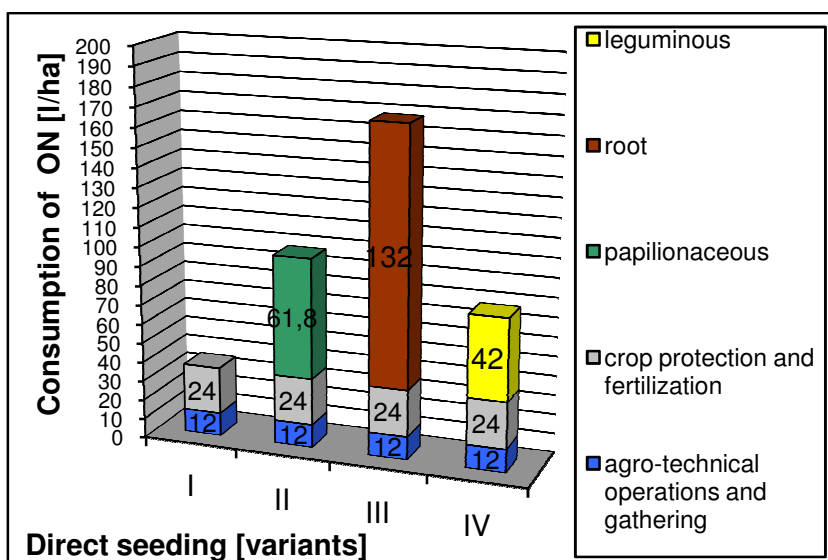


Fig. 2. Consumption of fuel on a hectare of plantation during direct seeding with various forecrops [source: own study]

Tab. 1. Energy consumed during several variants of agro-technical operations for three methods of cultivation for 50 ha plantation

	E_{ex} [MJ]				
	I	II	III	IV	V
traditional	97200	208440	334800	172800	205200
simplified	70200	181440	307800	145800	81000
direct seeding	64800	176040	302400	140400	-

Summarized data presented in Table 1 indicate very large diversity of energy demand of particular variants. At this moment it is difficult to establish embodied energy, not only because of some ambiguities occurring in estimation, but because this contribution should be evaluated for each type of machine and other technical means used in operations. Such data are not available at this stage of work. On the other hand one might consider that agro-technical machines are usually long living, and consequently only small part of embodied energy would require to be taken into account. Taking into account estimations made by Borjesson [16] embodied energy strongly depends upon technical development of producers of agro-technical production means (machinery, fertilizers, herbicides or insecticides), and consequently evidently decreases with time. Basing on the data presented in [16] this contribution may roughly be estimated as total 25000 MJ/year for 50 ha plantation.

The other task is to determine amount of energy obtained from plantation. This task requires some assumptions. Especially in rapeseed planting the plants on the field are not direct energy source. They require further processing in industrial part of the production system. Industrial subsystem contains several steps, and also requires inputs of energy at each conversion step. Since yield of the rapeseed grain from the plantation is known, and the final yield of biodiesel related to the mass of grain is also known, it is assumed here that final amount of energy that is obtained in form of biodiesel after industrial treatment will be used as a reference (E_{bio}). Consequently it is taken that the yield from 1 ha is 3Mg of grain, what gives 380 liters of biodiesel. Therefore for 50 ha taken as an example it gives 150 Mg of grain and 19000 liters of biodiesel. Taking into account caloric value of biodiesel, equal to 34,59 MJ/l one obtains 657210 MJ energy from 50 ha of plantation. Values of the ratio of the above amount of energy obtained from the field to the energy expended during agro-technical operations is presented in Table 2. Those values, being the first approximation of energetic efficiency (or EROEI) vary from two to more than ten depending on chosen variants of tillage. Such result obviously indicate the importance of the choice of production technology.

Tab. 2. Ratio of energy obtained from plantation to energy expended in tillage operations for three methods of cultivation for 50ha plantation

	$E_{\text{bio}} / E_{\text{ex I}}$	$E_{\text{bio}} / E_{\text{ex II}}$	$E_{\text{bio}} / E_{\text{ex III}}$	$E_{\text{bio}} / E_{\text{ex IV}}$	$E_{\text{bio}} / E_{\text{ex V}}$
traditional	6,8	3,2	2	3,8	3,2
simplified	9,3	3,6	2,1	4,5	8,1
direct seeding	10,1	3,7	2,2	4,7	-

In the computations presented so far transport and embodied energy terms (cf. eq. 1) have not been considered. Accepting rough estimation based upon [16] one may correct the results presented in Table 2. Such corrected values are presented in Table 3. As it was presumed, the values shown in Table 3 are lower than those in Table 2. The decrease is of the order of magnitude about 10% to 25%.

Tab. 3. Ratio of energy obtained from plantation to energy expended in tillage operations including rough estimation of embodied energy consumed by utilization of production means for three methods of cultivation for 50ha plantation

	$E_{\text{bio}} / E_{\text{ex,agr I}}$	$E_{\text{bio}} / E_{\text{ex,agr II}}$	$E_{\text{bio}} / E_{\text{ex,agr III}}$	$E_{\text{bio}} / E_{\text{ex,agr IV}}$	$E_{\text{bio}} / E_{\text{ex,agr V}}$
traditional	5,4	2,8	1,8	3,3	2,9
simplified	6,9	3,2	2	3,8	6,2
direct seeding	7,3	3,3	2	4	-

Concerning transport energy term, describing energy used for transport outside of the fields, it is easy to compute for the specific cases, when distances outside the fields are explicitly specified. It is difficult, however, if not impossible, to formulate a general rule that would give a relationship between field's areas and distances separating those fields. To overcome this problem, and present some – possibly general solution – it is proposed to assume that energy used for transport should not exceed some fraction of that part of energy obtained which exceeds the total energy input into agro-technical operations. Assuming that this fraction is 10% one obtains the total distance that could be driven outside of the fields:

Tab. 4. The total distance that can be driven outside of the field under assumption that the consumed energy for transport is 10% of the energy gain above the input of energy into agro-technical operations.

	D_{tr0,1} I [km]	D_{tr0,1} II [km]	D_{tr0,1} III [km]	D_{tr0,1} IV [km]	D_{tr0,1} V [km]
traditional	4954	3924	2754	4254	3954
simplified	5204	4174	3004	4504	5104
direct seeding	5254	4224	3054	4554	-

The values shown in Table 4 seem to be quite large, but for better estimation of their real meaning it is necessary to take into account some details of the needs. The yield of rapeseed grains is about 3 Mg from hectare, this means that from the plantation 50 ha, taken as an example, the total amount of grains is 150 Mg. This Amount of grains can be transported by at least 50 trucks of 3 Mg capacity (the volume of 3 Mg of grains might exceed the volume capacity of a truck). Consequently, the distance given in table 3 is the total distance available for all those truck or for several courses made by smaller number of trucks. Sum of distances that can separate fields and industrial facilities for each of tillage variants (which assure that total distance driven by required number of trucks, in eventually a number of courses would be equal to those given in Table 4) is presented in Table 5.

Tab. 5. The total distance that can separate the fields and industrial facility under assumption that the consumed energy for transport is 10% of the energy gain above the input of energy into agro-technical operations

	D_{tr0,1} I [km]	D_{tr0,1} II [km]	D_{tr0,1} III [km]	D_{tr0,1} IV [km]	D_{tr0,1} V [km]
traditional	99,08	78,48	55,08	85,08	79,08
simplified	104,08	83,48	60,08	90,08	102,08
direct seeding	105,08	84,48	61,08	91,08	-

It is seen that the plantation, in order to fulfill assumption assuring rational possibility to sell energy obtained above the internal consumption, has to confine activities to distances between 50 and 100 km.

4. CONCLUSIONS

Basing on the model elaborated, and computations performed on the data corresponding to real conditions occurring in agricultural production systems, it can be concluded that in the case of biofuel production, the agro-technical subsystem may assure efficiency (defined as a ratio of the sums of outputs to the sum of inputs of energy) between 1,8 and 7,3. The observed diversity of efficiency results of the choice of agricultural technology (methods of tillage and that of cultivation, fertilizing, crop protecting etc.). From technical viewpoint, and requirements of sustainability of the production processes it is important to assure possibly high energetic efficiency in spite of the fact that due to several economic methods of supports offered to producers financial profits might appear independent upon this efficiency. Obviously governmental institutions should also care about compatibility between economic and energetic efficiency.

Another conclusion concerns the size of production systems including agricultural and industrial subsystems. The size of plantations is determined by demand from industrial facility. In the case of very big facility, and correspondingly big demand for rapeseed grain, the distance for grain transportation, as well as for transportation of production means between fields might easily exceed rational distance, and drastically diminish the amount of fuel available for consumption outside of production system.

Further development of the model, by constructing computer program that could be used for analysis of particular case studies, especially prior to investment, will be valuable tool for practical applications, valid for various types of biomass plantations for energetic use.

REFERENCES

- [1] MATHEWS J. A.: *From the petroeconomy to the bioeconomy: Integrating bioenergy production with agricultural demands*. Biofuels, Bioprod. Bioref. 3:613 – 632, DOI: 10.1002/bbb, 2009.
- [2] CHUM H. M., OVEREND R. P.: *Biomass and Renewable Fuels*. Fuel Processing Technology, no. 71, 2001, pp. 187-195.
- [3] BARNWAL B. K., SCHARMA M. P.: *Prospects of biodiesel production from vegetable oils in India*. Renewable and Sustainable Energy Reviews, no. 9, 2005, pp. 363-378.
- [4] FONTARAS G. et al.: *Integrated environmental assessment of energy crops for biofuel and energy production in Greece*. Renewable Energy, no. 43, 2012, pp. 201-209.
- [5] PAINULY J. P., RAO H., PARIKH J.: *A rural energy-agriculture interaction model applied to Karnataka state*. Energy, vol. 20, no. 3, 1995, pp. 219-233.
- [6] ABNISA F. et al.: *Utilization possibilities of palm shell as a source of biomass energy in Malaysia by producing bio-oil in pyrolysis process*. Biomass and Bioenergy, no. 35, 2011, pp. 1863-1872.

- [7] SINGH K.P. et al.: *Effect of tillage management on energy-use efficiency and economics of soybean (Glycine max) based cropping systems under the rainfed conditions in North-West Himalayan Region*. Soil & Tillage Research 100, 2008, pp.78-82.
- [8] JULISZEWSKI T., ZAJĄC T.: *Biopaliwa rzepakowe*. (Rapeseed oil biofuels) PWRiL, Poznań, 2007, pp. 49-51.
- [9] JASIŃSKA Z., KOTECKI A.: *Szczegółowa uprawa roślin 2. (Detailed tillage of plants)* Wydawnictwo Akademii Rolniczej we Wrocławiu, Wrocław, 1999, p. 412-434.
- [10] IGILIŃSKI B., BUCZKOWSKI R., CICHOSZ M.: *Technologie bioenergetyczna (Bioenergetic technology)*. Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika, Toruń, 2009, pp. 218-223.
- [11] Small rapeseed plantation for home-made biodiesel – private communication.
- [12] PERRIER T.: Private communication – agricultural enterprise „Barycz”, 2014.
- [13] LORENCOWICZ E.: *Poradnik użytkownika techniki rolniczej w tabelach (Handbook for the user of agrotechnology)*. Agencja Promocji Rolnictwa i Agrobiznesu, Bydgoszcz, 2012.
- [14] WASIAK A., ORYNYCZ O.: *Formulation of a model for energetic efficiency of agricultural subsystem of biofuel production*. IEEE ENERGYCON 2014, Dubrovnik, Croatia, 2014, p. 1333-1337.
- [15] ODUM H.T.: *Environment, power, and society for the twenty-first century. The hierarchy of energy*. Columbia University Press, New York, 2007.
- [16] BORJESSON P. I. I.: *Energy Analysis Of Biomass Production and Transportation*. Biomass and Bioenergy, vol. 11, no. 4, 1996, pp. 305-318.