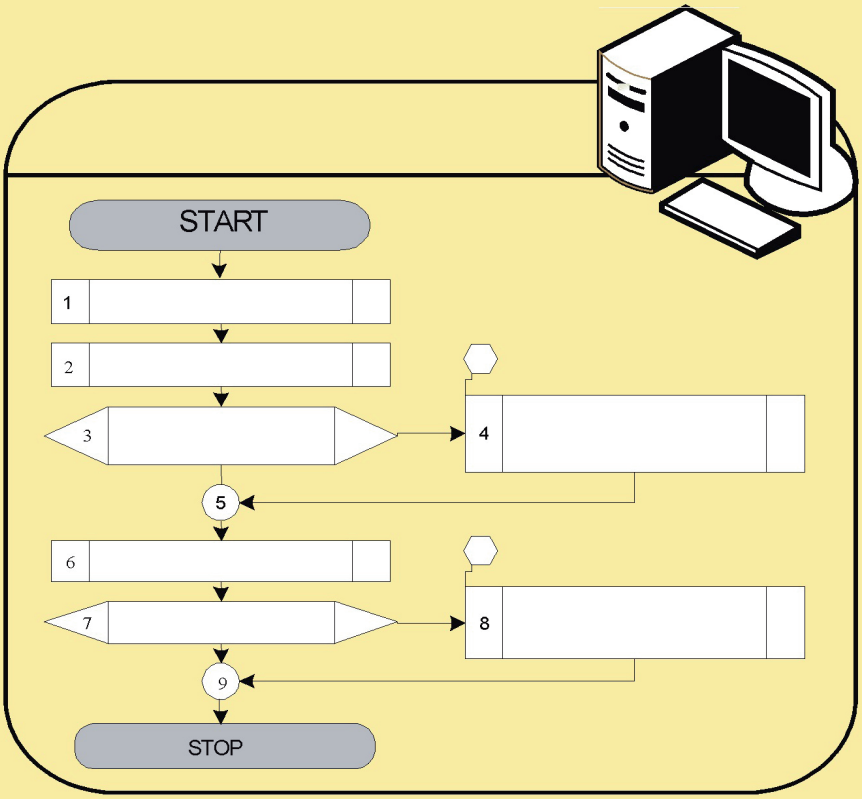
APPLIED COMPUTER SCIENCE

Vol. 10, No. 1, 2014



LUBLIN UNIVERSITY OF TECHNOLOGY

INSTITUTE OF TECHNOLOGICAL SYSTEMS OF INFORMATION

www.acs.pollub.pl

ISSN 1895-3735

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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

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The Journal is published quarterly and is indexed in BazTech. Publication in Applied Computer Science is free of charge.
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CONTENTS

Reyes GONZALEZ[*]*, Jose GASCO*[**]*, Juan LLOPIS*[***]

ICT IN HIGHER EDUCATION: AN EXPERIENCE WITH E-BOOKS

Abstract

The present paper seeks to explain the diverse advantages of virtual books and also the main barriers that make it difficult their implementation in the classroom. A brief review of the literature on ICT, e-learning, distance education and e-books will be complemented with a case study about the preparation, development and implementation of an e-book. The paper could be helpful both for systems analysts and for teachers when they are developing and implementing e-books.

1. INTRODUCTION

Recent years have been characterized by an extensive growth in the use of Information and Communication Technologies (ICT) in the education. These technologies not only have provided tools for data analysis or access to huge scientific resources, but also enable students to communicate with each other or with their teachers or instructors through email, electronic forums etc. [1]. E-books represent one of the recent applications of ICT in the educational arena.

Although the expression "e-book" or "electronic book" is not new, its meaning is not completely clear either. The definition of e-book is not confined to any digital text which can be read on an LCD screen. In fact, it implies many more concepts. The first attempts that were made in the development of e-books took place in 1970 with the so-called Gutenberg Project, at Illinois University [12]. E-books were usually published in CD-ROM or made to be used in PDAs (Personal Digital Appliances) at the time. Nowadays, e-books are accessible in a wide range of devices, including PCs, PDAs, BlackBerry's, pocket PCs, tablets, mobile telephones and iPods [10].

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In the early 21st century, the e-book industry has grown to a considerable extent, but the e-book market on a European level has not been too successful yet. In fact, many publishers have not launched themselves into the world of e-books because they fear the effects on their revenues. However, they have invested in the production of supplementary electronic material, such as CD-ROMs or links to web pages, meant to support the sale of their conventional books. Vassiliou and Rowley [12] propose a definition of the e-book concept in two parts. The e-book is a digital object with textual or another type of content which arises as a result of adding the characteristics provided by an electronic environment to the familiar book concept.

Furthermore, e-books typically have features such as the search and cross-referencing function, links to hypertext, bookmarks, notes, underlining or highlighting, multimedia objects and interactive tools [8].

While the first part of the definition is quite well-defined, the second one gradually changes as e-books are further developed [12].

The present paper discusses electronic books and the broadest concept of ICT, e-learning and distance education, especially supported on mobile technologies. For this purpose, a brief review of the literature about these topics will be complemented with a description of our experience in the preparation, development and implementation of e-book publishing software.

2. LITERATURE REVIEW

E-learning can be defined as the delivery of educational and learning programs through electronic means, including the Internet, Intranets, audio/video tapes, interactive TV and CD-ROM. This term is utilised as a synonym of the expression "technology-based teaching" and implies a greater variety of equipment and facilities than on-line education or teaching alone. E-learning comprises not only synchronous teaching, such as real-time chats, video/auto conferencing, web-based conferencing, etc. or asynchronous teaching, but also self-learning methods, the mere exchange of e-mails with mentors, instructors or lecturers, or the use of an electronic discussion group [2]. In short, e-learning implies the full integration of ICTs into educational processes.

The concept of e-learning has been linked to that of mobile technology in recent years [7] because the miniaturisation of ICTs has led users to demand all the possibilities that these technologies can offer us in a mobile format. Hence the idea of mobile learning, or m-learning, which consists in the type of learning that occurs through different locations and benefits from the opportunities provided by portable technology. Mobile learning takes place on actual students' demand because they can make the best of their time in their learning processes anywhere and at any time.

Several aspects related to mobile technology make it different from the point of view of teaching and learning. First of all, mobile devices are nearly always with students. There are three things that people always carry with them today: the keys, the wallet and mobile technology, which includes the mobile telephone and the PDA. They usually have these mobiles on them not only because they want to be reachable but also because they are a tool for taking down notes, finding a place or searching for information. Thanks to its easy access, mobile technology makes it easier to study anywhere and at any time. Students can somehow guide their own learning, through which that learning can become more efficient [2].

Mobile technologies are not restricted to informal learning. Numerous schools and universities use it to manage tasks such as calendars and timetables, task assignments, reminders, announcements, enrolment and communications between the household and the study centre.

The utilisation of ICTs in teaching processes presents multiple advantages, like the following ones:

Interaction: ICT-based learning is interactive. Using an interactive learning system can increase the student's enjoyment and can also enhance aspects such as understanding, effectiveness and efficiency in the long term. It additionally helps to improve their motivation and confidence. The learning environment can be referred to as interactive if it allows the student to perform tasks such as navigating through it, receiving feed-back from his own actions, selecting information, answering questions using the keyboard or the mouse, touching the screen or via voice, solving problems, creating presentations, collaborating with others, and thus becoming involved in all sorts of learning activities. Learning interaction can occur at three levels: a) student-instructor, when the student interacts with an expert; b) student-content, when interaction only exists with information and various contents; and c) student-student, when students have the chance to interact or cooperate with one another [9]. The interaction between students and teachers through ICTs reduces the cultural and communication barriers that separate these two human groups.

Cooperation: ICTs are naturally social technologies, which is why they improve cooperative learning. Therefore, they can help students to share information through the creation and upkeep of their own social networks. Data exchange as well as the collaboration with other students allows students to satisfy their innate need for communication. A shared environment can be created by connecting students' PDAs or their computers to data collections or to a communications network. Furthermore, different studies [3] have proved that collaborative learning, defined as the activity which makes learning easier through social interaction, leads to better academic results. Students learn more, can better retain what they have learnt, develop a higher reasoning level and feel more valued and self-confident.

Individuality: Many e-learning programs include the possibility of introducing several difficulty levels which can be adapted to different students.

Change of roles: As mentioned above, ICTs promote interaction and communication among students; in other words, they are encouraged to discover the principles by themselves. This means a role change within the learning process that is in keeping with the demands of the new EHEA. In fact, the EHEA at least theoretically leads us to a more student-centred teaching system, as students must become the real protagonists of their own learning [11]. Teachers consequently abandon their role as a "source" of knowledge, assuming another as a "guide" or "counsellor" towards knowledge, as this role can not only be found in the teaching staff but also in multiple formats, both traditional (books, journals, conference papers) and virtual ones. The teacher only gives assistance in learning and design activities meant to ensure a high interaction level between the students themselves and with the learning materials as well. This means that the teacher's role changes to become a facilitator who provides general guidelines and allows students to explore around the course materials without any restrictions. The teacher must explain how to learn and how to use electronic tools effectively, acting as a guide for the student to be able to navigate through the different resources [4].

Time, flexibility: ICT use will most probably reduce learning costs and time through the physical reduction of classroom attendance and its consequences. The aim is not to eliminate face-to-face interaction but rather to reduce it, to complement it with technology [9]. Moreover, the demand for ongoing training among professionals has to face limits regarding time, financial resources and responsibilities that workers have both at work and outside the home. That is why, thanks to their flexibility and mobility, the new technologies represent a suitable tool for us to be able to offer education to those students who have more time-related problems [4].

Competitive advantage: The inclusion of ICTs in teaching-learning processes would be beneficial even if it did not – as it actually does – increase teaching quality, since students acquire a significant competitive advantage in today's globalised and computerised world: these technologies prepare students for the roles and the way of work that they are going to use in their future working environment.

Despite all these advantages, ICT-based teaching is not free from problems and hindrances, both of a technological and essentially of a human nature. With regard to the former, technology developers must place special emphasis on problems related to privacy and security, as these systems can contain different access levels – for instance, a restricted area for teachers, for students, an area for marks and progress – which can be neither visible nor accessible to everyone. Furthermore, technologies must be friendly enough to ensure that learning to use the technological tool is not more complex than learning the

subject matter that one seeks to teach through them. The economy is another basic aspect that needs to be considered; the student must perceive that technological tools are more economical than the conventional media, such as paper books, for instance.

Nevertheless, the most complex barriers for the adoption of ICTs in teaching are undoubtedly of a human nature. Teachers as well as students can have problems when it comes to adopting technology. For example, those students who own more technological skills may have an advantage above the rest and lead themselves to a certain degree of isolation with respect to the less-technologically-gifted ones [14].

As for teachers, some authors [6] distinguish four teaching staff models according to the way in which innovative technologies are incorporated into teaching. The first group is formed by the "entrepreneurs", who are at the forefront both in innovation and in the assumption of the risks associated with it. The entrepreneurs are committed to quality teaching, are up-to-date with educational technologies and have become expert users of those technologies. The second group of teachers can be described as "risk-aversive". Although they are committed to quality in teaching, they are not experienced enough in the field of technology and are therefore afraid of changing their way of teaching. That is why this second group – unlike the entrepreneurs – needs some support and assistance in order to take full advantage of using the new technologies inside the classroom. In third place, some teachers can be described as "reward seekers", that is, they only adopt technologies if they obtain a personal benefit such as promotion opportunities or financial compensations. The fourth group is represented by the "reluctant" ones, who have a low level of technological skills and resist change because they think that they have already invested a great amount of time in the most conventional educational models.

It would be highly advisable to check what kind of teachers we are addressing in order to be able to offer them the support that they need for the implementation of ICTs in the teaching processes. Softening barriers and improving the means and resources available are basic steps when it comes to adopt technologies in the teaching context. ICT-based interactive education requires the existence of training in ICTs not only for students but first and foremost for the teachers themselves, who must learn not only to use those new technologies but also the new teaching methods which are made possible thanks to them [13].

3. METHODOLOGY

The case method was used to observe the pertinence, advantages and drawbacks of ICTs in general and e-books in particular in higher education. This method stands out for being one of the most popular in studies related to ICT implementation inside organisations [5]. Case studies are very well suited to the study of ICTs because they represent a first step in empirical research, especially appropriate when there is little information available about the specific variables to be used. The problem about this method lies in its essentially qualitative nature, which is why it is sometimes criticised for its lack of scientific rigour. To this must be added that it has difficulties when it comes to result generalisation, since it is risky to generalise conclusions from one or a few specific cases.

Despite the aforementioned drawbacks, an effort should be made to eradicate the belief that the *normal* way of doing research basically depends on statistical analyses and large samples. What is more, as opposed to the inflexibility of other scientific methods, case studies are highly flexible, which makes them suitable for the study of phenomena which have not previously received much attention and are therefore ideal for our study object, namely: the implementation of e-books and the advantages and hindrances associated with that implementation.

4. CASE STUDY: LA UNIDIGITAL (THE DIGITAL UNIVERSITY)

Launidigital is a project undertaken by the SIRHO Research Group and financed by the Prosegur Chair of the University of Alicante (fig. 1). Its main goal is the development of software meant to encourage the publication of virtual materials oriented to teaching at all its levels, from primary education to university. The aim is to make authors assume a starring role in the production and edition of their own teaching materials.

Fig. 1. LaUNIdigital presentation [source: own study]

The reasons which led to its development within the group at the end of 2011 are listed below:

- The great disappointment and little interest currently found among the potential authors when it comes to quality book publication, mainly because this activity does not bring any significant economic returns. The big business is done by the publishing companies which take the lion's share of the book's retail price.
- The experience of over 20 years that the SIRHO research group members have as authors of teaching textbooks and as classroom teachers both in undergraduate and postgraduate courses.
- The experience acquired in advisory agreements with five important multinationals for research on teaching methodologies in management matters: Tea Cegos, Deloitte, Randstad, Sage and Walters Kluwer Group.
- The success obtained at the teaching of the course "The community manager in the firm" – which has become a referent in the Spanish-speaking context – through the MOODLE platform.
- The financing provided by the Prosegur Chair of the University of Alicante, which has been used to carry out the acquisition of multimedia material for video recording and editing.
- The economic crisis as an optimum moment to offer alternatives which mean real and significant savings for the student, while simultaneously improving content quality in comparison with the traditional teaching system, a demand fostered by the EHEA.

The results obtained with the project, in the second semester of 2013, can be summarized as follows:

1. A software program in the format of an internet portal (http://www.launidigital.com) which has as its purpose to act as a virtual library in the cloud with five books inside its catalogue.
2. The publication of an e-book entitled "Lessons of Human Resource Management", which includes 150 videos with an average duration of 7 minutes, 400 pages of texts and 60 power point files. More than 500 copies of the e-book have been sold, sales being basically concentrated at the University of Alicante and the Tarragona Rovira i Virgili University.

The experience lived during the development of the launidigital project and the aforesaid e-book is explained next.

4.1. The structure of launidigital software

With regard to project development, the first stage consisted in the analysis of the needs identified by the students enrolled in the Master's Degree in Human Resource Management of the University of Alicante, which was being imparted in a semi-physical format through the MOODLE platform. Based on their experience and their contact with students, the researchers collected the potential requirements for such a portal. A document with technical requirements was drawn up using this information.

Work subsequently started for the design of the portal structure and its functionalities were selected. Once the structure and functionalities had become clear, the attention moved towards the visual line of the portal along with its usability. After determining the graphic line, our next step was to do the design layout in HTML5 for the portal to be visible in any browser. HTML5 was selected because, although it is not a standard for W3C yet, it has been adopted *de facto* by the whole industry. Parallel to the portal design layout process is the development of the computer analysis work oriented to the program structure design.

Our decision to use a database for the project was based on the fact that it allows us to store the data corresponding to students, teachers and books. An estimate for its consumption was carried out in different scenarios, after which a decision was made to use the MySQL technology for its scalability and usefulness in projects characterised by a low simultaneous traffic.

As for the portal, it was necessary to develop two parts: the server part and the browser part. Our decision to use PHP as the development language for server programming stemmed from the fact that it interacts very well with MySQL and also because this language permits to carry out very fast developments. A Linux server – in this specific case the Debian distribution with Apache as web server – was chosen both to execute this language and to install the database.

Portal programming came next. After finishing a first version, a private beta was launched in order to carry out tests internally. These tests revealed a number of bugs that were progressively corrected, ultimately allowing us to launch a public beta that soon became a production version.

This version was launched in September 2012 and, as students used it, they sent us feedback thanks to which new functionalities have been added to the portal.

The software includes a set of modules, each one of which provides the e-book with a number of advantages:

1. Users' system with a student or a teacher profile (fig. 2): The portal allows accessing different functionalities depending on the user profile. Students can buy books, read books and do exams. Teachers can create exams, call for exams and mark them.
2. Storage system for digital books: The portal makes it possible to store books in a digital format and establish security permits to restrict book access exclusively to authorised users.
3. Digital book playback system: Students and teachers can use their browsers to see the content of digital books stored in the portal.
4. Digital book purchase system (fig. 3): The portal provides a payment gateway to buy the books on sale stored in it. Book shopping is connected to the users' system.
5. Book trial system: The portal permits to active a trial mode with the books stored in the portal so that users can see some parts of those books.
6. Exam creation and management: The portal allows teachers to create exams and add questions, either multiple choice test or essay- type ones (fig. 4).

Fig. 2. Teachers' room [source: own study]

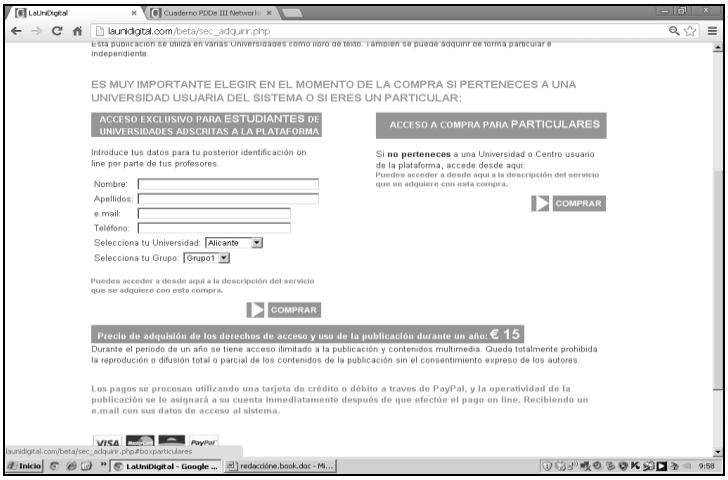

Fig. 3. Shopping (cart) interface [source: own study]

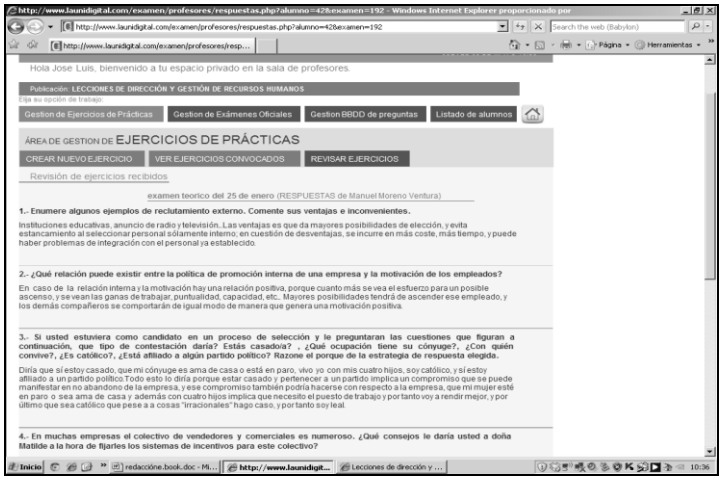

Fig. 4. Practical exercises [source: own study]

7. Automatic multiple choice test marking system. Test-type exams are self-marked when students answer them.
8. Essay exam marking system: The teacher can mark essay-type exams.
9. User support system: Students and teachers can request technical support to solve any technical incidents through the portal.
10. Multiple media: This portal is accessible from any type of device, whether it is a computer, a tablet or a mobile, even if their design is computer-oriented.

4.2. The book "Lessons of Human Resource Management"

Ever since 1995, the lecturers belonging to the SIRHO group involved in this project have used textbooks in paper format written by themselves and published by Civitas/Aranzadi/Thomson in their classes. The retail price of these books is 35€ at present. As a consequence of the high price, most of the students photocopied the book. The cost of the photocopies with the corresponding coil amounts to 13€ more or less.

A decision was made to prepare an e-book for the purpose of reducing the price and increasing the quality of the book. This e-book would contain all the material from the printed book plus approx. 70-90 minutes of video footage for each unit, a power point per unit and a set of multiple-choice questions so that students could check their degree of comprehension of the topics studied (fig. 5).

Fourteen lecturers specialised in human resource management took part in the video recording process, which meant that content quality was guaranteed. The recordings were carried out at a workshop of the Universidad of Alicante called la FragUA (the initials for a Spanish word meaning "forge"). Each lecturer recorded a specific number of videos with an average length of seven minutes. After their edition, they were lodged in the VIMEO server because it has a very low cost and is more reliable than YOUTUBE (figure 6).

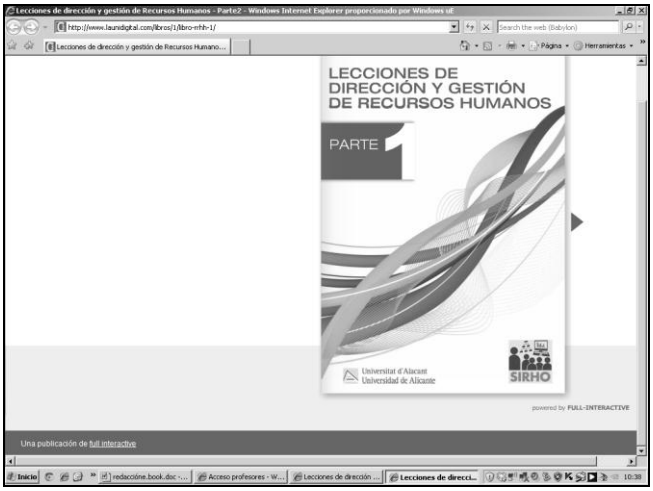

Fig. 5. E-book cover [source: own study]

Fig. 6. Video interface [source: own study]

At the end of the 2012/13 academic year, 400 students enrolled at the University of Alicante and 150 from the University Rovira i Virgili have used the e-book. The experience has been highly positive. The most favourable comments came from those students who had more difficulties to attend classes and the Erasmus students who found it difficult to follow a normal class due to language problems. However, a number of issues have emerged which can influence the effectiveness of these books:

1. The paper culture. The students who have used the book –mostly enrolled in the final degree years– have had physical books all their life; changing that mind-set is hard. The need to underline, to paint with highlighters and touch the folio is still evident.
2. The "totally free" culture. Students are used to paying 30€ for a ticket of a concert or a football match but they have the deeply-rooted belief that everything on the Internet is free and even if it is not, it can be copied, even fraudulently. This is the *infringement culture*, which means that computer and internet crimes are so easy to commit that users are very often unaware of the crime.
3. Physical problems. Students usually dedicate many hours to studying. Many students often prefer the paper format when they have to memorise because computer screens cause problems such as tired eyes.
4. Internet access. The online book needs a good connection to the Internet and some students, such as Erasmus students or those with less economic resources, do not have a 24-hour connection to the Internet.
5. Obsolete Technology. Despite being basic Internet users, some students have not updated their browsers or use relatively old computers. These aspects may result in a far from enthusiastic reception of the e-book in the first days.

Regarding the teaching staff, they have hardly shown any resistance to the implementation of the e-book as they have actually taken part in its development and, in that sense, they can be considered entrepreneurs-lecturers according to [6].

5. CONCLUSIONS

The university cannot waste the advantages offered by ICTs in the teaching-learning processes because, although knowledge is the basis and the heart of university and technology alters people's skill to process information, there must be an impact on the way in which universities carry out their mission. Our experience has allowed to identify the multiple advantages brought by the use of e-books, taking into account financial aspects – with a price far below that of a conventional book – and its manifold possibilities: adapted to different profiles, with various access levels, with a simple shopping system, with the chance to generate and do exams, both with automatic marking and with marking by the teacher. Furthermore, the e-book to which this paper is dedicated has an assistance technical support for any problems that can be posed by users and can work in multiple media, including the mobile [14].

Nevertheless, different signs of reluctance to its implementation have been detected, essentially among students. Some of these barriers stem from cultural problems (paper culture, infringement culture), physical problems (above all tired eyes) and technical problems (bad Internet connections and having old or deficient technological media).

Hopefully, thanks to the experience acquired with this e-book and to its proven advantages, it will be possible to help students to overcome the aforesaid barriers.

REFERENCES

[1] BARACK M.: Instructional principles for fostering learning with ICT: teachers' perspectives as learners and instructors. Education and Information Technologies, vol.11, no. 2, 2006, pp. 121-135.

[2] CHUANG K-W.: *Are you Ready for Mobile Learning?* Educase Quarterly, vol. 30, no. 2, 2009, pp. 51-58.

[3] DELGADO-ALMONTE M., BUSTOS ANDREU H., PEDRAJA-REJAS L.: *Information Technologies in Higher Education: Lessons Learned in Industrial Engineering.* Educational Technology & Society, vol. 13, no. 4, 2010, pp. 140-154.

[4] DUHANEY D.C.: *Technology and Higher Education: Challenges in the Halls of Academe.* International Journal of Instructional Media, vol. 32, no. 1, 2005, pp. 7-15.

[5] GONZALEZ R., LLOPIS J., GASCO J.: *Information Systems Offshore Outsourcing: Managerial conclusions from Academic Research.* International Entrepreneurship and Management Journal, vol. 9 no. 2, 2013, pp. 229-259.

[6] LANE C. A. LYLE III H. F.: Obstacles and supports related to the use of educational technologies: The role of technological expertise, gender, and age. Journal of computing in High Education, vol. 23, 2011, pp 38-59.
[7] LIU Y., LI H., CARLSSON CH.: *Factors driving the adoption of m-learning: An empirical study.* Computers & Education, vol. 55, no. 3, 2010, pp. 1211-1219.
[8] LAM P. et al.: *Usability and usefulness of eBooks on PPCs: How students' opinions vary over time.* Australasian Journal of Educational Technology, vol. 25, no. 1, 2009, pp. 30-44.
[9] SABRY K., BARKER J.: *Dynamic Interactive Learning Systems.* Innovations in Education and Teaching International, vol. 46, no. 2, 2009, pp. 185-197.
[10] SHIRATUDDIN N. et al: *E-book Technology and its potential Applications in Distance Education.* Journal of Digital Information, vol. 3, no. 4, 2003.
[11] STUART G.: *Personal Knowledge Management and Student Learning.* Journal of Business & Economics, vol. 8, no. 12, 2010, pp. 43-47.
[12] VASSILIOU M., ROWLEY J.: *Progressing the definition of 'e-book'.* Library Hi Tech, vol. 26, no. 3, 2008, pp. 355-368.
[13] YU S.Q., WANG M., CHE H.: *An Exposition of the Crucial Issues in China's Educational Informatization.* Educational Technology, Research and Development, vol. 53, no. 4, 2005, pp. 88-101.
[14] CORBELL J.R., VALDES-CORBELL M.E.: *Are you Ready for Mobile Learning?* Educase Quarterly, vol. 30, no. 2, 2007, pp. 51-58.

flanging, hollow parts, AlMgSi alloy, FEM

Grzegorz WINIARSKI[*]

COMPUTER-AIDED ANALYSIS OF A NEW PROCESS FOR FLANGING HOLLOW PARTS

Abstract

The paper presents a new process for flanging hollow parts. This process is performed using a specially designed set of tools with movable sleeves. The principle of operation of the tool set is described and examples of the numerical analysis results are given. The FEM simulation was performed on the assumption that the hot-formed hollow workpiece (tube) is made of AlMgSi aluminum alloy. The obtained FEM results show changes in the workpiece shape during flanging, variations in the forming force and the damage function distribution computed according to the C-L failure criterion. The theoretical results of the new flanging method provided basis for experimental tests.

1. INTRODUCTION

Hollow parts find more and more applications in numerous sectors of industry. Given the constant pursuit of machinery producers to reduce weight of machines, new technologies for producing individual parts need to be developed; also, this requires that materials with the lowest possible density and, at the same time, high immediate and fatigue strength be used. For this reason, magnesium, aluminum and titanium alloys are more and more often industrially applied due to their low density and relatively high strength. Nonetheless, the cost of these alloys is relatively high, which can be an obstacle to series production. Hence, if these materials are to be used, technologies that enable increased material yield must be implemented.

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Currently used methods for producing flanged hollow parts mainly consist in connecting the hollow part with the flange by welding, pressure welding or soldering. These methods cannot however be employed to produce solid parts, for example ones that are used in the aviation industry. To produce such parts, machining is applied, where solid or hollow bars are used as semi-finished products. Other metal forming methods can be applied, too, for instance flanging of tube ends by rigid tools performing a translational [1] or translational-rotary motion [2]. There are also studies on the flanging of an end of tube (sleeve) by orbital forging [3] cold upsetting-extruding [4] and cross-wedge rolling [5]. These methods, however, reveal some limitations, such as a disadvantageous state of stress in the deformation zone, low effective strain as well as quickly occurring cracks. In addition, the thickness of walls of the flanges produced thereby is lower than the thickness of the billet wall.

The present paper describes a new flanging method [6] which ensures producing a part that is free from the defects that occur in the flanging of tube ends.

2. NEW PROCESS FOR FLANGING

2.1. Description of the process

The forming process for flanged hollow parts is characterized by a number of limitations, which means that there are few methods that enable producing defect-free parts. The higher the flange-to-core-diameter ratio D/d (Fig. 1), the more difficult the process for producing the part by metal forming methods.

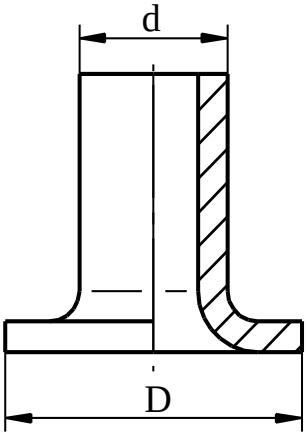

Fig. 1. Typical hollow part with a flange [source: own study]

The fundamental limitation of the flanging process is radial cracking caused by circumferential tensile stresses. The stresses increase with an increase in the flange diameter, which means that the process can be carried out only until the occurrence of first cracks, as cracking prevents obtaining the maximum flange diameter from the billet. The effect of the circumferential tension of the flange is that the further it is from the axis of the hollow billet, the higher the decrease in the flange thickness.

One advantage of the new proposed method for flanging hollow parts [6] is that it overcomes the above mentioned technological limitations, which means that parts produced with this method have better quality compared to those produced by other methods. Another benefit of the process is that it enables producing a flange with constant thickness; the thickness can be equal to or lower/higher than the thickness of wall in the non-deformed fragment of this part.

The flanging process consists in forming a flange in three stages according to the schematic shown in Fig. 2. The tool consists of a mandrel, punch, two movable sleeves, one internal sleeve and one external sleeve. A tube section is put on the mandrel and inside the internal sleeve. The internal sleeve prevents the billet from buckling, while the mandrel prevents radial flow of the material toward the inside. Initially, the two movable sleeves are located on the frontal surface of the mandrel; the spacing between the internal sleeve and the frontal surface of the mandrel is equal to the flange thickness (Fig. 2a). Flanging takes place due to the impact of the punch on the billet. The punch moves until the free space between the internal sleeve, first movable sleeve, punch and mandrel is completely filled up with the material (Fig. 2b). When the punch is stopped, the first movable sleeve is lifted by a value equal to the thickness of the flange being formed. Due to the lifting of the sleeve the process can be continued because there is some new free space created; this time, the space is created between the internal sleeve, both movable sleeves, punch and mandrel (Fig. 2c). As previously, flanging is continued until the space between the tools is completely filled up with the material. With the punch stopped, the second movable sleeve is lifted, and flanging can be carried out again (Fig. 2d).

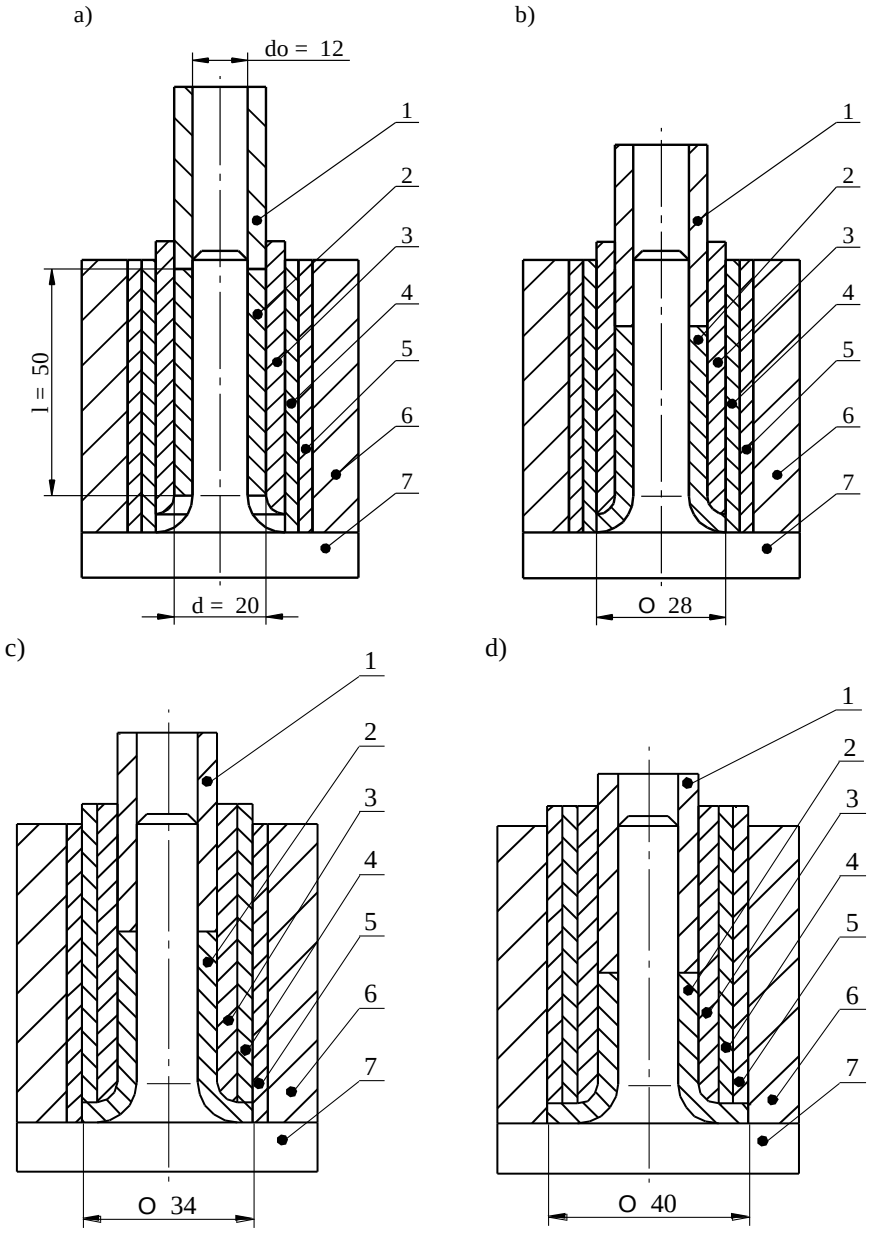

Fig. 2. Design of the flanging process, where: 1 – punch, 2 – workpiece, 3 – internal sleeve, 4 – first movable sleeve, 5 – second movable sleeve, 6 – external sleeve, 7 – mandrel, a) initial stage of flanging, b) first stage of flanging, c) second stage of flanging, d) third stage of flanging [source: own study]

2.2. Numerical model of the process

The numerical analysis of the flanging process was performed by the finite element method using DEFORM-3D. In the simulations, the mandrel, punch, movable sleeves, internal sleeve and external sleeve (Fig. 2) are rigid bodies, while the billet is a deformable body divided into four-node tetragonal elements and described by a rigid-plastic model. It was decided that the billet would be made of AlMgSi aluminum alloy, the material properties of the alloy were taken from the library database of the program. The initial dimensions of the billet (Fig. 2) were: (d x d0 x l) : ø20 x ø12 x 50 mm. Following the forming process, a flanged tube with the external diameter D (Fig. 1) equal to 40 mm is produced. The initial temperature of the tools was set to 300 °C, while the billet temperature was set to 450 °C. The punch velocity applied in the calculations was maintained constant at 100 mm/s. The tool-billet contact conditions were described by a constant friction model, with the friction factor m set to 0.3 and the tool-material heat exchange coefficient set to 14 kW/m^{2}K.

The model of material damage applied in the calculations corresponded to the modified Cockcroft-Latham criterion [7]:

$$\int_0^{\varphi^*} \frac{\sigma_1}{\sigma_m} d\varphi = C \tag{1}$$

where: φ^* – the effective strain,
σ_1 – the largest principal stress,
σ_m – the mean stress,
C – the critical damage parameter.

2.3. Numerical analysis results

Figs. 3a, 4a and 5a show changes in the workpiece shape in three stages of flanging and the damage function distribution respectively at the end of the first, second and third stage of the process performed with the movable sleeves. In contrast, Figs. 3b, 4b and 5b present analogous numerical results for the flanging process performed using the internal sleeve only.

The initial phase of individual stages of flanging are similar to the flanging process performed without the use of the movable sleeves. The material is deformed until it contacts a check surface (the first or second movable sleeve, or the external sleeve). The contact between the material and the check surface accounts for the use of the movable sleeves and external sleeve. The initial phase is relatively short compared to conventional flanging methods [8-10].

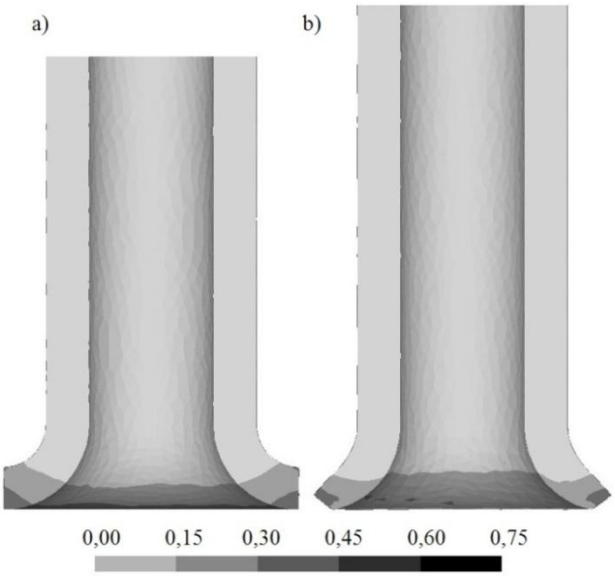

Fig. 3. Changes in the workpiece shape and the damage function distribution (calculated according to the Cockcroft-Latham criterion) in the first stage of the flanging process: a) flanging with a movable sleeve, b) flanging with an internal sleeve [source: own study]

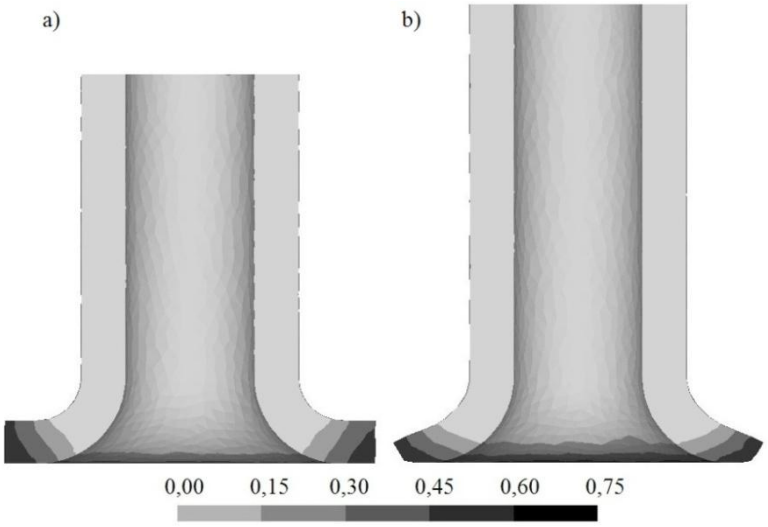

Fig. 4. Changes in the workpiece shape and the damage function distribution (calculated according to the Cockcroft-Latham criterion) in the second stage of the flanging process: a) flanging with a movable sleeve, b) flanging with an internal sleeve [source: own study]

The calculation results demonstrate that it is vital that the first movable sleeve have the smallest possible internal diameter, which allows reducing the time of unconstrained material flow. Nevertheless, given the assumption saying that the thickness of the flange is equal to the thickness of the tube wall, the internal sleeve has a rounding with a radius equal to the tube wall thickness. Hence, the resultant value of the internal diameter of the first movable sleeve is 28 mm, which is equal to the diameter of the flange produced in the first stage.

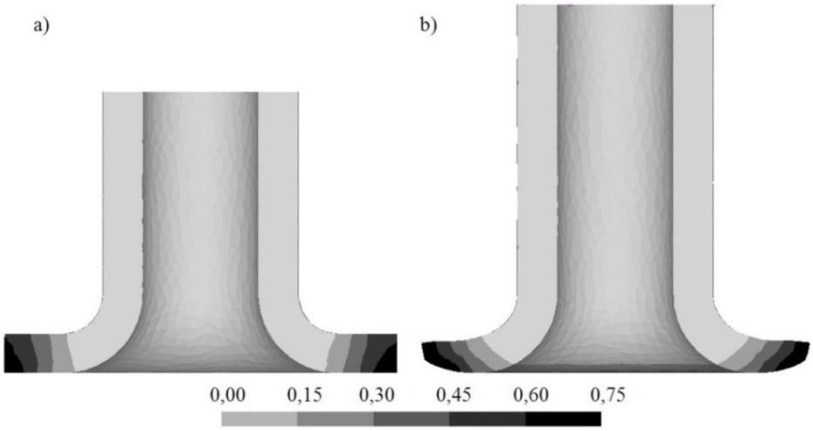

Fig. 5. Changes in the workpiece shape and the damage function distribution (calculated according to the Cockcroft-Latham criterion) in the third stage of the flanging process: a) flanging with a movable sleeve, b) flanging with an internal sleeve [source: own study]

After the contact with the first movable sleeve, the flange diameter does not increase any further. What increases is the thickness of the flange; simultaneously, compressive stresses are generated and they should prevent radial cracking. It is also worth observing that lapping does not occur when the flange thickness is being increased. This stage is characterized by the fact that the internal edge of the billet (one that is changed into the lower external edge of the flange) remains in constant contact with the surface of the mandrel until it contacts the first movable sleeve. When the thickness of the flange is equal to the that of the billet wall (Fig. 3a), the punch is stopped and the first movable sleeve is lifted by a value equal to the flange thickness; after that, the punch is set into motion again. And the second stage of the flanging process begins (Fig. 4b). In this stage, the flange diameter increases from 28 mm to 34 mm. Like in the first stage, the increase in the flange diameter immediately results in a decrease in the flange thickness, which can be observed until the flange contacts the second movable sleeve. The decrease in thickness is lower than was the case in the first stage: the increase in the flange diameter in the second stage is lower by 25% compared to the decrease which took place in the first stage.

Summing it, individual stages of the process are characterized by a number of differences. Unlike in the first stage, in the second stage of the process the lower external edge of the flange does not contact the mandrel surface, while the upper external edge of the flange does not contact the first movable sleeve. In the third stage, the lower external sleeve of the flange does not contact the mandrel surface, either; yet the upper external edge of the flange contacts the second movable sleeve. Local changes in the direction of material flow can therefore be observed in individual stages of the flanging process.

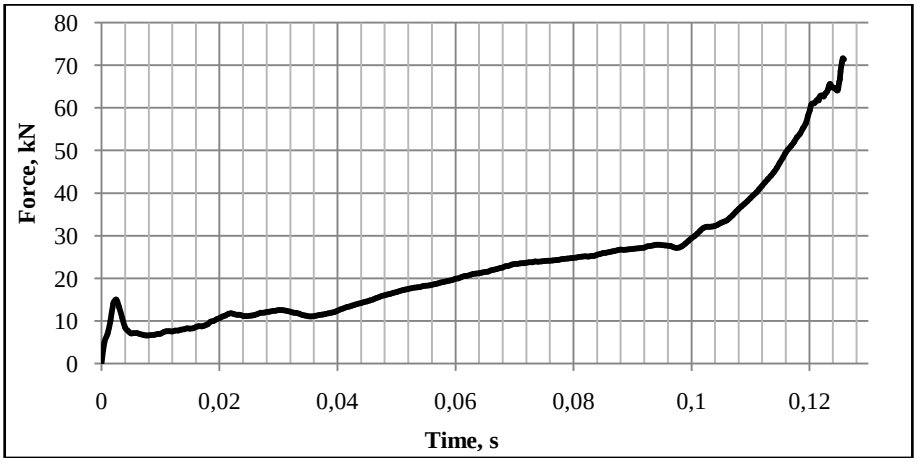

Fig. 6. Forming force versus time in the first stage of the flanging process [source: own study]

The differences also pertain to variations in the forming force (Figs. 6-8). At the beginning of the first stage, the force exerted by the punch on the billet increases at a slow rate, almost in a linear fashion, until the billet contacts the first movable sleeve. From this moment on, the increase in the force versus time is higher, reaching the maximum value of about 70 kN. In the second and third stages of flanging, the forming force is initially almost constant, equal to 35 kN and 42 kN, respectively. As soon as the billet material contacts the second movable sleeve or external sleeve, the increase in force versus time is almost constant, reaching the maximum value of about 70 kN, both in the second and third stage.

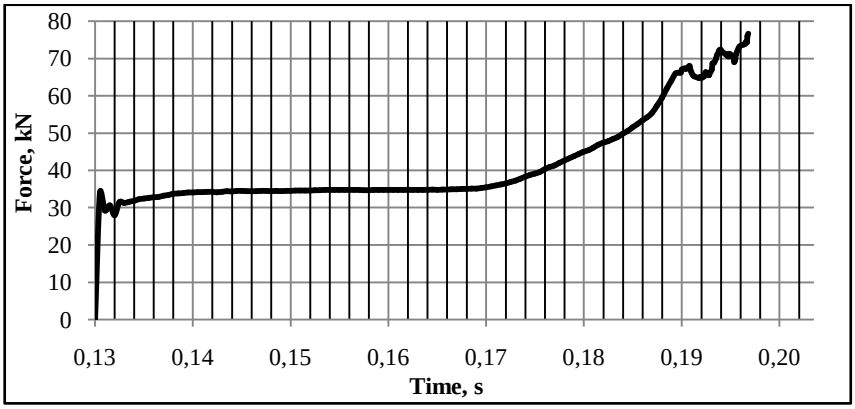

Fig. 7. Forming force versus time in the second stage of the flanging process [source: own study]

The maximum values of the forces in particular stages of the process are similar. Differences can only be observed in the initial phases of particular stages, i.e. only until the flank of the flange remains unconstrained by the movable sleeves or external sleeve.

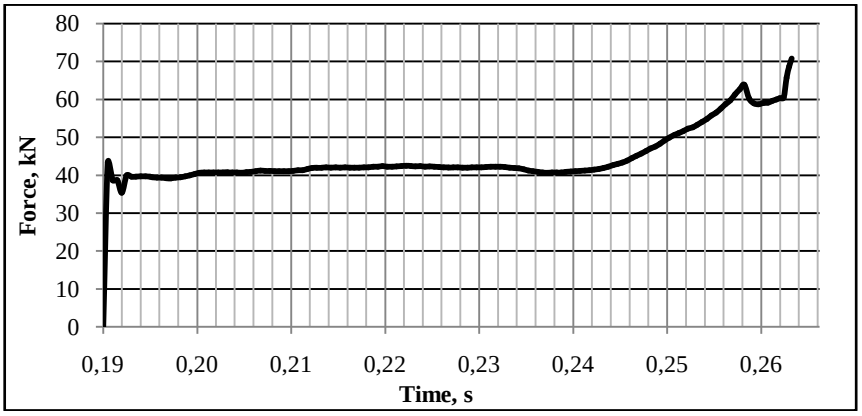

Fig. 8. Forming force versus time in the third stage of the flanging process [source: own study]

The stabilized value of the force in the initial phase of the second stage is 35 kN, while in the initial phase of the second stage – it is 42 kN. The increase in the force is caused by the increase in the flange diameter. Nonetheless, the variations in the forces are relatively small because the increase in the flange diameter leads to a decrease in the length of the flanged sleeve; this, in turn, results in decreased friction forces between the tubular part of the sleeve and the mandrel and the internal sleeve in the total forming force.

Comparing flanging with the movable sleeves to flanging based on the use of the internal sleeve only, the following differences can be observed (Figs. 3-5): the application of the movable sleeves allows producing a flange with a thickness equal to the thickness of wall of the tube on which the flange is made. The flange thickness is constant, irrespective of the distance from the billet axis and flange diameter. flanging leads to a decrease in the flange thickness along with an increase in its diameter. The damage function distribution presented in Figs. 3-5 is similar to both flanging performed without the use of the sleeves and flanging performed with the movable sleeves. The longer the distance from the axis of the billet, the higher the value of the C-L function. Small differences can only be observed in particular zones. For example, the damage function distribution given in Fig. 5 shows that the maximum value of the examined damage function is 0.75, which pertains to the part of the flange with the diameter exceeding 28.8 mm and 24.1 mm for flanging performed with the movable sleeves and without these sleeves, respectively. As a result, the application of the movable sleeves prevent radial cracking in the flange.

3. CONCLUSIONS

The paper presented a new process for flanging hollow parts. The proposed method consists in forming a flange in three stages using two movable sleeves. The FEM simulations were based on the assumption that the movable sleeves have a wall density of 3 mm. The proposed value can be higher or lower; also, there can be more than just two movable sleeves. It is expected that increasing the number of movable sleeves and decreasing their wall thickness will have a positive effect on the quality of the flange being formed. It is demonstrated that the application of the movable sleeves enables forming a flange with constant thickness irrespective of its diameter. In addition, the application of the movable sleeves helps prevent radial cracks on the flange.

By using specialized computer software (DEFORM-3D and Solid Edge), it is possible to further analyze the process. The use of computer techniques accelerate research and reduce their costs.

Further research on the process will focus on determining the effect of the wall thickness of particular movable sleeves and the number of movable sleeves on the process feasibility and product quality.

The research is conducted as part of the project "Modern Materials Technologies Used in the Aviation Industry" No. POIG.01.01.02-00-015/08-00 under the Innovative Economy Operational Programme (IE OP). The project is co-financed by the European Union from the funds of the European Regional Development Fund.

REFERENCES

[1] MUZYKIEWICZ W. i inni: *Wywijanie kołnierzy elementów rurowych sztywnymi narzędziami w warunkach statycznych i metodą tłoczenia elektrodynamicznego*. Rudy i Metale Nieżelazne R47, nr 10-11, 2002, s. 545-550.

[2] GONTARZ A., WERONŃSKI W. S., OKOŃ Ł.: *Badanie zjawiska wyboczenia ścianki w procesie wywijania kołnierzy w wyrobach drążonych*. Rudy i Metale Nieżelazne, R54, nr 11, 2009, s. 778-782.

[3] SAMOŁYK G.: *Orbital forging of a sleeve-type part with a simultaneous flanging*. Steel Research International, 2012, Nr Spec. Ed., pp. 175-178.

[4] ZHONGJIN WANG, JUN LU, Z. R. WANG: *Numerical and experimental research of the cold upsetting–extruding of tube flanges*. Journal of Materials Processing Technology, Volume 110, Issue 1, 1 March 2001, pp. 28-35.

[5] BARTNICKI J., PATER Z.: *The aspects of stability in cross-wedge rolling processes of hollowed shafts*. Journal of Materials Processing Technology, vol. 155-156, 30 November 2004, pp. 1867-1873.

[6] WINIARSKI G., GONTARZ A.: *Sposób i urządzenie do wywijania zewnętrznego kołnierza*. Polskie zgłoszenie patentowe nr P.406427, 2013.

[7] SAMOŁYK G., BARTNICKI J., GONTARZ A.: *Fracture Model for FEM Modelling of Cold Metal Forging*. Steel Research International, vol. 81, no. 9, 2010, pp. 302-305.

[8] HU X. L., WANG Z. R.: *Numerical simulation and experimental study on the multi-step upsetting of a trick and wide flange on the end of pipe*. Journal of Materials Processing Technology 151, 2004, pp. 321-327.

[9] FOULY A. MOHAMED, SAUSY ZEIN EL-ABDEN, MOHIELED A. R.: *A rotary flange forming process on the late using a ball-shaped tool*. Journal of Materials Processing Technology, vol. 170, 2005, pp. 501-508.

[10] BARTNICKI J., PATER Z.: *Walcowanie poprzeczno - klinowe wyrobów drążonych*. Wydawnictwo Politechniki Lubelskiej, Lublin 2005.

Rostyslav STRUBYTSKYI[*]

MODELLING AND FORECASTING OF CLOUD DATA WAREHOUSING LOAD

Abstract

Cloud data storages in their internal structure are not using their full potential functionality because of the complexity of behavior of network traffic, which affects the quality of service. The paper describes various models of network traffic and analyzes the most promising models for cloud data storages that take into account the phenomenon of self-similarity. The result of research found the frequency of cloud data warehouse traffic and that the intensity of storage load mainly depends on the incoming and outgoing traffic. Sufficiently high value of Hurst parameter indicates the potential for modelling and prediction of congestion cloud data storage in the long run.

1. INTRODUCTION

During the processing and storage of information we can observe a need to exchange data between the players of the process. At the end of 70s the rapid development of computer networks and corresponding network equipment began. Local and global networks continue to evolve, new data transfer protocols appear, the hardware capabilities of network equipment expand the number of connected users, and the total volume of traffic increase.

Existing modern cloud data storages by its internal structure do not use its potential capabilities functionality to the fullest. One of the reasons is complexity in behavior of network traffic, both within in and outside the cloud that affects the quality of service.

In terms of current trends in telecommunications and not only cloud data warehousing the topical task is to build a converged multi-service network. Such a network ought to provide an unlimited range of services to provide flexibility for the management and creation of new services. The latter requires the implementation of universal transport network with distributed switching,

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where the interaction between devices and applications is done by creating of virtual connections. Intricacies of the management of which significantly affect the features of the stochastic dynamics of packet switching processes influence on its management to a great lengths.

On the other hand, intensive development of the industry entails a number of problems. One of them is the increasing number of consumers of information services together with the increasing demands for network and server equipment needed to maintain the proper level of service quality.

2. RELEVANCE OF THE TOPIC

Development of network equipment and transport protocols ought to be based on appropriate mathematical models and parameters of traffic simulation tools network processes. The nature of the network traffic is determined by several factors starting with the behavior of users or application software and finishing with the transmission protocols and equipment used. It goes without saying that macro-parameters of network traffic on a relatively large time intervals are defined by the man. However, the nature of the traffic at the intervals of microseconds is mainly determined by the order of transport protocols, network equipment and server software. Thus, the study of the basic characteristics of cloud server, such as the allocation of memory, CPU usage and process status of the operating system set against the intense network traffic is a topical task.

One of the most relevant problems of the study of cloud data warehouses temporal probability characteristics is consideration of the features of the network traffic. The aim of the study is to examine different models of network traffic and analyze the most promising models for cloud data warehouses, which takes into account the properties of self-similar traffic as a time series.

On the basis of real cloud data warehouse the dynamic characteristics of incoming and outgoing traffic as well as the distribution of hardware capacity of cloud server worked out. For all processes the self-similarity was defined. It confirms the applicability of fractal models to work with cloud data warehouse, particularly to predict the behavior of the servers of cloud data storage.

3. PURPOSE AND PROBLEM STATEMENT

The classical theory of remote traffic approaches are based on the assumption that the input streams are stationary Poisson flow type, that are superposition of a large number of independent stationary ordinary flow evenly without aftereffect of low intensity. For telephone networks with channel switching this assumption is valid. However, studies show that modern telecommunication

network traffic cloud data storage packet has a special structure that can not be used in the design of conventional methods that are based on Markov models and formulas of Erlang. This is a manifestation of the effect of self-similarity remote traffic is always present in the implementation of a certain amount of emissions sufficiently strong against the background of relatively low average. This phenomenon significantly affects the properties (increasing losses, delay and jitter) of the self-similar traffic passing through the network.

Until recently, the theoretical basis for the design of information distribution provided teletraffic theory which is a branch of queuing theory.

This theory sufficiently describes the processes occurring in such systems distribution information like telephone networks built according to the principle of switching channels. The most common call flow model (of data) in teletraffic theory is the simplest torrent (ordinary stationary stream without aftereffect), also known as a stationary Poisson flow.

The current state of rapid development of high technology has led to the emergence and spread of ubiquitous networks, packet data, which gradually began to force the system switching network, but still they were designed on the basis of the general provisions of the theory of teletraffic.

Thus "the teletraffic problem of self-similarity" formed, to which in recent years more than a thousand works were devoted, and that still has not lost its relevance. Despite the considerable popularity of the subject and a long period of active learning, we have to admit that there are still a lot of questions and unsolved problems.

The main ones are:

- virtually no theoretical framework that would come to replace the classical queuing theory in the design of modern information distribution systems with self-similar traffic, there is no single universally accepted model of self-similar traffic;
- there are no credible and recognized methods of calculation of the burst for a given flow, which corresponds to the ratio of peak intensity to the admission process service requests to its median;
- parameters and indicators of quality of information distribution subject to the influence of the effect of self-similarity;
- no algorithms and mechanisms providing quality of service in terms of self-similar traffic.

The aim is to determine the characteristics of fractal processes of different data streams in cloud data warehouses to make relevant decisions about how to manage them.

To achieve this goal the following problems have to be solved:

- to examine traffic cloud data repositories;
- to analyze combined data streams;
- to conclude that the dependence of the total flux of fractal self-similar properties of individual flows which it contains.

4. NETWORK TRAFFIC IN THE CLOUD MODELS REVIEW

Stochastic traffic models, which were widely used in the past [7], based on Markov-Term represented processes that have short-term dependence. Such models were described by Poisson distribution with variable-length messages according to law of exponent, and were based on queuing theory. These models were formed during the early networks of ARPANET. Simulation results of traffic based on theory of queuing were corresponding to time distribution of calls in telephone networks.

However, with time we can observe the works in which the tendencies of data gateway exchange and the total volume of traffic were indicated. Similarly, the nature of the traffic began to affect new data transfer protocols on the network, particularly in the internal environment of cloud storage data. Based on similar researches the concept of "chain of packets" was developed in 1986. In the model it is considered that the network packets are transmitted together but at the same time each package of the Poisson model is worked separately [10].

In recent years a model within which the volume of traffic has a long-term relationship has became popular. It was also found that traffic is self-similar and is characterized with heavy tails distribution [9].

Within the classical traffic model it is considered that the data sources work shifts [2]. That means that periods of high activity are changed by long delays. Thus, it was defined that an incoming message length and its time obey the exponential distribution, and the process of incoming messages of data sources is Poisson process. All the processes are stationary and independent.

Poisson model does not take into consideration that real network traffic has periods of strong bursts of activity. For classical model autocorrelation function tends to zero for large samples, the same time as the presence of bursts of activity in the real test traffic leads to positive autocorrelation.

Traffic patterns as a message thread was formulated and became popular in the 80s [5]. Within the model it is considered that the traffic packets are transmitted together and can be processed as a unit. Networking at each point in the network may decide to further processing chain for the first message. Such an algorithm would prevent the network from unnecessary operations analysis staff. However, it should be noted that this is the model of source messages.

The model can be applied only to messages that have the same destination. It is evident that the implementation of transport protocols and network equipment model for a message thread and classic models will be radically different.

In many modern works it is observed [6, 9] that combining traffic from multiple sources of variables leads to the fact that traffic becomes auto-correlated of long-term dependence [8]. This leads to the fact that the stability of correlation structures doesn't vanish not even for large values of lag. In other words, a set of a plurality of data sources that exhibit infinite variance syndrome, as a result provides integrated self-similar network traffic, which is close to the fractal Brownian motion. Moreover the studies of various traffic sources show that strongly variable behaviour is a property that is inherent to client/server architecture.

The problems of self-similarity of network traffic were exploited by many scientists. In particular the paper [14] studied the properties of actual traffic in networks with packet switching. Using of the R/S analysis shows self-similar nature of network traffic in information networks. Based on this approach, a model of traffic generator that implements the multifractal behaviour of data streams in real-world information systems which allows simulating traffic with given performance self-similarity has been developed. The work [16] shows that the standard 802.16b network traffic self-similar properties are shown at data link as well as transport layers. The values of the main exponents of fractal network traffic were obtained and the methods of aggregating the output statistics were suggested [15].

The work [6] is devoted to experimental removal of network traffic of a major Internet - providers, as well as the results of the analysis of structural features of the given traffic are provided. The authors have shown that self-similar properties manifest themselves as data link and transport layers. In paper [1], U.S. researchers studied the processes of long-term dependence. To generate such processes the authors propose the use of the fractal model integrated moving average.

Self-similarity is a property of the object the parts of which are similar to the whole object as unit. Many objects in nature have the following properties, e.g. coast, clouds, the circulatory system of a person or animal.

Informally self-similar (fractal) process can be defined as a stochastic process whose statistical characteristics exhibit scaling property. Self-similar process does not change significantly when considering species at different scales on the time scale. In contrast to processes that do not have fractal properties, there is no quick “smoothing” process at a scale averaging process saves time, that is the process is penchant for bursts.

Let $\{X_k; k = 0,1,2,...\}$ is a stationary random process. Taking into consideration the assumption of stationary and the existence and finiteness of the first two points, let us introduce the notation:

When averaging timeline let us understand the transition to process $\{X^{(m)}\}$, as such that

$$X_k^{(m)} = \frac{1}{m} \sum_{i=km-m+1}^{km} X_i \qquad (1)$$

where: $m = E[X_t]$ – the average value or expectation,

$\sigma^2 = E[X_t - m^2]$ – dispersion,

$R(k) = E[(X_{t+k} - m)(X_t - m)]_{\infty}$ – correlation function,

$r(k) = R(k)/R(0) = R(k)/\sigma^2$ – correlation coefficient.

When modelling network traffic value X_k is interpreted as the number of packets (less frequently as the total volume of data in bytes) that entered the channel or network for k-th time interval. The output process is thus already averaged. In some cases where there is a need to avoid this initial averaging either a point process or flow of events are considered, that is a sequence of points in receipt of individual packets in the network.

There is no single causal factor that causes self-similarity. Different correlations that exist in the self-similar network traffic and affect the different time scales can occur due to various reasons, manifesting themselves in characteristics to specific time scales.

The reasons for the long-term dependence in network traffic can be the following factors:

- user behaviour and application software;
- generation, structure and retrieval of data;
- combining of traffic;
- network administration tools;
- optimization mechanisms based on feedback;
- complexity of network structure, increasing the number of subscribers.

The process X is called self-similar with parameter $H = 1 - (\beta/2)$ if its autocorrelation coefficient is

$$r(k) = \frac{1}{2}[(k+1)^{2-\beta} - 2k^{2-\beta} + (k-1)^{2-\beta}] = g(k), k \in N \qquad (2)$$

where the function is:

$$g(k) = \frac{1}{2}\delta^2 k^{2-\beta} \qquad (3)$$

expressed by means of the central difference operator of 2nd order $\delta^2(f(x))$, which affects on the function $f(x) = x^{2-\beta}$ such that $\delta(f(x)) = = f(x+1/2) - f(x-1/2)$.

The essence of self-similarity is evident in the fact that for a process that satisfies the first condition, the equality $rm(k) = r(k)$ is valid, which means that this process does not change the coefficient of autocorrelation after averaging over blocks of any length m. Therefore, for the process of self-similar statistical characteristics of the second-order normalized aggregate process $X(m)$ is not different from the characteristics of the output process X with a significant range of change m.

The parameter H is an indicator of degree of self-similarity process and indicates that he has such properties as persistence/anti persistence and long term memory [4]. The parameter can accept values from 0 to 1. For white noise (Markov process) Hurst parameter is equal to 0.5, which means a complete lack of long-term or short-term dependence and the process is completely random, respectively, the simplest (Poisson) flow is called "the stream of pure randomness of the first kind".

If $H \in [0.5,1]$ the process is persistent, has a long-term dependency [3]: if for some time in the past, there has been an increase in process parameters, then in the future there will be the average growth. In other words, the probability that at step $k+1$ the process deviates from the average in the same direction, as at \$k\$ step is as large as the parameter H is close to 1.

If $H \in [0,0.5]$ process inherent anti persistence, it has short-term dependence [4]: high values of the process are followed by low and vice versa. That is, the probability that at step $k+1$ the process deviates from the average in the opposite direction (relative deviation k step) is as large as the parameter H is close to 0.

Long-term dependence is causing sharply pronounced fluctuation process, but gives the opportunity to discuss some predictability within narrow limits of time. From the point of view of the theory of queues, an important consequence of correlation flow is unacceptability of parameter estimation queues that are based on forecasts of identical and independent distribution of intervals in the input stream.

5. PRACTICAL RESEARCH OF NETWORK TRAFFIC OF DATA STORAGE

In order to confirm the existence of self-similarity properties of the different data streams of multiservice network, it is necessary to measure some of the characteristics of different types of network traffic. This requires statistics on traffic flows and data, and a study of the combined flow and variables cloud data storage should be conducted.

For studying purposes the cloud data storage was used. The physical server is divided into multiple virtual areas using the Solaris operating system, each of which is used to perform a number of tasks. Most of the traffic is transmitted by HTTP/HTTPS, FTP/FTPS and SFTP protocols.

For remote monitoring of data warehouse parameters in real-time application Zabbix is used [13]. Zabbix is a client-server application used to collect, store and process information about the network status, network load, and the state of the operating system of the data warehouse server in real-time.

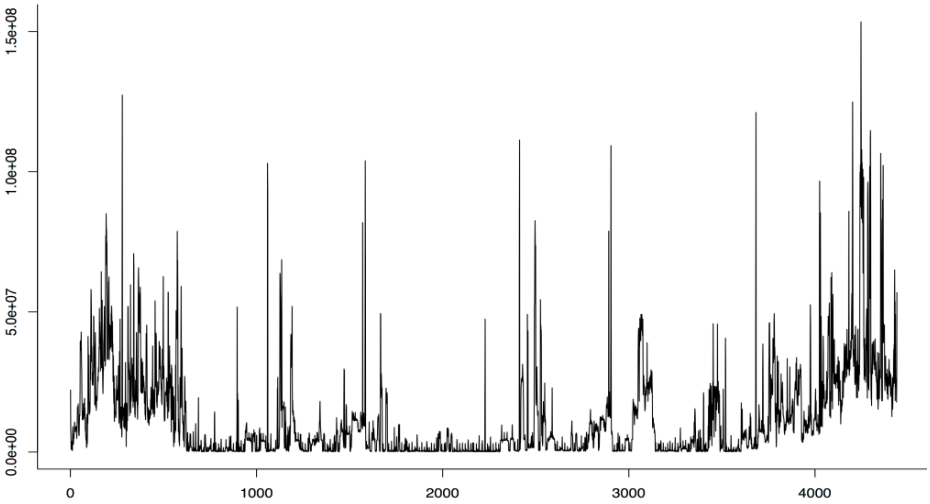
For further processing the following parameters of a data warehouse were used:

- incoming / outgoing traffic;
- number of running processes;
- load and idle processors;
- the average load on the processor;
- the amount of cache.

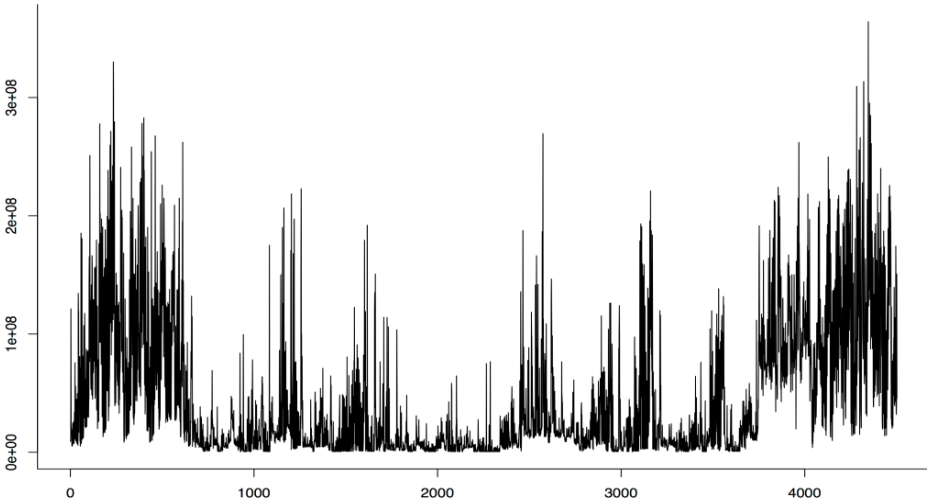
The received data is consolidated during the week, so we can assume that they represent the real picture of cloud data storage usage. The time dependence of the volume of traffic is shown in Figure 1 for input (a) and output (b).

Similarly to the data graph of the incoming and outgoing traffic (Figure 1), the other dependencies of other dynamics repeat. This is due to the fact that the main function of a cloud data warehouse is input, storage and output of users' data. Therefore the main load on the servers of data warehousing represents incoming and outgoing traffic. Thus the analysis and modeling of cloud storage can be limited to traffic patterns only or congestion model of processor.

Graphical representation of the autocorrelation coefficient allows visual verifying that the analyzed traffic has a long-term dependency.



a)



b)

Fig. 1. The time dependence of the incoming (a) and outgoing (b) traffic [source: own study]

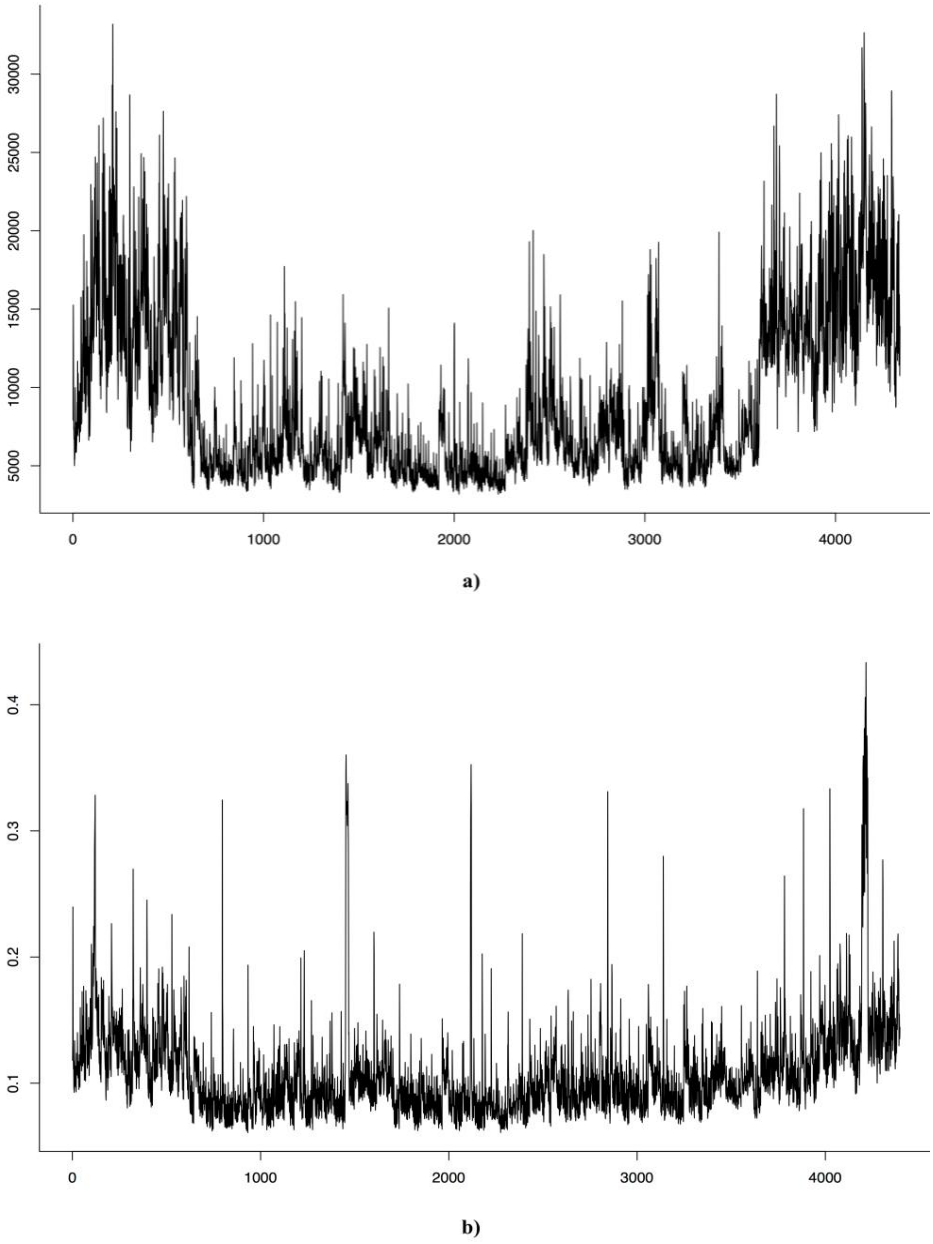
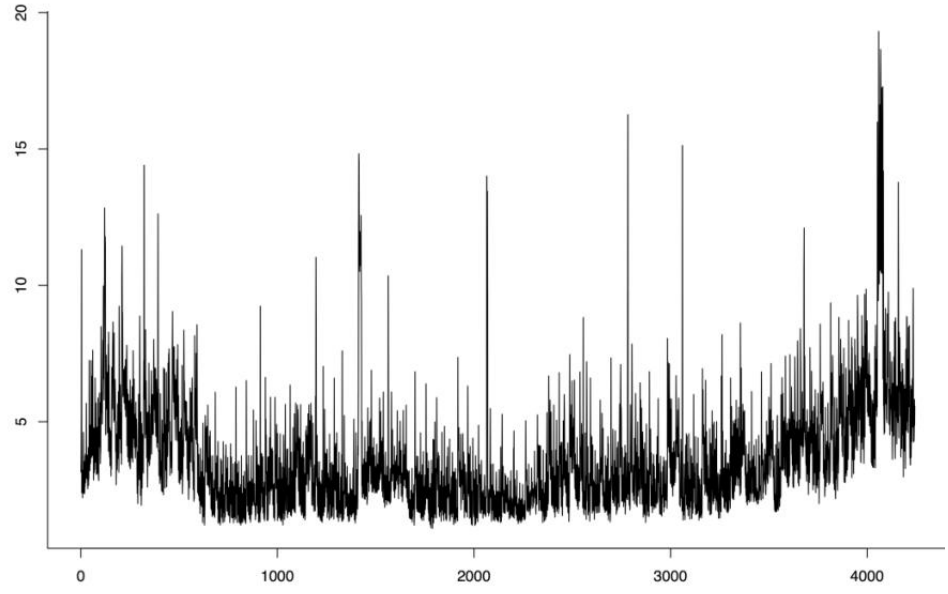
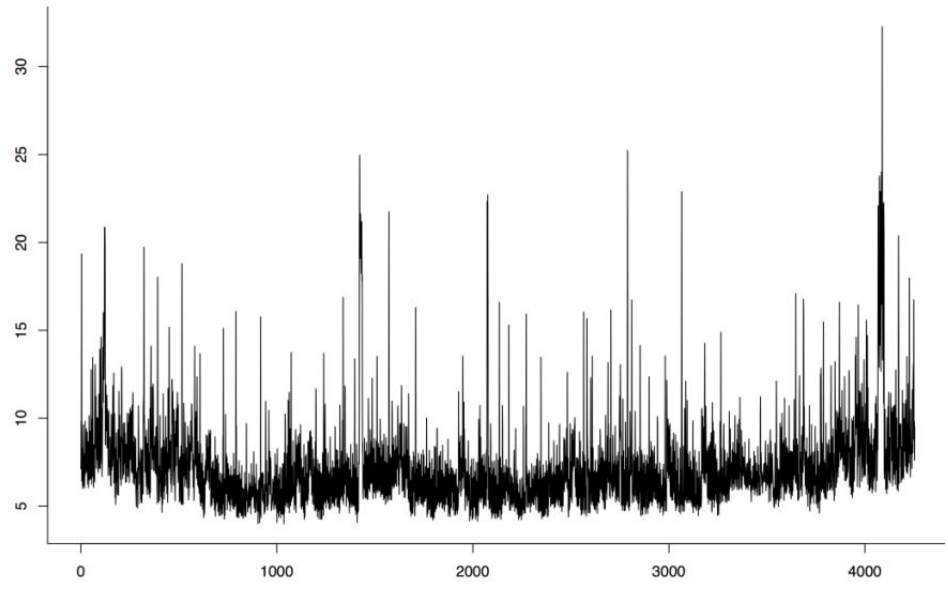


Fig. 2. Time dependence of switching (a) and load (b) of processors [source: own study]



a)



b)

Fig. 3. Time dependence of system CPU (a) to user (b) usage [source: own study]

In Figure 4 the graph of correlation coefficient for the process that matches incoming traffic on a logarithmic scale is given. It is evident that the points on the picture as a whole are grouped around a straight line whose slope can be determined by linear regression.

If the process is self-similar, then according to (2) slope coefficient $\beta = 2(H-1)$. If the resulting value $\beta = -0.2125$ Hurst parameter was found to be 0.8937.

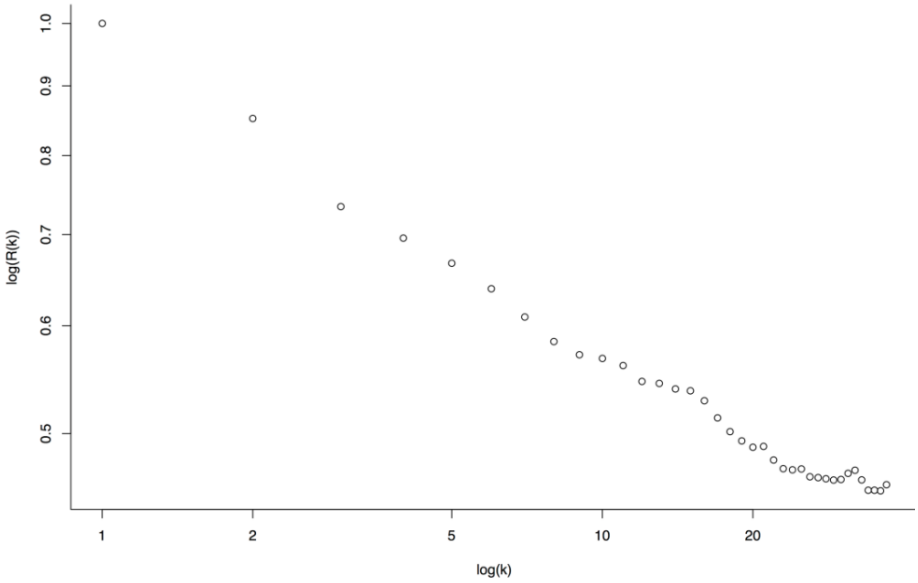


Fig. 4. The logarithmic dependence of the autocorrelation coefficient of incoming traffic [source: own study]

For outgoing traffic the graph of correlation coefficient – Figure 5, as well as for incoming traffic points are generally grouped around a straight line whose slope can be determined by linear regression. For a self-similar process slope coefficient $\beta = -0.1986$ Hurst parameter was at 0.9007.

Traditionally, self-similarity in any stochastic process is revealed through the definition of Hurst parameter H. The fact that $0.5 < H < 1$, thus Hurst parameter value is other than 0.5 is considered a sufficient basis for the recognition of self-similar process. It should be noted that the value of H, which is approaching to 1 could mean that the process is deterministic, that is not accidental: for some strictly deterministic processes structure is strictly repeated on any scale, leading to Hurst parameter of 1.

Observing the time dependence of traffic the presence of a periodic component in it that also leads to a large value of the Hurst was noted. The proximity of Hurst parameter to 1 allows performing more accurate predictions. In order to investigate the traffic details one needs to consider the temporal dependence separately within the same day.

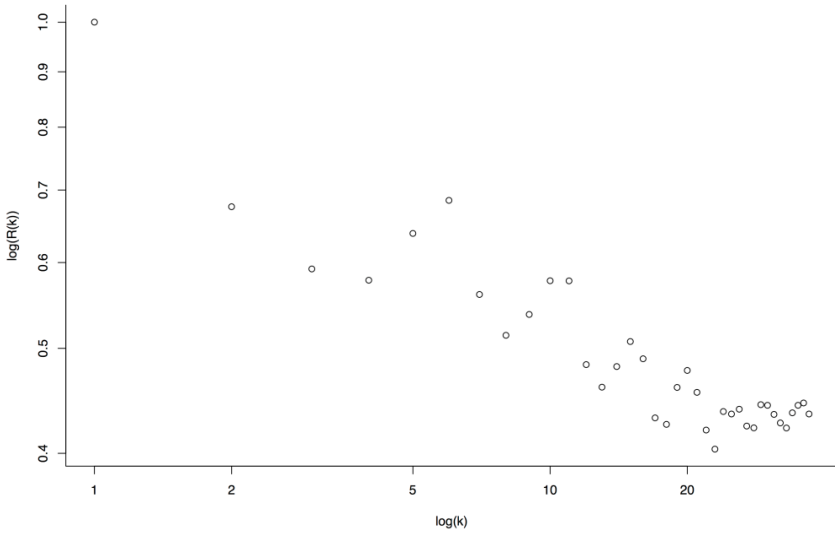


Fig. 5. The logarithmic dependence of the autocorrelation coefficient of outgoing traffic [source: own study]

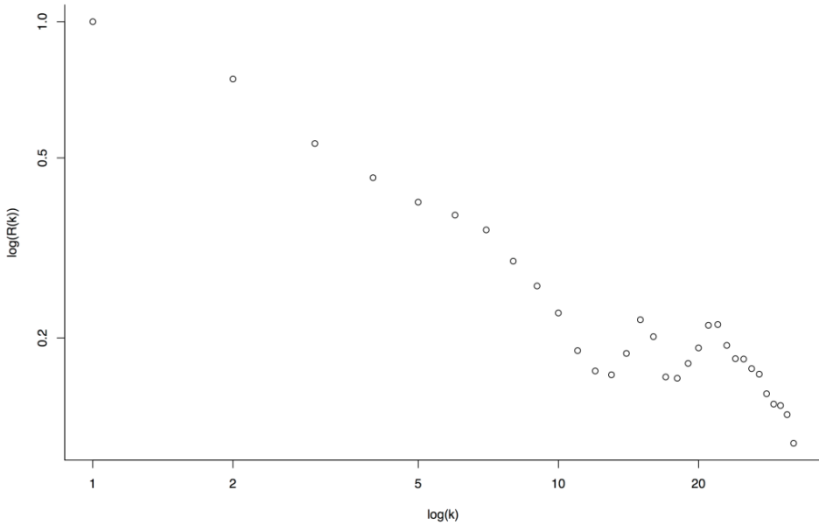


Fig. 6. The logarithmic dependence of autocorrelation coefficient for one-day traffic [source: own study]

Excluding the daily periodic component of traffic analysis and separating it within one day (Figure 6) shows a bit smaller Hurst parameter value, it ranges from 0.70 – 0.87.

5. CONCLUSIONS

As a result of this study the frequency of traffic cloud data warehouse, which has daily character was found. Intensity of storage load mainly depends on the incoming and outgoing traffic. Sufficiently high value of Hurst parameter indicates potential possibility of modelling and forecasting workload cloud data storage in the long term.

REFERENCES

1. HARMANTZIA F. C., HATZINAKOS D.: *Heavy Network Traffic Modeling and Simulation using Stable FARIMA Processes*. IEEE Trans. Signal Proc. Lett., 2000, pp. 48-50.
2. HEYMAN D. P., SOBEL M. J.: *Stochastic Models in Operations Research: Stochastic optimization*. Dover Publications, 2003.
3. HURST H.: *Transaction of the American society of civil*. Long term storage capacity of reservoirs, New York, 1951, pp. 770-799.
4. HURST H. E., BLACK R. P., SIMAIKA Y. M.: *Long-term storage: an experimental study*. Constable, 1965.
5. JAIN R., ROUTHIER S.: *Packet Trains--Measurements and a New Model for Computer Network Traffic*. IEEE J. Sel. A. Commun., vol. 4, 2006, pp. 986-995.
6. LELAND W. E. et al.: *On the self-similar nature of Ethernet traffic (extended version).* Volume. IEEE Press, Piscataway, NJ, USA, 1994, pp. 1-15.
7. BASKETT F. et al.: *Open, Closed, and Mixed Networks of Queues with Different Classes of Customers*. ACM, vol. 22, New York, NY, USA, 1975, P. 248-260.
8. KHAYARI R. et al.: *The Pseudo-self-similar Traffic Model: Application and Validation*. Elsevier Science Publishers B. V., vol. 56, Amsterdam, The Netherlands, 2004, pp. 3-22.
9. WILLINGER W. et al.: *Self-similarity Through High-variability: Statistical Analysis of Ethernet LAN Traffic at the Source Level*. IEEE Press, vol. 5, Piscataway, USA, 1997, pp. 71-86.
10. SONG CH.: *Packet Train Model: Optimizing Network Data Transfer Performance*. The University of Wisconsin – Madison, 1989.
11. STALLINGS W.: *High-speed networks and internets: performance and quality of service*. Pearson Education, 2002.
12. TANENBAUM A. S., WETHERALL D. J.: *Computer Networks*. Prentice Hall, 2011.
13. VACCHE A.D., LEE S.K.: *Mastering Zabbix*. http://books.google.co.uk/books?id=d1ZwAgAAQBAJ, 2013.
14. БЕССАРАБ В.І., ІГНАТЕНКО Е.Г., ЧЕРІВНСЬКИЙ В.В.: *Генератор самоподібного трафіку для моделей інформаційних мереж*. ДонНТУ, vol. 15, no. 130, Донецьк, 2008, pp. 23-29.
15. БЄЛЬКОВ Д.В.: *Дослідження мережевого трафіку*. ДонНТУ, vol. 10, no. 153, Донецьк, 2009, pp. 212-215.
16. ПЛАТОВ В.В., ПЕТРОВ В.В.: *Дослідження самоподібної структури телетрафіку бездротової*. vol. 3, 2004, pp. 38-49.

Justyna PATALAS-MALISZEWSKA[*]

CAN LOCAL KNOWLEDGE WORKERS SIGNIFICANTLY CONTRIBUTE TO THE GROWTH OF THE NATIONAL LEVEL OF INNOVATION?

Abstract

This paper systematically examines the role of knowledge workers on the level of innovation development in Poland. Specific hypotheses on the importance of the collaboration of knowledge workers for the growth of national innovation in two areas: knowledge creation and knowledge exploitation are examined. The study is based on a survey and interviews with 40 IT workers in small Polish businesses. The results show that cooperation between knowledge workers enables an improvement in the amount of human resources in science and technology and an increase in the number of high- and medium-tech Polish manufacturing enterprises. Specifically, the results confirm the hypothesis that the greater the amount of collaboration between knowledge workers, the higher the level of national innovation measured in these two indicators.

1. INTRODUCTION

The concept of innovation involves the production and the transfer of technological knowledge into new products or new processes. Innovations can be distinguished as various types: social, organizational, administrative or technical, incremental or fundamental, product or process [10]. It has been argued that countries can achieve higher rates of growth by specialising in knowledge-intensive products with higher added value [14]. Hakansson and Olsen (2011) [8] stated that innovation is the result of interaction among several actors like firms, suppliers, customers, universities, laboratories, technology centres, trade unions, service providers and financial institutions.

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The author believes that the determinants of the level of national innovation output, as defined actors, mainly consist of innovation inputs. Studies from a macro-perspective investigate the impact of innovation networks on macro systems in which a single actor has a secondary role [12, 13].

Innovative firms and R&D policies have identified knowledge workers as a key resource. According to Fabrizio 2009, [6] personal knowledge networks are critical for innovation development. On the other hand, Lechner and Dowling (2003) [11] stated that IT firms need a specific mix of networks in different developmental phases; and unfortunately collaboration within this network decreases with the firm's development.

According to Archibugi (2005), [2] the national innovation system (NIS) is a state network encompassing all science and technology resources and organizations related to innovation and the interaction between them. I agree with Altuzarra (2010), [1] that the primary innovation activities and resources of regional innovations systems include: research activities, infrastructure, human skills, capital, and many other components. A regional innovation strategy (RIS) examines how various elements, actors and networks influence regional success in innovation.

This paper combines considerations of the diversity of the actors: knowledge workers within personal knowledge networks, as well as of the outcomes deriving from them, in order to call for more research on the role that knowledge workers play in the processes of the growth of the national innovation level. The subject seems to be relevant because, starting from a micro-perspective of observation - including the features of actors and their interaction, can be helpful to understand the effectiveness of the growth of the national innovation level.

This paper aims to address these issues by systematically examining the relative significance of IT workers (information technology) on the growth of the national innovation level. The results are based on a survey and interviews with 40 IT workers – including technology managers, and managing directors in a number of micro businesses. The paper tests whether the role of personal knowledge networks varies the growth of the national innovation in the field of knowledge creation.

The remainder of the paper is structured as follows. First, the existing literature is critically discussed, gaps are highlighted and the hypotheses are developed in Section 2. Section 3 outlines the material and methodology used in the study. Afterwards, Section 4 presents and discusses the results. Finally, Section 5 concludes and reflects on the implications and limitations of the study.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1. Knowledge Workers within Personal Knowledge Networks

Knowledge workers create, distribute or apply knowledge within their jobs. Based on the example IT workers, this study aims to define the collaboration of knowledge workers within personal knowledge networks in a way that that can be exploited for the growth of the level of Polish innovation.

In the literature we can find that knowledge relationships with (local or non-local) external partners are considered to be essential for innovative geographical clusters [3, 4, 5, 9]. Personal knowledge networks refer to the interactions of a set of knowledge workers, whereas personal knowledge contacts refer to the person with whom somebody has a knowledge relationship. Factors of collaboration between IT workers within personal knowledge networks in the Polish companies in study were based on feedback surveys and their sources are listed here:

Collaboration between IT workers within personal knowledge networks: The degree of contact between an IT worker from one company with an IT knowledge worker from another company and by which one employee can help to share the knowledge of another:

- **Collab-factor1**: I share my knowledge from work with colleagues in my organization and in other organizations infrequently.
- **Collab-factor2**: I share my knowledge from work with colleagues in my organization and in other organizations frequently.
- **Collab-factor3**: I share my knowledge from work with colleagues in my organization and in other organizations very frequently.

2.2. The Level of Polish Innovation

Poland, together with Slovakia, Lithuania, Hungary, Romania, Latvia and Bulgaria is among those countries who have a low share of innovative enterprises (from 27% to 36%). In 2010, the leaders of innovative activity were Germany and Luxembourg, whose share of innovative enterprises were respectively (79%) and (68%) (*Eurostat Statistics Database).*

In line with theoretical considerations on the structure of a local innovation index [3, 16] this study focuses on the two key dimensions of the level of Polish innovation, namely: knowledge creation and knowledge exploitation. The following set of innovation measurement indicators were used to define the level of Polish innovation in this area:

Knowledge Creation (KC):

(1) Government R&D expenditure (per capita),

(2) Basic research expenditure (per capita),

(3) Human resources in science and technology (HRST) (per capita),
(4) Number of graduating students in Science and Engineering per capita (per capita).

Knowledge Exploitation (KE):

(1) Average number of valid home patent applications for four years (per capita),
(2) Corporate R&D expenditure (per capita),
(3) Applied research expenditure (per capita),
(4) Experimental research expenditure (per capita),
(5) Number of high- and medium-tech manufacturing enterprises.

Therefore, based on data from the Polish Central Statistical Office, the values of the indicators were defined which would be the result of the cooperation of knowledge workers within personal knowledge networks (see Table 1).

Tab. 1. Set of indicators which result from knowledge workers within personal knowledge networks

	2007	2008	2009	2010	2011
Knowledge Creation (KC)					
Gross domestic expenditure on research and experimental development (GERD) per capita in PLN	175	202	238	207	303
Basic research expenditure per capita in PLN	66.15	77.16	91.39	82.18	110.29
Human resources in science and technology (HRST) per capita	159.97	165.14	179.75	189.97	194.45
Number of graduating students in Science and Engineering per capita	49.83	49.81	47.23	44.74	41.49
Knowledge Exploitation (KE)					
Patent applications to the Patent Office of the Republic of Poland	2392	2488	2899	3203	3878
Average intramural expenditure on R&D in Polish enterprises and entities which conducted research and experimental development in millions of PLN	-	-	-	-	2.01
Applied research expenditure per capita	41.83	45.25	44.98	42.23	72.72
Experimental research expenditure per capita	67.03	79.59	101.63	82.39	119.99
Number of high- and medium-tech (innovative) Polish enterprises	-	-	302 908 18.1% of the total number of enterprises	291 806 16.9% of the total number of enterprises	301 597 16.9% of the total number of enterprises

It is clear that many aspects of innovation activities are indeed local [15]. Therefore, an attempt was made to examine the relative significance of Polish local IT workers (information technology) on the growth of the Polish innovation level.

The factors of the examination of the Polish innovation level were based on feedback surveys and their sources are listed here:

The Polish innovation level – the degree to which the growth of the Polish innovation level is affected from the knowledge sharing of local IT workers:

- **InnovGERD-factor1**: I know that sharing knowledge with local IT workers is not very important for Polish gross domestic expenditure on research and experimental development (GERD).
- **InnovGERD-factor2**: I know that sharing knowledge with local IT workers is quite important for Polish gross domestic expenditure on research and experimental development (GERD).
- **InnovGERD-factor3**: I know that sharing knowledge with local IT workers is very important for Polish gross domestic expenditure on research and experimental development (GERD).
- **InnovBR-factor1**: I know that sharing knowledge with local IT workers is not very important for Polish basic research expenditure.
- **InnovBR-factor2**: I know that sharing knowledge with local IT workers is quite important for Polish basic research expenditure.
- **InnovBR-factor3**: I know that sharing knowledge with local IT workers is very important for Polish basic research expenditure.
- **InnovHRST-factor1**: I know that sharing knowledge with local IT workers is not very important for Polish human resources in science and technology (HRST).
- **InnovHRST-factor2**: I know that sharing knowledge with local IT workers is quite important for Polish human resources in science and technology (HRST).
- **InnovHRST-factor3**: I know that sharing knowledge with local IT workers is very important for Polish human resources in science and technology (HRST).
- **InnovSSE-factor1**: I know that sharing knowledge with local IT workers is not very important for the number of graduating students in Science and Engineering in Poland.
- **InnovSSE-factor2**: I know that sharing knowledge with local IT workers is quite important for the number of graduating students in Science and Engineering in Poland.
- **InnovSSE-factor3**: I know that sharing knowledge with local IT workers is very important for the number of graduating students in Science and Engineering in Poland.
- **InnovPATENT-factor1**: I know that sharing knowledge with local IT workers is not very important for the number of valid patent applications in Poland for four years.
- **InnovPATENT-factor2**: I know that sharing knowledge with local IT workers is quite important for the number of valid patent applications in Poland for four years.

- **InnovPATENT-factor3**: I know that sharing knowledge with local IT workers is very important for the number of valid patent applications in Poland for four years.
- **InnovR&D-factor1**: I know that sharing knowledge with local IT workers is not very important for Polish corporate R&D expenditure.
- **InnovR&D-factor2**: I know that sharing knowledge with local IT workers is quite important for Polish corporate R&D expenditure.
- **InnovR&D-factor3**: I know that sharing knowledge with local IT workers is very important for Polish corporate R&D expenditure.
- **InnovAR-factor1**: I know that sharing knowledge with local IT workers is not very important for Polish applied research expenditure.
- **InnovAR-factor2**: I know that sharing knowledge with local IT workers is quite important for Polish applied research expenditure.
- **InnovAR-factor3**: I know that sharing knowledge with local IT workers is very important for Polish applied research expenditure.
- **InnovER-factor1**: I know that sharing knowledge with local IT workers is not very important for Polish experimental research expenditure.
- **InnovER-factor2**: I know that sharing knowledge with local IT workers is quite important for Polish experimental research expenditure.
- **InnovER-factor3**: I know that sharing knowledge with local IT workers is very important for Polish experimental research expenditure.
- **InnovEnterprise-factor1**: I know that sharing knowledge with local IT workers is not very important for the number of Polish innovative enterprises.
- **InnovEnterprise-factor2**: I know that sharing knowledge with local IT workers is quite important for the number of Polish innovative enterprises.
- **InnovEnterprise-factor3**: I know that sharing knowledge with local IT workers is very important for the number of Polish innovative enterprises.

This paper aims to develop a model to evaluate the growth of the national innovation level in terms of the work of knowledge workers within personal knowledge networks, also it aims to investigate the relationship between the collaboration of knowledge workers and the Polish innovation level within two key areas: knowledge creation and knowledge exploitation. A research model can be presented, as shown in Fig. 1.

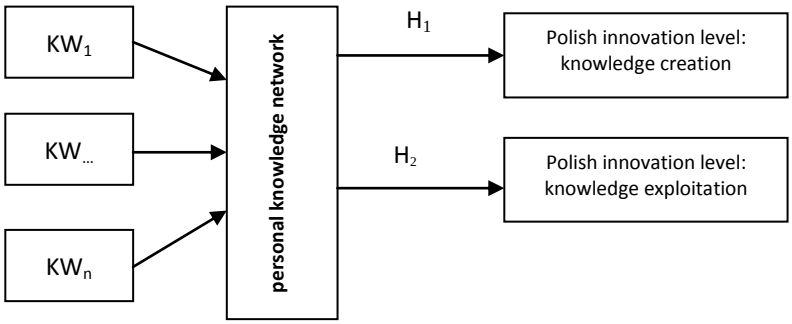

Fig. 1. A research model [source: own study]

where: KW – knowledge worker: IT workers – including technology managers, and managing directors in micro businesses.

Thus, this paper proposes the following hypotheses:

H1. The collaboration of knowledge workers within personal knowledge networks positively influences the Polish innovation level in the area of knowledge creation.

H2. The collaboration of knowledge workers within personal knowledge networks positively influences the Polish innovation level in the area of knowledge exploitation.

As presented in Fig.1, the research model posits, from the preceding argument, that the collaboration of knowledge workers within personal knowledge networks will have a positive influence upon the defined level of Polish innovation.

The following section describes the item measurement and data collection carried out in the research.

3. MEASURES AND METHODS

A survey was conducted in Poland to test the research model. The data for this study were collected from 40 IT workers – including technology managers, and managing directors in micro businesses between April-May 2013 through the use of direct interviews with respondents. Each employee was required to complete a questionnaire. A three-point scale was used for all survey items, ranging: "disagree" (one point), "agree" (two points), "strongly agree" (three points).

4. RESEARCH RESULTS AND STRUCTURAL MODEL

The research model was analysed using a correlation approach in order to estimate the effect of the collaboration of knowledge workers within personal knowledge networks on the level of Polish innovation. A moderated correlation approach using Statistica ver.10.0 was used to test the hypotheses. The data were carefully examined with respect to linearity, equality of variance and normality. No significant deviations were detected. Table 1 presents descriptive correlations for the main variables.

Tab. 2. Correlations analysis

Construct	Item/Factor	Correlation	r2	t	p
Knowledge Creation (KC)					
Collaboration of local IT workers GERD	Collab-factor1/Collab-factor2/Collab-factor3/ InnovGERD-factor1/ InnovGERD-factor2/ InnovGERD-factor3	-0.097428	0.009492	-0.603456	0.549791
Collaboration of local IT workers BR	Collab-factor1/Collab-factor2/Collab-factor3/ InnovBR-factor1/InnovBR-factor2/InnovBR-factor3	-0.144053	0.020751	-0.897359	0.375178
Collaboration of local IT workers HRST	Collab-factor1/Collab-factor2/Collab-factor3/ InnovHRSTfactor1/InnovHRST-factor2/InnovHRST-factor3	0.203448	0.041391	1.280929	0.207981
Collaboration of local IT workers SSE	Collab-factor1/Collab-factor2/Collab-factor3/ InnovSSE-factor1/InnovSSE-factor2/InnovSSE-factor3	-0.071429	0.005102	-0.441443	0.661394
Knowledge Exploitation (KE)					
Collaboration of local IT workers PATENT	Collab-factor1/ Collab-factor2/Collab-factor3/ InnovPATENT-factor1/ InnovPATENT-factor2/ InnovPATENT-factor3	0.031010	0.000962	0.19125	0.849346
Collaboration of local IT workers Polish corporate R&D expenditure	Collab-factor1/Collab-factor2/Collab-factor3/ InnovR&D-factor1/ InnovR&D-factor2/ Innov R&D -factor3	-0.257465	0.066288	-1.64249	0.108739
Collaboration of local IT workers Polish applied research expenditure	Collab-factor1/Collab-factor2/Collab-factor3/ InnovAR-factor1/ InnovAR-factor2/ InnovAR-factor3	-0.073284	0.005371	-0.45297	0.653145
Collaboration of local IT workers Polish experimental research expenditure	Collab-factor1/Collab-factor2/Collab-factor3/ InnovER-factor1/InnovER-factor2/ InnovER-factor3	-0.073284	0.005371	-0.45297	0.653145
Collaboration of local IT workers Number of Polish innovative enterprises	Collab-factor1/Collab-factor2/Collab-factor3/ InnovEnterprise-factor1/InnovEnterprise-factor2/InnovEnterprise-factor3	0.316468	0.100152	2.05654	0.046645

The study tests the hypotheses using a correlation analysis because an interaction effect exists only if the interaction term makes a significant contribution.

Table 2 presents descriptive correlations for the main variables. This includes the results of the correlation analyses which estimate the effect of the collaboration of local IT knowledge workers, as well as their interaction with the Polish innovation level. The primary interaction of the collaboration of local IT knowledge workers makes a significant contribution to one of the defined factors of the Polish innovation level: human resources in science and technology (HRST) (correlation = 0.203448). The second interaction of the collaboration of local IT knowledge workers makes a significant contribution to one of the defined factors of the Polish innovation level, namely: the number of Polish innovative enterprises (correlation = 0.316468).

The results of the analysis indicate that cooperation between knowledge workers enables an increase in the amount of human resources in science and technology and number of Polish innovative enterprises. This means that this cooperation, whether formal or informal, can lead to the creation of new work-groups and furthermore to the creation of new companies based on knowledge. Knowledge plays a special role in the innovation creation process. According to Garvin (2006), a knowledge-oriented company is one with the cooperation and collaboration of first-class professionals (knowledge workers) who possess the necessary responsibilities to achieve a competitive position for the organization. Therefore, it can be stated, that knowledge workers are one of the main determinants in the growth of the national innovation level. The results of the structural model are shown in Fig. 2.

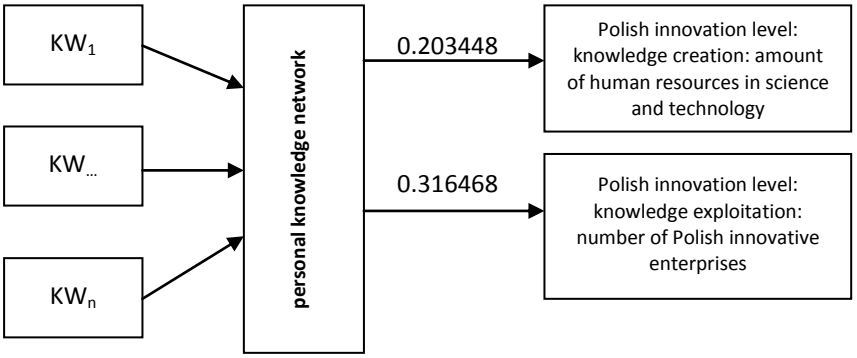

Fig. 2. Analysis of the results [source: own study]

5. CONCLUSIONS AND RECOMMENDATIONS

This section of the paper summarizes the new findings of this study and discusses the implications.

This research analyzes the effects of the collaboration of local IT knowledge workers on the Polish innovation level in two areas: knowledge creation (KC) and knowledge exploitation (KE). By proposing a model which addresses the influence of cooperation between IT workers on the national innovation level, this study contributes to filling the gap which exists in the literature. The empirical findings of this study confirm the general hypothesis. It is therefore clear that among knowledge workers, those with sound knowledge can create the innovations necessary for businesses. Innovation is defined as the introduction of new, improved ways of doing things at work. It can be stated that knowledge workers can enhance the innovation level, whether at the company level, or national.

Like all studies, this one has certain limitations that further research should aim to overcome. Firstly, because the intention is to analyze the Polish innovation level, this study focuses on Polish IT workers. It would be unwise to generalize the findings too broadly to other countries. Furthermore, all the variables are measured at the same moment in time. So, it would be useful to provide such research over a longer time period and at different stages. These conclusions and limitations suggest proposals for future research directions, such as exploring additional factors that could improve the effect of the collaboration of knowledge workers on the national innovation level.

REFERENCES

1. ALTUZARRA A.: *Public funding for innovation at different levels of government: an analysis of Spanish manufacturing*. European Journal of Economics, Finance and Administrative Sciences 20, 2010.
2. ARCHIBUGI DC, ALBERTO: *Measuring technological capabilities at the country level: a survey and a menu for choice*. Research Policy, vol. 34, no. 2, 2005, pp.175-94.
3. BELUSSI F., SAMMARRA A., SEDITA S. R.: *Learning at the boundaries in an "Open Regional Innovation System": a focus on firms' innovation strategies in the Emilia Romagna life science industry*. Research Policy 39, 2010, pp. 710-721.
4. COOKE P., URANGA M. G., ETXEBARRIA G.: *Regional innovation systems: institutional and organisational dimensions.* Research Policy 26, 1997, pp. 475-491.
5. EISINGERICH A. B., BELL S. J., TRACEY P.: *How can clusters sustain performance? The role of network strength, network openness, and environmental uncertainty*. Research Policy 39, 2010, pp. 239-253.
6. FABRIZIO K. R.: *Absorptive capacity and the search for innovation*. Research Policy 38, 2001, pp. 255-267.
7. GARVIN D. A.: *Building the learning organization*. Knowledge Management, Helion, Gliwice, 2006.
8. HAKANSSON H., OLSEN P. I.: *Innovation in networks*. Naples Service Forum, 2011.

9. HUBER F.: *Social capital of economic clusters: towards a network-based conception of social resources*. Tijdschrift Voor Economische En Sociale Geografie 100, 2009, pp. 60-170.
10. JOST A., LORENZ T., MISCHKE G.: *Modelling the Innovation-Pipeline*. System Dynamics Society Conference, Massachusetts Institute of Technology, Sloan School of Management, Cambridge, Massachusetts USA, 2005.
11. LECHNER C., DOWLING M.: *Firm networks: external relationships as sources for the growth and competitiveness of entrepreneurial firms*. Entrepreneurship and Regional Development 15, 2003, pp. 1-26.
12. LUNDVALL B.: *National systems of innovation*: Towards a theory of innovation and interactive learning, London: Pinter, 1995.
13. METCALFE J. S.: *The economic foundations of technology policy*. In Stoneman, P. (ed.), Handbook of the economics of innovation and technological change, Oxford University Press, Oxford, 1995.
14. OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual. OECD, Paris, 1997.
15. VARGA A.: *Térszerkezet és gazdasági növekedés*. Budapest, Akadémiai Kiadó, 2009.
16. ZOLTÁN B.: *Constructing a Local Innovation Index: Methodological Challenges Versus Statistical Data Availability*, Appl. Spatial Analysis 6, 2013, pp. 69-84.

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CONDITIONS OF MANUFACTURING IN CONTEMPORARY SMALL AND MEDIUM ENTERPRICES

Abstract

In accordance with the requirements of the modern market, small and medium-sized enterprises (SMEs) need to offer a wide range of products tailored to the specific and individual requirements. The article presents the conditions of production using modern computer techniques. Presented solutions are used in modern practice.

1. INTRODUCTION

Mass production tendency has turned into mass customization tendency [17, 27, 33]. In the past the fundamental objectives for most companies were to produce as cheaply and efficiently as possible and to reach as large a customer group as possible with the same product (mass production philosophy). The customer orientation is one of the most essential strategies for every manufacturer. Previously the primary source of competitive advantage for manufacturing companies in many industries was related to price. Therefore, all manufacturing strategies were driven by attempts to reduce the cost of the product. Technological advances, in manufacturing as well as in information, have provided the impetus for change in many paradigms, including customer expectations. Customers have become more demanding and want products that can meet their specific individual requirements. Producing customized products at a low cost, which seemingly is a paradox, is the purpose of many enterprises. The production cycle consists of, among others: the processing time and setup time.

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Despite using modern management techniques e.g. SMED (Single Minute Exchange of Die) technique, in the conditions of unit production in SME, total setup time is still significant.

For high-variety production the cumulative amount of setup time results from the number of changeovers [1]. To shorten the production time and reduce costs the methods of group technology have been used for many years [15]. Despite having many input data from this kind of information systems area of organization of the production process is still supported at insufficient level. The manufacturing system should be supported by efficient IT tools targeted at the possibilities of implementation in small and medium enterprices. To manufacture in efficient way, expert system and methods, which enable quick identification of situation with a crucial impact on the production are needed [3, 5, 12, 16]. Fulfilling customer needs, results in production by unit and small batch process. Enterprises, which manufacture in this conditions have at their disposal modern and universal machinery equipment. For high-variety production the cumulative amount of setup time results from the number of changeovers. In studied SME enterprises proportion between changovers time and processing time is high and it is from several to over a dozen percent of processing time [18, 24].

Research based on real data of enterprises, which use ERP systems in production managment, have induced author to develop method of changeovers time reduction by dynamic grouping and scheduling tasks of operating production plan. Above article presents a problem of optimization of manufacturing using element's grouping techniques with dynamic classification of machine elements (at the level of operation of manufacturing process). Concept of classification refers to the issues connected with group technology [25, 23]. In order to reduce labor intensity of this method data needed to establish "similarity" has been taken from ERP system, using information which has been introduced "on another occasion". Above research has been applied in production practice.

Success of many enterprises, which work in mass production system and use economic effect of scale production slowely is a thing of the past. IT systems focused on management in big companies start to to be interested in manufacturing systems in smaller enterprises. There are many enterprices, generally small and medium manufacturing in unit and small batch production, for which it is necessary to develop optimal methods of production management taking into account the flexible production requirements, matched to the time-varying customer's demand [28, 2, 19, 21].

An example of flow processes in small and batch production is shown in Fig. 1.

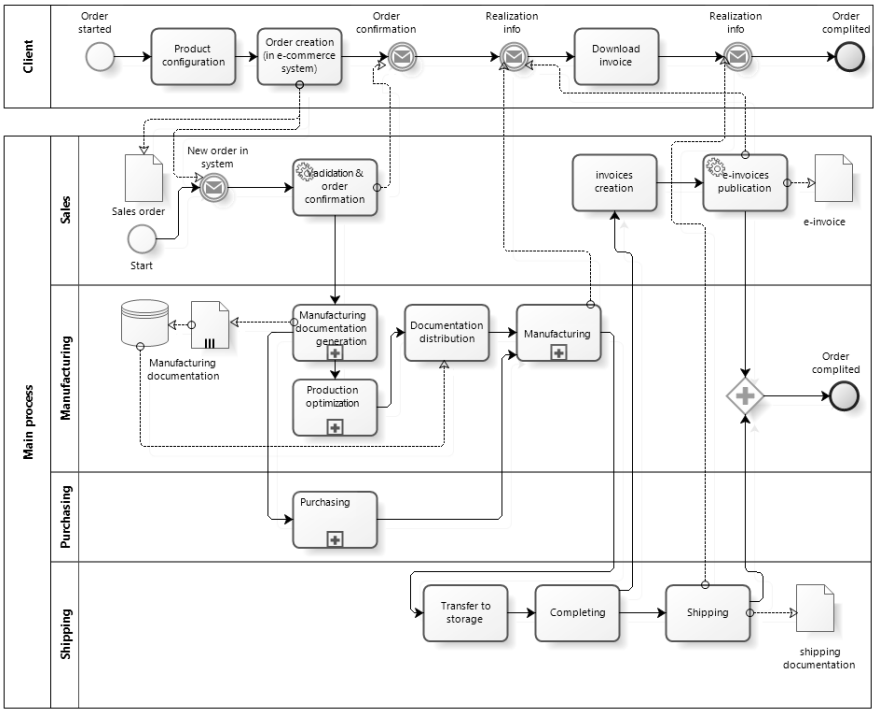

Fig. 1. Processes Flow for the unit and small batch production [source: own study]

For this purpose, it is necessary to use appropriate methodology of scheduling production tasks and IT system, which have functionality for efficient planning and controlling realization of production processes. To be able to manage production efficiently, system and methods, which enable quick identification of situation having big influence on manufacturing are required. Suitable reaction to threats of deadlines or budget, continuous improvement of organization of the production process are still challenge for IT systems in SME. Enterprises to adapt to conditions of modern market invest in modern, universal machines park, which is able to fulfil changeable and unpredictable requisition. Presented method of production management support with using dynamic tasks classification can be one of the elements in optimization of high-variety production in SME [2, 29, 22].

2. DESIGNING STEPS OF THE PRODUCTION PROCESS

Today, manufacturing is complex activity, connecting people, who follow different professions, with using different machines, equipment and tools, which are in varying degrees automated, including computers and robots. This process consists in appropriate utilization of resources: materials, energy of capital and people and it leads to manufacture products from raw materials according to well-prepared plan [7, 35, 4].

Designing of manufacturing process consists of several elements:

- structural design, which aims at development of shape and geometric features of products fullfiling human needs,
- materials design, in order to ensure necessary durability of a product or its elements made from engineering materials with required physico-chemical and technological features ,
- manufacturing process design, which enable giving the required geometric features and property to particular elements of the product, and also their proper cooperation after assembly, taking into account the volume of production, the level of automation and computer support, and at the lowest cost of this product,
- organization of manufacturing process design.

Number of factors and criterions, which are necessary to properly design the product, prepare and organise production connected with launching a product needs continuous development, and above all implementation in production practice modern aided design systems, manufacturing and organization of production process. It means implementation in area of engineering design of computer systems CAx (CAD, CAM, CAP, CAPP), management of product data and life cycle of products PDM, PLM, PLM II also production using manufacturing executive system (MES), enterprise resource planning system (MRPII/ERP/ERPII) and supply chain management system (SCM) [4, 13, 14, 8, 3, 22].

3. PRODUCT DESIGNING

A characteristic feature of traditional, used in the 70's and 80's of the twentieth century way of organizing the design work was big participation of manual work, i.e. design ideas were manually transferred to the paper by successively drawn sketches and illustrations of particular machines' elements, devices or subassemblies and assemblies. On the basis of these drawings strength calculations of designed constructions, which aim was preliminary determination and selection of materials have been made. After the development of design documentation, this documentation was passed to technological department, where cost calculation of product and analysis of the possibility of its manufacturing using owned

machinery were done. The next step was designing the manufacturing processes for individual parts using the available resources of the enterprise [35, 9, 11]. More and more often the organization of the design work changes. Customer more frequently takes part in this process.

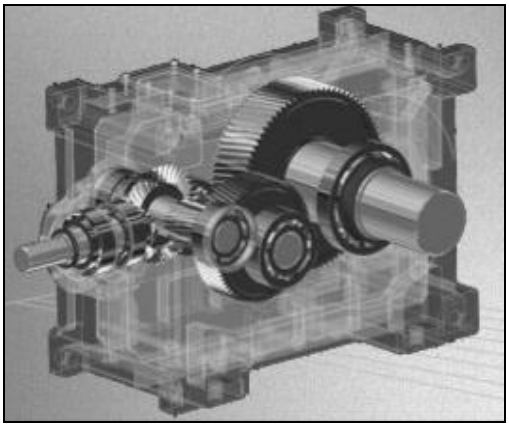

Fig. 2. The 3D model of helical-bevel reducer BH [32]

In the vast number of enterprises, which create design projects CAD systems are standards. Besides the possibility of drawing on the plan, first of all, they give the ability of designing and creating the 3D model in virtual space (Fig. 2) [8, 19, 14]. Traditionally in the superficial design building the model of newly designed object in order to exact fit subassemblies and assemblies, which were supposed to be placed inside the model was necessary. CAD systems enable generating a 3D model on a computer screen and realization of analogical operations without building such a model in practice [21]. For this purpose numeric entry model surface, generating a spatial grid, in which every spot inside the model is clearly, geometrically defined is used. This function enables precise fitting components of the model by unequivocal downloading the design data from a spatial model of the product [35, 14].

The effects of changes in the organization of design work, resulting from the application of computer support are reducing labour intensity of work and shorter product designing. Owing to new tools it is possible to control progress in the designers' works and to apply changes. Not without significance is also synergy effect in the teamwork, the designers have stopped working in solitude, often not seeing the results of their work. Computer technology gives the ability of simultaneous working on the product and evaluating the effects of own work on a virtual model of a new product. Also applying changes is much easier and it involves the modifying of the drawing in electronic form, and then printing or sending it in electronic

form to production department. By visualizing 3D model manufacturability of product becomes much simpler. With having a model it is easier to check the possibility of manufacturing the machines' elements. Additionally model can form the basis to automatic generation of CNC program [35, 30, 32, 3].

4. DESIGNING OF MANUFACTURING PROCESSES

Nowadays designing of manufacturing process is supported by IT systems. An important role in this process is played by CAPP (*Computer Aided Process Planning*) systems. CAPP systems are the connecting elements between CAD systems and CAM systems, providing database and graphical representation of the manufacturing process. CAPP systems can be separate applications (eg. Sysklass) or they can be modules of ERP systems [22, 3].

The concept of a Sysklass computer system is based on creating opportunities of as precisely as possible identifying relevant parameters of any object which is the subject of production. On the basis of specified by the identification information, system can generate certain technical solution, feasible to apply in given production conditions. The effectiveness of the identification provides classifier (Fig. 3) based on a combination of methods of shape and parameters of objects recognition, construction features and element's properties database and data connected with manufacturing process. Sysklass has parts database of the firm base and standard norms clearly arranged in graphic classification system with possibility of quick searching based on shape similarity and properties defined by user. Such capabilities are particularly important in SME, which use unit and small batch production [34, 21].

5. DESIGNING THE ORGANIZATION OF MANUFACTURING

5.1. Modern methods and techniques of designing the organization of manufacturing

The technical progress, development of information systems in the twenty-first century also cause changes in the organization of the manufacturing process. In their offer many SME have high-variety products, customized to customer's needs. This kind of requirements intensify need for reducing to minimum time and cost of designing the manufacturing processes. In this context, particular importance has the term of "Digital Factory" [8, 20]. The "Digital Factory" is seen as the planning instrument of the future. A large part of the factory planning, production- and product-planning is already supported by digital tools. These various planning phases are not integrated and thus are generally carried out in isolation. The goal is to achieve a holistic

planning, evaluation and continuous improvement of all significant processes and resources in the factory in connection with the product. All elements within the production should be modelled during planning by means of computer-supported methods, in such a way that the physical manufacturing of the product meets all quality, time and costs goals.

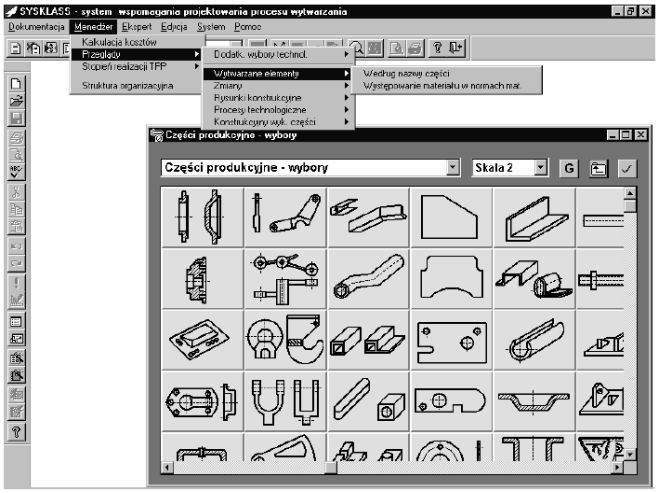

Fig. 3 Graphical classifier Sysklass [34]

The computer-supported models within the Digital Factory must document and visualize all the elements of the future factory as well as describe their interplay. Only when the digital product has successfully passed through the Digital Factory, the product is released into the real factory [8, 20]. "Digital Factory" technologies enable complex modelling and simulation through virtualization of processes. Methods and techniques of "Digital Factory", due to the cost find use in big corporations [20, 26]. However, it is expected, that in the future this kind of designing will be applied in SME. One of the major problems connected with organization the manufacturing process using tools of digital factory is problem with data acquisition. The development of laser technology has initiated the gradual emergence of scanners making quick acquisition of point clouds and its record in a form that allows further processing. Now, in the field of non-contact measurement of laser beam techniques, a whole range of devices, varied due to the accuracy and size of the scanned object is offered. While the acquisition of information and data from measurements performed using 3D scanners does not cause considerable difficulties, processing received by this method point clouds – does. Although the manufacturers of laser scanning equipment give customer IT programs, but usually it is used only for integration of data sets from different measuring stations and visualization of received cloud [20, 21].

The use of 3D scanners enables performance of virtualization of production systems before the designing of real system. After creating a virtual model of the production system simulation analysis using a three-dimensional applications can be carried out. An example of this type of tool is Delmia system or Technomatix system by Siemens. DELMIA Digital Solutions allow manufacturing organizations to design and visualize the entire manufacturing process for digitally specified product before implementation it to production. They are closely integrated with the CATIA design solutions, and also with ENOVIA and SmarTeam used to data management and to teamwork and therefore they provide significant benefits for customers, who implement PLM [6].

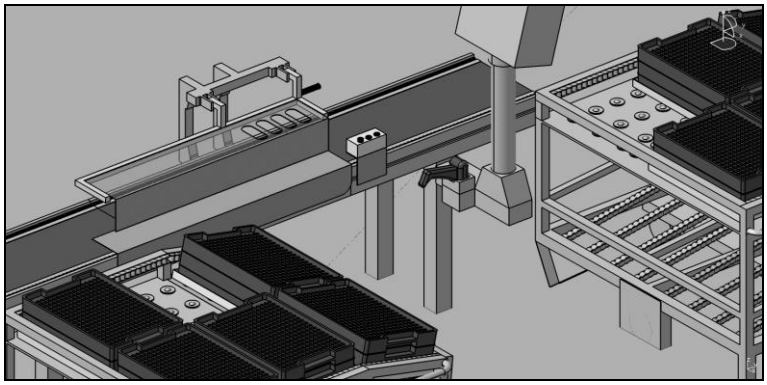

Fig. 4. Simulation of the assembling line [10]

Figure 4 shows an example of digitalized assembling line. Virtualization of workstations of one of the enterprises in the Bielsko-Biala region was created after the 3D scanning and transferring data to environment of Delmia software. After building a model of workstations , simulation of the manufacturing process in a virtual environment was done.

Above project was realized in "Polish-Slovak Cross-Border Networks of Innovation and New Technologies", co-funded by the European Union (European Regional Development Fund) [10].

5.2. Designing organization of manufacturing in conditions of unit and small batch production

In the processes of the organization and management of production most of manufacturing enterprises use in practice ERP systems. Using this kind of systems under current market conditions in the traditional form often becomes (is) insufficient. Traditional areas of application of such systems like finances, materials management have to be significantly expanded in the field of production management. The current market situation forces companies to

shortening manufacturing cycles of variant production, manufactured in ever smaller batches and at the same time to reducing costs and cutting time of availability of products. The answer to these requirements is change of machine park, organization and techniques of manufacturing as well as inclusion in the decision making process information systems [21]. The most important change in the ERP systems is starting treating them not, as the target applications, self-operating, but as the intermediate layer, enabling operation of management support systems in the area of operational management production. These systems have became more open. They enable superstructure of dedicated (customized) solutions on the universal solutions, specific for individual companies. The new quality is supporting decision at the operational level (in the) "on line" [24, 25].

So far in conditions of unit and small batch production often only one variant of the manufacturing process has been designed. Currently this approach is not enough. Due to the variable nature of the availability of resources it is necessary to separate organizational preparation of production in two stages. In the first stage – static, database of the available variants of the manufacturing process is created. In the second stage, at the operational level, from the available process variants optimal variant, which takes into account the current availability of renewable and non-renewable resources is chosen.

6. SUMMARY

The requirements of today's customer, determine manufacturing systems. Strategies of small and medium enterprises are more and more often directed towards manufacturing customized products. At present manufacturing systems must be prepared to produce families of products in the shortest possible production cycle. In conditions of unit and small batch production information system to support management decision making process is in many cases insufficient This is result of both, the assumptions of management model and insufficiency of used algorithms. Large variability of the planning factors and variety of products have an impact on this situation. Because of labor consumption of building the model, the use in decision making process standard simulation methods is too expensive and can bring correct results too late. In the processes of the organization and management of production part of enterprises use ERP systems use in production practice. The use of this class of systems under current market conditions in the traditional form often becomes insufficient. The traditional application areas of this kind of systems as finance, materials management must be considerably expanded in the area of production management. The current market situation forces enterprises to shorten production cycles of variants products, manufactured in smaller batches and at the same time reducing costs and shortening time of availability of products. The answer to these requirements is a change of machine park, organization

and manufacturing techniques, and inclusion in decision making process IT systems. The most significant change in the area of ERP systems is to start treating them not as a target application, self-operating, but as an intermediate layer, enabling the operation of management support systems in the area of operational management of production. Systems of this class have become more open, enabling superstructure above universal solutions of dedicated solutions specific to individual enterprises. The new quality is decision support at the operational level in the "on line" mode. So far, in conditions of unit and small batch production often only one variant of the manufacturing process has been designed. This approach currently is not enough. Due to the dynamic nature of the availability of resources it is necessary to divide organizational preparation of manufacturing into two stages. In the first stage - static, a database of the available manufacturing process variants is created. This course of action with the use of computer system is not very expensive. In the second stage, at the operational level, from the available process variants, optimum variant, taking into account the current availability of reusable and consumable resources is chosen.

Because of the complexity of the issue and the fact that the coding method depends primarily on the specific conditions of the enterprise, the use of this classification under practical conditions faces serious difficulties. An alternative approach is the use of grouping requiring no coding, carried out in an automatic way not at the level of manufactured element, but at the level of organization of operations of the manufacturing process. The new method of approach also assumes the automatic generation of operations of manufacturing process considering the results of the dynamic grouping.

Both, carried out research and production practice have proved utilitarianism of the proposed solutions.

REFERENCES

1. BARE M., COX J. J.: *Applying principles of mass customization to improve the empirical product development process.* Journal of Intell. Manuf., 2008, pp. 565-576.
2. BANASZAK Z., BZDYRA K., SANIUK S.: *Systemy wspomagania inżynierii zarządzania*. Wydawnictwo Uczelniane Politechniki Koszalińskiej, Koszalin.
3. BANASZAK Z., KŁOS S., MLECZKO J.: *Zintegrowane systemy zarządzania*. PWE Warszawa, 2011.
4. CHLEBUS E.: *Techniki komputerowe CAx w inżynierii produkcji.* Wydawnictwa Naukowo-Techniczne WNT, Warszawa, 2000.
5. DA SILVEIRA G., BORENSTEIN D., FOGLIATTO F. S.*: Mass customization: Literature and research directions.* International Journal of Production Economics 72, 2001, pp. 1-13.
6. Materiały konferencyjne DS PLM Forum, Kraków, 2010.
7. DOBRZAŃSKI L.: *Komputerowe wspomaganie w inżynierii maszyn i materiałów*. Agenda Wydawnicza Wrocławskiej Rady FSNT NOT, Wrocław, 2005.
8. GREGOR M. et al.: *Digitálny podnik.* Žilinská univerzita, Ústav konkurencieschopnosti a inovácií, Žilina (SK), 2006.

9. GREGOR M. et al.: *How simulation helps to improve manufacturing system.* Proceedings of the Second World Congress on Intelligent Manufacturing Processes and Systems, Budapest, 1997.
10. GREGOR M. et al.: *Cezhraničná pol'sko-slovenská inovačná a technologická siet (Transgraniczna polsko-słowacka sieć innowacji i nowych technologii).* Žilina: Slovenské centrum produktivity, 2011.
11. HROMADA J., PLINTA D.: *Modelowanie i symulacja systemów produkcyjnych*. Wydawnictwo Politechniki Łódzkiej filia w Bielsku Białej, Bielsko-Biała, 2000.
12. JASIŃSKI Z.: *Podstawy zarządzania operacyjnego*. Oficyna Ekonomiczna, Kraków, 2005.
13. KNOSALA R.: *Zastosowania metod sztucznej inteligencji w inżynierii produkcji.* WNT, Warszawa, 2002.
14. KNOSALA R.: *Komputerowe wspomaganie zarządzania przedsiębiorstwem*. PWE, Warszawa, 2007.
15. KUSIAK A.: *A Generalized Group Technology Concept*. Int. J. Prod. Res., vol. 25, no. 4, 1987, pp. 561-669.
16. LECH P.: *Zintegrowane systemy zarządzania ERP/ERP II.* Wykorzystanie w biznesie, wdrażanie, Wydawnictwo DIFIN, Warszawa, 2003.
17. MACCARTHY B., BRABAZON P.G., BRAMHAM J.: *Fundamental modes of operation for mass customization*, Int. J. Production Economics 85, 2003, pp. 289-304.
18. MATUSZEK J.: *Metody i Techniki zarządzania w Inżynierii Produkcji.* Wydawnictwo Akademii Techniczno-Humanistycznej w Bielsku-Białej, Bielsko-Biała, 2006.
19. MATUSZEK J.: *Metody i Techniki zarządzania w Inżynierii Produkcji.* Wydawnictwo Akademii Techniczno-Humanistycznej w Bielsku-Białej, Bielsko-Biała, 2007.
20. MATUSZEK J., GREGOR M., KURCZYK D.: *Zastosowanie wielkoformatowego skanowania obiektów przemysłowych w procesach przygotowania produkcji.* Materiały konferencyjne Konferencja Komputerowo Zintegrowane Zarządzanie, Zakopane, 2009.
21. MLECZKO J.: *Komputerowe wspomaganie planowania przebiegów procesów produkcyjnych.* Wydawnictwo Fundacji Centrum Nowych Technologii, Bielsko-Biała 2008.
22. MLECZKO J.: *Komputerowo wspomagane zarządzanie wytwarzaniem (na przykładzie oprogramowania REKORD.ERP).* Wydawnictwo Fundacji Centrum Nowych Technologii, Bielsko-Biała, 2008.
23. MLECZKO J.: *Dynamic classification of tasks in condition of unit and small batch production.* Management and Production Engineering Review, vol. 1, no. 3, 2010, pp. 41-55.
24. MLECZKO J.: *High-variety products manufacturing based on dynamic classification.* Advances in Manufacturing Science and Technology, vol. 35, no. 3, 2011, pp.71-86.
25. MLECZKO J.: *Product family manufacturing based on dynamic classification*. Management and Production Engineering Review, vol. 2, no. 2, 2011, pp. 29-38.
26. MLECZKO J.: *Data of configurable products for digital factory and ERP systems.* Digital factory management methods and techniques in engineering production, vol. 5, 2011, pp. 101-119.
27. PINE B.J.: *Mass Customization: The New Frontier in Business Competition*. Harvard Business School Press, Boston, 1993.
28. SKOŁUD B. i inni: *Zintegrowany system wspomagania zarządzania produkcją w małych i średnich przedsiębiorstwach*. Materiały V Konferencji Naukowo-Technicznej Inteltrans 2009, Wydawnictwo PK, Kraków, 2009.
29. SKOŁUD B.: *Wspomaganie podejmowania decyzji w zakresie zarządzania przepływem produkcji.* Efektywne zarządzanie przepływem produkcji, Inżynieria Maszyn, vol. 3, 2009.
30. STANISŁAWSKI M. *W poszukiwaniu pudełka z napisem PLM.* Projektowanie i Konstrukcje Inżynierskie, no. 10, 2008.
31. GREGOR M., MEDVECKÝ Š.: *Žilina University Concept of Digital Factory*. Komunikacie, vol. 10, no. 2, 2008, pp. 60-66.

32. STANISŁAWSKI M.: *Od 2D do 3D… Historia komputerowych systemów wspomagających projektowania, wytwarzanie i analizy inżynierskie cz. II.* Projektowanie I Konstrukcje Inżynierskie, no. 12, 2008.
33. SPRING M., DALRYMPLE J. F.: *Product customization and manufacturing strategy*. International Journal of Operations and Production Management, vol. 20, no. 4, 2000, pp. 441-467.
34. Materiały wewnętrzne, foldery katalogi firmy Komputerowe Systemy Inżynierskie Bielsko-Biała, 2010.
35. SZATKOWSKI K.: *Przygotowanie produkcji*. PWN, Warszawa, 2008.
36. SLAMKOVÁ E., DULINA Ľ., TABAKOVÁ M.: *Ergonómia v priemysle*. 1st edition. Žilina: Georg, 2010, p. 262.
37. MIČIETA B., DULINA Ľ., SMUTNÁ M.: *New Approach of Ergonomics Workplace Design*. The 22nd International DAAAM Symposium, Vienna: DAAAM International Vienna, 2011, p. 303.
38. GREGOR M., ŠTEFÁNIK A., HROMADA J.: *Lean Manufacturing Systems Optimisation Supported by Metamodelling*. IFIP International Federation for Information Processing. vol. 257, 2008, pp. 175-183.
39. GREGOR M., MEDVECKÝ, Š.: *Žilina University Concept of Digital Factory*. Komunikacie, vol. 10, no. 2, 2008, pp. 60-66.

passenger lift, CAD, designing, disk springs

Paweł LONKWIC[*]

USING DISK SPRING SOLVER APPLICATION FOR PROTOTYPING DISK SPRINGS IN PASSENGER LIFT CATCHERS

Abstract

The foregoing study presents the use of Disk Spring Solver DSS application for prototyping configurations of disk spring pile applied in the design of friction lift catchers. The methodology of disk springs selection was presented on the basis of possibilities given by DSS application. On the basis of this application and the conducted analyses disk springs were optimally matched with catchers as main flexible element. The design of catchers was worked out in model environment SolidWORKS 2012 together with MES analysis.

1. INTRODUCTION

Nowadays virtual prototyping is a very convenient tool, not much increasing the costs of manufacturing new products. With the application of the newest tools from the domain of rendering the product can be very realistically visualized, with emphasizing of its aesthetic values. On the basis of the created 3D documentation structural changes can be made quickly, as well as rendering and preparing offers for customers. To obtain full computer support, except the above-mentioned advantages of 3D systems, there are still other programs by means of which our work can be easily and quickly supported, especially in technical domains.

In the foregoing study we showed the use of SPRING DISK SOLVER application for selecting disk springs applied in constructing catchers which have been worked out in SolidWORKS 2012 environment. Literature contains many examples of supporting engineering works with computer applications [1, 2, 4, 5, 6, 7].

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2. EMERGENCY CATCHER BRAKING

Figure 1 shows the project of a new solution for catchers which are to be manufactured as first in Poland. Catchers are nothing else but brakes, the tasks of which is to arrest the moving car of passenger lift. Catchers are to arrest accelerated lift car burdened with nominal load in the case of exceeding the speed by 0,3 m/s in relation to nominal speed. The increase of the moving car speed can be in fact caused by two cases [8, 10]:

– by breaking carrying springs,
– by sudden acceleration of driving system.

In actual working conditions of lift appliances none of these cases occurred.

3. DESIGN OF CATCHERS

Figures 1 and 2 show the virtual prototype of catchers worked out in SOLIDWorks 2012 environment. Catchers belong to the group of subassemblies with percussive working conditions. This means that all the elements of catchers during braking undergo overloading caused by losing energy of accelerated car weight.

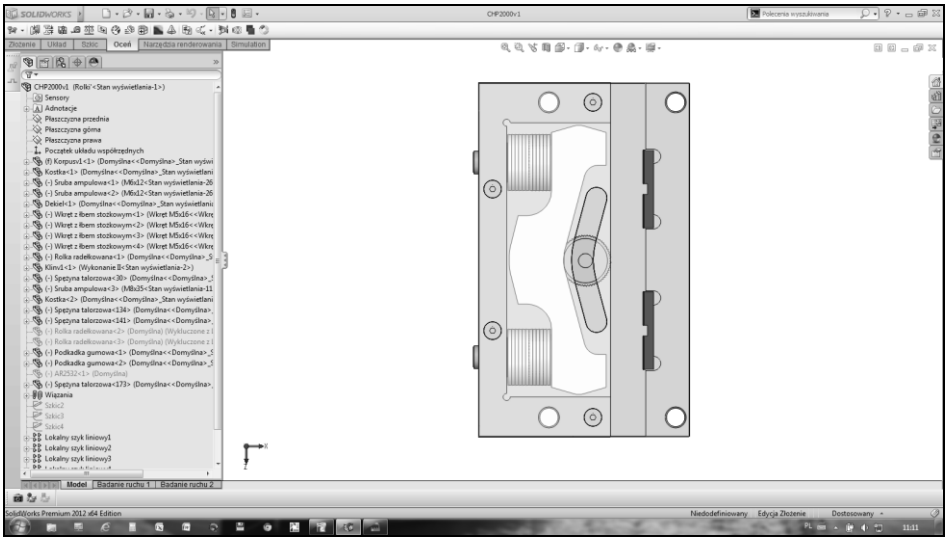

Fig. 1. Virtual design of catchers worked out in the environment SolidWORKS 2012 with a braking roll placed in neutral position [source: own study]

Figure 2 shows a catcher with a braking roll placed in the position where the roll contacts the guide after it is stopped. In other words, the presented figure shows the maximum position of braking roll in the catcher body.

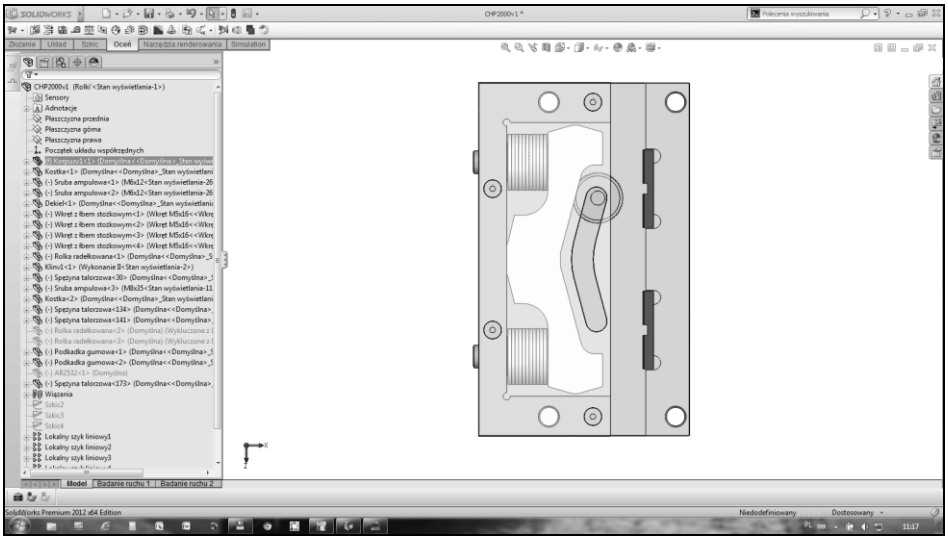

Fig. 2. Virtual design of catchers worked out in SolidWORKS 2012 environment with braking roll in the position of maximum deflection from neutral position [source: own study]

On the basis of survey of the available literature [3, 8, 9] and the solutions available in the market, we suggested a solution of catchers shown in figure 1 below 1.

An innovative approach to the presented catcher structure is that during braking, the force generated by the package of disk spring is variable in relation to the braking distance made and that the braking force changes with the change of roll position in relation to cam. The above means that the trace left on the guide after braking is of variable depth, and that braking depth depends upon the value of braked weight. Such an approach is aimed at soothing braking with simultaneous securing the highest comfort of the passengers.

Having performed the CAD project validation by means of MES software, we eliminated all the unfavorable places in the body and roll, thus obtaining the optimum shape of catcher structure.

To secure the appropriate catcher work, the methodology of selecting disk spring package, in result of which changes can be made easily and quickly in the spring pile configuration arrangement in the catcher.

To optimize the selection of spring packages the available application named SPRING DISK SOLVER was used.

4. SPRING DISK SOLVER – DECISION SUPPORTING TOOL

The available application for selecting disk springs is based on the base of disk springs available in the market. Selecting an appropriate spring pile the user is able to lie the characteristics of the load of single spring and the required package on the basis of input data.

Figure 3 shows the main window of the program where in field I (Pole I) we enter the dimensions of spring we are interested in, in field II (Pole II) we determine the pile of springs, in field III (Pole III) we calculate loads and stresses of strings used in the configuration (pile), and in field IV (Pole IV) we lie the characteristics of springs, on the basis of which we can check at which deflection the required load of the matched spring package will take place [11].

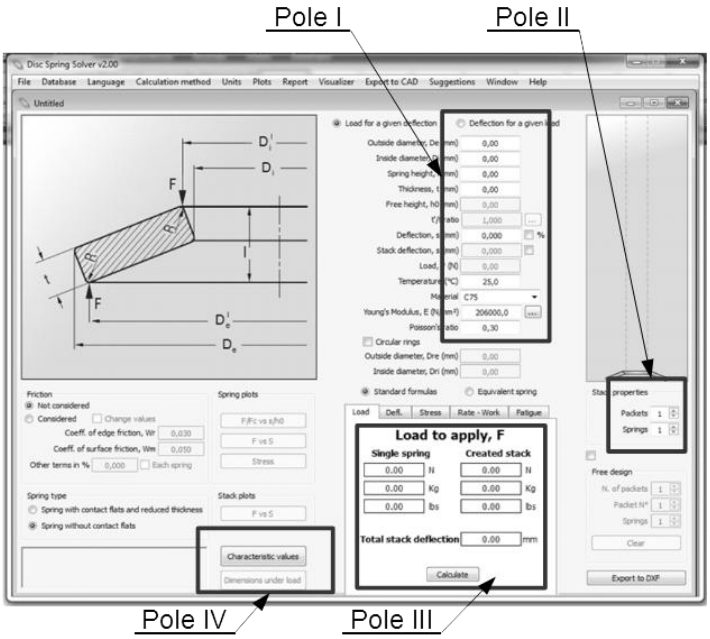

Fig. 3. Window of SPRING ISK SOLVER program for disk spring selection [source: own study]

5. SKID CATCHERS – DESIGN

The characteristic feature of skid catchers is that braking the accelerated car weight must be smooth, so that overload happening in the car during braking ranges from 0.2 to 1 g [10].

The presented idea of catcher has a simple and compact structure. The catcher components are presented in figure 4.

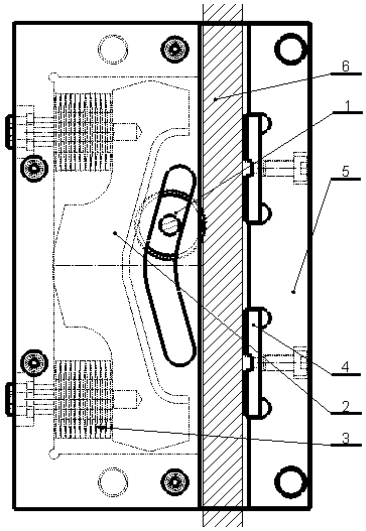

Fig . 4. Structure of skid catcher designed by LIFT Service S.A. [source: own study]

The catcher consists of the body 5, in which a cam 4 is fixed with the use of screws. Between cam 2, and the body 5 there are two packages of disc springs 3, assembled in appropriate piles, securing obtaining proper braking forces. Along cam 2 roll 1 moves, the position of which is controlled by lever which is not shown in Figure 4. The roll cooperates with guide 6 , exerting braking force on a part of it. On the other side of the guide, in the catcher body packing plates are fixed 4, which help to stop the accelerated weight.

6. SELECTION OF DISK SPRING PACKAGE ON THE BASIS OF CATCHER DESIGN

To determine the characteristics of disk spring package the following catcher working parameters were initially determined:

- Nominal lift velocity v = 1,6 m/s,
- Maximum load F = 25000 N,
- Overload coefficient 125%.

Maximum catchers load Q is determined by a mathematical relationship (1):

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

where: P – car weight [N],
K – car frame weight [N],
D – car door weight [N],
Q – nominal lifting capacity [N].

During operation tests of the appliance the catchers are overloaded on the basis of standard regulations [10]. In accordance with the relationship (1), the hoisting capacity Q during operation tests must be increased by overload factor of 125%. Therefore, the above relationship takes the following form:

$$Q = P + K + D + 125\% * Q \tag{2}$$

For the considered catchers design the maximum hoisting capacity for which catchers are designed equals 31250 N. In connection with the relationships (1) and (2), the nominal hoisting capacity will equal 25000 N, to which such pile of disk springs should be selected, so that losing the velocity of accelerated weight is possible.

Using the computer application SPRING DISK SOLVER the disk spring package was selected that met the set requirements. Figures 5 and 6 present screen projections from the application, showing particular stages of decision support in selecting spring package.

Figure 5 shows the main program window with inscribed quantities characterrizing the selected disk springs on the basis of catchers design.

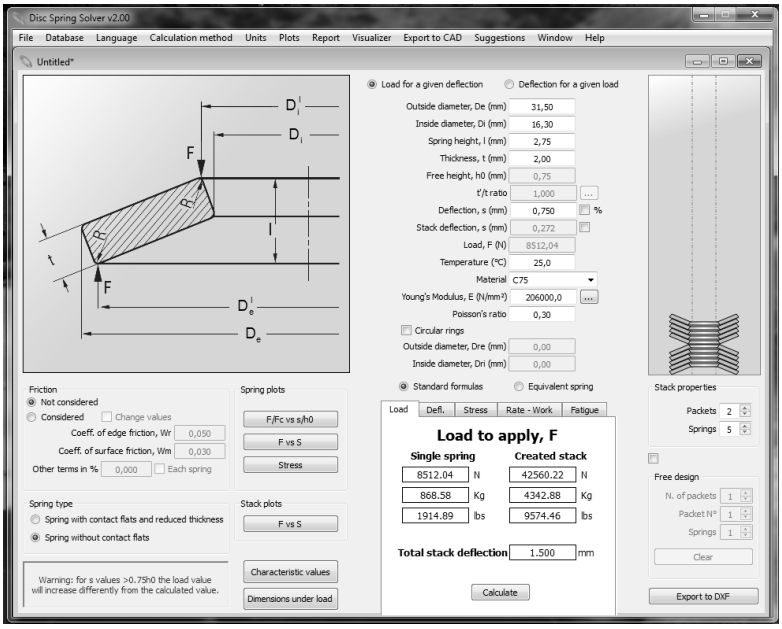

Fig. 5. Main window of Disk Spring Solver application [source: own study]

Figure 6 shows a screen with characterization determined on the basis of the selected disk spring package.

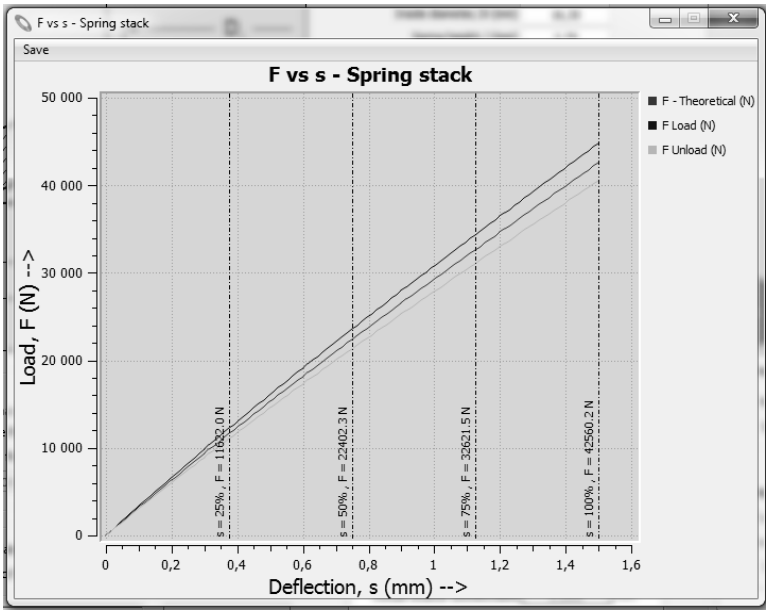

Fig. 6. Deflection characteristics of disk spring package matched with catchers in Disk Spring Solver application [source: own study]

On the basis of the presented characterization we can determine the value of force occurring in each braking phase. The main criterion of determining the value of force with which the spring package affects the roll is the vale of package deflection. According to the standard [11] the value of affecting force depends on the deflection, which is determined on the levels 0,25; 0,5; 0,75 and 100 % of package height. One can read from the presented characterization that for the value designed package deflection the force value is on the level of 32000 N, which, in the considered case is the expected value from design [11].

7. CONCLUSIONS

Supporting virtual prototyping with applications becomes very common in engineering. Such a procedure is connected not only with the possibilities given by the available applications, but also with related savings in constructing expensive prototypes. The foregoing study presents decision supporting connected with fast and easy selection of appropriate set of disk springs in the catcher structure. In the above-described case the presented application gave very positive results as to the changes, which cannot be avoided in the case of prototyping. The authors of many publications emphasize that supporting engineering works in the time of cost restricting becomes more and more common.

REFERENCES

1. CACKO R.: *"Review of different material separation criteria in numerical modeling of the self-piercing riveting process-SPR"*, Archive of Civil and Mechanical Engineering, 2008.
2. HUANG, N.HOU, D.CHEN, Y.KANG, R.: *"Metoda oceny niezawodności sieci oparta na aplikacjach i strukturze topologicznej"*, Eksploatacja i Niezawodność nr 3, Lublin 2011
3. JANOVSKY L.:, *„Elevator Mechanical Design"*, Third Edition, Elevator World, USA, 2004.
4. LONKWIC P., BOROWIK Ł.:, *„Przejście 2D do 3D – zwiększenie potencjału konstruktora"*; Obróbka Metalu nr 3, 2011.
5. LONWKIC P.:, SZYDŁO K., BOROWIK Ł.:, *„Nesting na przykładzie wycinarki laserowej i wykrawarki rewolwerowej"*, Obróbka Metalu nr 1, 2010.
6. LONKWIC P.; *„Sprężyny talerzowe w dźwigach osobowych",* Dozór Techniczny nr 4, 2012.
7. LONKWIC P.: *„Modelowanie zespołu napędowego windy"*, Eksploatacja i Niezawodność nr 2, Lublin, 2002.
8. KACZMARCZYK S., ANDREW J. P.: *„Systems Engineering of Elevators"*, Elevator World USA, 2011.
9. KWAŚNIEWSKI J.: *„Dźwigi osobowe i towarowe. Budowa i eksploatacja"*, Wydawnictwo: AGH, 2006.
10. PN EN 81-1 +A3, Przepisy bezpieczeństwa dotyczące budowy i instalowania dźwigów, Część 1, Dźwigi elektryczne.
11. PN/M-80707: Sprężyny talerzowe.
12. DISK SPRING SOLVER, Help aplikacji.