Acta Tecnología - International Scientific Journal about Technologies
Volume: 2 2016 Issue: 3 Pages: 1-4 ISSN 2453-675X

SIMULATION OF AIR FLOW RATE AT POINT OF CONTACT WITH A STREAM OF MELTED POLYMERIC MATERIAL

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Keywords: PET-fiber, extrusive blowing method, air flow, elementary fibers
Abstract: This paper presents the research of interaction of air flow and melted material in production of fibrous materials. Correlations for calculation of air flow rate in different cross sections of a stream are acquired. The developed method of calculation of air flow rate at point of contact with stream of the melted polymeric material can be used in construction of blow heads models with a slot nozzle in production of fibrous products from different polymeric materials.

1 Introduction

In the technological chart of producing the thermo bonded products from polymeric fibrous materials by extrusive blowing method the most important is determination of air flow rate from slot nozzle of blow head at point of its contact with stream of the melted polymeric material flowing from exit nozzle of the melting unit.

2 Methods and materials used for research

Quality of the received fiber significantly depends on air flow rate at the contact point with stream of the melted material [1]. In equipment for implementation of the vertical blowing method, calculating of this rate does not present essential difficulties. For this purpose it is enough to know air outlet rate from annular nozzle of blow head and the current rate of the melted material. Required rate is defined as difference of marked rates as the directions of the considered flows match. Researches [1], [2] have proved that the average diameter of elementary fibers in production of basalt fiber by the duplex way decreases with increase of the considered rate. For one of three possible concept versions of fiber production process [1], where from single stream of the melted material of diameter d_c, the single fiber thread of diameter d_b is produced, after drawing up the equation of continuity of air flow and the melted material moving in one direction as it has been proved in research [1], formula for determination of average diameter of elementary fiber received:

$$d_b = d_c (V_c/V_{bc})^{0,5} \quad (1)$$

where V_c - the rate of flow of the melted material stream, m/s; V_{bc}-the contact rate of melted material stream with air flow from a blow head, m/s, which for the case above is defined as a difference:

$$V_{bc} = V_b - V_c \cos \gamma \quad (2)$$

where V_b - air flow rate in the merger coordinate of the melted material stream and air flow, m/s; γ - angle between the directions of the air flow movement and melted material stream at the merger coordinate, deg.

When producing the thermo bonded products from polymeric fibrous materials by extrusive blowing method, the directions of the air flow movement from a blow head nozzle and the melted polymeric material stream flowing from extruder exit nozzle do not match. Possible options of the given streams arrangement are presented in figure 1. All six presented options can be produced but have their special features, significant during the design process for the manufacturing of the thermo bonded products using the above method. Options (c) and (e), where air flow and the melted material stream contact under a right or acute angle, assume a vertical arrangement of extruder for melting and feed of the melted material.

Thus there is an opportunity to significantly reduce the space, occupied by the equipment, while increasing the dimensional height yielding the convenience of equipment operation.Options (a), (b), (d) and (f) assume a horizontal arrangement of extruder, where the melted material stream horizontally flows from a form-building extruder head and changes its movement direction to the vertical by gravity. The advantage of each option is in the fact that the operating equipment is placed horizontally, at a small height, that allows to observe and conduct the process without operator's moving up and down.

The experimental tests of the process similar to the presented (the process of fibrous materials production from secondary polyethyleneterephthalate by vertical blowing method) indicated, that the moving rate of melted material stream is not high and measures at V_c = 0,05 … 0,2 m/s. Air flow rate in the merger coordinate of melted material stream and air flow is significantly higher and measures at V_b=10…250 m/s.

At such rate values, for example, for option (e) interactions of air flows and melted material stream with diameter of the melted material stream d_c = 0,003 m and at angle between the directions of their movement γ = the 30 deg, diameter of elementary fiber determined by a formula (1) will measure at d_b = 0,425…425 microns. Experimental tests indicated that the range of diameters of elementary fibers at various modes of technological process of their production measured at 1…200 microns. This fact confirms that from a single melted material stream single fiber is produced and it is divided into separate staple fibers by the turbulence of air flow.

The contact rate of the melted material stream and air, flowing from blow head and defining quality of the received product is mostly influenced by air flow rate at the merger coordinate with melted material stream which depends on a rate of the air, flowing from a slot-hole nozzle of a blow head, parameters of its flowing part and distance from the cut of a slot-hole nozzle to the merger coordinate of air flow and the melted material stream. For calculating of this rate you can use results of the research by G. N. Abramovich [3], [4] and other authors studying processes of flowing of the free air current from nozzle units of various design - cylindrical, slot-hole or profile channels - to the atmosphere.

Imagining the air current flowing from slot-hole nozzle of a blow head as classical free air flow [3], [4] we will notice that it has two typical parts different on flowing structure: initial and the main.

Sometimes transitional part is also allocated. In initial cross section the profile of air flow rates $V_b = u_o$ is close to be steady. Within an initial part the core of constant rates remains. Its width linearly decreases from the size of a slot-hole nozzle in the vertical direction to zero. Outside the constant rate part, rates of the stream u naturally decrease both towards the current periphery and along the stream length. The rate profile on the initial part changes under laws of an boundary layer.

On the main part of a stream there is a decline of rate along the axis of the stream from $V_b = u_o$ to $V_{bm} = u_m$. The length of an initial site $X_н$ is defined by formula [2]:

$$X_н = 0{,}67\ R/a \quad (3)$$

where R - the internal radius of a cylindrical nozzle in output section (we will consider previously that for a slot-hole nozzle this size is equal to a half of nozzle width), m; a - coefficient of stream structure which for symmetric axis streams is measures at ≈ 0,08.

When designing the joint of bulge of stream melted air flowing from a slot-hole nozzle of a blow head it is required to correctly appoint the adjustment range of distance from a cut of a slot-hole nozzle to a cut of an output nozzle of an extruder. Thus, for further calculation of diameter of the received elementary fiber, it is necessary to know air flow rate at the merger coordinate with the melted material stream. For this purpose it is possible to use data [3] again, however, with adjustment, which will be discussed below. The change of rate along the stream axis $V_{bm} = u_m$ in the main site for an symmetric axis stream is determined by correlation:

$$u_m = 0.96 V_o\,(ax/R + 0.29) \quad (4)$$

where x – the distance from a cut of a slot-hole nozzle to the required coordinate, m.

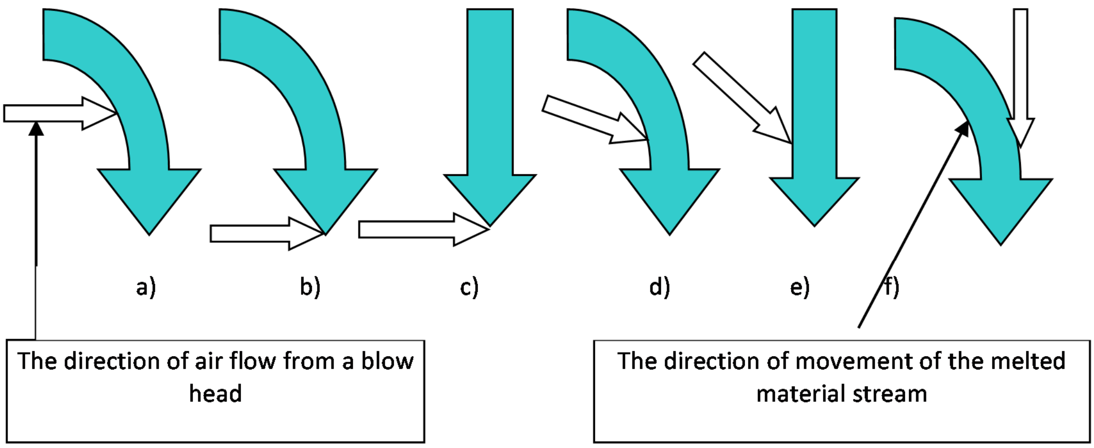

Figure 1 Options of directions of air flows and melted material interaction

Acta Tecnología - International Scientific Journal about Technologies
Volume: 2 2016 Issue: 3 Pages: 1-4 ISSN 2453-675X

Table 1. The parameters of a flat stream

Cross sections	Parameters of a flat stream	Relative distance from the considered point to a stream axis					
		0	0,2	0,4	0,6	0,8	1
Transitional section	Stream rate in point *u*, m/s	14,46	11,99	8,07	4,14	1,17	0,00
	Absolute distance from the point to a stream axis, m	0	0,008	0,016	0,024	0,032	0,04
x=2 Xн	Stream rate in the point *u*, m/s	11,04	9,15	6,16	3,16	0,89	0,00
	Absolute distance from the point to a stream axis, m	0	0,014	0,028	0,042	0,056	0,07
x=4 Xн	Stream rate in point *u*, m/s	8,15	6,76	4,55	2,33	0,66	0,00
	Absolute distance from the point to a stream axis, m	0	0,024	0,048	0,072	0,096	0,12

Table 2. The parameters of a round stream

Cross sections	Parameters of a round stream	Relative distance from the considered point to a stream axis					
		0	0,2	0,4	0,6	0,8	1
Transitional section	Stream rate in point *u*, m/s	14,46	11,99	8,07	4,14	1,17	0,00
	Absolute distance from the point to a stream axis, m	0	0,006	0,012	0,018	0,024	0,03
x=2 $X_{н}$	Stream rate in the point *u*, m/s	8,52	7,06	4,75	2,44	0,69	0,00
	Absolute distance from the point to a stream axis, m	0	0,012	0,024	0,036	0,048	0,06
x=4 $X_{н}$	Stream rate in the point *u*, m/s	4,67	3,87	2,61	1,34	0,38	0,00
	Absolute distance from the point to a stream axis, m	0	0,02	0,04	0,06	0,08	0,1

Volume: 2 2016 Issue: 3 Pages: 1-4 ISSN 2453-675X

The cross profile of rate on the main part of a symmetric axis stream has the form close to the Gaussian curve. With some mistake shares which can be considered after experimental calculating of rate distribution of a stream flowing from a slot-hole nozzle, the rate *u* in any stream point on its main part in the vertical direction is defined by the correlation presented in the research [3]. As the rate *u* on the stream cross section decreases asymptotically, the stream border is established conditionally: the line, on which the rate *u* value is 1% of the rate on the axis u_m, is accepted for a border. If believe that the stream flowing from a slot-hole nozzle extends in the same way as the symmetric axis free stream, it enlarges in each of two cross directions under the linear law [3]:

$$tg\alpha = 3{,}4\ a \qquad tg\beta = 3{,}4\ a \tag{5}$$

where α и β – angles' halves of the extending stream in the cross directions.

Using data [3], the cross sizes of a stream *R* and *H* on the main part are defined by correlations:

$$r = \left(3{,}4ax / r_0 + 1\right) r_0 \tag{6}$$

$$h = \left(3{,}4ax / h_0 + 1\right) h_0 \tag{7}$$

where R_0 and H_0 - the cross sizes of a slot-hole nozzle, M.

3 Results and achievements

To justify the possibility of use of above correlations for calculation of air flow rate in various stream sections we will use data [5] where the comparison of results of air flow rates calculation for the specified cases is presented.

In Table 1 there are data for a flat stream, and in Table 2 - for a symmetric axis stream or round stream. Analyzing data of these tables, it is possible to draw a conclusion that up to transitional section at a distance of X_H from a nozzle cut a flat stream extends under the laws of symmetric axis one – the stream rates at different distances are identical.

At increase of distance from a cut of a round or slot-hole nozzle to x=2 $X_{H,}$ the rate on a round stream axis is 8,52 m/s, and on an flat stream axis - 11,04 m/s. At further increasing of distance from a cut of a round or slot-hole nozzle to x=4 $X_{H,}$ the rate on an round stream axis is 4,67 m/s, and on an flat stream axis - 8,15 m/s. Therefore the attenuation of air flow rate in a flat stream happens much more slowly, and designing the bulge joint of the melted polymer stream with the application of a blow head with a slot-hole nozzle, it allows to increase the distance from the merger coordinate of this stream with an air flow.

Conclusions

The developed method of calculation of air flow rate in a point of its contact with a stream of the melted polymeric materials can be used when construction of blow heads models with a slot-hole nozzle for production of fibrous products from various polymeric materials.

References

[1] Sentyakov, B. A., Timofeev, L. V.: *The production technology of heat-insulating materials on the basis of basalt fiber*, Izhevsk: Publishing house of ISTU, p. 232, 2004.
[2] Balog, M., Maľcovský, M.: Optimization of the production process of the plastic injection molding engineering with the technology of reverse engineering application. *Acta Tecnología*, Vol. 1, Issue 2, p. 9-12, 2015.
[3] Abramovich, G. N.: *The theory of turbulent streams*, M: Publishing house of physical-mat. literature, p. 715, 1960.
[4] Svyatsky, V. M., Shirobokov, K. P.: The research of influence of diffuser design data on the characteristic of fiberizer, *Messenger of ISTU*, Vol. 2010, No. 3., Izhevsk, p. 42-44, 2010.
[5] Vikharev, A. N.: *Solution of applied tasks in hydromechanics*, Manual, Arkhangelsk: Publishing house of ASTU, p. 68, 2000.

Review process
Single-blind peer reviewed process by two reviewers.

IMPACT OF IMPLEMENTATION AND USE OF BUSINESS INTELLIGENCE ON COST REDUCING IN CONSTRUCTION PROJECT MANAGEMENT

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Keywords: implementation and use of Business Intelligence, cost reducing, construction project management
Abstract: Last years period is characterized as a period of dynamic progress and expanding use and implementation of information communication and knowledge technology generally. Data and information requirements in the knowledge society heads grow every day. The competitive environment is forcing companies to make quick and effective decisions on a daily basis. The increasing amount of data and information promotes greater selection and requirements for use relevant data to support of decision making in the management and coordination of enterprises and projects in each area. The exploitation of advanced technologies to support management in many enterprises is a priority and one of the main steps and procedures to successfully manage enterprises and projects. Business intelligence is one of the possible solutions for decision support. Article discusses issue of implementation and use of Business intelligence in Slovak construction industry from various point of view. The main objective of this article is to confirm impact of implementation and use of Business Intelligence on cost reducing in construction project management. Enterprise size, enterprise owner, participant of construction project and SK NACE classification present important factors for selection of research groups.

1 Introduction and theoretical backround

Construction industry has an important place in the economy of each country [1]. In the long term contributes, construction industry in Slovakia Significantly contributes to the gross domestic product in the long term. The long-term average, it is about 8%. In parallel, the construction industry accounts for the same proportion to the employment in Slovakia. Construction industry in Slovakia confirms the significance and impact on the economy in the scope and volume of public investment. In general, investment in the construction industry with information and communication technologies are investments constitute a first place in the volume of public investment in the United States economy. Based on the above, it can be stated that the need to discuss of innovation in the construction sector plays a significant role in the development of the economy and the country's future.

Construction industry is Characterized by a number of specifics [2]. These specifics of the construction industry differs from other industries. Seasonality plays an important role, Which has significant influence over the management of construction enterprises and construction projects. Difficulty of the construction industry highlights the originality of each realized project. Range of construction projects places high demands on the economics of construction projects. This causes requirement on the amount of funds to implement and pressure to the construction project financing. The range of construction projects it affects the number of participants in the construction project [3]. This gives rise to information flow and relationships between the participants of the construction project that are differentiated with respect to the interest of each.

Business Intelligence is the processes, technologies, and tools that help us change data into information, information into knowledge and knowledge into plans that guide organization Technologies for gathering, storing, analysing and providing access to data to help enterprise users to make better business Decisions [4]. According to Gartner Group, Business intelligence represents includes the applications, infrastructure and tools, and best practices that enables access to and analysis of information to improve and optimize decisions and performance. All this is a general definition. Many other definitions have been presented above. On the other hand, it is important to say what is Business Intelligence in the construction industry. According to Vynderzyde, Construction Business Intelligence Provides information across multiple systems to allow each person to succeed in their role. Furthermore, the author has specified roles like:

- Role of CEO,
- Role of project manager,
- Role of construction enterprise employees,
- Role of controller or finance staff.

The main benefits of Business Intelligence using in construction project management include improving the decision-making to improve the quality of construction work and shorten the construction period of the project [5]. Several empirical studies to address this issue benefits of the use of information and communication in the building or for the purpose of managing construction projects.

Another important advantage is the impact use of Business Intelligence on cost reducing in construction project management. What is the impact on cost in management of construction enterprises or projects? What are differences between selectet research group (for example according to enterprise size, SK NACE classification and so on)?

2 Methodology of research

2.1 Methods and research objectives

The establishment of research in construction industry was Carried out in a logical sequence. Based on a thorough analysis of theoretical approaches it has been set basic research problem of research in construction industry and fundamental research questions raised. Subsequently it was Formulated main aim of the research, Which is supported by partial objectives. The methodology of the work and methods of research, we define the research methodology of processing. We have identified a sample clarify the methods of data collection and data processing method.

In research in construction industry were exploited empirical research methods research. In the empirical methods have been used on a larger scale observation, questionnaire surveys, interviews and representatives of enterprises. From theoretical methods it was most used method of abstraction, analysis, synthesis methods of induction to deduction. It was extensively along with application and even the method of comparison.

The research is based on two types of data and the data on secondary and primary data. In view of the considerations discussed was the use of secondary data to a lesser degree. The work was based both in internal and external data. To carry out the analysis was more relevant use of primary data. The source of relevant information on which it is processed chapter describing the current state of research problems at home and abroad, the domestic and foreign publications, monographs, journals, databases (e.g., EBSCO, ProQuest, Scopus, Web of Science, etc.) and other Internet resources (similar as a research in all industries).

2.2 Data collection

For the main purpose of the research were used primary sources for data collection in the form of a questionnaire survey. The questionnaire is a research, evaluation (diagnostic) tool at a relatively rapid and mass inquiries about the views and attitudes of individual respondents on these issues [6]. The questionnaire was used as a tool to collect information for analysis of the current state of the use of information and communication technologies in the process for construction projects. Same for the purpose of mapping, identification and quantification of the use of Business intelligence in the management of construction projects and purpose of what is impact of implementation and use of Business Intelligence on cost reducing in construction project management.

The questionnaire survey is the fastest and most effective way of information and necessary data collection for research purposes. The questionnaire was designed and distributed in electronic form. For the compilation of the questionnaire it was used online platform FORMEES which permit the questionnaire in electronic form, accessible to him of the selected target group respondents based on the destination address where the questionnaire is placed. This form ensures that the questionnaire can only see us respondent and no adverse unprofessional bystanders. The questionnaire was anonymous, but the identification of IP addresses, which allows the system to prevent a recurrence identify the same person completing the questionnaire, which was prevented from completing the duplication of data, one respondent. The research sample was approached by e-mail with the request to participate in the research.

1 276 respondents were total of addressed (participants in construction projects). In the questionnaire survey participated of 125 respondents, but only 55 companies completed the entire questionnaire to use in our research, which represents a return of 4.31%.

2.3 Data processing and research questions

The next step to achieving of the research objectives was to evaluate and data processing. This was especially the processing of data from a questionnaire survey. These data were evaluated based on several statistical methods through software MS Excel and STATISTICA version 12. When processing the results of research conducted within this research has been used mostly descriptive and inductive statistics.

When considering data from research the impact of implementation and use of Business Intelligence in construction construction project management was used impact rate, respectively level of influence that used in research aimed at identifying and quantifying the benefits of ICT use in the construction by Kyakula[7].

Arithmetic average of the selected areas, we get peace. To determine the answer was used "Likert scale ranging" from 1 to 5 on the basis of fixed values has been done the arithmetic average of the values for the selected area under consideration. The result was mentioned impact rate, or rate of impact. Subsequently the results were interpreted in verbal and graphic form. For image processing and presentation of results was used a tool Microsoft Excel software.

Statistical significance was tested by Kruskal - Wallis test at the significance level α = 0.05. Kruskal - Wallis test [8] is a direct generalization of the Wilcoxon test case dvojvýberového several independent samples. Kruskal - Wallisow test is similar to the non-parametric one-way analysis of variance [9]. Kruskal - Wallisow test is based on the rows and to the non-parametric method for testing. The idea is statistically re-tested, and research samples come from the same division. It is used to compare two or more samples dependent on the same or different size [8,10].

Based on theoretical approaches, analysis and mapping of existing relations between the participants of construction project, dealing with research and case studies abroad were raised basic research questions:

1. What is the impact of implementation and use of Business Intelligence to cost reducing in construction project managemnt from the perspective of enterprise size.
2. What is the impact of implementation and use of Business Intelligence to cost reducing in construction project managemnt from the perspective of enterprise owner (use of ofreign private equity).
3. What is the impact of implementation and use of Business Intelligence to cost reducing in construction project managemnt from the perspective of participant of construction project.
4. What is the impact of implementation and use of Business Intelligence to cost reducing in construction project managemnt from the perspective of SK NACE classification.

2.4 Research sample

Breakdown of research sample is very important in terms of correlation between the studied variables. Due to the content page of research was defined this basic specification of the statistical of research sample:

- Enterprise size,
- Use of foreign equity,
- Participant of construction project,
- SK NACE classification.

Based on the set hypotheses and fundamental research issues, it can be stated that the selection of research sample by enterprise size is very important in analysing and interpreting scientific conclusions. The frequency and size representation is described in more detail in Figure 1. Selection of enterprises was carried out on the basis of the breakdown of the European Commission Recommendation 2003/361 / EC. Respondents were represented as follows:

- Large enterprises (250 and more employees) - 7 enterprises,
- Medium sized enterprises (from 50 to 249 employees) - 12 enterprises
- Small enterprises (from 10 to 49 employees) - 17 enterprises,
- Microenterprises (from 0 to 9 employees) - 19 enterprises.

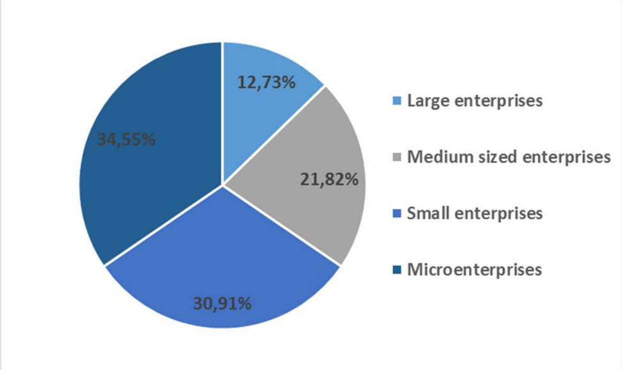

Figure 1 Research sample according to enterprise size

Very important in terms of the correlation effect on the use of Business intelligence has a breakdown by the majority owner of the enterprise, respectively use of foreign private equity (Figure 3).

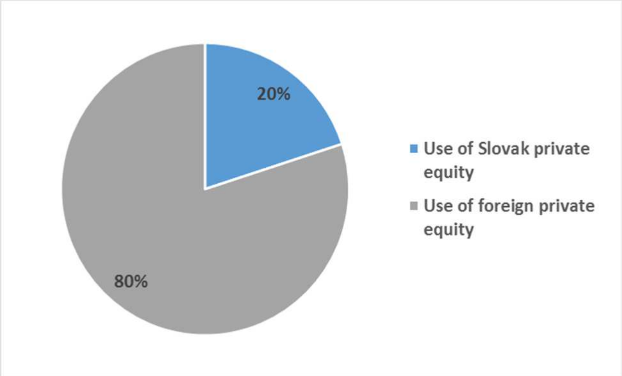

Figure 2 Research sample according to enterprise owner (use of foreign private equity)

One of the most important selections of respondents in the content of research sample is based on the determination and definition of the relationship with construction projects. Connection between a particular participant and the other variable is substantively the most important relationship in the context of research. Figure 3 describes a more detailed representation of individual participants in research.

- Main contractor - 28 enterprises,
- Sub-contractor - 14 enterprises,
- Designer / architect - 9 enterprises,
- Developer - 4 enterprises.

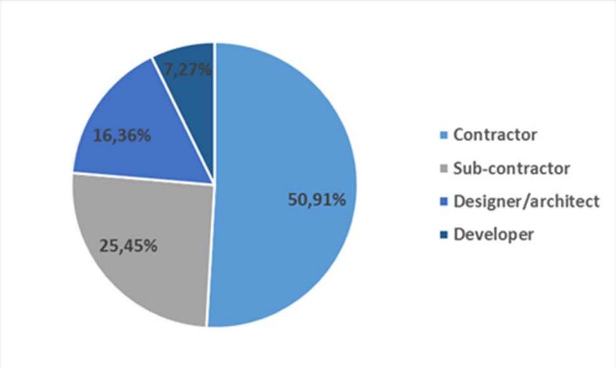

Figure 3 Research sample according to participant of construction project

Another view of the selection of research sample is described in Table 1. Enterprises are categorized by SK NACE classification.

Table 1 SK NACE Classification of research sample

SK NACE (Section F - Construction)	Number of enterprises
41.1 Development of building projects 41.2 Construction of residential buildings	10 16
41 Building construction	**26**
42.1 Construction of roads and railways 42.9 Construction of other civil engineering projects	7 2
42 Engineering buildings	**9**
43.1 Demolition and site preparation 43.2 Electrical, plumbing and other construction installation works 43.3 Building completion work 43.9 Other specialized construction works	3 5 1 11
43 Specialised construction works	**20**

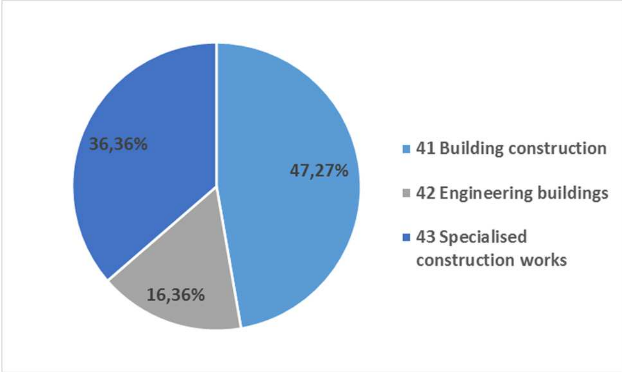

Figure 4 Research sample according to SK NACE classification

3 Results and discussion

Construction industry is currently subject of number of challenges. The economic situation after 2008 has changed significantly in several sectors. Construction industry is among the sectors that are subject to faster business cycle. A lot of competition, reduced orders, few projects, the high costs of employers to employees, these are just some of the factors that impact on the Slovak construction companies. The effort to penetrate the market entails the need to be more effective than others. Be an effective means to optimize costs and maximize production. It must be done fast and right decisions. The same applies in the implementation of construction projects. One of the conditions, how to implement a successful construction project is to have a prompt and correct decisions. Business intelligence is a tool for decision-making.

One of the big advantages and benefits of Business intelligence use is cost reducing on management processes in construction industry in Slovakia. Very important view on impact of Business Intelligence from site enterprise size, enterprise owner, participant of construction project and SK NACE classification.

Figure 5 describes impact of Business Inteligence on cost reducing in field of construction project management. Business Intelligence for large enterprises present ipmact level on cost reducing 3.25 and Business Inteligence for medium-sized 3.01. Small enterrpises achieved ipmact level 2.98 and mciroenterprises only 1.25 value. Microenterprises don´t ude Business Intelligence tool, it´s probalby reason, why it achieved a very low impact level. On the other side, figure 5 presents results from use of foreign private equity view.

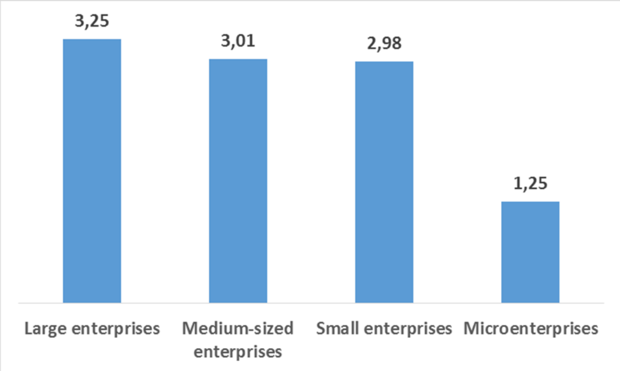

Figure 5 Impact of implementation and use of Business Intelligence on cost reducing of construction project management (enterprise size view)

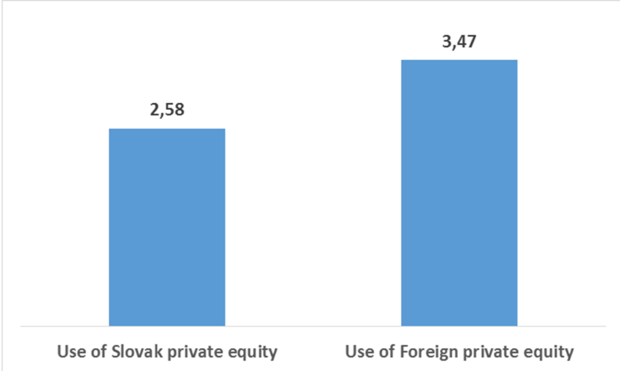

Figure 6 Impact of implementation and use of Business Intelligence on cost reducing of construction project management (use of foreign private equity)

Table 2 describes the Kruskal - Wallis test for examining the statistical significance of construction enterprises size impact of implementation and use of Business Intelligence on cost reducing in construction project management. Business Intelligence amounted p = 0.0297. From that it follows that statistical significance was confirmed a confidence level of α = 0.05.

Table 2 Kruskal-Wallis test for examing of the statistical significance (factor: enterprise size)

	Kruskal-Wallis ANOVA based on ranking, Variable – size of construction enterprise p=0,0297		
Construction size	Code	Number of valid responses	Impact rate
Large enterprises	1	7	3,25
Medium-sized enterprises	2	12	3,01
Small enterprises	3	17	2,98
Microenterprises	4	19	1,25

In this view, situation is very similar then priviusly view. Use of foreign equity is in this case as key. Construction enterprises used foreign private equity using and implmenting Business Intelligence solution. It has impact on cost redusing. Contenporary, construction enterprises that use only Slovak private equity, they invest to new progressive technology less financial resources, their impact is lower.

Table 3 describes the Kruskal - Wallis test for examining the statistical significance of construction enterprises size impact of implementation and use of Business Intelligence on cost reducing in construction project management (factor – use of foreign private equity). Business Intelligence amounted p = 0.0186. From that it follows that statistical significance was confirmed a confidence level of α = 0.05.

Table 3 Kruskal-Wallis test for examing of the statistical significance (factor: use of foreign private equity)

	Kruskal-Wallis ANOVA based on ranking, Variable – owner of construction enterprise p=0,0186		
Owner of enterpise	Code	Number of valid responses	Impact rate
Use Slovak private equity	1	44	2,58
Use foreign private equity	2	11	3,47

Next view, participant of construction project (figure 7) achieved results of impact level follow. The most hight value was for investor and developer. This value was 3.94 and it is a significant impact level. Other groups achieved low value (from 2.18 for designer and architect to 2.32 for contractor.

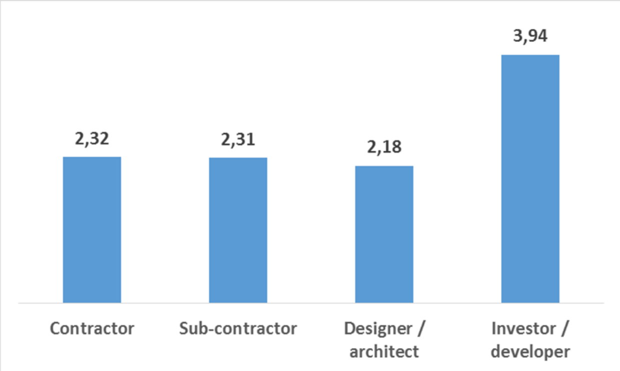

Figure 7 Impact of implementation and use of Business Intelligence on cost reducing of construction project management (participant of construction project)

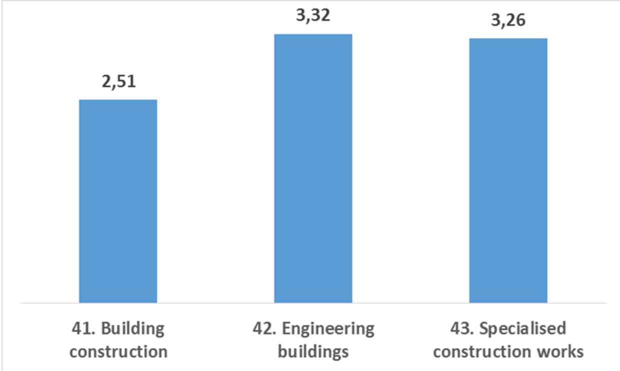

Figure 8 Impact of implementation and use of Business Intelligence on cost reducing of construction project management (SK NACE classification)

Table 4 describes the Kruskal - Wallis test for examining the statistical significance of construction enterprises size impact of implementation and use of Business Intelligence on cost reducing in construction project management (factor – participant of construction project). Business Intelligence amounted only p = 0.2531. From that it follows that statistical significance was confirmed a confidence level of α = 0.05.

Table 5 describes the Kruskal - Wallis test for examining the statistical significance of construction enterprises size impact of implementation and use of Business Intelligence on cost reducing in construction project management (factor – SK NACE classification). Business Intelligence amounted only p = 0.0418. From that it follows that statistical significance was confirmed a confidence level of α = 0.05.

Table 4 Kruskal-Wallis test for examing of the statistical significance (factor: participant of construction project)

	Kruskal-Wallis ANOVA based on ranking, Variable – participant of construction project p=0,2531		
Participant of CP	Code	Number of valid responses	Impact rate
Contractor	1	28	2,32
Sub-contractor	2	14	3,31
Designer/architect	3	9	2,18
Investor/developer	4	4	3,94

Table 5 Kruskal-Wallis test for examing of the statistical significance (factor: SK NACE classification)

	Kruskal-Wallis ANOVA based on ranking, Variable – SK NACE classification p=0,0418		
SK NACE classification	Code	Number of valid responses	Ipmact rate
Building construction	1	26	2,51
Engineering buildings	2	9	3,32
Specialized construction works	3	20	3,26

Last one view descibes situation based on SK NACE classification. It´s copies trend of enterprise size devided. Building construction enterprises present mostly small enterprises. Engineering building enterprises and enterprises doing specialised construction works present mostly large enterrpises. Their value of impact rate on cost reducing is higher (figure 8).

Conclusions

Results shown, that implementation and use has impact on cost reducing in construction project management. Research results also shown that this impact is significant in condition of Slovak constrcution market. However, not all factor confirm this statement. Factors as enterprise size, enterprise owner and SK NACE classification confirm diferencess between selected groups. It confirms statistical significance based on Kruskal-Wallis teste. But for participant of construction project this difemcess was not confirm. Generally, we could say that implementation and use of Busienss Intelligence has a possiteve implact on const reducing and factors as enterprise size, owner and SK NACE classification are significant of this isse.

Acknowledgement

"The paper presents partial results of the research project VEGA No. 1/0562/14 „The impact of Business Intelligence tools on corporate performance".

"The paper presented a partial research result of project "Identification of key competencies of university students for the needs of knowledge society development in Slovakia", which is supported by the Ministry of Education, Science, Research and Sport of the Slovak Republic in supplying incentives for research and development from the state budget in accordance with Act no. 185/2009 Z.

"The paper presented a partial research result of project VEGA - 1/0677/14 "Research of construction efficiency improvement through MMC technologies".

References

[1] RADZISZEWSKA-ZIELINA, E.: Fuzzy control of partnering relations of a construction enterprise. *Journal of Civil Engineering and Management*. Vol. 17, No. 1, pp. 5-15, 2011.

[2] ZIMA, K.: The use of fuzzy case-based reasoning in estimating costs in the early phase of the construction project. *AIP Conference Proceedings*. Vol. 1648, 2015.

[3] MANDIČÁK, T., MESÁROŠ, P., RAKOŠIOVÁ, AM.: Exploitation of economic information systems for cost management in Slovak construction companies. *Acta Tecnología*. Vol. 2., No. 1, pp. 1-5, 2016.

[4] S.SUBHASHINI, .C.S., RAMANI GOPAL: Quality of work life among women employee working in garment factories in Coimbatore district, *Asia pacific journal of research* .Vol I issue XII, page no.22-29, 2013.

[5] GUNASEKARAN, A., PATEL, C. AND TIRTIROGLU, E.: Performance measures and metrics in a supply chain environment, *International Journal of Operations and Production Management*, vol. 21, no. 1/2, pp. 71-87, 2001.

[6] OECD ORGANIZATION FOR ECONOMIC CO–OPERATION AND DEVELOPMENT: Main economic indicators – Sources and methods: labour and wage statsitics. Paris: OECD Publishing, p. 72, 1997.

[7] MUTESI, E.D., KYAKULA, M.: Application of ICT in the construction industry in Kampala. *Second International Conference on Advances in Engineering and Technology*, pp. 263-269, 2011.

[8] KRUSKAL; WALLIS: Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*. vol. 47 (260), pp. 583–621, 1952.

[9] MARKECHOVÁ, D., TIRPÁKOVÁ, A., STEHLÍKOVÁ, B.: *Základy štatistiky pre pedagógov*. UKF Nitra, 2011. (Original in Slovak)

[10] CORDER, GREGORY W., FOREMAN, DALE I.: *Nonparametric Statistics for Non-Statisticians.* Hoboken: John Wiley & Sons, pp. 99–105, 2009.

Review process

Single-blind peer reviewed process by two reviewers.

TYPOLOGY OF MANUFACTURING FLEXIBILITY IN THE ENGINEERING INDUSTRY: A REVIEW

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Keywords: manufacturing, flexilibility, industry
Abstract: Classification of manufacturrring flexibility represents a risk for the company as face this challenge. Reactions to these changes, based on late responses market leading executives to flexible manufacturing. In other words, flexibility is the ability to cope with change and insecurity by configuration of system elements within target-oriented way to maintain stable performance in the context of changing conditions.

1 Introduction

Author Benjaafar classifies manufacturing flexibility related to the product or process. The flexibility of the product refers to the production possibilities associated with the product [1]. The flexibility of the process is characterized by the ability of the process to adapt to different operating conditions or functions. An example, it is a multi-purpose machining center [1], [2]. Operating and sequence, the processing flexibility are associated with the production of parts. Operational flexibility is intended to perform operations on more than one machine. Sequence flexibility allows you to change the order of operations [2], [3]. The processing flexibility is determined by the possibility to have the same production function with alternative operations or sequences of operations.

2 Classification of the flexibility

In view of the classification flexibility, author Hajduk categorized flexibility in the industry as:

- *Expansion flexibility* - declares the ability to expand the system. It is expressed on modularity and compatibility.
- *Volume flexibility* - is the ability to produce different amounts of products.
- *Operational flexibility* - represents an opportunity to perform the same operation on different machines.
- *The flexibility of the layout* - is consistent with structural flexibility.
- *The flexibility of the process* - reflects the ability to produce a given set of components using various methods, ability to machine a variety of materials.
- *Machine flexibility* - examines the speed of adaptation of production equipment to produce a given set of components.
- *Structural flexibility* - this is the flexibility of the material flow, reflects the diversity of material flow, it allows to change the flow of parts between machines, and strive to achieve occupancy machines.
- *Product flexibility* - ability to produce new products without worsening the efficiency of the system [4].

The value of production flexibility is divided into the basic level, the system level and at the aggregate level. Flexibility at a basic level includes machine flexibility, material handling, system responsiveness and flexibility of operation (Table1) [4].

Table 1 Correlation of production levels and types of flexibility[7]

		Types of flexibility							
		Machine flexibility	**Process flexibility**	**Product flexibility**	**Routing flexibility**	**Volume flexibility**	**Expansion flexibility**	**Operating flexibility**	**Manufacturing flexibility**
Flexibility level	**Source flexibility level**	x	x	x		x	x	x	
	Business flexibility level			x	x	x	x	x	x
	Industry flexibility level			x		x		x	x
	Network flexibility level		x	x	x	x		x	x

Flexibility at the system level concerns the whole production system and depends on the type of flexibility at ground level [2], [5].

The high flexibility and low sensitivity to the changes in the production system has the three major advantages that influence from different types of flexibility. Author Chryssolouris presented to him three essential types of manufacturing flexibility, which contribute to the high elasticity:

- *Production flexibility* enables the production system to discriminate in parts using the same equipment. This means that the system is economically capable of using a small amount of sizes to adapt to the changing demands of various products. In the long term, this means that system devices can be used in several product life cycles, rising investment efficiency.
- *Capacitive flexibility* enables the production system to change the volume of different products and adapt to changes in the volume of requests so that the company benefited. It is used in the construction contracts and so in mass production, in particular for high-value products such as automobiles.
- *Operational flexibility* is focused on the ability to produce a range of products using a variety of machines, materials, operations. Allows a sustainable production level and in case of failure of the machine or staff shortages [5].

An important starting point for measuring the manufacturing flexibility is the classification of the type of flexibility. Development of flexibility referred to the various breakdowns typology of flexibility in terms of different authors. Author Mandelbaum proposed two types of flexibility, elasticity, and action static elasticity. The first type occurs on a dynamic view of the situation in which the future is unknown. Static flexibility in situations occurs, the system is capable of working correctly in different circumstances [6].

According to Gerwin, exist five types of flexibility and the mixed elasticity, flexibility of products, flexibility in routing, flexibility of design changes, volume and material flexibility. Author Slack defined five types of flexibility and to flexibility, quality, volume, delivery and product range. Jaikumar introduced three types of flexibility product, program flexibility and process flexibility. Program flexibility related to the ability to operate the system on a computer [3], [5]. Flexibility divided the process into three types of flexibility: equipment, materials and product pallets. Yamashina et al. proposed three types of elasticity. Flexibility options, volume and product life. The flexibility of options is equal to the production flexibility. The flexibility of a product life refers to the flexibility of the product [3], [6].

2.1 Time classification of the flexibility

The main problem of manufacturing flexibility is time stability. Flexibility as elusive phenomenon, but within the existing production system comes in various lengths of time. The first time the classification of flexibility has been proposed according to Gustavson [2], [5].

Author Carter came to the proposition that different types of flexibility in different time frames have four categories of time and very short, short, medium and long term. This corresponds to one to three day, one to two months, six months to two years and five years or more [3]. Description of the different classifications defined author Hajduk, which categorized the flexibility for short-term and long-term flexibility.

- *Short-term flexibility*- is characterized by the capability of adapting to the system in its structure changes to the object of production, sorting plant, failure of a component replacement tools. This is a short-term time horizon of a few minutes, days or months. Decisive is the time of inactivity. The idea is to reduce the rearrange time resulting in continuous effect on the time of production parts. It is expressed as the ratio of "pure" time to the total time of production of a certain set of components for a certain period. The disadvantage is the requirement of the border, for which may be valid, and the size of dose and time operations. Otherwise it may happen that the system that over time a number of times in a short time is sorted, should some flexibility such as a system that is sorted once, but in a longer time.
- *Long-term flexibility* applies the changes that occur at intervals of several months to several years. These include new products as a result of modifications, resulting in the reduction of the original component spectrum that is being replaced by new parts. Life components is 3-5 years, the life of 6-10 years. With long-term elasticity of cell aging, loses its elasticity and the necessary investments. Cell aging, we understand a certain obsolescence of machines that have been designed for the building. Obsolescence of the machine can be understood if the system is no longer able to adapt to constant product innovation and by developments in the area, which hampers its functioning. Long-term flexibility is achieved by creating cell-based production of flexible compatible modules that allow easier and faster expansion in the future. In the short term flexibility able to adapt the changing conditions, using the existing settings and the resources. In the long term, measures the ability to introduce new

products, new production methods and sources and their integration into the existing production system [4], [7].

3 Classification of flexible manufacturing systems

There are several definitions of a flexible production system, but all definitions are based on the definition of the system. Browse et al. defined "flexible manufacturing system" as an integrated computer-controlled complex composed of NC machines and automatic handling, designed for the manufacture of parts in small and medium series [3].

For flexible manufacturing system is consider a system that meets the requirements for the area:

1. *Testing the variety of products* - enables manufacturing system to process a variety of products without benefits?
2. *Testing planning changes* - the system can easily accept changes in the production plan (volume, diversity of products)?
3. *The error recovery* - the system can be readily restored after a failure of the device, so that the production is not completely disrupted?
4. *Testing a new product* - new product can be introduced easily into the existing product range [3], [5], [6], [7].

Figure 2 shows an automated production cell with two machining centres and manipulators (robots), meeting the criteria of flexibility:

1- can be produced in a variety of products that are administered robot from the conveyor,

2- a possible change in the production program without affecting the operation of the robotic arm and two machining centres,

3- system is capable of operating activities and in case of failure on one machining centre,

4- allows to produce new types of products, based on the numerical control program that you can download the system for the implementation of production.

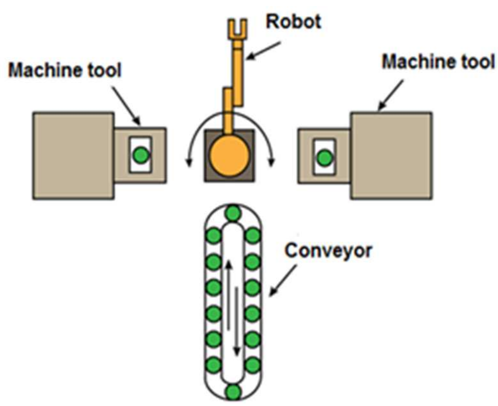

Figure 2 Automated production cell with two machining centres and robots [7]

Flexible manufacturing cell belongs to a flexible manufacturing system, consisting of technological equipment with program management and means of automation of technological processes, working autonomously. Automation tools are stacks of workpieces Pallet, equipment for exchanging tools, clamps, waste disposal and diagnostics. Flexible manufacturing cell is a system of two or more machines under the control of a central computer with or without automatic handling of the material in the system and the cell system in which cells are classified according to the production process, the production volume and the range of product types, in practice did not produce a clear classification of a grouping machine in respect of a defined type. Thus, it may form a group of parts that require one or more machines, according to next division [6]:

Flexible production machines - (SFM) is defined as a production unit formed by NC machines, supplemented by a manipulation device for the exchange of objects of production.

- *Multimachines flexible manufacturing system (MMFMS)* is a grouping of several production machines without interdependence of their activities. The machines are connected individually with no dependence on other machines. Characteristic is longer operating time. Substantially terms of machining centres, machines for special operations
- *Flexible manufacturing cells – (FMC)* is a manufacturing system consisting of multiple NC machines, designed for a particular group of components that combines the sequence of operations. The hallmark of the material and information connectivity between machines. Generally, use common handling equipment in inter-handling.
- *Multicellular production system - (MCFMS),* is based on a number of production cells and flexible manufacturing machines and cells. Characteristic of the intracellular transport system as an integrating element. [1], [7]

Classification according to the manufacturing cell clusters:

- *Flexible manufacturing cells*-are characterized by their high automation of the handling process. They are used for medium volume production e.g. 400-2000 units of one product, and the average number of product types 4-100 kinds.
- *Production cell manned* - are highly flexible because the staff quickly accommodate changes in production conditions. They are designed for low-15-500 units of one type but for a large number of product types in the interface 40-800.

- *Flexible production lines* - are characterized by a high number of units from 1,500 to 15,000 pieces and a low number of product types 2-8 [7].

Conclusion

In generally we can say that one of the performance indicators in recent decades, after cost, quality and reliability becomes flexibility. Studies manufacturing flexibility were made more widely in developed countries such as Japan, the US and Western European countries. The requirements for flexibility of production systems differ in countries with different economic uncertainty. Current literature offers some flexibility definitions, classifications and speculative guesswork to understand and assess the flexibility of the production system. Literature offers a variety of studies have flexibility in production, but the only deal of flexibility at the operational level.

References

[1] BALOG, M. et al.: Automation monitoring of railway transit by using RFID technology, *Acta Tecnología*, Vol.1, No.1, p.9-12, 2015.

[2] BIGOŠ, P., KISS, I., RITÓK, J.: Materiálové toky a logistika, Košice: Technická Univerzita. Strojnícka fakulta, p.8-113. 2008. (Original in Slovak)

[3] DEVISE, O., PIERREVAL, H.: Indicators for measuring performances of morphology and material handling systems in flexible manufacturing systems, *International Journal of Production Economics*, 64 (2000), p. 209-218, 2000.

[4] GEORGOULIAS, K., PAPAKOSTAS, N. et al.: Evaluation of flexibility for the effective change management of manufacturing organizations. *Robotics and Computer Integrated Manufacturing*, 25, 2009.

[5] KARA, S., KAYIS, B.: Manufacturing flexibility and variability, An overview *Journal of Manufacturing Technology Management*, Vol. 15, No. 6, p. 466-478, 2004.

[6] KOSTE, L.L., MALHOTRA, M.K., SHARMA, S.: Measuring dimensions of manufacturing flexibility, *Journal of Operations Management*, Vol. 22, No. 2, p.171-196, 2004.

[7] LIPTAKOVÁ, A.: Vplyv dopravných a manipulačných faktorov na pružnosť výrobných systémov, Dizertačná práca, FVT TUKE, Prešov, 2014. (Original in Slovak)

Review process

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