Chapter 8

Daniel Kleszcz[1], Robert Ulewicz[2], Joanna Nowakowska-Grunt[3]

THE USE OF LEAN TOOLS IN THE CERAMIC INDUSTRY

Abstract: Results of measurements connected with implementation of Lean tools are presented in this chapter. The object of the study was a functional ceramics manufacturing plant. The process of pot moulding was analysed, which is an important manufacturing stage from the point of view of generating added value. The effect of instruments and tools of the Lean management concept on the increase of effectiveness of functioning of a work-place.

Key words: LEAN, Lean tools, ceramic industry

8.1. Introduction

Lean manufacturing – Lean management – is to the growing extent implemented in the structure of business management of both manufacturing and services. The technological portfolio available to companies provides a large number of possibilities and tools necessary for rational managing companies and processes occurring in these companies. The 21st century provides numerous innovative solutions in techniques, technology, organization and management that are successfully used by businesses. However, there is a problem connected with selecting the appropriate tools and instruments in the process of development. An inappropriately selected may result in development of numerous problems in a given environment and, consequently, in deterioration of functioning of the company, despite the fact that the expected effect was achieved in another company, in another line of business. This is why entrepreneurs need appropriate knowledge and

[1] MSc.Ceramik sp. z o. o. e-mail: danielkleszcz@go2.pl
[2] Assoc. prof. Czestochowa University of Technology Faculty of Management, Institute of Production Engineering, e-mail: ulewicz@zim.pcz.pl
[3] Assoc. professor Czestochowa University of Technology Faculty of Management, Institute of Logistics and International Management, e-mail: jnowakowskagrunt@gmail.com

a review of the system to make the implemented solution bring the expected results. The preliminary studies that were carried out in ceramic manufacturing plants show that selection of appropriate tools is the key element in implementing changes in a given process, whereas an appropriately designed model of a process aids effective flow of material during the manufacturing process.

Lean management process is mainly used in the automotive industry. A significant growth of interest in these tools has been observed in other branches of industry in recent years (NOWAKOWSKA-GRUNT J. 2006, ŠUJANOVÁ J. 2004). Lean management tools can also be found in the ceramics industry. The processes taking place during manufacturing of ceramic ware are more and more often supported by Lean tools. Contemporary requirements set by the clients and strong competition motivate companies to provide products that are more competitive in terms of quality, assortment, as well as prices. Companies develop and implement different solutions aimed at reduction of costs of production while maintaining high product quality. At present, however, a high level of quality is not the factor determining achievement of competitive advantage at present. It is the process of continuous improvement of quality by making effective use of the material and non-material reserves, combined with decreasing prime costs of company functioning that is the factor.

The primary assumption of this paper is an appropriate choice of Lean tool formula for the plants manufacturing ceramic ware in order to model effective production processes. The people working in given fields can provide the most reliable data about processes in which in which they participate or which they supervise (BORKOWSKI S. 2012, INGALDI M., SELEJDAK J. GAJDA P. 2013). Every individual process is characterised by certain properties of its own. The main aim should be maximum standardisation and repeatability of different processes in all branches, but differences are unavoidable

8.2. The object of study

The study was carried out in a company manufacturing household ceramics, such as ceramic plant pots and vases. The process of pot moulding was analysed. A work station before and after implementation of changes was described. Averaged results of the study are presented. On the basis of the obtained data, the work station was found to function significantly better. Other activities and parameters connected with industrial safety of the work station and remodelling it according to the Lean conception were analysed. The study is meant to identify critical points occurring during the process of moulding and generating losses. The study is also meant to show the difference in work station functioning before and after implementation of the Lean tools.

8.3. Ceramic potsherd moulding technology

The process of ceramic potsherd moulding is usually done with the use of hydraulic presses. Moisture content in semi-plastic mass usually fluctuates at the levels from 14 to 18%. Semi-plastic mass must satisfy certain definite properties to be used for moulding. The most important property for the mass is to have appropriate, repeatable physical parameters. It is also important for the mass to have a constant apparent density, which is conditioned by a definite and unchanging size analysis. Constant and smooth mass moistness guarantees constant contraction and correct moulding. Strict adherence of the listed parameters is important in terms of quality.

Moulding is done by placing the right amount of raw material in a mould appropriate for a given detail. The right amount of ceramic white clay is necessary to avoid defects when press-forming products. The right amount of the supplied ceramic mass depends on the size of a moulded product. Metal or plaster dies press-form the products into the required shape and at this stage the moulding process is regarded as complete. The production process of ceramic ware was described in detail in naother paper (KLESZCZ D., ULEWICZ R.2010).

The analysed company uses modern technology, which allows continuous improvement of the manufacturing processes and achieving higher business competitiveness. Modernised management methods are applied in these processes now and then, including concepts of Lean production management. The development of knowledge and technology in the field of management is directly translated into dynamic increase of production and more effective manufacturing. Fig. 8.1 shows an automatic press for potsherd moulding.

Fig. 8.1. Hydraulic press – potsherd moulding

Source: Ceramik sp. z o.o.

8.4. Selected Lean concept tools and techniques

There are many tools and techniques used in the Lean concept. In the case of ceramic potsherd moulding, the most important tools from the point of view of lean management were selected.

The following tools and techniques were used in order to improve the functioning of the process:

- HOSHIN PLANNING
- PDCA – (Plan-Do-Check-Act – the Deming circle is the basis of the Kaizen continuous improvement),
- 5S – (sort, set in order, scrub, standardize, sustain)
- TPM – the OEE (Overall Equipment Effectiveness) index (KLESZCZ D., ULEWICZ R. 2011, LESTYÁNSZKA ŠKŮRKOVÁ K., MRVOVÁ L., MARKOVÁ P. 2013),
- SMED (Single Minute Exchange of Die – the method which consists in reducing the time of retooling; the target is to reduce the retooling time to less than 10 minutes),

- MUDA (a Japanese word meaning „wastefulness”; there were 8 types of MUDA identified),
- CURRENT STATE MAP,
- KAIZEN,
- 5 Why (minimum 5 iterations of asking “why” a particular problem occurred; the task of this technique is getting to the source of a problem),
- THE TABLE OF NEEDS – (on the basis of the obtained results of the study, a Table of Needs is drawn up).

Selected benefits achieved by the use of the Lean tools in the studied object:

General benefits

- Industrial safety of the work station was increased
- The morale of employees working at the work station was increased.

Benefits in conducting business activities

- There was a reduction of direct and indirect operating expenses,
- The efficiency of manufacturing ceramic ware was increased,
- Cost-effectiveness of manufacturing was increased,
- Manufacturing was speeded up,
- Wastefulness was decreased,
- Lead Time was shortened (Lead Time - is the latency (delay) between the initiation and execution of a process).

Benefits connected with further implementation of the concept

- The process of implementation of heijunka – production levelling was speeded up,
- Targets for mapping of the future state were charted,
- The process of SMED implementation was speeded up,
- The OEE index was improved,
- Standardisation of the manufacturing process was accomplished – (standardisation – substantiation of the best methods and methods of repeated use of a given work),
- Implementation of the OPF was speeded up (OPF – one-piece-flow),
- The obtained data was used to build the Table of Needs – a new management tool.

8.5. Description of a work station before implementation of tools

The process of ceramic potsherd forming used to be performed in a chaotic and unscheduled way. Individual activities were performed without appropriate preparation and tools and raw materials were not kept in the same place.

Specification of major errors:

- All the tools were kept in one box,
- The toolbox was used by different workers and could be found in many places all over the shop floor,
- The major raw material was stored about 50 m away from the work station,
- Moulds were stored about 30 m away from the work station,
- Each time, a worker had to switch off the machine and go to the storehouse to collect ceramic clay for production,
- Post-production waste was placed in containers that were emptied at the end of each shift and processed to be re-used as a second class raw material.

Before implementation of tools, there were no standards of the performed work. Machine operators were unable to perform the planned standards of quantity. Due to absence of planning, the work performed by the employees was ineffective. Raw materials were placed several dozen meters away from the workstation. In order to retool the machine, a worker had to switch it off go to the storehouse to collect moulds as well as the necessary tools and components. The tools were not kept in one place and each time the operators had to look for the necessary accessories all over the production hall. Time was wasted on processing the waste mass.

Fig. 8.2 and Fig. 8.3 show the state before implementation of the lean management tools.

Fig. 8.2.a) Hydraulic press – changing of the mould before implementation of changes, b) hydraulic press – looking for tools before implementation of changes
Source: Ceramik sp. z o.o.

Fig. 8.3. Storing moulds in the store house before implementation of changes
Source: Ceramik sp. z o.o.

Results of tests and taken measurements are shown in Table 8.1. The obtained data was averaged. Seconds were used as units of measurement of individual steps taken by the operators, and the total time was given in minutes. The Table shows the time of exchanging moulds as the process requiring 30 steps. On average, there is one retooling taking place during one shift.

Table 8.1. Time of individual re-tooling parameters before implementation of changes

	Before the changes	
No.	**Operation**	**Time taken [s]**
1	Machine stop – the end of the preceding batch A	**12**
2	Switch-over from automatic to manual mode – mould replacement	**8**
3	Selecting appropriate tools from the toolbox	**45**
4	Securing the machine with a woodblock – easing the fastenings and unscrewing the bolts	**25**
5	Lowering of the upper part of the mould	**32**
6	Selecting appropriate tools from the toolbox	**45**
7	Starting dismantle of the mould – unscrewing of the mould clamping screws	**125**
8	Dismantling of the upper part of the mould	**45**
9	Shifting the table with the bottom part of the mould	**28**
10	Selecting appropriate tools from the toolbox	**4**
11	Dismantling of the bottom part of the mould	**110**
12	Selecting appropriate tools from the toolbox	**45**
13	Dismantling of the aluminium part of the mould	**65**
14	Change of programme from product A to product B	**15**
15	Putting away the old A mould and collecting the new B mould from the store house	**550**
16	Selecting appropriate tools from the toolbox	**45**
17	Assembling of the aluminium part of the mould	**120**
18	Selecting appropriate tools from the toolbox	**45**
19	Assembling of the bottom part of the mould	**130**
20	Shifting the table with the bottom part of the mould	**28**
21	Selecting appropriate tools from the toolbox	**45**
22	Assembling of the upper part of the mould	**115**
23	dokręcenie wszystkich śrub i mocowań	**110**
24	Starting the B product moulding in the manual mode – checking the settings	**20**
25	Correction of settings - if necessary	**102**
26	Re-checking	**16**
27	Starting production of the sample batch	**5**
28	Quality control of the sample batch	**12**
29	Starting production of the sample batch	**8**
30	Starting production in the automatic mode	**10**
		1965
	TOTAL RESULT in minutes	**32,75**

Source: Own study

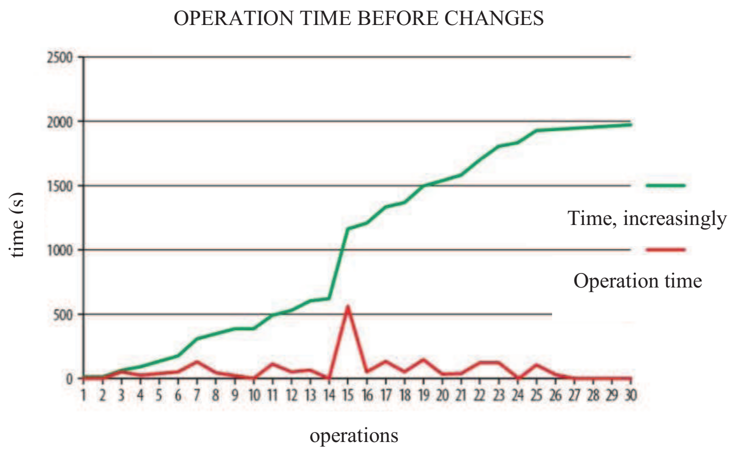

Fig. 8.4. Time of individual parameters before tool implementation

Source: Ceramik sp. z o.o.

Total time necessary for mould exchange in case of the state before implementation of lean tools was 32.75 min. The time necessary for making individual steps ranged from 4 to as much as 550 seconds. Figure 8.4. shows individual times of the performed operations and lists increasingly the total time necessary for retooling.

8.6. Implementation of changes according to the conception of lean production management

Action was taken in order to implement the expected changes and to improve functioning of the workstation. A number of activities and techniques of the lean conception was implemented, which significantly contributed to improvement in functioning of the studied area. Implementation of the changes was started from working out a vision of the workstation in the future, determining the approximate deadline for implementation of the changes and selecting the working group. The working group included machine operators, their direct supervisor, who was responsible to the entire section, and a lean production management adviser.

The entire undertaking was approved by the head management. After working out the vision, the group proceeded to implementation of changes. There were activities introduced in compliance with the 5S tool, aimed at cleaning up the workstation, separating the unnecessary things from the necessary ones. The next step was systematizing – planning localisation of all the raw materials, components, tools and moulds. Raw materials were placed 5 meters away from the machine, not – as it was done in the past – 50 meters. Tool Outline board was introduced, which significantly shortened the time of looking for the appropriate tools (CZERSKA J., 2011). The workstation was reorganised and assumed as a standard, which was the basis for further improvement – in compliance with the KAIZEN philosophy (MASSAKI I., 2006). MUDA types of wastefulness, which occurred in a given area, were defined LIKER J., 2004).

Fig. 8.5. Storing moulds at the workstation

Source: Ceramik sp. z o.o.

Figure 8.5 shows a systematised place for storing moulds. The working group analysed rotation of the assortment and decided to store moulds that are systematically used for production. The moulds used at least once a week are stored at the workstation. The distance between the machine and the storing place of the moulds is about 3 meters. The distance is ten times shorter than earlier. The changes allowed to change certain external activities into internal activities, i.e. activities that can be done while the machine is working. Figures from 8.6 to 8.9 show the workstation after implementation of the lean production management conception.

One of the successive stages of action was organising a Tool Outline board, which allows searching out of the indispensable tools, necessary for retooling of the machine. The time was reduced from over 40 to about 4 seconds. The tenfold saved parameter of the repeatedly performed action allowed to achieve significant savings and eliminate wastefulness.

Fig. 8.6. Storing moulds at the workstation

Source: Ceramik sp. z o.o.

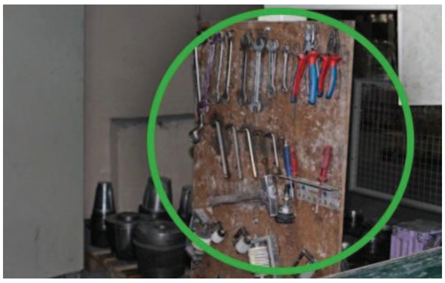

Fig. 8.7. Tool Outline board near the workstation

Source: Ceramik sp. z o.o.

Fig. 8.8. Control panel on an extension arm

Source: Ceramik sp. z o.o.

The control panel is mounted onto a rotational arm, which significantly improved the comfort of operator's work.

Fig. 8.9. Tool Outline board.

Source: Ceramik sp. z o.o.

Suitable localisation of the panel and tools on the Tool Outline board introduced order and the right organisation of work at the workstation.

After introducing changes and facilities, there were workstation efficiency tests carried out to measure (BASKIEWICZ N. 2012, DIMA I. C., GRABARA J., KOT S. 2012,):

- Single minute exchange of die SMED
- OSH of the workstation,
- Wastefulness
- OEE coefficient

8.7. The obtained effects after implementation of the tools and techniques of lean production management

Table 8.2 shows time of performance of individual activities after implementation of the concept. Table 8.3 shows total time savings achieved in consequence of implementation of lean management tools. In Figure 8.10, the graph shows the time of performance of individual operations after implementation of the changes. Additionally, the graph shows the total time as it increases.

Table 8.2. Time of individual re-tooling parameters after implementation of changes

No.	Operation	Operation time s
	After the changes	
No.	**Operation**	**Operation time s**
1	Machine stop – the end of the preceding batch A	**12**
2	Switch-over from automatic to manual mode – mould replacement	**8**
3	Collecting appropriate tools from the Tool Outline board	**4**
4	Securing the machine with a woodblock – easing the fastenings and unscrewing the bolts	**25**
5	Lowering of the upper part of the mould	**32**
6	Collecting appropriate tools from the Tool Outline board	**4**
7	Starting dismantle of the mould – unscrewing of the mould clamping screws	**125**
8	Dismantling of the upper part of the mould	**45**
9	Shifting the table with the bottom part of the mould	**28**
10	Collecting appropriate tools from the Tool Outline board	**4**
11	Dismantling of the bottom part of the mould	**110**
12	Collecting appropriate tools from the Tool Outline board	**4**
13	Dismantling of the aluminium part of the mould	**65**
14	Change of programme from product A to product B	**15**
15	Putting away the old A mould and collecting the new B mould from the store house	**30**
16	Collecting appropriate tools from the Tool Outline board	**4**
17	Assembling of the aluminium part of the mould	**120**
18	Collecting appropriate tools from the Tool Outline board	**4**
19	Assembling of the bottom part of the mould	**130**
20	Shifting the table with the bottom part of the mould	**28**
21	Collecting appropriate tools from the Tool Outline board	**4**
22	Assembling of the upper part of the mould	**115**
23	Tightening up of all screws and clamps	**110**
24	Starting the B product mould in the manual mode – checking the settings	**20**
25	Correction of settings - if necessary	**102**
26	Re-checking	**16**
27	Starting production of the sample batch	**5**
28	Quality control of the sample batch	**12**
29	Starting production of the sample batch	**8**
30	Starting production in the automatic mode	**10**
		1199
	TOTAL RESULT in minutes	**19,98**

Source: Own study

OPERATION TIME AFTER CHANGES

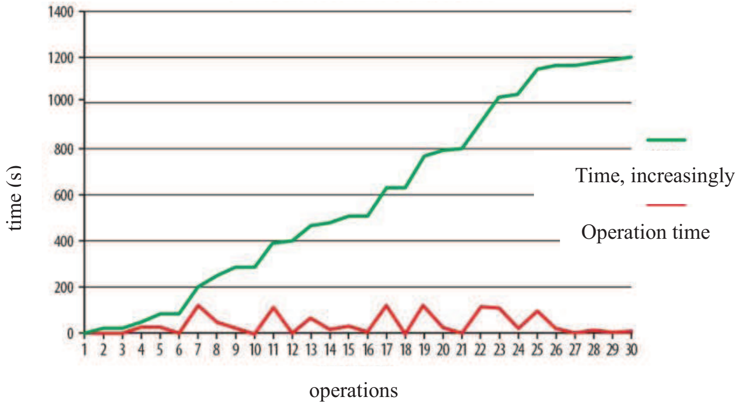

Fig. 8.10. Total time of die exchange saved after implementation of tools

Source: Own study

Table 8.3. Total time of die exchange saved after implementation of tools

Minutes before change	Minutes after the change	Time reduction in min.
32,75	19,98	12,77

Source: Own study

OPERATION TIMES SAVED AFTER CHANGES

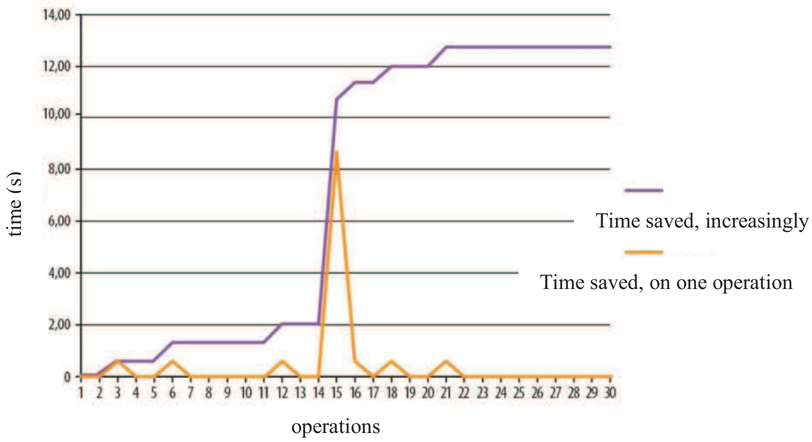

Fig. 8.11. Time saved after implementation of Lean management techniques

Source: Own study

Fig. 8.11 shows time savings resulting from implementation of tools and techniques. The following results were achieved: Total mould exchange time was reduced from 32.75 minutes to 19.98 minutes, which means reduction by as much as 12.77 minutes, i.e. 38.98%. Thus, the assumptions mentioned by the SMED tool was closely approached. The next step to be taken in the future, will be changing the way of fixing the moulds. On the basis of the simulation that was carried out, it is estimated that this improvement will result in shortening the exchange time to less than 10 minutes, in compliance with the assumptions of SMED. A significant improvement of OHS has been observed at the workstation. The higher comfort of health has significantly boosted the employees' morale. Work output was achieved in the ceramic threshold forming department. Appropriate localisation of the necessary raw materials and components reduced time and machine wastefulness. Excessive stocks of raw materials in the course of production were eliminated. More effective results in production levelling were observed.

Fig. 8.12. Waste mass container

Source: Ceramik sp. z o.o.

Fig. 8.13. Hand processing of the waste mass.

Source: Ceramik sp. z o.o.

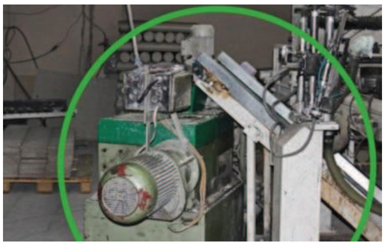

Fig. 8.14. Automatic processing of waste mass
Source: Ceramik sp. z o.o.

Figures 8.14 and 8.13 present the manual method of waste mass processing. Before implementation of the changes, the waste mass, which was accumulated during the manufacturing process, was manually processed by the workers in a vacuum press. On average, the activity took 53 minutes during each shift. The saved time was set aside for generating added value. The team decided to move the vacuum press and place it next to the hydraulic press. Figure 8.14 shows the state after the changes. The feeder feeds the ceramic chips directly into the vacuum press, which significantly reduces waste of time.

On the basis of the results of the study, the savings were compared. Two parameters were verified:

a) Die exchange,
b) Manual processing of waste mass.

The following assumptions were made for the calculations:

- Monthly maintenance expenses per one employee were assumed to be at the level of 1931.84 PLN;
- time saved on one die exchange is 12.77 minutes;
- average number of die exchanges per one shift is 1;
- the time of manual processing of ceramic waste mass is 53 minutes per one shift;
- the number of working days in a month is 21;
- the working time of one shift is assumed to be 8 hours.

Annual savings are as follows:

a) Savings resulting from the shorter die exchange time equal 2537.64 PLN;
b) Savings resulting from elimination of the manual processing of the waste mass equal 611.4 PLN;
c) Total annual savings equal **3149.04 PLN.**

8.8. Summary

The conducted study reveals that implementation of the Lean concept in ceramic industry is recommended. In the analysed process, a significant influence of individual instruments and tools of the lean management on production efficiency was observed. The applied concept reduces time of performance of individual operations and the operating expenses, while increasing work output at the workstation. On the basis of the obtained results it is clearly evident that the lean management tools significantly contributed to increasing work quality, which makes employees work better and more efficiently. Tables 10.1 and 10.2 show average results of the 30 steps measurements performed during exchange of the mould.

By using the SMED technique, the die exchange time was reduced by 12.77 minutes, which significantly increased the effectiveness of production and reduced wastefulness of time. 5S practices introduced order and good organisation of work at the workstation, which directly increased competitiveness of the business and boosts the worker's morale. A Tool Outline was constructed, which reduced the time of looking for tools. Standardisation was introduced in performing individual tasks, which is one of the bases of constant development. Wastefulness of material, time, and money was reduced.

The process of manufacturing functional ceramics requires meeting definite clients' requirements. In order to obtain the expected parameters, required by the clients, an organisation must make use of the Lean concept and develop continuously. The calculations show that making use of the Lean tools directly contributes to reduction of the operational expenses. At the same time, work output is growing and the competitiveness of the Company significantly increases.

Bibliography:

1. BASKIEWICZ N. 2012. *Techniczne Przygotowanie Produkcji a Efektywność Procesu Produkcyjnego W Warunkach Organizacji Procesowych*, Zarządzanie przedsiębiorstwem w kontekście zrównoważonego rozwoju. Monografia. Red. nauk Izabela Krawczyk-Sokołowska, Sekcja Wyd. WZ. Częstochowa.
2. BORKOWSKI S. 2012. *Toyotaryzm. Wyniki badań BOST*. Wydawnictwo Menedżerskie PTM. Warszawa.
3. CZERSKA J. 2011. *Pozwól płynąć swojemu produktowi*. Wydawnictwo PLACET. Warszawa.
4. DIMA I. C., GRABARA J., KOT S. 2012, *Using the Simulation in Planning of the Production Systems*. Manufacturing and Industrial Engineering Vol.11 nr 3
5. INGALDI M., SELEJDAK J. GAJDA P. 2013, *The Quality Analysis of Glass Products. Chapter 14*. Product Quality Improvement and Companies' Competitiveness. Monography. Editing and Scientific Elaboration S. Borkowski, M. Ingaldi. Faculty of Logistics, University of Maribor, Celje.
6. KLESZCZ D, ULEWICZ R. 2011. *The Role of TPM in Implementation of Heijunka in the Manufacturing Process in Ceramics. Chapter 12*, in: Toyotarity. Heijunka. Monography. Editing and Scientific Elaboration Stanisław Borkowski, Robert Ulewicz. Publish.Yurii V. Makovetsky, Dnipropetrovsk
7. LESTYÁNSZKA ŠKŮRKOVÁ K., MRVOVÁ L., MARKOVÁ P. 2013. *What says the new CAF model in the criterion 5: processes?* WoodEMA. Visegrad Innovations. Innovation as the Source of Values in the Forestry Wood Processing and Furniture Manufacturing. Conference Proceedings, Częstochowa.
8. LIKER J. 2011, *Droga Toyoty*, MT Biznes, Warszawa.
9. MASAAKI I. 2006, *Gemba Kaizen*, Kaizen Instytute Polska and MT Biznes Ltd. Warszawa.
10. NOWAKOWSKA-GRUNT J. 2006*, Koncepcja zarządzania wyszczuplającego (Lean Management) w zarządzaniu łańcuchem dostaw przedsiębiorstwa "Tesco"* in: Restrukturyzacja i konkurencyjność w warunkach procesów globalizacji. Ed.by Ryszard Borowiecki, Tomasz Rojek, Ofic. Wyd. ABRYS, Kraków.
11. ŠUJANOVÁ J. 2004, *Potreba uplatňovania vedomostného manažmentu v projektovom manažmente*. Application of the knowledge management in the project management. In: Projektový manažment a jeho využitie v praxi. Metódy a nástroje : Medzinárodný seminár. - Bratislava : STU v Bratislave.