Conference Proceedings

DOKBAT

14th Annual International Bata Conference

for Ph.D. Students and Young Researchers

Tomas Bata University in Zlín
Faculty of Management and Economics
Mostní 5139 – Zlín, 760 01
Czech Republic

CHANGEOVER TIME REDUCTION THROUGH LEAN TOOL "SMED" – A CASE STUDY FROM FOOD SECTOR

Kateřina Gálová

Abstract

With the expansion of the product portfolio, businesses are faced with the problem of rising costs and downtime associated with changeovers. The classic approach to this issue is based on a system of large production batches, which will minimize the number of changeovers, thus eliminating the costs associated with them. However, customer requirements often do not allow them to produce in large batches, which also entail relatively high storage costs. Therefore, it is necessary to focus attention on their efficient operation when reducing production batches and simultaneously increasing the frequency of changeovers. One way of actively influencing the cost and downtime that occurs during the changeovers is the Single Minute Exchange of Die method. The presented article approximates a case study that deals with the implementation of this method in a specific food industry company. The results obtained show that saving only thirty minutes of the average length of one of the most frequent changeover can save up to CZK 130,000 per year.

Keywords: Industrial engineering, lean, SMED, changeover time, setup, food production

1 INTRODUCTION

A challenging business environment is a relatively big challenge for many companies. Changes in recent decades have forced businesses to find ways to reduce costs, shorten production and delivery times, and yet increase performance. The company must be competitive and meet changing customer requirements, otherwise its market position is unusable. Flexibility is one of the key elements in this dynamic environment that allows businesses to survive. (Krugman, 1994; Chase et al., 2001; BlackBurn, 1991)

According to Sahin (2000), there are four basic systems to help the company maintain its competitive edge and market position: specialized factories, lean factories, mass customization and flexible production. Any activities in this context that do not add value to the customer and are therefore unnecessary need to be eliminated. One of the options here is industrial engineering (IE) with its tools, which allows to achieve the basic factors contributing to competitiveness: namely continual improvement; simple, reliable and flexible devices; employee involvement; reducing machine settings and changeover times. (Anand & Kodali, 2009; Sahin, 2000).

The trend in lot size reduction and mass customization brings one great waste area – the total times of changeovers. Set up the machine from one type of product to another can be time consuming, especially if the machine needs to be perfectly cleaned or the setting up are done very often. The IE method, which deals with the reduction of the time required for changeovers, is the SMED method. This article deals with the possibility of using SMED methods in specific conditions of the food industry. In this sector of the national economy, there is a specific requirement for perfect cleanliness of the plant from the production of one type of food to another. In the selected company dozens of products are produced in different variants, which in a limited space and a limited number of machines represents a huge amount of castings per

day. In the form of a case study, it introduces the introduction of this method and its possible benefits.

2 LITERATURE REVIEW

The performance of the business and its ability to sustain its position on the market is a key feature today (Yoo & Seo, 2017). Businesses are therefore looking to find ways to get any competitive advantage. These include, for example, increasing productivity, focusing on shop floor improvements, increasing customer value (Smith, 2003). One of the possible tools to achieve this is IE, or lean.

The lean concept was designed to eliminate all kinds of waste, thereby increasing customer value (Shah & Ward, 2003) and includes various tools that, among other things, help identify the direction of improvement (Holweg, 2006).

Lean is a concept originally from Toyota, which is aimed at eliminating any waste. In this context, waste is characterized as any redundant operation or cost-inducing activity that does not generate any added value to the customer. Several studies have shown that lean is a very powerful tool for increasing performance in terms of quality, stock minimization, productivity gains, or cost reductions (Fullerton and Wempe, 2009; Cua et al., 2001).

The reasons for implementing the lean concept are many. It can be, for example, efforts to improve quality at low cost (Liker & Wu, 2000) or to increase productivity while eliminating waste (Worley & Doolen, 2006; Bhamu et al., 2012). Stone (2012) summarized the basic knowledge of the literature as follows:

- the Lean concept has gradually evolved to be applicable everywhere in the organization (not only in production) and is also universally applicable in all sectors (also outside of industry)

- modern lean literature is already paying a lot of attention to the development of human resources

- the successful transformation of the enterprise towards the lean is conditioned by strategic support throughout the enterprise

The number of tools actively used by the lean concept is relatively large. The professional literature is largely inconsistent in their uniform classification. E.g. Shah and Ward (2003) divided the methods into four basic categories, namely: JIT, TPM, TQM and human resource management. Compared to that Moyano-Fuentes and Sacristan-Diaz (2012) defined their four basic categories from a completely different perspective: shop floor, value chain, work organization and geographical context.

According to Melton (2005) basic lean tools and techniques include:

- Kanban
- 5s
- Visual control
- Poka-yoke
- SMED

Focusing on reduction of setup time is one of the key activities of lean thinking. The total setup time has traditionally been solved in enterprises by the effort of large lot sizes and thus minimizing the number of setups required. (Holweg, 2006) However, this contradicts the

philosophy of the lean, which focuses primarily on eliminating all waste (an activity that does not add value to the customer). And the customer currently requires flexible fulfilment of his often-unique requirements. This bring out the need for product customization and production in small doses, which contradicts the efforts of companies to minimize casting time by using large lot sizes. (Ezeiruaku, ResearchGate, 2004; McIntosh et al, 2000) Companies therefore need to be able to produce a large variety of products in small quantities and therefore have the necessary competencies quick changeover activities. To compete, companies need to look for ways to shorten setup time and eliminate waste and non-value-added activities. In addition, they must be able to transfer the idle time to the normal production time. (Park et al., 2001)

SMED was developed by Shingo is characterized as a scientific approach for substantially reduction of setup times and it can be used in any industry and any machine (Shingo, 1985; Ani & Shafei, 2012). This method was originally developed through the study of a die change process. In general, the SMED method deals; with the simplification and standardization of shuffle operations, which also entails a reduced need for professionally trained staff. (Shingo, 1985; Ulutas, 2011)

Changeover time is the time that is required to prepare a machine for the batch of different products. Specifically, the total changeover time is time from the end of production of the last good piece to the end of the production of the first good piece of the new batch. This means that the activities in the cast are, for example, setup, warm up, trial run, adjustment, first-piece inspection. (Ezeiruaku, ResearchGate, 2004)

In the Single Minutes Exchange of Die there are four stages, including the preliminary stage, involved to make some setup reductions (Shingo, 1985):

- Preliminary stages.

- Stage 1: Separate internal and external setup.

- Stage 2: Convert internal to external setup.

- Stage 3: Streamlining all aspect of setup.

The most critical phase is phase one, in which it is necessary to divide all the activities that are performed during the casting into internal and external. Internal activities cannot be performed during the machine activity, while external activities can be performer during the machine activity. The primary task of the SMED method is then to transfer as many internal activities as possible to the internal workforce that can be handled by the machine during the machine's time. (Shingo, 1985; Moxham & Greatbanks, 2001) Only activities that cannot be performed (typically for safety) during operation of the machine, such as picking tools or parts, should be performed during the machine stop. (Sivasankar et. al, 2011)

However, the SMED method is not implemented in isolation from other lean tools. According to Pellergrini et al (2012) are some of another lean tools typically implemented at the same time as SMED, e.g. Kaizen and PDCA for continuous improvement, standardization to maintain the established changes or 5S for clean, orderly and safe workplace. Similarly, it has been demonstrated (Trovinger et.al, 2005) that the SMED method of the sophisticated computer methods should not be separated because their maximum effect can be achieved by their mutual use.

The SMED method deals with a relatively large number of expert articles. Their main outcomes are summarized in Dave & Sohani (2012):

- To maximize the true potential of the SMED method, it is necessary to implement continuous training an awareness program from top to bottom management.

- The SMED method is suitable for any type of industry

- In order to increase the benefits of introducing the SMED method, it is also appropriate to introduce 5S and various forms of visual control.

- The SMED method (as well as other lean management tools) should not be implemented in isolation, but at the same time with other tools.

3 METHODOLOGY

The main objective of this case study is to find out how much savings can be achieved by reducing the average time of the changeovers without significant financial investment in new machinery and equipment in the conditions of the selected manufacturing enterprise.

The selected enterprise is one of the main players in the food industry in the Czech Republic. It is part of a multinational company that focuses on a wide range of products - such as sweets, spices and soups, coffee, cereals, baby food, canned food, fruit juices, mineral water, and the non-food sector – feed for dogs and cats. The plant itself, in which the case study was processed, focuses on the production of chocolate and chocolate confectionery.

The study was prepared on the basis of a real project that took place in a selected company with the participation of an author who was part of the project as a project team member and project coach. The project consisted of basic project management structures, i.e. a project team was formed at the beginning, a project sheet was created, a project objective and its potential benefits were set. The main goal of the project was to reduce the time of the chosen changeover on the given line and thus increase its capacity by at least 15 tons per year and to achieve an average shuffle time of 220 minutes from the original 244 minutes.

For the purpose of the study, it was necessary to obtain detailed information about the activities within the entire changeover. This data was collected directly at the shop floor during the changeovers. To record the individual activities and their duration, stopwatch time study was used and the data were recorded in the pre-prepared checklist. Concurrently, a video was made for later detailed analysis.

On the basis of the analyses conducted, the project team designed and implemented changes to improve the current state (and to achieve the project goal).

4 CASE STUDY

4.1   Specific project assignment

Before the start of the project, a project team consisted of a team leader (head of IE), a sponsor (production manager), process owner (production master), coach (IE department employee), 4 team members, 1 operator, 1 mechanic.

For the project only one line was selected in the production plant (see next chapter). The first step was to collect data. In order to select a specific changeover, Paret's several-step analysis was carried out. For Pareto analysis data from the company's internal information system was used over the last 12 months. In the first step, the largest contributor to the total loss in the production area (planned vs. unplanned stoppages, loss of speed, etc) was found, in the second step a specific centre was selected, then the specific line of the given centre was selected, then the type of stoppages and finally the specific changeover was outlined, which was further analysed.

When selecting a project (SMED method and specific product type), a historical analysis of all recorded stoppages at the factory was performed. The first step (Figure 1) was the analysis of the individual stoppages types (planned stoppages, unplanned stoppages, loss of speed, waste and rework). It is clear from the chart that the most important were planned stoppages with total time 10184 hours.
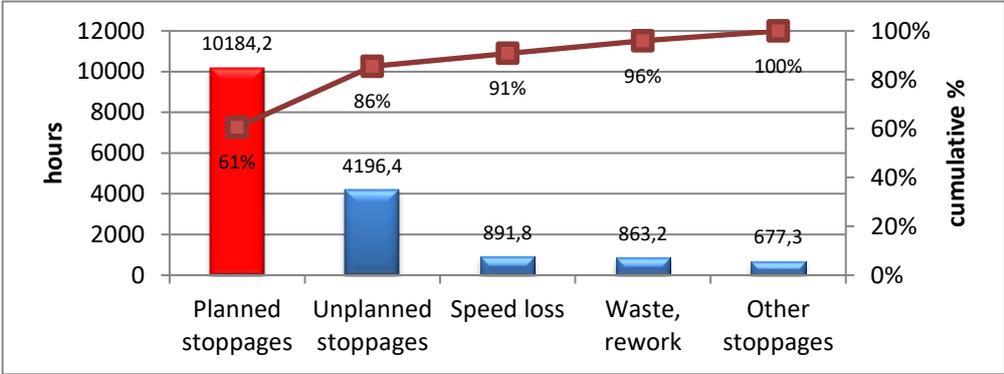

Figure 1 Analysis of plant stoppages. Source: own

In the next step (Figure 2), planned stoppages were analysed considering the location where these stoppages were reported. From this point of view, the most planned stoppages were recorded at the dessert centre, where, at the time of the preparation of the project, the improvement projects were already in progress. Therefore, the second centre - the tables - was selected for further analysis.
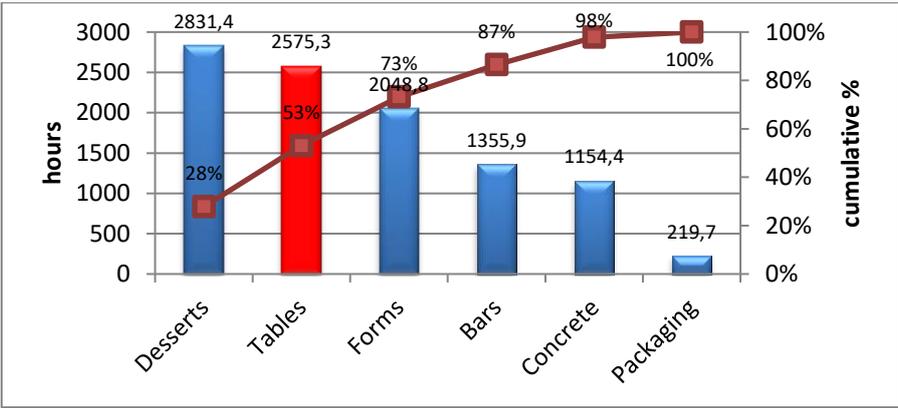

Figure 2 Planned stoppages. Source: own

At the tables centre, data is collected from five lines. By analysing the planned stoppages on these lines (Figure 3) it was found that D1 line has the largest share of these stoppages.
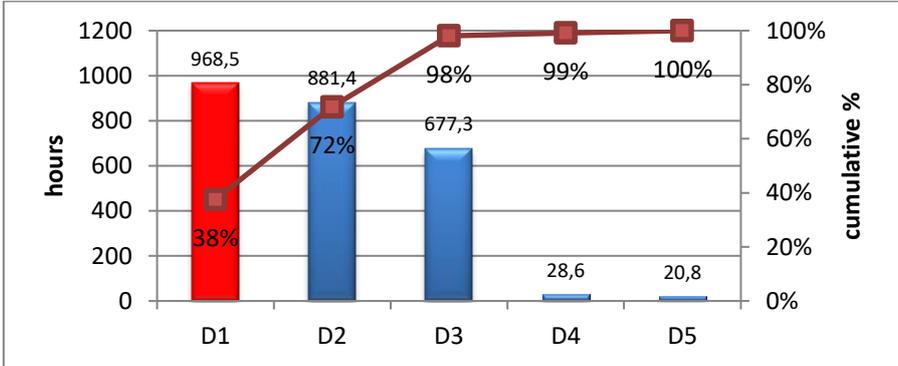

Figure 3 Planned stoppages – Tables. Source: own

Various types of planned stoppages are reported on the D1 line (Figure 4). The most significant share of these stoppages is occupied by changeovers (76% of all planned D1 sites). For this reason, the SMED method was selected.
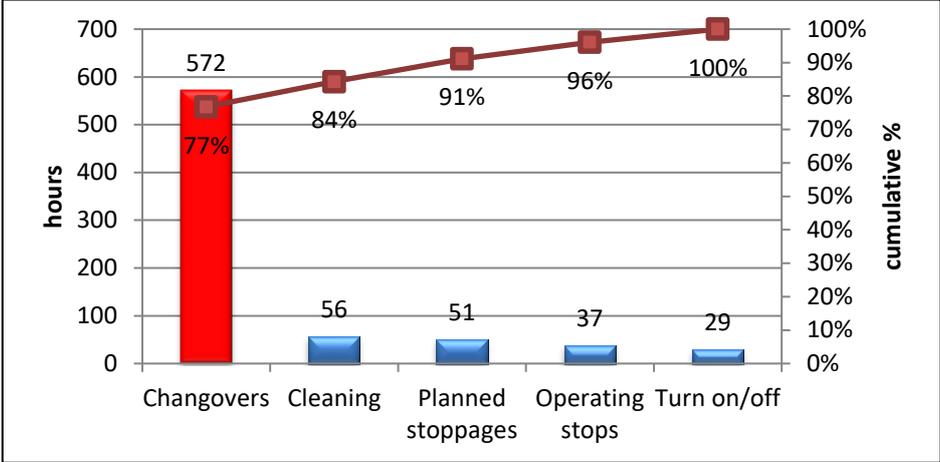

Figure 4 Types of planned stoppages on the D1 line. Source: own

It was also necessary to select a specific type of changeover. There are fourteen types of changeovers on the selected line, the total time and frequency of them is shown in the following chart (Figure 5). Of these types of changeovers, the fourth longest changeover was the most frequent (which would take 185 minutes), but the longest and second most frequent type of changeover (240 minutes) was eventually chosen by project team for the next step.
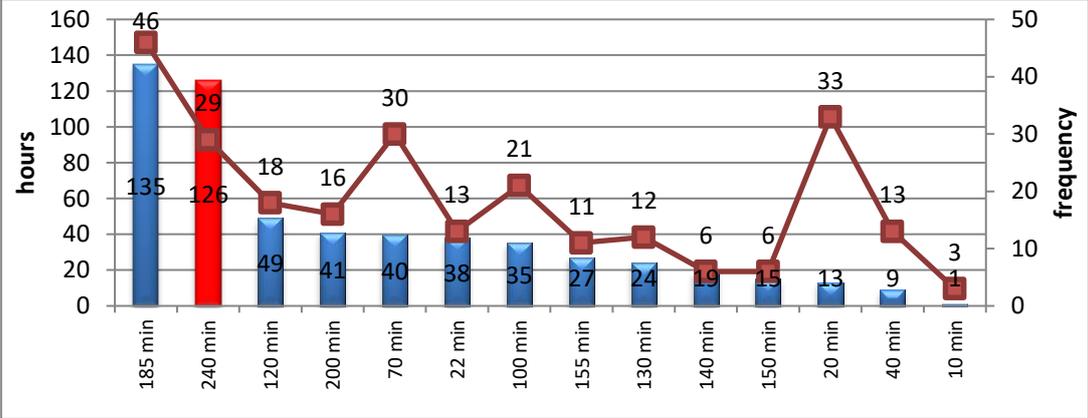

Figure 5 Changeovers on D1 line. Source: own

4.2 Specific project assignment

Problem: The selected line has the second largest loss in scheduled times, with up to 1500 machine hours per year lost. It is also necessary to optimize the entire changeover process.

Benefit of the project: The goal of the project is to reduce the changeover time and thus increase the capacity of the line by up to 15 t while maintaining the price of the product, which can save up to CZK 92,000.

Expected output of the project: Reduction of the changeover time, correct timing of cleaning, maximum use of staff during cleaning, standard updating, standardization of cleaning time.

The project benefits from the company's main priorities, which are safety, cost, quality, innovation. It is expected to increase the safety of the job during the changeover, shortening the

planned downtime and thereby reduce costs, reduce the risk of foreign objects entering the product during the changeover, increase the flexibility of the production.

Specification of the project objective: The next step was to analyse the total times of the selected kind of changeover in the last seasons, and to calculate the average time of this changeover. The times of the individual changeovers were variable, ranging from 195 minutes to 375 minutes. The project team decided on the main goal of the project, which was to reduce the time of the selected sort by 10% of the average changeover time, from 244 minutes to 220 minutes.

At the beginning of the project was a simplified financial analysis prepared and a quantification of the expected savings have been described. At a frequency of 58 changeovers per year and with a given number of operators and wage rates, the annual savings would be 91 thousand. CZK. At the same time, the time savings (23.4 hours) would allow the line capacity to increase by 15 tons.

The following table (Table 1) shows the basic data needed to calculate the total cost of a given type of changeover: changeover time (CT) for original changeover (OC) and expected status after changes (EC), calculated costs for both before and after project changes and expected savings.

Table 1 Expected project savings. Source: own

	CT [minutes]	Frequency	Number of operators	Rate [CZK/hour]	Number of mechanicals	Rate [CZK/hour]	Costs
OC	244	58	14	227	2	394	934 041
			3172		788		
EC	220	58	3960				842 169
Expected saving	24	58	3960				91 873

Analysis of the selected changeover

The following activities and times were identified during the recording of the individual activities of the selected changeover (based on the wishes of the company, only groups of activities that group shorter activities and individual movements of operators). The total changeover time was 3:36:59.

Table 2 Changeover activities. Source: own

Changeover process		
Activity	**Time**	
Original production ending	0:23:00	
Flushing masses	0:39:00	
Dismantling the divider	0:28:00	
Cleaning of parts and dividers	1:07:00	
Assembly of dividers	0:22:00	
Valve failure	0:13:00	
Flush with butter	0:06:00	
Exchange of molds	0:04:00	
Forming of molds	0:07:00	
Blowing the front of the bass	0:06:00	
Start of production	0:03:00	
First good form	0:03:00	
First good product	0:27:00	

The distribution of internal and external activities is shown in the following Chart (Figure 6). Internal activities occupied 83% of the total time.
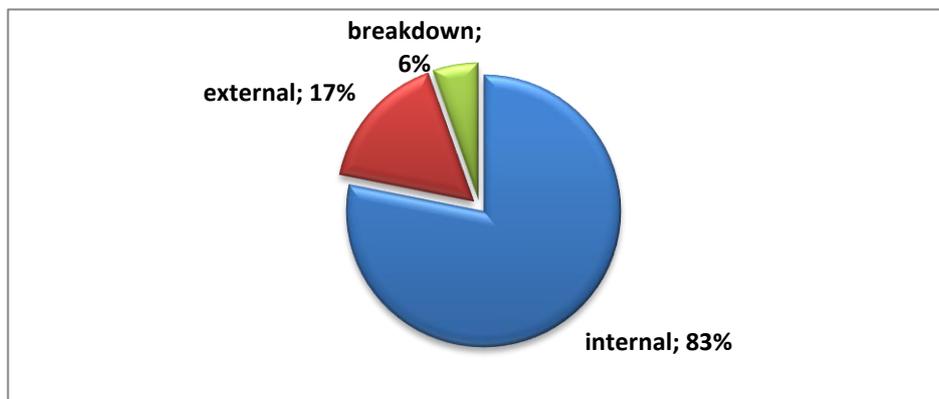

Figure 6 Internal vs external activities. Source: own

Suggestions for improvement

During several brainstormings, the project team came up with ideas on how to shorten the time of the selected changeover. Supporting the preparation of remedial measures was the ECRS internal methodology based on the basic steps of improvement and IE - elimination, combination, reduction, simplification. Proposals that were selected for implementation by the point method are listed in the following table (Table 3).

Table 3 Proposals to improve the current state

What	Activity	Specific activities
1 - simplified	valve opening - start of flushing	Flushing time for approx. 8 min
2 – reduction	dismounting the divider	accelerate screw making - frequency, length
3 – simplified	removing parts of the dishwasher	original cart for plates
4 – reduction	flushing mass into the trolley	trolley for whitewash + 1 trolley

5 – reduction	cleaning the dividers	scraping the divider before washing - do not take the pistons separately
6 – simplified	drying parts	chamber for component drying
7 – simplified	cleaning of mixers-pipes	better tool on the dishwasher
8 – simplified	scraping the sheet under the divider	a larger sheet under a divider – taking out from the other side
9 – elimination	piston lubrication	define what work the mechanic performs and what operator and try to use lecithin against seizure
10 – elimination	start-up fault	to prevent breakdowns
11 – simplified	exchange of molds	control of trucks in line - camera
12 - reduction	mold heating	mold heating - automatic switching off
		mold heating - other type - smaller / OSH / energy

Based on the project team's suggestions, an action plan for each activity was defined, which defined the problem and action to resolve the problem, the specific date by which the action is to be met and the person responsible for the action. Of the twelve original actions, four were cancelled (due to technological difficulty or the need for a major financial investment). All other proposals have been implemented.

Of course, standardization of new procedures was a matter of course. New SOPs (standard operating procedure), new APIs, and line breakers have been created to monitor adherence to the changeover time. Part of the project included training all operators for a new SOP and filling out new indicators.

Actual impacts of the project

After implementing all suggestions for improvement and training all of operators, the times of the selected changeover were re-recorded. The average throw time dropped from 244 minutes to 194 minutes (Figure 7) and the target was met. The new changeover time was even lower than the project goal, but in the long run, the time was 210 minutes. This time is kept without any major problems.

Figure 7 The impact of our project on changeover time

From a financial point of view, the project was also more successful than it was commissioned. Total savings amounted to 130 thousand CZK. Savings in the form of released production were 21 tons / year.

Table 4 Financial impact of the project

	CT [minutes]	Frequency	Number of operators	Rate [CZK/hour]	Number of mechanicals	Rate [CZK/hour]	Costs
OC	244	58	14	227	2	394	934 041
			3172		788		
EC	210	58	3960				803 888
Expected saving	34	58	3960				130 153

In addition to visible or measurable impacts (financial savings, capacity savings, documentation, etc.), the project had other impacts. One of these other impacts was a relatively large expansion of the competencies matrix of the concerned workers. Team members have increased their competencies both in SMED methods and in other aspects. Another big plus of the project was the involvement of operators. Documentation related to the standardization of new activities was created directly by operators who had the opportunity to comment on the proposals and, if necessary, to revise them after approval by the team.

The SMED project has created room for further improvement. Already during the project, proposals were made to further shorten the changeover time by involving operators from other parts of the line or other changes in the activities performed. The successful completion of the project also has, due to the large number of changeovers on all parts of the line, a great potential for expansion to other sections.

5 CONCLUSION

Industrial engineering and LEAN concepts are one of the basic building blocks that can increase the production performance of a business and thus also have a positive impact on competitiveness. Literary research has identified the basic assumptions of relations between methods and tools of industrial engineering and the competitiveness of the enterprise.

The SMED method was applied to a selected line in a case study case. The goal of the project was to reduce the average casting time by 10%, i.e. from 244 minutes to 220 minutes. Based on the analysis of available data from previous months, a specific changeover was selected. This changeover, according to available data, represents one of the largest contributors to the total stop time reported from the entire company. Plates fall into planned stoppages, accounting for 61% of all stoppages of the company. Changeovers on a particular selected line then account for a total of 77% of all planned stoppages on this line.

After selecting a specific line and a changeover, a detailed analysis of this changeover was performed. It was found that 83% of all the activities performed during the changeover are external. Based on the analysis of the activities and the progress of the work during the changeover, the project team defined several amendments that should lead to a reduction in the total time of the changeover.

All selected suggestions were implemented directly on the shop floor. Of course, standardization of corrective actions and thorough training of all operators was a matter of course. After a few months, the target was met. The average changeover time was reduced to 194 minutes after the standardization of all proposed measures, which represents a decrease of 21%. At the same time, an increase in production capacity was achieved by 21 tonnes per year. For company that is constantly struggling with insufficient capacities, this improvement is a fairly significant step forward.

The case study then illustrated how the SMED can achieve significant annual cost savings through selected industrial engineering tools.

References

Anand, G. & Kodali, R. (2009). Selection of lean manufacturing systems using the analytic network process – a case study, Journal of Manufacturing Technology Management, 20(2), 258-289. https://doi.org/10.1108/17410380910929655

Ani, M., & Shafei, M. (2012). The Effectiveness of the Single Minute Exchange of Die (SMED) Technique for the Productivity Improvement. International Journal of Sciences: Basics and Applied Research, 5(1), 9-13.

Bhamu, J., Kumar, J. V. S. & Sangwan, K. S. (2012). Productivity and quality improvement through value stream mapping: a case study of Indian automotive industry. International Journal of Productivity and Quality Management, 10(3), 288-306. https://doi.org/10.1504/IJPQM.2012.048751

Blackburn, J. D. (c1991). Time-based competition: the next battleground in American manufacturing. Homewood, Ill.: Business One Irwin. ISBN 15-562-3321-3.

Chase, R. B., Aquilano, N. J., & Jacobs, F. R. (2001). Operations Management for Competitive Advantage, (9th Edition). New York: McGraw Hill/Irwin.

Cua, K., Mckone, K. & Schroeder, R. (2001). Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. Journal of Operations Management, 19(6), 675-694. https://doi.org/10.1016/S0272-6963(01)00066-3

Dave, Y. & Sohani, N. (2012). Single Minute Exchange of Dies: Literature Review. International Journal of Lean Thinking, 3(2), 28-37.

Ezeiruaku, S. C. (2004). Single Minutes Exchange of Die (SMED) By Solomon C. © 2008-2018 ResearchGate GmbH.

Fullerton, R. R. & Wempe, W. F. (2009). Lean manufacturing, non-financial performance measures, and financial performance. International Journal of Operations, 29(3), 214-240. https://doi.org/10.1108/01443570910938970

Garcez, A. C. M. (2013). Implementation of the Single Minute Exchange of Die (SMED) Methodology in Small to Medium-sized Enterprises: A Portuguese Case Study. International Journal of Management, 30(1), 66-87.

Holweg, M. (2006). The Genealogy of Lean Production. Journal of Operations Management, 25, 420–437. https://doi.org/10.1016/j.jom.2006.04.001

Krugman, P. (1994). Competitiveness: A Dangerous Obsession. Foreign Affairs. 1994, 73(2), 28-35. https://doi.org/10.2307/20045917

Liker, J.K. & Wu, Y.C. (2000). Japanese automakers, US suppliers and supply-chain superiority. Sloan Management Review, 42(1), 81-93.

McIntosh R. I, Culley. S. J, Mileham A. R, & Owen. G. W. (2000). A critical evaluation of Shingo's 'SMED' (Single Minute Exchange of Die) methodology. International Journal of Production Research, 38(11), 2377-2395. https://doi.org/10.1080/00207540050031823

Melton, T. (2005). The benefits of lean manufacturing: what lean thinking has to offer the process industries. Chemical Engineering Research and Design, 83(A6), 662–673. https://doi.org/10.1205/cherd.04351

Moxham, C. & Greatbanks, R. (2001). Prerequisites for the implementation of the SMED methodology: A study in a textile processing environment. International Journal of Quality & Reliability Management, 18(4), 404-414. https://doi.org/10.1108/02656710110386798

Moyano-Fuentes, J. & Sacristan-Diaz, M. (2012). Learning on lean: a review of thinking and research. International Journal of Operations & Production Management, 32(5), 551-582. https://doi.org/10.1108/01443571211226498

Park, K. S. & Han, S. W. (2001). TPM—Total Productive Maintenance: Impact on competitiveness and a framework for successful implementation. Human Factors and Ergonomics in Manufacturing & Service Industries, 11(4), 321–338. https://doi.org/10.1002/hfm.1017

Pellegrini, S., Shetty, D. & Manzione, L. (2012). Study and Implementation of Single Minute Exchange of Die (SMED) Methodology in a Setup Reduction Kaizen. Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management. 2353-2363.

Sahin, F. (2000). Manufacturing competitiveness: different systems to achieve the same results. Production and Inventory Management Journal, 41(1), 56-65.

Shah, R. & Ward, P.T. (2003). Lean manufacturing: context, practice bundles, and performance. Journal of Operations Management, 21(2), 129-149. https://doi.org/10.1016/S0272-6963(02)00108-0

Shingo, S. (1985). A revolution in manufacturing: the SMED system. Cambridge, Ma: Productivity Press Inc.

Sivasankar M., Dhandapani N., Manojkumar S., Karthick N., Raja K. & Yuvaraj J. (2011). Experimental verification of Single Minute Exchange of Dies (SMED). Recent Research in Science and Technology, 3(3), 92-97.

Stone, K. B. (2012) Four decades of lean: a systematic literature review. International Journal of Lean Six Sigma, 3(2), 112-132. https://doi.org/10.1108/20401461211243702

Trovinger, S. C. & Bohn, R. E. (2005). Setup Time Reduction for Electronics Assembly: Combining simple (SMED) and IT-based methods. Production and Operations Management Society, 14(2). https://doi.org/10.1111/j.1937-5956.2005.tb00019.x

Ulutas, B. (2011). An application of SMED Methodology. International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering, 5(7), 1194-1197.

Worley, J. M. & Doolen, T. L. (2006). The role of communication and management support in lean manufacturing implementation. Management Decision, 44(2), 228-245. https://doi.org/10.1108/00251740610650210

Yoo, S. H. & Seo, Y. W. (2017). Effect of supply chain structure and power dynamics on R&D and market performances. Journal of Business Economics and Management, 18(3), 487-504. https://doi.org/10.3846/16111699.2017.1326979

Contact information

Ing. Kateřina Gálová
Tomas Bata University in Zlín, Faculty of Management and Economics
nám. T. G. Masaryka 5555, Zlín
+420 737 681 718
kgalova@utb.cz
ORCID: 0000-0002-5639-6281