RESEARCH IN LOGISTICS & PRODUCTION

APPLICATION OF SMED METHODOLOGY IN A PRINTING-HOUSE

Irena Pawłyszyn*, Agnieszka Stachowiak* and Łukasz Hadaś*

* Faculty of Engineering Management, Poznan University of Technology, Poznan, 60-965, Poland,
Email: irena.pawlyszyn@put.poznan.pl
Email: agnieszka.stachowiak@put.poznan.pl
Email: lukasz.hadas@put.poznan.pl

Abstract Implementation of Lean Management striving for elimination of all the waste in business units becomes more and more important and even necessary in industrial companies, as well as in service providing organizations. The following paper is focused on analysis of a setup process in polygraph industry with application of one of the most common Lean tools – SMED. As in printing-houses times of setup is usually much longer than time of production, analysis of a setup process seems to be crucial for efficiency of printing process. Hence, the following paper includes brief description of Lean approach and introduction of its goals, as well as presentation of SMED methodology in scientific literature. In its second part it presents main ideas of SMED methodology and description of its stages. The next part of the paper provides presentation of the real process of setup in the analyzed company.

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1. INTRODUCTION

Competitiveness, globalization, changing demand and fashion continuously cutting down lifecycle of products drive companies to customization of their products which is adjusting products to specific needs of customers. This approach is inherently connected with volatility of logistics processes within the company. This variability, driven by a desire to meet the needs of the maximum number of clients entails increasing transport costs, personnel, machinery, inventory, etc. Customized products, complex structure, expectations for customer service and a strong emphasis on minimizing costs to meet these requirements, leads to innovative solutions such as improved organizational structures, improved logistics networks and supply chains, or leaning process (*Lean Management)* (Wiśniewski, 2011, pp. 20-21). *Lean Management* is one of strategies (the other is *Agile Management*), dominating contemporary production management (Głowacka-Fertsch & Fertsch, 2004, p. 16). Lean Management, is the result of relentless efforts to eliminate all types of waste, provides for the inclusion in the improvement of business processes of each employee and the maximum customer orientation (Крот, 2011, p. 212). Typically, the losses are incurred defects, unnecessary processing steps, overproduction, transportation, unjustified processes engaging unnecessary equipment and improper delegation of tasks and levels of unauthorized persons (Emiliani, 2002, pp. 615-631). Any waste is a source of cost. Businesses are looking for ways to enable the reduction of costs as well as the time of production, in order to improve the efficiency of production processes and increase product quality. Lean is accompanied by a number of tools to achieve these goals. One of them is SMED (*Single Minute Exchange of Die*), which is a team process, reducing machine setup time, which increases the time available for production and at the same time reduces the size of a production batch, the quantity of inventory, lead time, and as a result will reduce production costs (Predoń & Raszka, 2010). The nominal duration of the changeover is a maximum of 10 minutes. In other words, SMED is a quick changeover of machines. Long times of changeovers in enterprises are mainly due to (Bednarek, 2007, p. 87):

- Organizational chaos in manufacturing departments (lack of documentation, lack of proper equipment or operating procedures);
- Switch the machinery off, not only for changeover of the machine, but also during the execution of tasks that are necessary to overcome the existing organizational mess.

SMED was developed in the 50-60 of the twentieth century by Shigeo Shingo - employee of Toyota, - for whom the plant manager Taiichi Ohno set a task to improve the productivity of Toyota. Shigeo Shingo developed the methodology which made it possible to produce in smaller batches, and was the basis for the operational inventory reduction (Shingo, 1983). Quick changeover is key to manufacturing flexibility, as well as a response to the demands of the ever-changing needs.

2. ASSUMPTIONS OF SMED

As SMED is one of the tools of Lean, which is aimed at eliminating waste, it presents three main reasons for reduction of changeover time (Bamber, 2000, pp. 291-298): (1) Flexibility – to be able to respond very quickly to changing market demands, there is need to be able to produce small lot sizes in an a economical way; (2) Bottleneck capacities – reducing set-up times increases the availble capacity,which can be interesting as an alternatives to buying new equipment or installing an extra shift in situations where the market demand increases; (3) Cost reduction – since, especially on bottlenecks,the direct production cost is related to machine performance, an OEE (*Overall Equipment Effectiveness*) can easily show the impact of setup reduction.

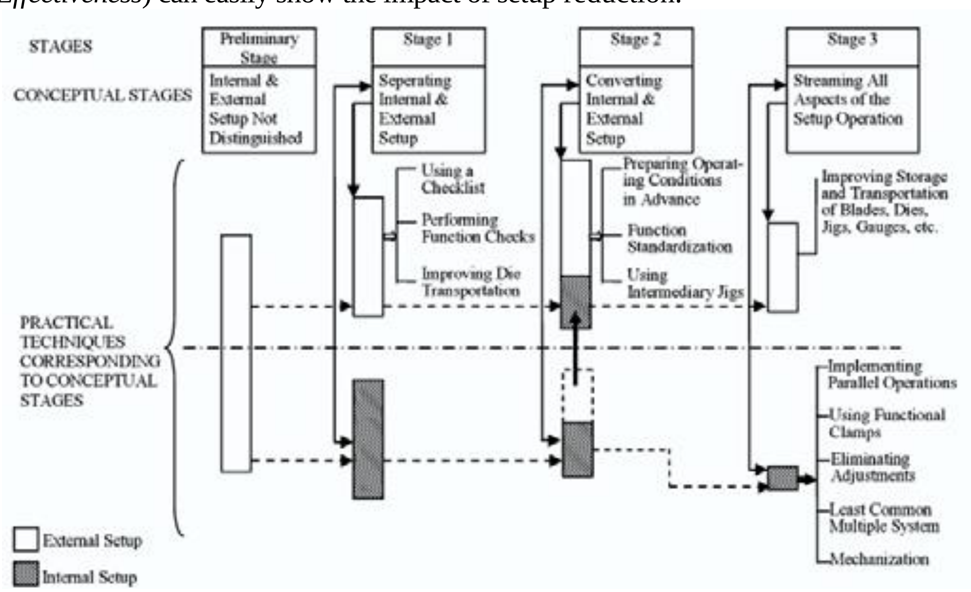

Fig. 1 SMED conceptual stages and practical techniques (Ulutas, 2011, p. 101)

It is important to discuss some of the basic concepts involving the SMED, namely, setup time, following internal and external activities. Thus (Koziar, 2005, p. 35), (Pawłowski, Pawłowski & Trzecieliński, 2010, p. 36):

- Changeover time - the time of the last of the good product A, the first good product B;
- Internal activities during the changeover to these activities, which are performed during machine downtime, or more - after finishing a good part A and before manufacturing good part B. Internal setup time also includes start time, start-up and achievement of the standard output;

- External activities are those activities that are carried out before the changeover and after the changeover. These are actions which may be performed during operation of the machine / line.

Rapid tool change is a critical factor for companies that want to use JIT or Single-piece-flow because it allows, in a short time, adjust the machine to the new conditions (Czerska, 2010). The main reason for the long changeover times is the lack of separation of internal operations retooling from external actions. A lot of activities that can be done with the machine turned on, are made only after a stop (Productivity Press, 2009, pp. 43-44). To shorten the time for retooling, Shigeo Shingo distinguished several important steps of SMED outlined below (Trietsch, 1992, p. 10) (Fig. 1): 0. Preliminary stage: internal and external setups are mixed; 1. First stage: separate internal and external setups; 2. Second stage: convert internal setup to external setup; 3. Third stage: streamline both internal and external setups.

The stages are to be briefly discussed below (Shingo, 1983).

Preliminary stage: internal and external setups are mixed. The first step SMED methodology is to consolidate the process of conversion to the camera, and then on the analysis of collected material. This step is also called stage zero due to the fact that at this stage any physical improvement of the process is not made, and it is only dedicated to indepth analysis of the process, including the content of the various steps of the process retooling and analysis of the resources required for retooling the machines.

First stage: separates internal and external setups. This step of SMED methodology is often regarded as the most important, and the correct operation reduces changeover up to 30-50% compared to baseline. The primary objective of this stage is a clear distinction between internal and external retooling and elimination of all measures that unnecessarily prolong the changeover.

Second stage: converts internal setup to external setup. The primary objective of this step is to change as many retooling operations as possible, from internal to external. The intention is to lead to a situation when the downtime of retooled machine or process is as short as possible, and thus the production of another type of product will begin immediately. This step gives an average of about 25% further reduction in the duration of the changeover in relation to the initial state.

Third stage: streamlines both internal and external setups. The last step of SMED methodology is action aimed at the greatest possible reduction in the duration of internal operations that could not be eliminated in step 1, or converted into external operations in step 2. This step improves changeover but has the least potential to significantly shorter changeover times and usually requires incurring more substantial funding for improvements, but also offers valuable solutions and tools that can help simplify the process of retooling. The potential of the third stage of SMED yet is often 10% reduction in changeover time.

Please note that in the process of shortening the time changeovers should be involved primarily the employees themselves. For this purpose, chief executives should create the right conditions for them to read the SMED methodology by organizing training and / or familiarization workshops.

3. CHARACTERICTICS OF CHANGEOVERS IN A PRINTING HOUSE – A CASE STUDY

The company, which has been analyzed is located in Poland. One of the departments of the company is printing all kinds of stickers, tags, sheets, etc. Printing identification in this organization is flexographic. The company is focused on innovation, and open to new technologies and concepts, such as Lean Management. Based on the above, an attempt to analyze the process of retooling machinery in order to simplify and speed up the process.

Characteristics of the production process in the printing is quite specific. The operator, upon receipt of a list of production orders himself, starting from his own experience and knowledge, based on the date of execution, color, width, material, etc. sequence of executed orders. The order is primarily dictated by the time of set-up, which is usually several times longer than the time to print the final product. Often, however, there are situations when the machine setup time to print two-or three-color over time, and the print lasts even longer than a few minutes. Under such conditions, reduction of setup times is a critical point in the production process. It is worth mentioning that in the analyzed company changeover takes one person - an operator that supports the machinery.

The analysis started from the observation of the whole process of retooling the machine (preliminary stage). The actions performed by the machine operator are listed, as each step took time, and specification whether the activity is an internal or external, as well as whether it adds value to the process. The list of activities is summarized in Table 1.

After counting it all up machine setup time was 2120 seconds, or 35 minutes and 20 seconds. However, in this analysis includes only the time spent to perform various tasks. The actual total setup time was 51 minutes and 30 seconds. This means that 16 minutes and 10 seconds of his time, employee devoted to walking. Therefore the path traveled by the employee during the set-up was examined and presented with the Spaghetti diagram (Fig. 2).

As it can be seen in the picture above the route employee crossed in the course of the changeover is quite long and often repetitive. In the figure, as well as a table the time that the operator spends on the search for raw materials in the warehouse and bringing it into the workplace is not included. But because they did not postpone the raw material to the warehouse after previously carrying out the order, the employee does not have to perform data operations. Conversely, the duration of retooling would be longer for another few minutes. Given that the production of a given production order took only 1 minute and 15 seconds, need to shorten changeover time becomes obvious.

Table 1 Operations in changeover process, own work

Nr	Operations	Value adding?	Time	Internal./External.
1	Stock form cylinder with the polymer of the machine	Yes	45 sec	I
2	Extrusion die and position it in its place	Yes	45 sec	I
3	Check the label number, finding the label in a notebook and read the technical data, counting the number of printed items	Yes	120 sec	E
4	Pulling the inking set out of the machine	Yes	230 sec	I
5	Preliminary purification and metering of anilox shaft	No	30 sec	I
6	Insert the correct anilox	Yes	20 sec	I
7	Cleaning the anilox	Yes	35 sec	I
8	Merging paint from ink bottle	Yes	180 sec	E
9	Washing parts of inkwell and metering shaft	Yes	120 sec	E
10	Inserting the cleaned parts to the machine	Yes	40 sec	I
11	Pre-cleaning the ink bottle	Yes	120 sec	E
12	Putting paint on its place	No	5 sec	E
13	Inserting the ink bottle to machine	Yes	5 sec	I
14	Search for paint	No	30 sec	E
15	Shaking the paint	Yes	10 sec	E
16	Metering shaft splines to anilox	Yes	20 sec	I
17	Pouring paint into the inkwell	Yes	24 sec	I
18	Placing anilox metering shaft and protecting it	Yes	5 sec	I
19	Inserting and setting the blade	Yes	20 sec	I
20	Choosing and cleaning of the printing roller	Yes	20 sec	E
21	Inserting the printing roller to machine	Yes	10 sec	I
22	Washing hands	Yes	25 sec	E
23	Stock previously used punch from magnetic cylinder	Yes	75 sec	E
24	Sticker on the proper punch on magnetic cylinder	Yes	80 sec	E
25	Stock material from the machine	Yes	38 sec	I
26	Inserting the correct material and putting it on the machine	Yes	75 sec	I
27	Stocking openwork	Yes	3 sec	I
28	Providing the printing roller	No	60 sec	I
29	Inserting a punch and providing its security	Yes	120 sec	I
30	Measuring the width of the blade settings to determine the appropriate values of cutting	Yes	120 sec	I
31	Taping undercut knives on the magnetic cylinder	Yes	150 sec	I
32	Insertion of a magnetic cylinder with knives to the machine	Yes	30 sec	I
33	Inserting a paper urging the shaft to the blade	Yes	30 sec	I
34	Preparation of openwork	Yes	40 sec	I
35	Tuning die	No	20 sec	I
36	Preparation for the actual production (taking off the roll of the device and setting the proper reel)	Yes	120 sec	I

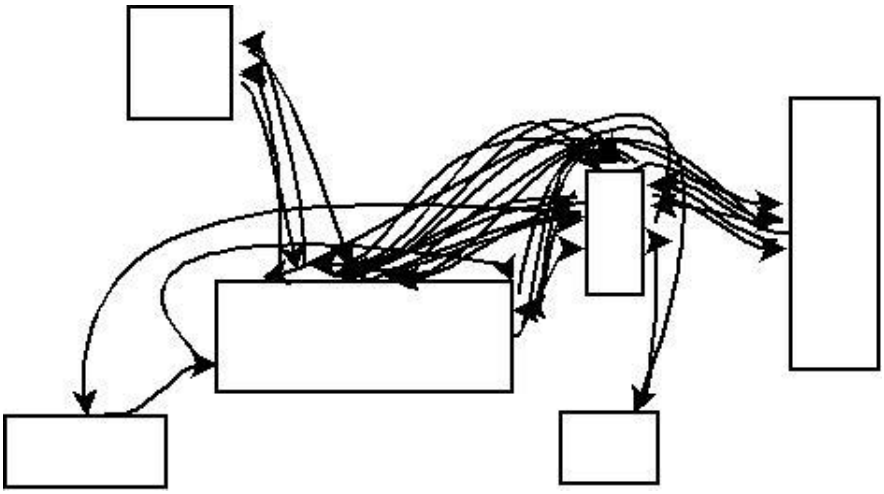

Fig. 2 Spaghetti Diagram before changes implementation, own work

4. SUGGESTED IMPROVEMENTS

Idea of the philosophy of production, according to Lean Management, is to reduce the production cycle by streamlining the flow of material through the value stream (Standard & Davis, 1999, p 73). SMED methodology, inclusive of four stages to shorten changeover time machine will serve as a basis for analysis of the performance of the operator and to continue as a basis for improving the demar-cation lines of set-up process.

Analyzing the performance of the staff during the changeover, in Table 1, the allocation of tasks performed on the exterior and interior of the SMED methodology, according to the first stage. Mentioning these activities gives the opportunity to sum up how much time can be saved by doing external activities while the machine is operating. The time spent on external activities amounted to 785 seconds, or 13 minutes and 5 seconds, which is equivalent to shortening changeover time by 37%. Note that in this case walking has not been included, which was related to the implementation of each external activity. Taking this time into account, the percentage of shortening changeover time would be even higher.

Worth stressing is that, if the company does not have bugs detection system (Jidoka), the operator is obliged to continuous supervision of print and - in the case of a defect -immediate reaction. Hence the separation of external actions in the above analysis is theoretically possible, but likely to prejudice the quality of products (eg, by omission occurring defects). Therefore, the best solution is to set up the machine operator helper that will not only be in a position to do external activities, but also improve the performance of internal operations, taking about 60% of time.

While the purpose of the second phase of the SMED methodology is leading to situations where downtime of retooled machine or process is as short as possible, it is proposed to perform this task of internal division among the two employees: machine operator and his assistant. The following table (Table 2) shows, therefore, the division of their operations, which are to be performed in parallel by two employees.

Table 2 Classification of internal operations (Ulutas, 2011, p. 101)

Employee	Numbers of operations perfomed	Time
Operator	1, 2, 21, 25-36	906 sec = 15 min 6 sec
Assistant	4-7, 10, 13, 16-19	429 sec = 7 min 9 sec
	Difference	477 sec = 7 min 57 sec

Operations are classified according to the part of the machine that is supported. The operator supports a front, and side part where the inking team work is supported by assistant operator. This division of responsibilities is to shorten the routes that employees travel at the same time eliminating unnecessary walking, associated with the waste of time. The time difference will enable at very short time of production (such as in this case) balancing the duration of the internal activities of the operator with internal and external activities, performed by assistant operator. In Figure 3, the internal activities, carried by the operator are indicated by constant arrows, while those that fall within the scope of assistant – by dotted (Fig. 3). Clear improvement over the previous situation can be seen (Fig. 2).

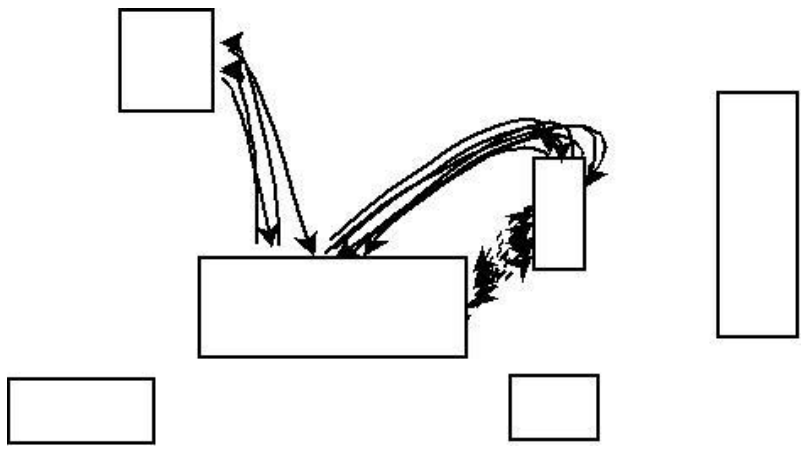

Fig. 3 Spaghetti Diagram after implementation of changes, own work

Although the setup time is shortened much by dividing responsibilities between the two employees, still the time will be quite long compared to the time of production. In this case, it is worth considering how to reduce the duration of the internal and external activities (step 3). Workers directly in contact with the machine working should be primarily involved in this process.

At this stage, it becomes clear that more lean management tools such as 5S or Kaizen could be used. 5S as a tool which aims to create a well-organized and orderly workplace (Gapp, Fisher & Kobayashi, 2008, p 567), it can shorten the time of searching for paints, punches or label designs in a notebook. Kaizen, in turn, means continuous improvement involving any wszystcy, both managers and line employees (Imai, 2007, p. 35). Minor enhancements associated with Kaizen can reduce the time and even eliminate activities such as die-tuning, security screws for anilox construction, etc. These and other tools of Lean in a consistent manner should be continuously reducing changeover time in a printing house.

5. CONCLUSION

Lean management as a management approach affecting especially operations and logistics has become important and proven for a variety of industries optimizing firm´s processes and performance indicators like costs, delivery service and quality (Bode & Mueller, 2012, p. 354). The goal of the manufacturing companies is the need to focus on operations, because basic attributes of their competitiveness depend first of all on management of this sphere (Lisiński & Ostrowski, 2006, p. 232).

Among the wide range of methods, techniques and tools used in Lean implementation in industrial enterprises (Moulding, 2010), (Ortiz & Park, 2011), (Rother & Shook, 2009), (Shimbun, 1988), (Willmott & McCarthy, 2001), (Louis, 2006), it was noted that SMED methodology that aims to achieve the shortest possible changeover time is extremely helpful in the printing industry. Taking into account the implementation of the range of activities necessary to start the machine before the next production order, an analysis, based on the four stages of the methodology for fast changeovers is the most efficient option. This analysis showed that the suggested simple solutions would significantly improve the process of retooling machines. After analyzing this process, the proposed employment of an employee who would assist the machine operator is the obvious solution. It is obvious to bear the costs of employment of such employee, as well as wage costs. However, these costs are not comparable to the costs resulting from loss of time, as consequence of long retooling of machines. In addition, the reduction in changeover time of printing will be clearly reflected in faster execution of client orders, as well as increase of their satisfaction.

The basis for all activities in the process of eliminating waste is the right attitude that will strengthen the ability to see waste (Productivity Press, 2008,

p. 65). Hence, it becomes undeniable that interest and the full involvement of employees in the improvement of business processes is crucial for success. Part of the team leader's role will be to understand the mechanics of the overall improvement process, Including That of the tools might be used and techniques That can be applied (Culley, Mileham, McIntosh & Owen, 2001, p 219). According to the analysis of the setup time is reduced to about 15-20 minutes, which is not a desirable result by SMED. Finding ways to improve internal operations is another high priority being placed on employees of a company.

The final step of SMED methodology should be standardization of activities performed. It will ensure the orderly execution of activities, which are currently the best method of work, while controlling their duration. Documenting them in a practical way is the foundation of excellence: stabilizes the process so that it can be monitored and meaningful conclusions can be drawn, clearly showing the waste in the process and facilitating fast and efficient learning of employees (Jakubik, 2010, p. 7). Please note that the standards adopted in the work not only can, but should be extended and improved by the employees of the organizations working in the area.

REFERENCES

Bamber L., Dale B.G., (2000), "Lean prouction: A sudy of application in a traditional manufacturing environment", Prod Plan Control, Vol 11, no. 3.

Bednarek M., (2007), Doskonalenie systemów zarządzania. Nowa droga do przedsiębiorstwa lean, Wyd. Difin. Warszawa.

Bode A., Mueller K., (2012), "Lean cooperation: learning to be lean", Research in Logistics & Production, Vol. 2, No.4.

Culley S., Mileham A., McIntosh R., Owen G., (2001), "Improving changeover Performance. A strategy for becoming a lean, responsive manufacturer", Butterworth-Heinemann.

Czerska J., (2010), „Skrócenie czasów przezbrojeń", available at: www.leanmanufacturing.pl (accessed 03 August 2013).

Emiliani M.L., "Lean behaviors", Manage Decisions 36(9), 2002.

Gapp R., Fisher R., Kobayashi K., (2008), "Implementing 5S within a Japanese context: an integrated managament approach", Management Decision, Vol. 46 (No. 4).

Głowacka-Fertsch D., Fertsch M., (2004), „Zarządzanie produkcją", Wyd. Wyższa Szkoła Logistyki, Poznań.

Imai M., (2007), "Kaizen, Klucz do konkurencyjnego sukcesu Japonii", Wyd. W.L. Anczyca, Warszawa.

Jakubik M., (2010), „Praca standaryzowana – trudne, lecz skuteczne narzędzie lean manufacturing", Konferencja Trade Media: Lean w produkcji i łańcuchach dostaw, Warszawa, available at: www.seminaria.trademedia.us (accessed 11 Audust 2013).

Koziar B., (2005), „Warsztaty SMED jako najlepszy sposób redukcji czasu przezbrojeń maszyn i urządzeń", [in:] Zarządzanie jakością, Vol. 2/2005 (2).

Крот Ю.В., (2011), „Непродуктивні витрати: визначення та зміст", Науковий вісник ЧДІЕУ, Управління підприємством, №4 (12).

Lisiński M., Ostrowski B., (2006), „Lean Management w restrukturyzacji przedsiębiorstwa", Wyd. Antykwa, Kraków.

Louis R.S., (2006), “Custom Kanban. Designing the System to Meet the Needs of Your Environment”, Productivity Press, New York.
Moulding E., (2010), “5S. A Visual Control System for the Workplace”, AuthorHouse, Central Milton Keynes.
Ortiz C.A., Park M.R., (2011), “Visual Controls. Applying Visual Management to the Factory”, CRC Press Taylor & Francis Group, New York.
Pawłowski E., Pawłowski K., Trzcieliński S., (2010), „Metody i narzędzia Lean Manufacturing”, Wyd. Politechniki Poznańskiej, Poznań.
Predoń B., Raszka A., (2010), "Efektywne przezbrajanie, czyli SMED w praktyce przemysłowej", available at: www.jakosc.biz (accessed 01 August 2013).
Productivity Press Development Team, (2009), „Быстрая переналадка для рабочих”, Институт комплексных стратегических исследований, Москва.
Productivity Press Development Team, (2008), „Identyfikacja marnotrawstwa na hali produkcyjnej”, Wyd. ProdPress.com, Wrocław.
Rother M., Shook J., (2009), „Naucz się widzieć” (wydanie drugie), Wyd. Lean Enterprise Institute Polska, Wrocław.
Shimbun N.K. (ed.), (1988), “Poka-Yoke. Improving Product Quality by Preventing Defects”, Productivity Press, New York.
Shingo S., (1983), “A Revolution in Manufacturing: The SMED System”, Productivity Press, Stamford, CA.
Standard C., Davis D., (1999), “Running today’s factory. A proven strategy for Lean Manufacturing”, Society of Manufacturing Engineers, Dearborn, Michgan.
Trietsch D., (1992), „Some notes on the application of Single Minute Exchange of Die (SMED)”, Naval Postgraduate School, Monterey, California.
Ulutas B., (2011), „An application of SMED methodology”, World Academy of Science, enginee-ring and Technology 55.
Willmott P., McCarthy D., (2001), “TPM – A Route to World-Class Performance”, Butter-worth-Heinemann, Oxford.
Wiśniewski K., (2011), “Globalizacja wyzwaniem dla logistyki”, Eurologistics, Paździer-nik-Listopad 2011, Vol. 5/2011 (66).

BIOGRAPHICAL NOTES

Irena Pawłyszyn is an Assistant at the Faculty of Engineering Management at Poznan University of Technology. She is also a PhD student at Poznan University of Technology. Her professional interests include Lean Management, Lean tools and clusters. She has published several publications in journals and monographs.

Agnieszka Stachowiak is an Assistant Professor at the Faculty of Engineering Management at Poznan University of Technology. She graduated from Poznan University of Technology in 2001. She received her PhD degree in 2005. Her professional interests include logistics, resources management and artificial intelligence applications.

Łukasz Hadaś is an Assistant Professor at the Faculty of Engineering Management at Poznan University of Technology. Specializes in logistics and procurement and production organization and shop floor control of production processes. Author of about 80 scientific publications in this thematic area, both in national and foreign journals.