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The Application of Single Minute Exchange of Die in the Production Process Improvement

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This paper concerns Single Minute Exchange of Die (SMED) which is one of lean tools applied for reduction of change over time on machines. It is a review paper on the basis of the literature collected from three electronic databases: Elsevier Science, Springer and E-resources from the library of Poznan University of Technology. The retrieved articles were screened following the inclusion/exclusion criteria. After applying the literature selection criteria 40 articles published between the years 2000-2017 were chosen. These papers were classified on the basis of the year of publication, the journal title, the main issue, tools and methods, type and also location. Their analysis revealed that SMED was applied in various range of enterprises in order to reduce time of setups and eliminate unnecessary activities which have no value for the process. It was also a useful tool for production process improvement as it may support lean tools in order to increase the process efficiency. The vast majority of papers was published in European countries. However, the increasing number of publications in recent years may suggest the increase of interest in this subject in different areas.

Keywords: lean, process improvement, Single Minute Exchange of Die.

1. INTRODUCTION

Nowadays, the quickly changing environment forces companies to increase their competitiveness using various methods and tools which are helpful in quality improvement. They have to offer the best possible products and service to develop and improve their market position. In order to achieve that, it is possible to implement Lean Manufacturing which is an innovative concept of business management, used especially in the restructuring process. It is a management methodology that creates such a work culture in an organization which makes all employees interested in a constant reduction of costs, improving the quality level and shortening the cycle of delivery. This concept emphasizes the elimination of wastes such as overproduction, motion, waiting, transportation, inventory, defects, over-processing, not-utilized talent and unsafe or ergonomic working conditions. It originates from the practice in a Japanese company Toyota whose international expansion and excellent economic results have led to the popularization of this conception (Wyrwicka, Zasada, 2014; Wyrwicka & Mrugalska, 2017). According to Womack and Jones (1990) the implementation of Lean Manufacturing should be based on the following principles:

- definition of value-added activities from the customer point of view,
- organization of all value-added activities according to value stream,
- establishment of smooth and continuous flow of values through the value stream,
- implementation of a system which enables value stream to react to customers' needs,
- continuous improvement (Koch, 2011).

It is often used with other methods and tools, such as 5S, Total Production Maintenance (TPM), Single Minute Exchange of Die (SMED) or standardization, in order to improve the process efficiency and eliminate unneeded activities (Mrugalska et al., 2019).

Over the last few years SMED is getting more and more popular in production companies from different industries. It is a relatively low-cost and

commonly available method which may bring many profits to enterprises. It has to be reduced only to one single digit of minutes, but any changes in decreasing the time will have a positive impact on the process improvement. The idea is to define external and internal activities during process of setups, eliminate external ones and then focus of minimizing the internal ones (Shingo, 2017; Robinson, 2017).

SMED is a method used to reduce the time needed for changeovers and setups of the machines. Single minute means that the time needed for a setup is with a single digit. However, it may be sometimes impossible to shorten the time to less than 10 minutes, it was noticed that each application of SMED results in very big shortening and simplifying of the process. According to Shigeo Shingo, SMED is the most effective method to achieve a Just-In-Time production (Shingo, 2017). The effectiveness of this method was proven many times, especially in a manufacturing sector while reducing the time needed for changeover from hours to minutes (Grzybowska & Gajdzik, 2012; Moreira & Garcez, 2013).

SMED is based on a simple division of every operation connected with an internal and external changeover. The internal changeovers are all the activities that have to be performed when the machine is switched off, for example replacement drill chuck, while external changeovers are these activities which may be performed before stopping the machine or after the restart of the process for the changeover on the production to a new product type. The analysis and the process of shortening the changeover usually start from an internal changeover. It may be observed that a bigger amount of improvements can be performed in the phase of preparation for a changeover as well as during a test run. The very first step is about recording the changeover to deeply analyze the whole process and make a specific documentation. The analysis should be performed in a group of specialists in the organization, such as a machine operator, manager of the department, Lean Management group member, health and safety manager etc. (Ulutas, 2011).

The most important benefits of shortening changeover time by using the SMED method are:

- greater flexibility of production by reducing the production batch which result in more rapid response to changing customer order - in consequence it causes an increase of customer satisfaction level,
- reducing inventory levels and raw materials, work in progress and finished products,
- higher productivity of changeover machines and processes,
- raising the standards of organization at the work station during changeover by of process and all equipment,
- improving financial liquidity by shortening the time the product passing through the organization,
- better control of changeover processes which results in raising work standards and stability of processes (www.lean.org.pl/smed-czyli-skracanie-czasowprzezbrojen-maszyn-i-urzadzen).

According to Shingo, setup procedures are varied depending on the type of operations and equipment. However, general rules of a setup process consist of:

- Preparation – it is important to ensure that all components are in the correct places and prepared for the process.
- Removing tools and parts – before starting to produce the next lot, all unnecessary tools and parts have to be removed.
- Settings and measurement – it is essential to measure all production operations such are dimensioning, measuring temperature in order to run the production process.
- Checking – this step will be easier if settings and measurements were performed in a correct way (Shingo, 1985; 2017).

2. THE SCOPE OF THE RESEARCH AND THE METHODOLOGY

In order to perform the review of the SMED method used in practice, the articles from the years 2000-2017 have been chosen. They were found in the following databases:

- Elsevier Science
- Springer
- E-resources from library of Poznan University of Technology

In these international databases there may be found articles published in different languages, however, for the purpose of the analysis only papers in English have been chosen. The selection has been made on the basis of the relevant topic found by keywords. The keywords, which were

used in order to find related articles, were the following:

- SMED
- Single Minute Exchange of Die
- SMED methodology
- SMED method
- SMED in production enterprises
- Lean manufacturing
- Lean tools
- Process improvement
- Process development

The main criterion taken into consideration while choosing the papers was utility and practical application of the method in enterprises and different areas of businesses. They contain scientific topics from various branches, such as engineering, management, economics and others.

3. LITERATURE ANALYSIS

The analyzed papers were classified according to the year of publication and journal title, main issue contained in the article, tools and methods, type and location (Table 1). They were ordered in a chronological way. Most of them were published in European countries, but there are also some from Asia and South America. They presented case studies, however some of them were based on questionnaires or interviews. The main issue concerned the SMED method implemented in enterprises referred to reduction of the changeover time. This method was also combined with other lean tools such as Just in Time or 5S.

The analysed papers were published between the years 2000-2017, however it is worth to emphasise that the number of them has been growing recently. It appeared that 50% of articles were released in the last two years (2016-2017). They mainly (26 papers) represented the state of art in European countries and 14 papers were from other regions, mostly from South America. It shows the world-wide application of this method. In 28 articles SMED was also combined with other lean management tools such as Pareto diagram, Six Sigma, Kaizen or QFD. The papers mainly discussed case studies in particular regions, and rarely interviews or questionnaires were applied in companies.

Authors	Journal Title	Main issue	Tools & methods	Type	Location
Moxham, Greatbanks (2000)	International Journal of Quality & Reliability Management	Discussed requirements of SMED practical implementation in textile environment	Requirement for implementation SMED - SMED ZERO	Case study	United Kingdom
Władysiak (2007)	Archives of Foundry Engineering	Applying SMED method on casting machines	SMED, Kanban	Case study	Poland
McIntosh *et al.* (2007)	IEEE Transactions of Engineering Management	Interpretation of SMED method	SMED	Research	United Kingdom
Peter (2010)	Papers of 34th International Electronic Manufacturing Technology Conference	Application of SMED in semiconductor manufacturing	SMED	Case study	Malaysia
Hodge *et al.* (2010)	Production Planning & Control	Implementation of lean manufacturing in textile environment	Lea manufacturing, VSM	Case study, interviews	USA
Simoes, Tenera (2010)	Management and Control of Production Logistics	Integrating classical industrial engineering techniques and SMED's reducing setup time principle	SMED	Case study	Portugal
Ulutas (2011)	International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering	Standard procedure for changeover operations using SMED	SMED	Case study	Turkey
Norzaimi, Sollahuddin (2012)	International Journal of Sciences: Basic and Applied Research (IJSBAR)	Implementing SMED and eliminating wastes in order to improve the productivity on the CNC machine process	SMED	Case study	Malaysia
Dhake, Rajebhosale (2013)	International Journal of Lean Thinking	Practical application of SMED on printing machine	SMED	Case study	India

Ferradas, Salonitis (2013)	Procedia CIRP	Improving changeover in welding cells	SMED	Case study	United Kingdom
Teran-Somohano, Smith (2013)	2013 IEEE Congress on Evolutionary Computation June 20-23, Cancún, México	Application of SMED in automotive industry using metaheuristic algorithm	SMED, lean manufacturing	Case study	USA
Jezierski, Janerka (2013)	Archives of Metallurgy and Material	Research about using lean manufacturing tools in manufacturing enterprises	5S, SMED, JiT, Kanban, Kaizen, TPM, benchmarking	Questionnaire, research	Poland
Djekic*et al.* (2014)	Organizacija, Volume 47 Special Theme: Application of Quality Management	Implementation and its effects of lean manufacturing in production company	5S, Visual control, PokaYoka, SMED, JiT, TPM	Case study	Serbia
Hashemzadeh*et al.* (2014)	Management Science Letters	Factors influencing SMED implementation in plastic injection industry	SMED, VIKOR	Case study	Iran
Pinjar*et al.* (2015)	International Journal of Scientific and Research Publications	Implementation of SMED on specific production machines	SMED, lean tools	Case study	India
Azizi, Manoharan (2015)	Procedia Manufacturing	Designing Value Stream Mapping	VSM, SMED	Case study	Malaysia
Mendez *et al.* (2015)	IFAC – Conference Paper Archive	Methodology of SMED and JIT	Just in Time, SMED, Kanban	Case study	Mexico
Alhuraish*et al.* (2015)	Materials of IESM Conference, October 2015, Seville, Spain	Proving that using lean manufacturing and six sigma is beneficial to companies	Six Sigma, SMED, 5S, Kaizen, Visual control	Questionnaire, research	France
Migza, Bogacz (2015)	Przeglądgórniczy	Using lean management methods in mining industry	Lean Manufacturing	Case study	Poland
Lipiak (2016)	Procedia Engineering	Factors affecting quality in printing industry	SMED, QFD	Case study	Poland
Filla (2016)	Journal of Competitiveness	Applying SMED to high-mix processing line in flat glass company	Pareto analysis, SMED	Case study	Czech Republic
Dombrowski et al. (2016)	Procedia CIRP	Research on different approaches of lean production systems	Lean tools, SMED	Research	Germany
Skotnicka-Zasadzień, Masoń (2016)	Zeszyty naukowe Politechniki Śląskiej, Organizacja i Zarządzanie z. 87	Using SMED to improve changeover process in steelwork	SMED	Case study	Poland
Diaz-Reza et al. (2016)	Sustainability 2016, 8, 1237; doi:10.3390/su8121237	Research in 373 Mexican companies about SMED implementation	SMED, lean manufacturing	Questionnaire, research	Mexico
Gadeet al. (2016)	International Journal of Scientific & Technology	SMED implementation at the automobile workshop	SMED	Case study	India
Rorizet al. (2017)	Procedia Manufacturing	Quality improvement in cartoon company	Lean tools for quality improvement	Case study	Portugal
Lozano et al. (2017)	Agric. Econ. – Czech	Management of spare parts connecting with supply chain management	SMED, supply chain management	Case study	Spain
Brito et al. (2017)	Procedia Manufacturing	Ergonomics and SMED in production area	Ergonomic, SMED	Case study	Portugal
Chen et al. (2017)	Procedia Engineering	Six Sigma, DMAIC cycle, SAP and SMED application	Six Sigma, DMAIC, SMED	Case study	China
Rosa et al. (2017)	Procedia Manufacturing	SMED used in automotive industry	SMED	Case study	Portugal

Oliveira et al. (2017)	Procedia Manufacturing	Suggestion of few lean tools which may be implemented in the company producing mechanical equipment	VSM, SMED, TMP, lean tools	Case study	Portugal
Mustafa (2017)	Procedia Manufacturing	Optimization of changeover process on production line	SMED, Virtual simulation	Case study	United Kingdom
Castro et al. (2017)	Procedia Manufacturing	Implementation and optimization of automatic system in automotive industry	Lean tools	Case study	Portugal
Lucherini, Rapaccini (2017)	Journal of Industrial Engineering and Management	Simulation of lean manufacturing implementation in SMED	VSM, JIT, SMED, CELLMFG	Case study	Italy
Sabadkaet al. (2017)	Advances in Science and Technology Research Journal	Proving that SMED implementation is important in Shaft manufacturing industry	SMED, Pareto	Case study	Slovakia
Ahmad, Soberi (2017)	Int J AdvManufTechnol (2018) 94:433–450	Advanced implementation of SMED in manufacturing industry	SMED	Case study	Malaysia
Jaroszewicz*et al.* (2017)	Zeszyty Naukowe Politechniki Śląskiej, Organizacja i Zarządzanie z. 100	Application of SMED on milling machine using recorded film	SMED, Gantt diagram	Case study	Poland
Nowakowska-Grunt, Salek (2017)	Advanced Logistic Systems	SMED as the method of streamlining warehouse processes	SMED	Case study	Poland
Kowal, Knop (2017)	ZeszytyNaukowePolitechnikiCzęstochowskiej	SMED implementation in automotive industry and its advantages	SMED, diagram spaghetti	Case study	Poland
Desai,Rawani (2017)	ARPN Journal of Engineering and Applied Sciences	Improving productivity in automobile industry using SMED methodology	SMED, productivity improvement, Kaizen	Case study	India

4. CONCLUSIONS

In spite of the fact that the SMED methodology was developed in the previous century, the interest in its practical applications has been growing recently. It results from the fact that its implementation has a positive impact on the whole organization as it allows reducing the changeover time, and improving the production process. The analysis of the literature also allowed indicating its applications with other methods and tools which support mainly Lean Manufacturing.

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