Single Minute Exchange of Dies: Literature Review

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ABSTRACT

To survive in cutthroat competition, industries need to reduce production time and costs in order to improve operating performance and flexibility. Single Minute Exchange of Dies (SMED) mainly focuses on recognition of internal and external activities. Accordingly, this article has as its main objective to review the literature addressing this less studied topic: SMED. This paper covers the literature review of SMED tool and purpose of this literature review is to develop an overview of the conceptual framework of SMED tool. The various industrial applications and the existing articles indicate the relevance of the topic and methodology. Flexibility and responsiveness are main pillars of manufacturing, which is operated by demands of greater product variety and improved quality.

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1. Introduction and literature survey

Single Minute Exchange of Die (SMED) is one of the many lean production methods for reducing waste in a manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. This rapid changeover is key to reducing production lot sizes and thereby improving flow. The phrase "single minute" does not mean that all changeovers and startups should take only one minute, but that they should take less than 10 minutes (in other words, "single digit minute"). SMED is the term used to represent the Single Minute Exchange of Die or setup time that can be counted in a single digit of minutes. SMED is often used interchangeably with “quick changeover”. SMED and quick changeover are the practice of reducing the time it takes to change a line or machine from running one product to the next. The need for SMED and quick changeover programs is more popular now than ever due to increased demand for product variability, reduced product life cycles and the need to significantly reduce inventories.

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Historical Background of SMED

Ohno at Toyota developed SMED in 1950. Ohno’s idea was to develop a system that could exchange dies in a more speedy way. By the late 1950’s Ohno was able to reduce the time that was required to change dies from a day to three minutes. The basic idea of SMED is to reduce the setup time on a machine. There are two types of setups: internal and external. Internal setup activities are those that can be carried out only while the machine is stopped, while external setup activities are those that can be done while the machine is running. The basic idea is to make as many activities as possible from internal to external and also concluded that setup reduction is a tool which is universally applicable. There has been lot of work done in detail for the SMED methodology in a textile processing industry and also suggest that the effective implementation of SMED necessitates a number of fundamental requirements, these are: team work, visual factory control, performance measurement, Kaizen and discussed about the role of manufacturing environment in implementation of SMED. The relationship between changeover and production leveling has also been studied and concluded that as the batch size decreases, the cost of each part will increase, since the changeover time will be spread over fewer parts. This leads to high manufacturing costs when changeover times are high and it also discussed the detail changeover analysis and concluded that in making a part, every degree of freedom of the machine must be specified and fixed. SMED is also used as a tool to improve flexibility and the greatest benefit from reduction in changeover time is the ability to produce parts in smaller batches. The relation between SMED and equipment design is also correlated and it indicated that SMED is suitable not only for manufacturing improvement but also for equipment development. SMED tool has been successfully used in the pine factory and empirically the result was reduction in setup time from 45 min to 15 min and underlines the importance of lean in the application of Information Technology to manufacturing. New modified improvement framework for lean implementation has also been proposed and lean implementation has been divided it in to “waves” and put the SMED tool in second wave amongst overall four waves. Shingo states that “SMED can be applied in any factory to any machine”. Work regarding the application of design changes to the changeover process and the balancing of production lines using the set up minimization.

Process of SMED:

1. **Observe the current methodology:** Current procedures generally recorded on video tape of all the changeover process. It covers the complete changeover from one model to another model.

2. **Separate the Internal and External activities:** Internal activities are those that can only be performed when the process is stopped, while External activities can be done while the last batch is being produced, or once the next batch has started.

3. **Stream line the process of changeover:** For each iteration of the above process, a substantial improvement in set-up times should be expected, so it may take several iterations to cross the ten minute line.

4. **Continuous Training:** After the successful first iteration of SMED application the prime requirement becomes the training of all the operator of the cell. Training has been given by cell champion (Master of Changeover). {See Figure 1}
SMED Terms:

- **Adjustment Waste**: Any activities that would cause the machine to cycle in a sample or trial mode which could create a part that must be inspected and then possible scrapped or reworded (Rubrich & Watson, 2004).
- **Batch**: A quantity of items that are processed together (Marchwinski & Shook, 2003).
- **Changeover**: The process of switching from the production of one product or part number to another in a machine or a series of linked machines by changing parts, dies, molds or fixtures, also called a set-up. Changeover time is measured as the time elapsed between the last piece in the run just completed until the first good piece from the process after the changeover (Marchwinski & Shook, 2003).
- **Die Set**: This is the tooling that is removed and replaced in a punch press during a changeover. A die set consists of a set of male punches and female dies which, when pressed together either creates a hole in the work piece or forms the work piece creating features desired by the customer.
- **Downtime**: Production time lost due to planned and unplanned stoppages. Planned downtime includes scheduled stoppages for such activities as shift start up, production meetings, changeovers to produce other products and scheduled maintenance. Unplanned downtime includes stoppages for breakdowns, machine adjustments, material shortages and absenteeism (Marchwinski & Shook, 2003).
- **External Setup**: That part of the setup which can be done while the machine is still running, for example, preparing a die to be used for the next run (Rubrich & Watson, 2004).
- **Internal Setup**: That part of the setup which must be done while the machine is shut down, for example, removing or attaching dies (Rubrich & Watson, 2004).
- **Lean Production:** A system of production that makes and delivers just what is needed, just when it is needed and just in the amount needed. Lean manufacturing aims for the total elimination of all waste to achieve the best possible quality, lowest possible cost and use of resources, and the lowest possible production and delivery lead times (Marchwinski & Shook, 2003).

- **Lot:** A quantity of items that are processed together (Krajewski & Ritzman, 2007).

- **Non-Value Added Activities:** The time spent on activities that add costs but no value to an item from the customer's perspective. These are activities that the customer is generally not willing to pay for (Marchwinski & Shook, 2003).

- **Punch Press:** A machine tool used to work materials (typically steel) by changing the shape of the raw material. Material shape is changed through application of direct pressure which forces the material to change shape. The function of the punch press is to hold the die set and apply the motion and pressure required to perform value added operations to raw materials.

- **Setup:** The process of switching from the production of one product or part number to another in a machine or a series of linked machines by changing parts, dies, molds or fixtures, also called a set-up. Changeover time is measured as the time elapsed between the last piece in the run just completed until the first good piece from the process after the changeover (Marchwinski & Shook, 2003).

- **Setup Reduction:** The process of reducing the amount of time needed to changeover a process from the last part for the previous product to the first good part for the next product (Marchwinski & Shook, 2003).

- **Setup Waste, External:** Activities such as searching, locating or moving jigs, tools, bolts, clamps, fasteners, gauges or instructions in the setup area (Rubrich & Watson, 2003).

- **Setup Waste, Internal:** Alignment activities required to remove and install tools, for example, the time associated with using a fork truck to maneuver the old tool out and the new tool in while setting up a press (Rubrich & Watson, 2004).

- **Shingo, Shigeo (1909-1990):** A consultant to Toyota who made key contributions to the development of the Toyota Production System, especially quick changeovers, SMED and standardized work (Marchwinski & Shook, 2003). The target of reducing changeover times to a single digit, or less than 10 minutes (Marchwinski & Shook, 2003).

- **Value Added Activities:** The time spent on activities that add value to an item from the customer's perspective. These are activities that effectively change the form and function of a raw material into a good or service that the customer is willing to pay for (Marchwinski & Shook, 2003).

- **Value Stream Map:** A diagram that defines each step of the material an information flow needed from initial order of a good or service through delivery (Marchwinski & Shook, 2003).

- **Waste:** Any activity that consumes resources but creates no value for the customer (Marchwinski & Shook, 2003).
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<tr>
<th>Year</th>
<th>Key Events &amp; Publications</th>
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<tr>
<td>1951-1955</td>
<td>Shiego Shingo conducted Efficiency program and developed the genesis of SMED</td>
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<td>1956-1960</td>
<td>A dramatic improvement in setup operation at Mitsubishi Heavy Industries Ltd.</td>
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<td>1961-1965</td>
<td>At Motomachi stamping plant, Toyota’s average die changeover time plunged from over one hour to around 15 minutes in 1962.</td>
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<td>1966-1970</td>
<td>Improved setup change for a 1000 ton press at Toyota motors main plant from 4 hours to 1.5 hour. Systematic technique for achieving SMED is born.</td>
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<td>1971-1975</td>
<td>At M Electric Japan setup time of 150 ton progressive die press reduced from 90 minutes to 9 minutes.</td>
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<td>1976-1980</td>
<td>European Industries started to implement the SMED system.</td>
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<td>1981-1985</td>
<td>1. At Toyota Gosei, Set up time of cold forging machine was reduced from 1 hour 40 minutes to 31 minutes and 15 seconds.</td>
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<td>1986-1990</td>
<td>Mito, Setsuo and Ohno Taiichi published “Why not produce the right part in the right amount at the right time” in 1986.</td>
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Research Methodology:
The literature review is a general method to analyze different aspects of the topic. This paper follows following steps:

Step 1: Literature review of SMED
Step 2: Develop a Classification framework to summarize the review
Step 3: Analyze the review

Step 1: Literature review of SMED:
In past, various research and articles have been published on SMED and its implementation. To accomplish this step, this is based on the consultation of various journals, all of which are related to Lean manufacturing and allied areas. Journals are used because they are the resources that are most commonly used to acquire information and report new findings (Ngai et al, 2008). Literature is searched across following resources:

Journals
1. Business Process Management
2. Gestão &Produção1
3. International Journal of Advance Manufacturing Technology
4. International Journal of systems Applications , Engineering & Development
5. International Journal of Engineering Research & Industrial applications
8. Journal of Technology Management and Innovation
9. Journal of theoretical and applied Information Technology
11. Journal of Manufacturing Technology Management
12. Metalurgija (SMED).
13. Production and Operation Management.
14. Recent Research in Science and Technology.
15. Udyog Pragati
16. World Academy of Science, Engineering and Technology

Single Minute Exchange of Dies (SMED): Globalization has created the need to produce small lots, causing a significant increase in the frequency of setup, causing the reduction of times production for each lot. For this reason it is important that changeovers are quick, so that the flexibility of respond to demand is not affected (McIntosh et al, 2007). Shingo defends that SMED system is a method that includes a set of techniques that makes it possible to have a setup less than 10 minutes, that is the number of minutes expressed by only one digit (Shingo, 1989) The single minute exchange of dies is one important lean tool to reduce waste and improve flexibility in manufacturing processes allowing lot size reduction and manufacturing flow improvements. SMED reduces the non-productive time by streamlining and standardizing the operations for exchange tools, using simple techniques and easy applications. (Ana Sofia Alves et.al, 2009). (Ana Sofia
Alves et.al, 2009) concluded that the SMED methodology can be combined with other classic tools, providing very positive results for companies such as chart analysis and statistical analysis allowed the identification and separation of different groups for analysis, and added value of traditional SMED methodology. (Trovinger et.al, 2005) applied the principles of SMED to pick and place chip shooter machines and they were able to reduce setup times by removing all activities that could be done off-line. They used a computerized information system to assist with feeder management and also used computerized tools, e.g. barcode readers and wireless terminals. This resulted in reducing the incremental setup time per feeder from 1.7 minutes to 11 seconds. They proved that SMED and sophisticated (computer) methods are interrelated to each other and having optimum effect while used in combination. (Cakmakci,2008) showed the relation between both the setup time reduction (SMED) and product design efficiency through quality control technique, and process capability analysis, he also showed that SMED is still a suitable method not only for manufacturing improvement but also for equipment/die design development. (Michels, 2007) stated that application of SMED methodologies is an effective way to analyze, improve and reduce existing processes used to change over manufacturing equipment. This field study has shown that it is possible to reduce the amount of time required to perform a changeover as well as reduce the amount of direct labor needed to perform a changeovers through improvement of processes. (Michels, 2007) applied the SMED methodology to the punch press changeover detailed in this study, the researcher concludes that SMED is an effective tool to provide improved changeover methods resulting in reductions in overall time and labor and also proved that setup reduction is an effective tool which can be applied to improve a manufacturing organization’s ability to improve customer satisfaction through better utilization of plant resources. The most important step in implementing SMED is distinguishing between internal and external activities. Preparation of parts, tools and maintenance activities should not be performed while the machine is stopped. (Sivasankar et. al, 2011) Performed the experimental verification of Single Minute Exchange of Dies and concluded that SMED improvement techniques may be assessed both in terms of their allocation to the methodology’s stages and in terms of their collective representation of a full range of potential improvement options. (Shingo, 1985) also shown that SMED consists of three conceptual stages namely separating internal and external setup, converting the internal setup to external setup, streamlining all aspects of the setup operation. (Cakmakci, 2008) concluded that SMED is suitable not only for manufacturing improvement but also for equipment development and integrated the SMED system and 5S technique. (Kayis et al, 2007) described the results of SMED system in three categories namely: Mechanical improvements, Procedural improvements and organizational improvements and also concluded that setup reduction (SUR) is an extremely valuable approach in modern manufacturing. To ensure its success it must begin at a grass roots level of the organization and a constant drive towards improvement must come from all levels of the company. (Patel et al, 2001) discussed about the distinction between setting and adjustment. (Moxham and Greatbanks, 2001) have discussed the prerequisites for the implementation of the SMED methodology in a small textile processing unit.

Step 2: Develop Classification framework to summarize the review:

Table 1 illustrates the classification scheme for the literature on SMED. The search process was focused on research paper from various journals through different electronic database. The total number of research
paper found in various Journals comes around 19. Table 1 illustrates the division of literature as found in Journals.

(Table 1: Classification of SMED Centered Literature)

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TOTAL YEAR WISE: 5 1 2 1 2 1 1 1 1 2 19

(Chart 1: Graphical Presentation of Paper Collected Year Wise)
Authors view on classification

After the review of the works mentioned in literature, a classification method is used. The method consists of parameter on which classification has been done, which is as follows:


As we have reviewed journals from various electronic databases, it is clear from the chart 1 that we have got maximum paper (5) which is published in year 2011. It can be assumed as an indicator that many industries and researchers are now being more focused on SMED concepts and its implementation.

Step 3: Analyze the review and Conclusion:

On analyzing the whole review it is clear that lot of work already has been done on SMED and its implementation. SMED if implemented properly can help in reducing sources of waste in systematic way. This literature review provides attention to a lot of works that have done to implement the SMED tool and emphasizes that the possible expansion of the SMED. In the process of analyzing and study we come across the following conclusive points which are as follows:

1. Continuous training and awareness program from top management to bottom management is essential for availing true potential of SMED technique.
2. SMED can be applied to any industry.
3. As suggested in literature, the use of visual control and 5S can increased the power of SMED by many folds.
4. Literature also resulted that particular lean tool such as SMED etc can be and should be combined with other lean tools.
5. Implementing SMED resulted not only in mechanical improvements but also in procedural and organizational improvements.
6. Implementation of SMED also results in saving manpower which is one of the crucial most resources for the industry.
7. As suggested by (McIntosh et. al, 2000) a comprehensive knowledge of possible improvement techniques has been found to be important if the ‘SMED’ methodology is to be applied effectively.

References


Berna Ulutas, An application of SMED Methodology, World Academy of Science, Engineering and Technology, 2011; 79;100-103.


McIntosh R. I, Culley. S.J, Mileham A.R, and Owen. G.W, A critical evaluation of Shingo's 'SMED' (Single
Minute Exchange of Die) methodology, International Journal of Production Research, 2000; 38(11); 2377-2395


Rother M and Shook J. Learning to see: Value-stream mapping to create value and eliminate muda Brookline, MA: The Lean Enterprise Institute; 2003.


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

Trovinger and Bohn, Setup Time Reduction for Electronics Assembly: Combining simple (SMED) and IT-based methods”, Production and Operations Management Society, 2005, 14(2), ISSN 1059-1478.