Optimizing equipment efficiency: An application of SMED methodology for SMEs

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ABSTRACT

Competitiveness in the era of globalization is tougher than ever before. Most of small medium-sized enterprises, especially in the manufacturing sector, are easily vulnerable due to lack of opportunities and resources to harness the economics of scale as well as business activities in research and development. To drive business competitiveness, the small and medium-sized enterprises (SMEs) must make use of resource efficiency in production processes and optimize the overall equipment effectiveness (OEE). The method of single minute exchange of dies (SMED) appears to be an effective approach, which does not require financial investments but only utilizes the current human resource, to improve and maximize the OEE. The paper describes the step-by-step approach to apply SMED and shows its results in the increase of 18% OEE in a semi-auto cutting machine.

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1. Introduction

Global trade and state-of-the-art technologies have made the world smaller, which in turn puts any entity in pressure and tough competition in the market place in which SMEs are crucial contributors in the economic development (Matt & Rauch, 2013), but have vulnerable competitive positions (Pius et al., 2006). To take advantages in the global competitive marketplace, the SMEs have struggled for getting flexibility and responsiveness to the changing competitive environment (Wilson, 2010) and making incremental improvements to world glass performance through the implementation of lean production system (Ahmad et al., 2009) in which optimizing and controlling the OEE, one of the most important indicators in the manufacturing sector, play a critical role to manufacturing excellence (Kuznetsov et al., 2018).

One significant reason behind the failure of achieving the best performance of lean initiatives in general and OEE in particular is a lack of an effective implementation methodology and planning (Felix et al., 2018). To capture the point, several methods have been introduced to improve the OEE. One of them was proposed to apply integer programming for finding the optimal point of OEE with the help of simulation software (Marin et al., 2010), the other introduced the fuzzy temporal performance model used to express the performance of OEE across the time line (Laurent et al., 2019). Besides, putting investments in automatic data collection of OEE measurements were also indicated for the data-driven decisions (Richard et al., 2016). Moreover, the DOE, design of experiments, was also used to analyze the impact levels of each OEE component for problem prioritization, but not showing how the OEE can be improved (Anand & Nandurkar, 2012). However, these approaches are not suitable for SMEs in most cases due to the fact that they are lack of resources and expertise to handle the technical models (Moeuf et al., 2016).The situation is more worse in Viet Nam where more than 80% of labor workforce are high-school graduates who are lack of chance to expose the models as well as lean initiatives (Nguyen & Nguyen, 2017).

The method is named as SMED that is one of the key tools for optimizing the operations (Womack & Johns, 1990) and can be effectively applied to improve the OEE without requiring special technical needs or investments (Eric et al., 2013).

SMED stands for Single Minute Exchange of Dies (Shingo, 1985) and its ultimate objective is to enhance the performance of equipment or machines in terms of time utilization (availability), qualified outputs (quality), capacity utilization (performance) and at the same time meet the requirement of output diversity or small lot-sized production. Regardless of business sizes, the SMED method has been applied in several different processes such as: mold industry, pharmaceutical industry, transformation industry, metallurgical industry, and textile manufacturing (Andreia & Alexandra, 2010).

The application of SMED was also proved to be effective in different industries. For SMED methodology's application, the Electric power controls company was benefited with the reduction in 59% to 90% on average of setup time of studied machines (Domingos et al., 2011), whereas its application in Fogor Press machine shows a very encouraging result in reduction of 70% changeover time and increase in productivity of 6.3% (Suresh Kumar & Syath Abuthakeer, 2012). Moreover, the SMED was also applied in combination with MOST (Maynard's Operation Sequencing Technique) in Aerospace Industry to indicate the improvement of OEE from 84.32% to 88.94% (Puvanasvaran et al., 2013).

Therefore, the SMED methodology is a simple but effective approach that can bring the business results as quick improvements without investment for SMEs. The purpose of this paper is to describe the step-by-step approach to apply the SMED and shows its results in the increase of 18% OEE in an semi-auto machine cutting the sheet of EVA (Etylen-vinyl axetat) into pieces as a typical example.

2. Materials and Methods

2.1. OEE measurement

The Overall Equipment Effectiveness (OEE) is one of the most critical key performance indicators of the Total Productive Maintenance (TPM) that has to be maximized by tacking and minimizing losses as described by the Figure 2.

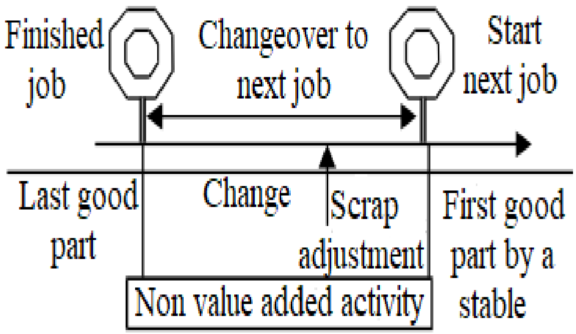

Figure 1. Representation of changeover time (Berna, 2011).

According to the Figure 2, each main component of OEE is responsible to represent for 2 major losses and by qualifying each following component the analyst will know what the most prioritized problem should be solved:

(a) Availability: Availability is a percentage number that indicates how the machine is effectively operated within the planned operating time. It points outs first two of the six big losses, breakdowns, setup/adjustments, changeover time (Figure 1) from one model production to another one.

(b) Performance: Performance efficiency takes into account the unoccupied downtime, such as waiting time due to operator inefficiency or lack of materials, and productivity losses due to machining running below its capacity. The ideal cycle time is needed to calculate the performance efficiency where it is multiplied with the total parts produced divided by the actual operating time.

(c) Quality: The quality rate captures the rejected parts or defectives during production and the losses from initial start-up to process stabilization.

(d) Overall Equipment Effectiveness (OEE): the product of three factors above. It shows how effectiveness (quality) and efficiency (availability

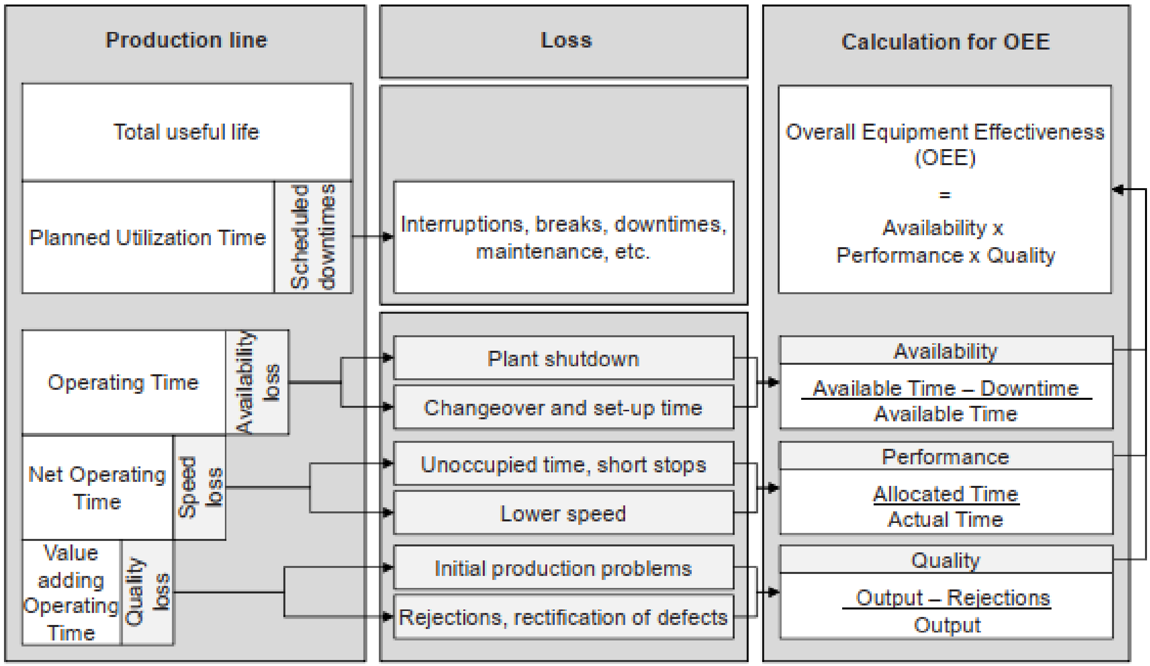

Figure 2. OEE measurement (adapted from Gisela et al., 2013).

and performance) of a machine or workstation are utilized.

2.2. SMED methodology

The classical approach to the SMED was initially proposed by Shingo (1995). It divides the process of changing one production model to another one on an operating machine supervised by the one or more operators into 2 different parts:

(a) Internal activities: Processing steps that can be done only when the machine is shut down, such as attaching and removing cutting dies.

(b) External activities: Processing steps that can be done when the machine is still running, such as preparation of the availability of input materials for the machine.

As illustrated by the Figure 3, the SMED can be done in 3 steps and last step for continuous improvements to drive forward optimization of OEE:

(a) Separating internal and external activities.

(b) Switching internal to external activities as many as possible.

(c) Streamlining all setup activities.

(d) Repeat the 3 steps above for operations excellence.

3. Results and Dicussion

The case study was conducted in a footwear manufacturing in which the semi-auto die cutting machine with traveling head was used to cut the EVA form into soles of slippers. Due to the nature of production of slippers, the machine was required to change the cutting die from one size to another size according to the production plan.

Because of too many changeover times from one size to others, the performance of the machine was affected negatively with low productivity that did not meet the customer output orders. To support for the statement, the OEE data collection was also created as the Figure 4.

In case of SMEs, they are normally lack of financial investment to equip an automatic collection system where the data are synchronized in real-time manner. Therefore, the good starting point for them is to use current equipment like excel and own-design hand-writing book for collecting and storing daily data.

The data collected, OEE and its components should be graphically shown in trends where the

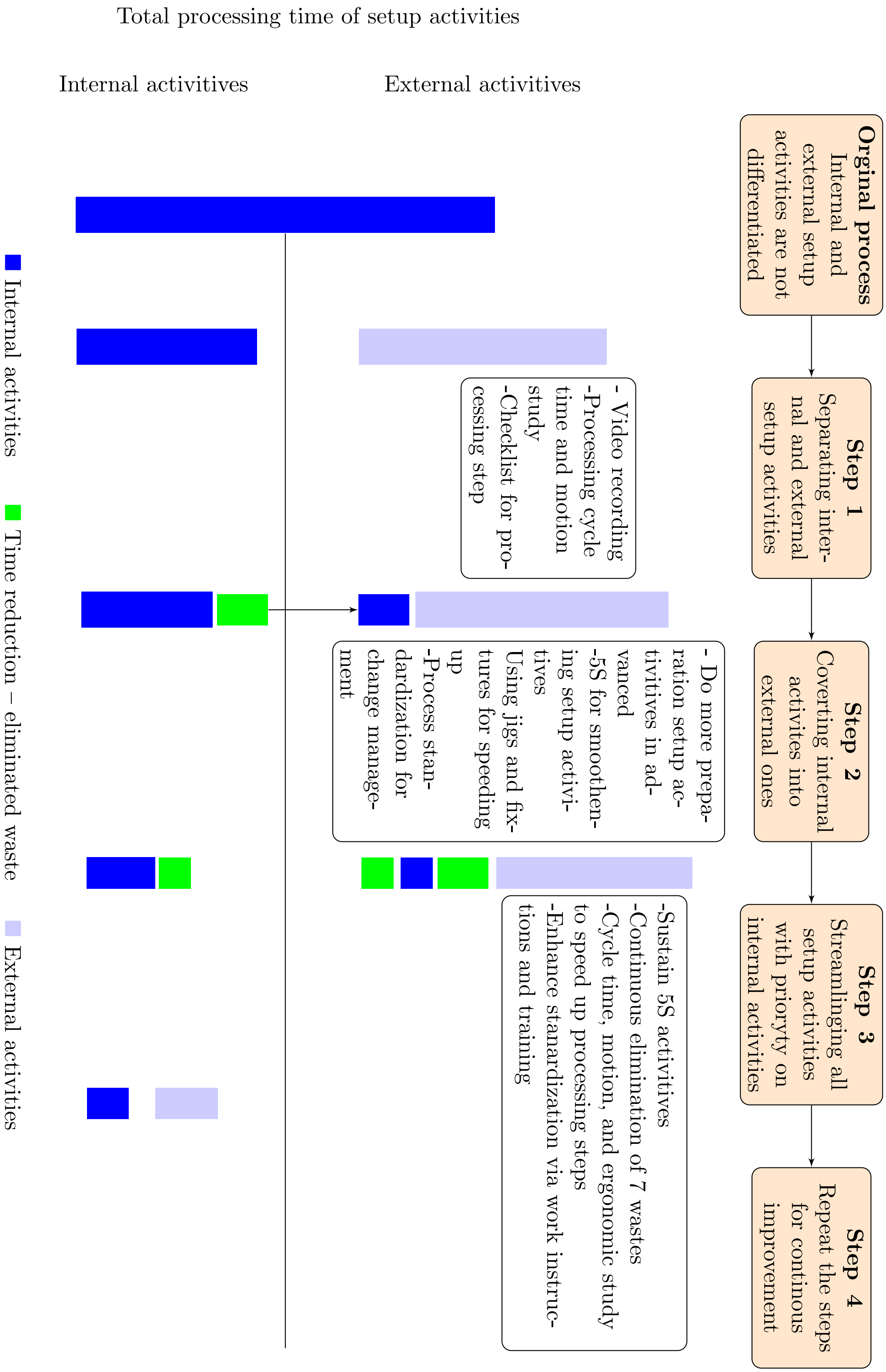

Figure 3. A step-by-step approach for SMED methodology associated with improvement tools.

Table 1. SMED analysis

Semi cutting machine			Before-Kaizen	After-Kaizen	Separating changover activities			Separating changover activities			
Total changover time (min)			7.5	1.9							
Step No.	Changeover processing steps	Associated tools	Cycle time element (s)	Cycle time element (s)	Internal activity (s)	External activity (s)	Waste activity (s)	Improvement actions	Eliminate	Internal → External	Reduce CT
1	Stop the machine	Production order (PO)	5	5	X						
2	Search for Hex key		48				X	6S (design rack for storate)	X		
3	Disassemble the mold	Hek key	9	9	X						
4	Detach the cutting die from the mold	Hek key	31			X		Do it while the machine is running		X	
5	Search for the next cutting die		27				X	6S (design rack for storate)	X		
6	Attach the new die into the mold	PO, Hex key, cutting die	57			X		Do it while the machine is running		X	
7	Search for EVA		80				X	6S (design rack for storate)	X		
8	Attach EVA into the mold	EVA, knife	85			X		Do it while the machine is running		X	
9	Assemble the mold	Hex key	12	12	X						

Table 1. SMED analysis (continue of page 5)

Semi cutting machine			Before-Kaizen	After-Kaizen	Separating changover activities			Separating changover activities			
Total changover time (min)			7.5	1.9							
Step No.	Changeover processing steps	Associated tools	Cycle time element (s)	Cycle time element (s)	Internal activity (s)	External activity (s)	Waste activity (s)	Improvement actions	Eliminate	Internal → External	Reduce CT
10	Set up the machine		75	60	X			Training and standardization			X
11	Get a pair of EVA sheets		6			X		Do it while the machine is running		X	
12	Put the sheets on place	EVA sheets	9	9	X						
13	Run the machine		5	5	X						
Total changover time				449	100	115	179	155			

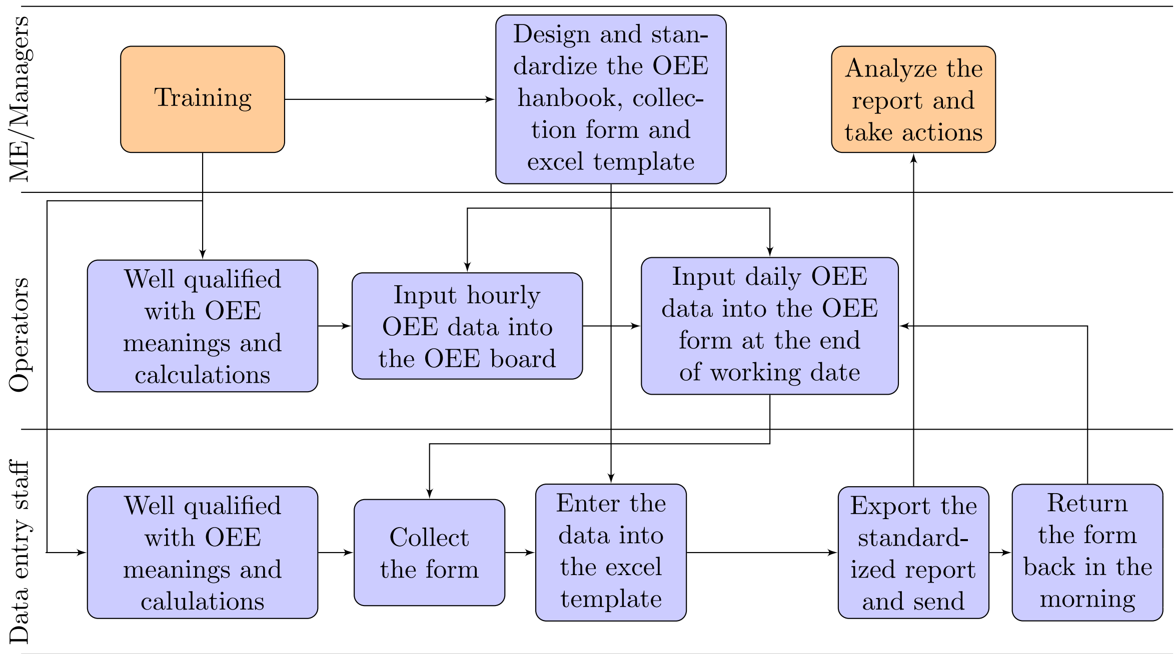

Figure 4. OEE data collection procedure.

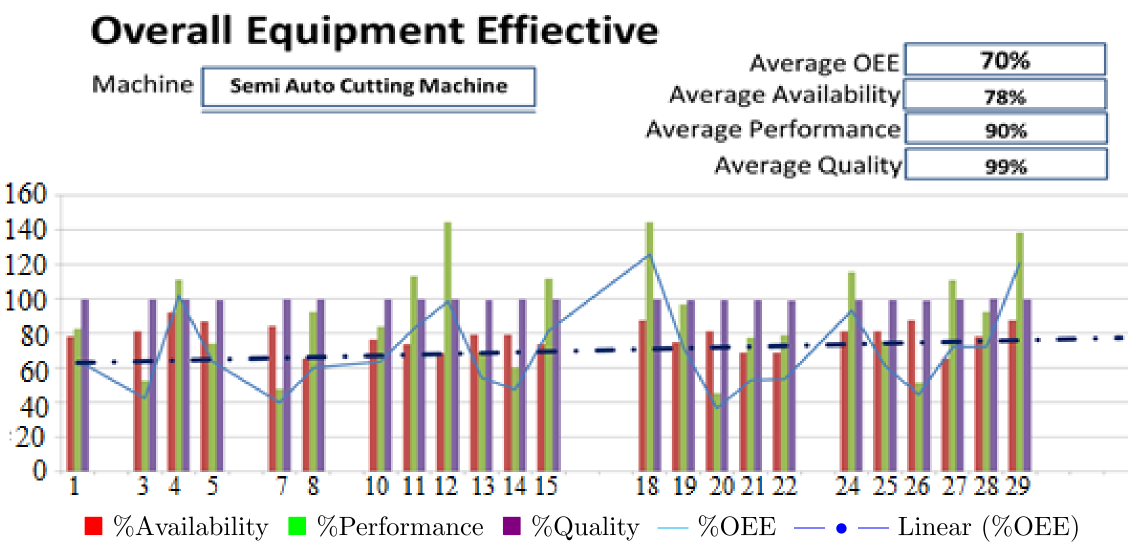

Figure 5. OEE descriptive statistics.

status of performance can be spotted as the following the Figure 5.

As can be seen on the Figure 5, the average availability was only 78%, which means that there was a room of 22% downtime the machine underwent. By breaking further the data of downtime, about 95% of downtime was accounted to changeover time. Hence, by making improvement in 67% reduction changeover time, the availability would be enhanced to 92%, leading to the increase of OEE from 70% to 82%. By doing that way, the analyst can show clear targets, which in turn gets the support from top management to carry out the improvement project.

To tackle the changeover time, the methodology of SMED was applied in the away described as the Figure 3. The result of analysis is indicated as the following Table 1.

The Table 1 shows before-after analysis of SMED on the machine where the highlighted red steps were categorized as waste activities that did not add the value to the process, whereas the yellow ones were internal activities that were converted to external activities while the machine still operated. The highlighted green step was the one whose cycle time was reduced after the operator was trained and the task was standardized in a work instruction. The column of improvement activities is to indicate the actions carried out to reduce the changeover time. For instance, searching activities that are considered as a waste were eliminated by 6S activities, including design a suitable storage of tools where the hex key was always available for the operator without searching for it.

By doing that way, the total changeover time was improved from 7.5 min per cycle to 1.9 min/cycle, which equivalents to 74% reduction in changeover time. The reduction in changeover in turn improved the availability from 78% to 93%, leading to an increase of OEE from 70% to 83%.

4. Conclusions

The paper has shown the most effective and easy-to-implemented methodology that can bring quick performance improvements for SMEs. The case study was also indicated as a comprehensive guidance for the implementation of SMEDs, which is specifically adaptable for SMEs who are lack of resources and expertise in terms manufacturing excellence. The future works after mastering the technique for the SMEs should be the case of digitalization on which the automatic OEE data collection and data analysis are implemented in their factory.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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