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To cite this article: A Q Basri *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **469** 012005

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The validation of productivity on the changeover activity at the automotive stamping press line by comparing the embedded SMED frame-work versus SMED approach: A witness simulation case study

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Abstract. Single-Minute Exchange of Die (SMED) is a popular method used to optimize the die change processing time. The purpose of this study is to identify on how to reduce set-up time by using Embedded SMED in automotive stamping press line. An actual case study at an automotive company XYZ in Malaysia was conducted based on parts supply issues. The observations, assessments and standard manufacturing practices were carried out during the study. WITNESS simulation software was used to identify the critical processes and also enable the validation of actual output based on the production. The result of the particular press line (combination of 800 Tons and 500 Tons machines) which produced 6 parts in 1-shift operations with small lot size output has been identified and improved. The significant improvement based on the Embedded SMED compared to conventional SMED approach showed a decreasing change-over time from an average of 12.51 minutes to 9.41 minutes (effectively a single-digit minute) resulting in circa 62% reduction.

1. Introduction

Over the years, the discovery of fresh or new ideas and/or innovation on improving SMED concept had shown significant or marked improvements from the year 90's until today [1]. Researched data in numerous situations in the industrial studies had proven the effectiveness and also the implication of the latest SMED frame-work [2]. Apart from obtaining solid data indirectly these industries had been impacted directly by increasing the production output and various benefits and/or savings had also been recorded in terms of costs, operational time and manpower resources [3].

Consequently the contributions of SMED in this decade has been expanded and it is now more flexible as it is not only focusing on stamping operations but any operations that need/require initial set-up process can also applies the approach or concept of SMED [2]. The current crop of researchers in this decade are more inclined or interested in optimizing/maximizing the impacts of SMED in various operational processes by implementing Lean Manufacturing tools, QC tools and others in order to provide greater impact in the respective/selected/chosen industries [4].



Studies had shown the clear comparison results from the conventional SMED compared with the new extended frame-work SMED that had been implemented at the 800 Ton Tandem Press Line at XYZ company in Automotive industry due to increase operation output with reducing waste in operation and press line efficiency up which is to produced 5 to 6 parts in 1-shift operations with small lot size output. This was also verified by the simulation activities, WITNESS Software in proving its implications on the production output.

2. Research Background

The SMED system is a theory and set of techniques that make it possible to perform equipment set-up and change-over operations in less than 10 minutes [5]. SMED improves change-over process and provides a change-over time reduction up to 90% with moderate investments [1, 4]. Change-over operations is the preparation or after adjustment that is performed once before and once after each lot is processed. Shingo divides the change-over operations into two parts; internal set-up and external set-up. Internal set-up is a set-up operations that can be done only when the machine is shut-down (attaching or removing the dies). External set-up is a set-up operations that can be done when the machine is still running [5]. These operations can be performed either before or after the machine is shut down. For example getting the equipment ready for the set-up operations before the machine is shut down [6, 7].

The set-up period is constituted by internal set-up and external set-up. During the internal set-up, no production is taking place. In the run-up period, re-adjustments and trial productions are taking place [5-7]. This period terminates when full output capacity is reached. SMED system includes 3 main steps. These steps are shown as in Table 1.

Table 1. SMED implementation standard approach [7].

Steps	Items	Description
1	Separating Internal and External Set-up	All change-over elements are performed while the equipment is stopped. These are referred to as internal elements.
2	Converting Internal Set-up to External Set-up	To identify the element that can be performed while the equipment is running and make them external to the change-over
3	Streamlining all Aspects to the Set-up Operation	Streamlining all aspects of the Setup Operation to judge and review all elements for streamlining and simplification. This shortens both change-over time and external time.

3. Methodology

3.1 Embedded SMED New Approach

The study was conducted by observing the complete dies set-ups at a benchmarked 800 ton Tandem Press Line in an automotive company XYZ in Malaysia. The current changeover procedure has been carefully evaluated to examine the type of improvements which can be made using the Embedded SMED approach referring to Figure 1. The observations were undertaken using manual means by employing a standardized recording and analysis sheet [8]. This is to comply with the company policy prohibited to the use of video recording during the set-ups as well as to prevent the operators from not co-operating during the study.

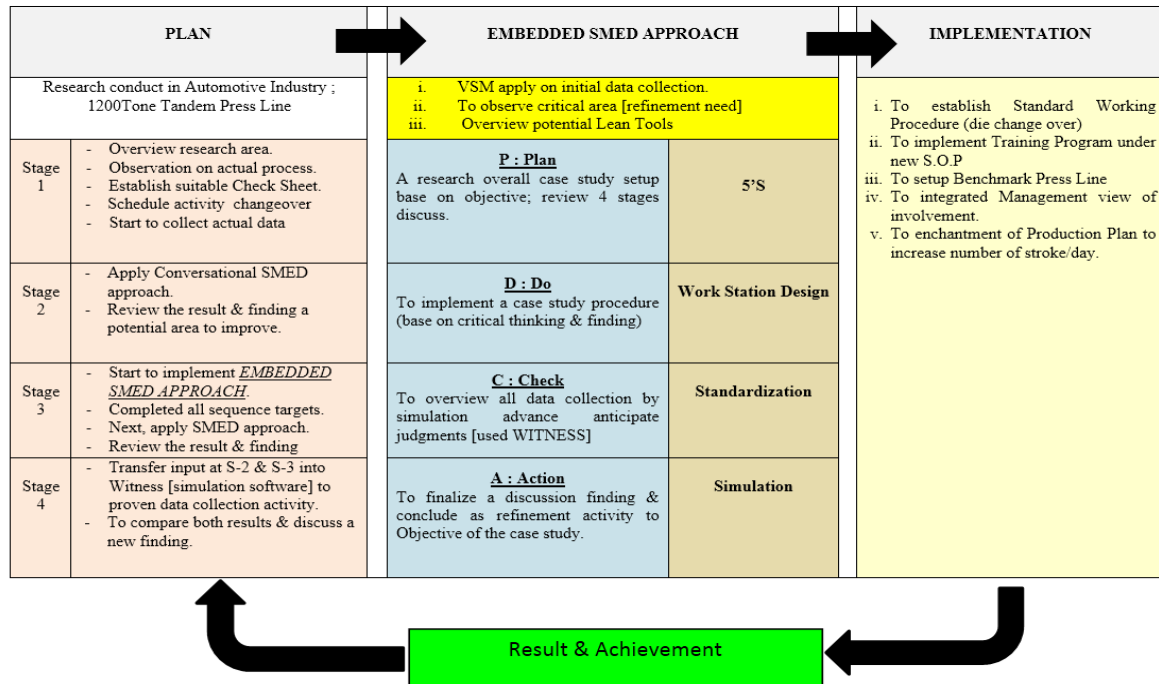


Figure 1. Embedded SMED frame-work.

The first step in the implementation of SMED was to separate internal (activities which can only be carried out when the machine is stopped) and external (activities which can be carried out when the machine is operating) changeover activities [2, 5, 7]. Once the internal and external activities were identified and separated, a checklist can be made which comprised of all the parts and steps during the current and preceding operations [6, 8, 9]. The checklist of the changeover procedure also considered the sequence of activities involved during the actual operation [7]. During the study, there were numerous waste unnecessary activities that need to be eliminated, which were contributing to longer set-up times.

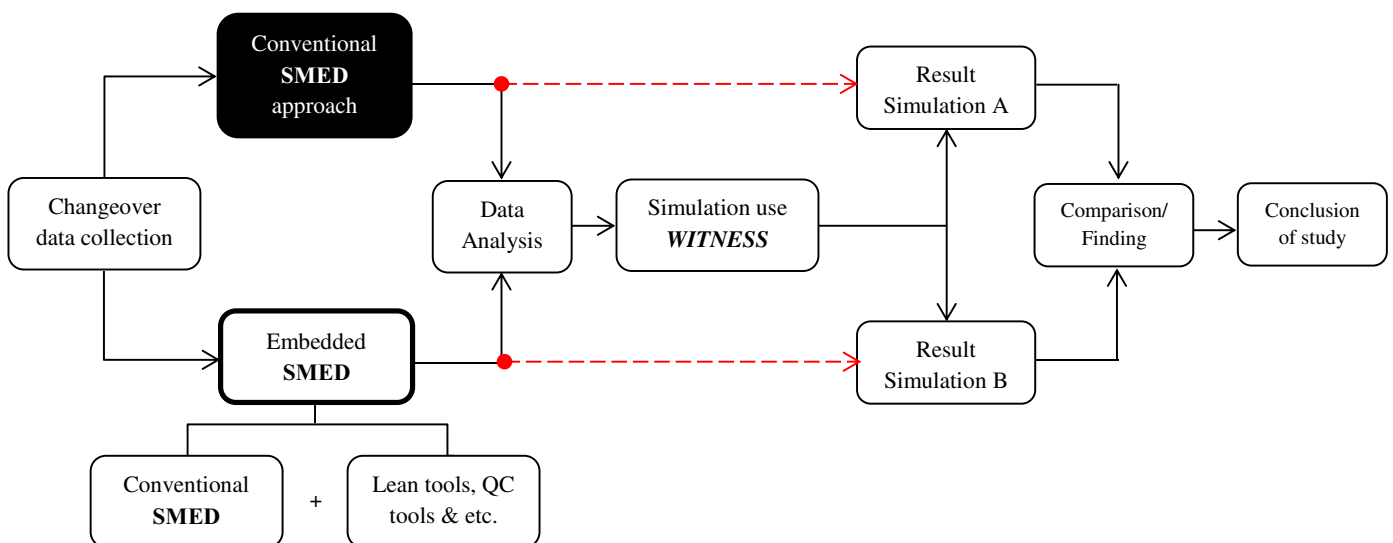


Figure 2. Schematic Process Flow in comparison of Conventional SMED approach vs. Embedded SMED

The basis for Embedded SMED approach was based on the conventional SMED method as illustrated in Figure 2. The framework of Embedded SMED is focusing more on Lean Tools as the key factor of successful continuous improvement criteria which includes Value Stream Mapping (VSM), Plan-Do-Check-Act (PDCA), 5S', and Work Station Design [2, 10-12]. The collected data; using same recording method as implemented in the previous approach; manual check sheet [8] from the combination of all related tools designed in this framework will be analyzed by Witness simulation software and validated at different press line [13].

Results comparison before and after Embedded SMED implementation was extensively reviewed during the study. The Witness simulation makes it possible in creating variety of discrete and continuous elements [10, 11]. Subject to the type of component, each can be in any quantity of 'states' which means either idle, busy, blocked, in-setup, broken down, and waiting for labor [11]. The data analysis had led to significant improvement which reflected to three major improvements such as mechanical, electrical, and organizational of the company.

4. Results And Discussion

4.1 Embedded SMED Approach

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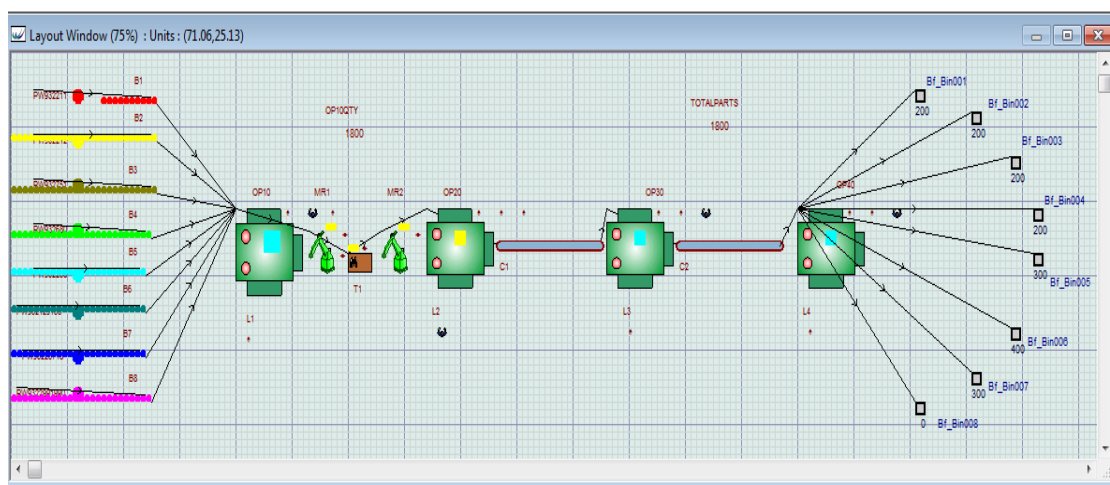


Figure 3. Simulation Layout with WITNESS Software.

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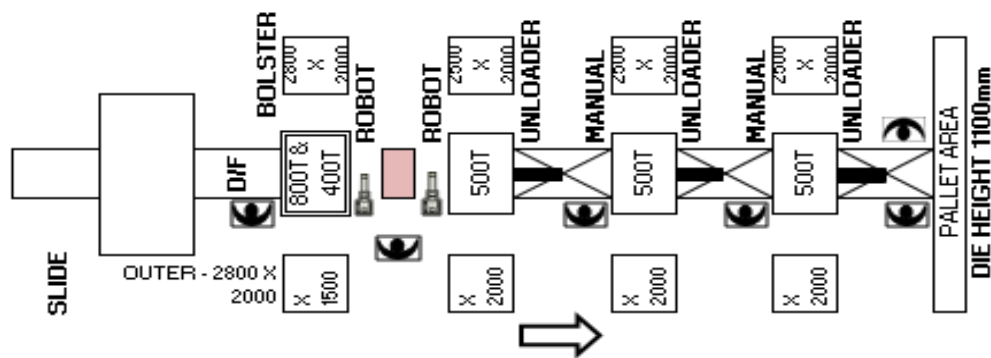


Figure 4. 800 Ton Tandem Press Line in XYZ Company.

The layout of the 800 tonnage Press Line is illustrated in Figure 4. It comprises of four press machines, two robots, and eight workers. During the study, the entire stamping production cycles data were taken for 60 working days [2]. The cycle time for each process performed was taken to ensure the accuracy of the data and to observe variations in each cycle time [12].

According to the actual production requirement, the 800 Ton press line needs to produce a minimum of five strokes/part/shift production planning with an additional of two hours allocated for over time. The production planning deployed for this press line is to ensure ample time for changeover period. Hence, it is among the important production criteria in order to achieve the demands with small batch of lot size. During the initial changeover activity, 21-sequence processes were recorded separately for each machine in this 800 Ton press line. The overall data was recorded in the average reading, representing the findings of the four machines used in this study [1, 6, 8].

In the new approach known as Embedded SMED, VSM was implemented to map every processes in the press line which enabled it to identify areas in need for refinements [2]. The findings have been classified as critical areas and need to be focused for the next activity.

Table 2. Summary of change-over data collection on 3 different situations.

Items	Stage 1	Stage 2	Stage 3	Stage 4	Average time	
					Sec.	Minute
Initial Data	1717	1402	1428	1491	1493.75	24.89
SMED Approach	747	751	731	774	750.75	12.51
Embedded SMED	561	551	555	592	564.75	9.41

Initial changeover data after implementing Conventional SMED approach reduced the average time from 24.89 minutes to 12.51 minutes (50.26% improvement). By implementing the novel Embedded SMED approach, a new changeover time recorded showed a decreasing time from an average of 12.51 minutes to 9.41 minutes, which was 62% achievement (refer to Figure 5). This method manifests a very promising results as the main target for the changeover in SMED approach needs to be in a single minute and it is achieved by using Embedded SMED.

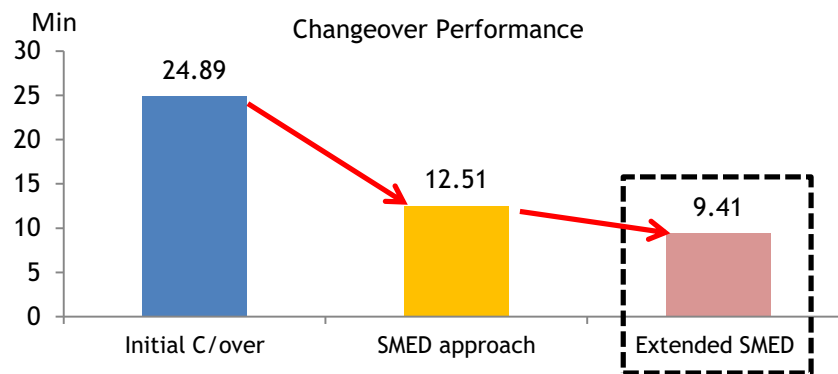


Figure 5. Changeover performance and comparison of final data/timing recorded. Simulation use WITNESS.

The performance for current production data was run in Witness software, and the input of data were shown in Tables 3 and 4 respectively for both Conventional SMED and Embedded SMED approaches which is main area, criticality of utilization with job work design and average time recorded [13]. Main database on four main elements of a station in SMED data collection. Simulation work conducted in 10 times for achieving accurate output. In detail, each sub-group are compared the level of utilization in changeover activities.

According to the results of performance comparison for overall changeovers, an output of production and machine performance had increased and able to produce 6 parts/shift instead of 5 parts/shift.

Table 3. Analysis by Witness software on SMED Conventional Approach.


Name	% Busy	% Idle	Quantity	No. of Jobs	No. of Job Started	No of Job Ended	Avg Job Time (s)
Sub-group 1	99.82	0.18	1	2164	1	0	0.22
Sub-group 2	99.82	0.18	1	2168	1	0	0.22
Sub-group 3	98.71	1.29	1	2151	1	0	0.22
Sub-group 4	99.78	0.22	1	2139	1	0	0.22

Table 4. Analysis by Witness software on Embedded SMED.

Name	% Busy	% Idle	Quantity	No. of Jobs	No. of Job Started	No of Job Ended	Avg Job Time (s)
Sub-group 1	98.80	1.20	1	2269	0	0	0.21
Sub-group 2	98.82	1.18	1	2273	0	0	0.21
Sub-group 3	98.23	1.77	1	2257	0	0	0.21
Sub-group 4	99.78	0.22	1	2244	1	0	0.21

Based on the simulation activities, by using Conventional SMED, it showed that the last part in the shift operation just could produce 199 out of 300 pieces as planned. Meaning that the remaining 101 pieces need to be produced in the next shift. However, by introducing Embedded SMED approach as shown in Table 5, all 300 pieces were able to be produced in the same shift operation.

Table 5. Result comparison of Witness simulation finding.

SMED Approach			Extended SMED Approach	
Name	Total In		Name	Total In
Bf_Bin001	200	Bf_Bin001	200	
Bf_Bin002	200	Bf_Bin002	200	
Bf_Bin003	200	Bf_Bin003	200	
Bf_Bin004	200	Bf_Bin004	200	
Bf_Bin005	300	Bf_Bin005	300	
Bf_Bin006	400	Bf_Bin006	400	
Bf_Bin007	400	Bf_Bin007	400	
Bf_Bin008	199	Bf_Bin008	300	

5. Conclusion

A novel approach known as Embedded SMED framework has been introduced to tackle the changeover issues faced by automotive stamping companies. Normally, the manufacturers run on small batch production to cater for supply demands and press machines optimization. Embedded SMED framework methodology applied lean tools and simulation technique in addition to the Conventional SMED. A comparative study was carried out (performed) on the actual press line in order to measure the effectiveness of the Embedded SMED approach. The results and achievements of before and after Embedded SMED implementation were analyzed.

6. Acknowledgements

The authors would like to acknowledge the Universiti Malaysia Pahang for laboratory facilities and financial assistance under Research Grant project No. RDU160386.

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