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Improvement of Overall Equipment Effectiveness through Application of Single-Minute Exchange of Die in Automotive Manufacturing

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Abstract:

In manufacturing, every process is performed according to the planned operation time. Wastes will be generated when downtime occurs and if correct standard operations are not followed affecting the manufacturing performance. Every company aims to eliminate waste in order to increase their performance and productivity. Therefore, this study attempts to improve the Overall Equipment Effectiveness (OEE) via the application of Single Minutes Exchange of Die (SMED) to improve the operation efficiency at an automotive industry manufacturing operation. Results of this study show improvement in the productivity and OEE rate. Thus, the application of SMED proved to improve the OEE performance measures and concurrently increase operation productivity.

Keywords: *Changeover, Waste, Productivity, Performance, Operation*

I. Introduction

The global competition in the manufacturing industries has become more critical. In order to be successful, every company is focused to improve the efficiency of their operation. According to Ebrahim et al. [1], each processing time in manufacturing needs to be managed well to achieve customer expectation. Thus, it is important to provide assessment tools to evaluate operation processes [2]. Many studies were done in the manufacturing industries which lead to the improvement of the company's profit. To achieve this, every manufacturing process needs to adhere to accurate planned operation time. Time loss will occur if the correct standard operation is not followed which then affects the overall manufacturing performance. As explained by Ebrahim and Abdul Rasib [3], it is very important for the manufacturing companies to recognize the non-valueadded tasks in the manufacturing processes in order to maintain efficient productivity. Every company aims to eliminate wastes in order to increase their performance and output to meet the customers' expectation for on-time delivery of their products. Abdul Rasib [4] stated that the serious issue company face was on how to manage the product that can be completed with limited operation time. Thus, eliminating or minimizing the value-added activities and

November-December 2019
ISSN: 0193-4120 Page No. 3650 - 3659

improving the product quality are among the many approaches employed to achieve the efficiency improvement in manufacturing.

A manufacturing will operate based on the customer requirement and productivity is the common issue which is direct affecting the customer delivery. Abdul Rasib [4] stated that productivity in the manufacturing operation needs to be well managed in order to increase the efficiency of the production. Thus, appropriate tools such as SMED and OEE should be used to improve the operation efficiency. Therefore, the objective of this study is to explore the advance function and relation of SMED and OEE. Further, this study also tested the application of SMED and OEE as the performance measures in the actual automotive manufacturing production. Finally, this study will provide recommendations for the company to increase production rates.

This study is focused on the operational activities at PEPS-JV Melaka Sdn. Bhd. This study will introduce an appropriate action to improve the operation efficiency through improvement of OEE results. By using SMED methodology, the result of OEE will automatically improve.

II. Understanding of OEE and SMED

II.1. Overall Equipment Effectiveness

OEE is among the most popular performance measurement tool to measure efficiency in manufacturing operation. According to Mansour et al. [5], OEE is a basic and fundamental measurement tool for performance measurement system in manufacturing operation. The benefits of OEE can be used to evaluate equipment quality, product performance, and availability. Moreover, OEE is also beneficial to systematically identify opportunities for improvement [6]. Therefore, OEE is the most suitable tool to be used for operation assessment.

OEE is generally used to measure the manufacturing system performance. According to Peter [7], OEE is defined based on arranged production time and the improvement of manufacturing performance can be achieved by using OEE tools. OEE can also be used to plan for future production by studying the current condition and investigating the OEE using different operational forecasts.

Basically, OEE consists of Availability, Performance, and Quality as main elements in the calculation of OEE [8]. The OEE is simply calculated by multiplication of availability, performance and quality as denoted in the equation (1).

OEE = Availability x Performance x Quality------------(1)

Availability is calculated based on operating time and downtime loss as mentioned as in (2). Performance is calculated based on net operating time and speed loss as in (3). Quality is calculated based on fully operative time and quality loss as in (4). According to Paul [9], the equations for individual components of availability, performance and quality are as follow:

Availability = Operating/Planned Prod---------------(2)

Performance = Net Operating Time/Operating------(3)

Quality = Fully Productive /Net Operating-------------(4)

OEE is measured based on the six big losses, which are essentially functions of the availability, performance rate, and quality rate of the machine [10]; [11]. Similarly, Nakajima [12] described the six big losses as the main causes of idle or wasted time which can further be classified by downtime losses, breakdown, set up machine speed losses, minor unrecorded stoppage, rework, yield reduction and quality losses. Table I shows the six big losses which contribute to the OEE measures. This study is only focused on the set up or changeover element of the loss.

II.2. Single Minutes Exchange of Dies (SMED)

Single Minute Exchange of Dies (SMED) is one of the lean tools required in every company especially in the manufacturing industry. According to Shingo [13], SMED is used to reduce changeover time by exchanging the internal setting time (performed during machine stoppage) to external time (performed while the equipment is running) and to simplify and streamline the remaining activity. Shingo's idea had resulted in reduced lead time, lower inventories, improved quality, productivity and profit.

The internal operation is the time taken for setup while the machine is not operating. Internal activities can be described as the activities that can be done by the operator when the machine is not running [14]. External activities can be done during the normal running operation of the machine.

External activities are designed for all of the setup activities which do not interfere directly with the equipment, and which can be carried out without interrupting production [15]. There are a few processes in production which need to identify the changeover between the ending of the first process and the starting of the next process. According to Gest et al., [16] and Coimbra [17], the time between the ultimate fine product from foregoing production order departure the machine and the arrival good product leaving out from the following production order can be defined as change over time as shown in Fig. 1.

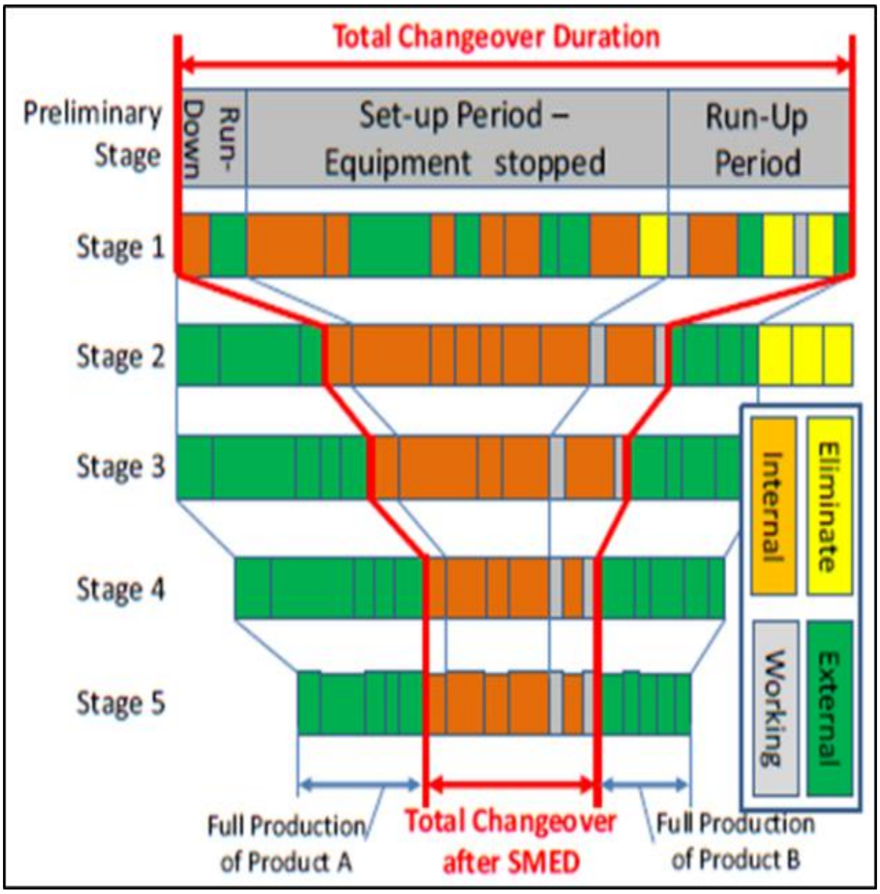

Fig. 1. SMED Improvement (Ferradás and Salonitis, 2013)

TEST Engineering & Management
November-December 2019
ISSN: 0193-4120 Page No. 3569 - 3573

III. Methodology

The methods used to gather data for this study are through observation and interview. Further, the data was analyzed and discussed to present the result. The methodology flowchart used for this study is as shown in Fig. 2. The studies started from the literature study in order to gain knowledge regarding OEE as the main performance measures and SMED. The focus of this study is on the operation productivity, OEE, SMED, and manufacturing changeover. In this study, the critical focus was to gain understanding of the relationship between OEE and SMED. In other hand, increasing the understanding of knowledge for both tools. Subsequently, the relation between OEE and SMED will be confirmed

through verification at manufacturing company. The verification will be performed by observation and interview with manufacturing company's staff to get a proof and confirmation regarding the internal and external activities for SMED.

TABLE 1

The Six Big Losses with Event Examples

Six Big Loss Types	OEE Loss Category	Event Example
Breakdowns	Down Time Loss	Tooling Failure
		Unplanned Maintenance
		General Breakdown
		Equipment Failure
Setup and Adjustment	Down Time Loss	Setup/Changeover
		Major Adjustment
		Warm-Up Time
Small Stops	Speed Loss	Obstructed Product Flow
		Miss feeds
		Sensor Blocked
		Child part stuck
		Cleaning/Checking
Reduce Speed	Speed Loss	Rough Running
		Under Design Capacity
		Operator inefficiency
Start-up Reject	Quality Loss	Scrap
		Rework
		In-Process Damage
		Incorrect Assembly
Production Reject	Quality Loss	Scrap
		Rework
		In-Process Damage
		Incorrect Assembly

In addition, Fig. 3.2 shows a detail research design flow to conduct the OEE performance measures through internal changeover time reduction in SMED. The details are as follows:

a. Research Approach: A way of considering or doing something for the research (Qualitative and Quantitative).

b. Process: A series of actions taken in order

November-December 2019
ISSN: 0193-4120 Page No. 3650 - 3659

to complete the research.

c. Method: Main activities planned for achieving success.

d. Source: Reference materials that supply information for the research.

e. Size: Size in his study refers to the volume of data collected.

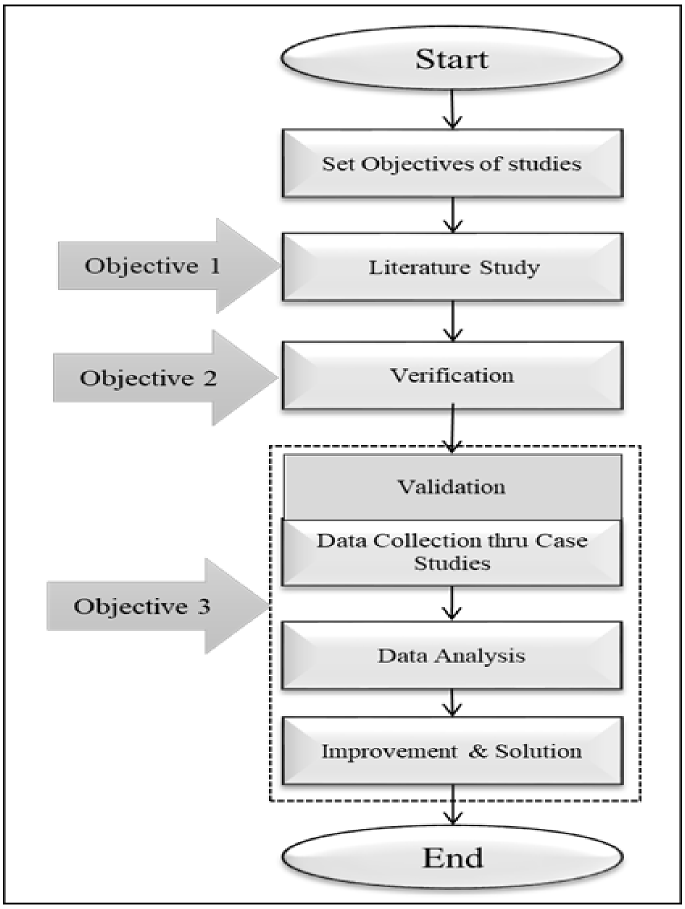

Fig. 2. Flowchart of Studies

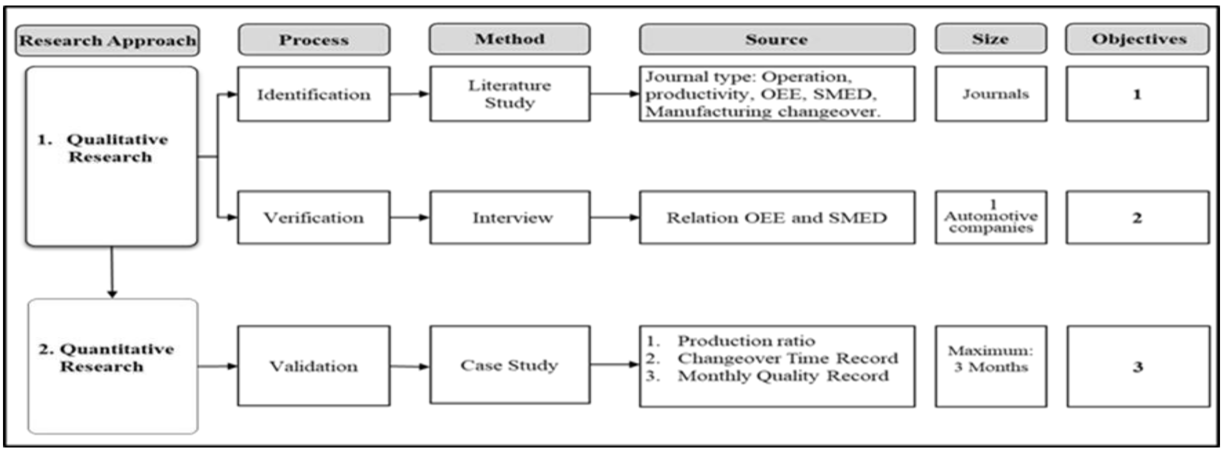

Fig. 3. Research Design

November-December 2019
ISSN: 0193-4120 Page No. 3569 - 3573

There are two types of data collection for the changeover time taken in this study which are Primary Data and Secondary Data. The primary data consists of observation, changeover process cycle time, and an interview which was conducted by the researcher. In addition, the secondary data known as second-hand data which is a form of data collected that is available from company resources was also taken. Next, the data was analyzed to determine the OEE improvement value through the reduction of changeover in SMED using the in-line production timetable. Consequently, the OEE before and after the improvement using SMED were measured.

IV. Results and Discussion

The results on the OEE before and after the improvement proposal were based on the data from the Internal and External SMED. The improvement proposed include reducing the internal jig change by converting this internal activity into external activity. In this study, the activities were focused in the production of the Honda models (BRV, HRV, and JAZZ) because of the highest problem in the jig change was due to the assembly process of these three models. There are plenty of codes being used in these production lines to identify the part types, components or models. Every model has its own code such asT7AW for HRV, T5AT for BRV and TSAY for JAZZ. This code will be changed whenever problem occurs, or changes being done in the manufacturing plant or process. The improvement was done by converting some internal activities to external activities. For example, converting the activity to bring the jig from storage, bring rack, remove spatter on the jig, check the filter and check push button.

IV.1. Overall Equipment Effectiveness

There are two types of data gathered; OEE and SMED. The data was collected based on all the recorded production activity to identify the problem. The data was then used to measure and improve the manufacturing productivity.

Table III shows the OEE results for the three model types which are HRV, BRV and JAZZ in line 9 for three months from April 2018 until June 2018. . However, for June 2018, there was no production of the HRV model and therefore, only two months data were gathered for this model.

The process Flow for the jig change was recorded using the SMED data template in order to identify internal and external activities of the process. The time for every jig changing activity was recorded. The details of the internal and external activities are presented in Table II. This result showed that there were too many internal activities compared to external activities which accounted for the long duration to change the jig. Specifically, about 1.3 hours to 1.45 hour were required to complete the process of changing the jig.

TABLE 2: OEE Results

	T7AW (HRV)			**T5AT (BRV)**			**TSAY (JAZZ)**		
Factors	**Apr**	**May**	**June**	**Apr**	**May**	**June**	**Apr**	**May**	**June**
Achievement (Performance)	88.9	78.8		88.3	89.7	89.9	89.9	82.9	83.8

November-December 2019
ISSN: 0193-4120 Page No. 3650 - 3659

Uptime (Availability)	87.4	89.9		92.0	89.6	89.9	87.7	88.6	86.4
Quality	99.7	99.5		88.4	95.1	77.0	99.6	99.5	99.1
OEE	77.5	70.5		71.8	76.4	62.2	78.5	73.1	71.8

IV.2. Overall Equipment Effectiveness

OEE is used as a benchmark, to identifying losses and to improving the productivity of manufacturing equipment. In this case, OEE was taken by multiplying the output achievement (performance), the uptime (availability), and the quality.

In addition to using the SMED approach on the jig change activity, the SMED was also applied on the robot at the welding machine. For example, the internal activities were taken when robot weld machine is stopped, and external activities are taken when the robot weld machine is running. From the data analysis, the changeover was another issue observed for the production line.

Based on Table I, the changeover activities related to downtime is under the Availability category, one of the OEE components calculated using the Operating time divided by Planned Production time.

In order to get the operating time, the downtime should be deducted from the Planned Production Time as shown in the equation (5) below.

Operating Time = Plan Prod. Time – Downtime--------(5)

In this case, downtime can be considered as the internal activities explained in the previous paragraph. The availability rate would be lower when the planned downtime is considered as one of compulsory activities in production time.

IV.3. Application of SMED on OEE

In order to reduce the time taken for changing jig through SMED application, reducing the time for internal activities can be achieved without incurring any cost. For example, taking jig from storage is a process that consume the highest time during the jig

change activity. This process time needs to be reduced by preparing the jig early before the line nine is stopped for the jig change. Moreover, the jig needs to be retrieved early from storage by the operator that work in a shift before. This means if the jig change is required in the morning shift, the night shift operator needs to prepare the jig for the morning shift so that the operator during the morning shift can focus only on the jig change.

Reduction of time taken for jig change also can be done by creating a space to store the jig next to the machine. This can further reduce the time taken to retrieve the jig from storage and reduce the travelling time for the operator to handle jig change task. Thus, the assembly layout needs to be changed in order to allocate the jig storage on closer to the assembly line.

The time for the internal and external activities can be further reduced by creating a proper schedule the operator. This schedule plan is to control the operator to perform the tasks as per the specified time. However, enough allowances need to be provided in order to ensure the safety and comfort while performing the work.

Another suggestion is to convert the internal

November-December 2019
ISSN: 0193-4120 Page No. 3650 - 3659

activities to external activities. These activities include:

i. Bring jig from storage

ii. Bring rack

iii. Remove spatter on a jig

iv. Check filter

v. Check push button

TABLE 3

Internal and External Results before SMED Improvement

Internal	**Time (min)**	**External**	**Time (min)**
Remove air compressor	1	Clear child part	1
Remove connector cable	1	Remove rack	2
Lower Jig to the ground	3	Prepare tool for cleaning	3
Take out Jig from the line	2		
Bring jig from the store	20		
Bring jig to the line	7		
Raise Jig up	5		
Connect the connector cable	1		
Connect the air compressor	1		
Doing 5S	7		
Bring rack	2		
Set programming on computer	10		
Remove spatter weld by using chisel and hammer	12		
Remove chip on cap tip by using dummy gun	7		
Inspection by line leader/line keeper	6		
Insert child part	4		
Check Filter Regulator Lubricant (FRL)	2		
Check Sensor	2		
Check Guide Pin / Air hose	2		
Check Upper and Lower Shank	2		
Check Pin Connector Jig	2		
Check Part Clamper	2		
Check Push Button	1		
Check Holder, Shank, and Adaptor	3		
Check Auto Cap tip Dressing	2		
Total	**107**	**Total**	**6**

Before SMED's application:

Planned Production Time = 16 Hours (2 x 8Hr Shift)

Downtime (planned & unplanned) = 107 Minutes (1.78 Hours)

Available Time (Uptime) = 16 Hours – 1.78 Hours = 14.22 Hours

Available Time / Scheduled Time = 14.22 Hours/16Hrs = 88.9% Availability

Performance = 89.9%

Quality = 77.0%

Therefore,

Availability x Performance x Quality = 88.9% x 89.9% x 77.0% = 61.5% OEE

After SMED's application:

Planned Production Time = 16 Hours (2 x 8Hr Shift)

Downtime (planned & unplanned)= 70 Minutes (1.17 Hours)

Available Time (Uptime) = 16 Hours – 1.17 Hours = 14.83 Hours

Available Time / Scheduled Time = 14.83 Hours/16Hrs = 92.7% Availability

Performance = 89.9%

Quality = 77.0%

Therefore,

Availability x Performance x Quality = 92.7% x 89.9% x 77.0% = 64.2% OEE

V. Conclusion

This study aims to improve of the production changeover in PEPS-JV's company. The focused of this study is to understand the relationship between SMED and OEE. Further, the SMED concept is applied to observe the impact on the OEE. In this regard, three components of OEE such as Performance, Availability, and Quality are detailed out. The results of this study showed the Availability component of the OEE can be improved through SMED application where 2.7% were increased when improvement done through reduction of internal time. Thus, the company was able to increase the volume and flexibility of production through minimizing internal time based on SMED application.

TABLE 4

Internal and External Results after SMED Improvement

Internal	Time (min)	External	Time (min)
Remove air compressor	1	clear child part	1
Remove connector cable	1	Remove rack	2
Lower Jig to the ground	3	Prepare tool for cleaning	3
Take out Jig from the line	2	Bring jig from the store	15
Bring jig to the line	7	Bring rack	2
Raise Jig up	5	Remove spatter weld by using chisel and hammer	12
Connect the connector cable	1	Check Filter Regulator Lubricant (FRL)	2
Connect the air compressor	1	Check Push Button	1
Doing 5S	7		
Set programming on computer	10		
Remove chip on cap tip by using dummy gun	7		
Inspection by line leader/line keeper	6		
Insert child part	4		
Check Sensor	2		
Check Guide Pin / Air hose / Fitting	2		
Check Upper and Lower Shank	2		
Check Pin Connector Jig	2		

Check Part Clamper	2		
Check Holder, Shank and Adaptor	3		
Check Auto Cap tip Dressing	2		
Total	**70**	**Total**	**43**

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