Setup Time Reduction in an Automotive Battery Assembly Line

Deros B.M.
Department of Mechanical & Materials Engineering, Faculty of Engineering & Built Environment, University Kebangsaan Malaysia

Mohamad D.
Department of Mechanical & Materials Engineering, Faculty of Engineering & Built Environment, University Kebangsaan Malaysia

Idris M.H.M.
Department of Mechanical & Materials Engineering, Faculty of Engineering & Built Environment, University Kebangsaan Malaysia

Rahman M.N.A.
Department of Mechanical & Materials Engineering, Faculty of Engineering & Built Environment, University Kebangsaan Malaysia

Ghani J.A.
Department of Mechanical & Materials Engineering, Faculty of Engineering & Built Environment, University Kebangsaan Malaysia

Ismail A.R.
Department of Mechanical & Materials Engineering, Faculty of Engineering & Built Environment, University Kebangsaan Malaysia

Abstract
One of the most critical challenges faced by many manufacturing industries is to produce high quality products using cost-efficient methods and tools in the shortest possible time and at the lowest operating costs. Many past researches had shown that in order to reduce setup time and manufacturing costs it need for fast setups and changeovers. Single Minute Exchange of Die (SMED) is one of the Lean Manufacturing System (LMS) tools used to measure setup and changeover efficiency. Setup time reduction is an important key parameter for improving manufacturing flexibility and reducing manufacturing costs. The three main objectives of this study are: first, to reduce machine setup time by 35% during a mould changeover; second, to identify the root causes of the bottlenecks operations; third, to propose and implement possible solutions to the bottleneck problems. SMED methods were applied at two major bottlenecks during setup operations, they are cast on strap and heat seal. Results and findings on the data analysis of the two bottlenecks before and after implementation of SMED are examined and analyzed. The setup operations performance is measured based on data analysis result with respect to machine setup time reduction. The result of this study shows significant reduction of cast on strap setup time to 54% and heat seal setup time to 47%. In other words, this study has achieved more than 35% of setup time reduction.

Keywords*: Setup time reduction, manufacturing costs, battery assembly line*

1 Introduction

Many manufacturers face cost-reduction and efficiency challenges in their manufacturing operations. To survive in today's highly competitive world, manufacturers need to find ways to reduce production time and costs in order to improve

operating performance and product quality. The survival of any industry in today's competitive market place depends on response time, production costs and flexibility in manufacturing [1]. In recent years, companies have become increasingly focused on market and customers responsiveness. This has led particularly in the automotive industry to the implementation and adoption of lean manufacturing techniques. Due to the complexity and demand behaviour from customers, the role of setup time reduction enabling better response and small batch manufacture [2]. The main goal of setup time is to reduce machine down time. Reducing machine down time will boost capacity, increase manufacturing flexibility, and help increase overall output [3]. Roy [4] believed that setup time can be reduced by using Single Minute Exchange of Die (SMED) concepts, which can be achieved through better planning, process redesign and product redesign. SMED is a scientific approach to setup time reduction that can be applied to any machine [5]. The ultimate goal of SMED is to perform machine setup and changeover operations under ten minutes. Past research conducted by Trovinger and Bohn [6] had combined SMED and IT-Based Methods to study about the lost of effective capacity to setup time in printed circuit board assembly. Their research results shows that reduction in key setup times had contributed to more than 80 percent in term of total cost and direct benefits of USD1.8 million per year. An investigational research had been performed by Cakmakci [7] to observe the relation between SMED methodology and equipment design in the automobile industry. The results of this research had indicated that SMED is a suitable method not only for manufacturing improvement but also for equipment and die design development. The three main objectives of this paper are: first, to reduce machine setup time by 35% during a mould changeover; second, to identify the root causes of the bottlenecks operations; third, to propose and implement possible solutions to the bottleneck problems.

2 Methodology

This study takes place in Company X. Only one battery assembly line involved which is known as the main assembly line A.

2.1 *Data Collection*

Statistical data were collected and analyse to measure the machine setup time in assembly line A. A data check sheet need to be developed first before data is collected and measured by using a stopwatch. Prior to that, the production process flow and standard operation procedure are reviewed briefly before setting up the data collection check sheet. Based on the real production, data is collected and recorded on a daily basis by different types of time loss from the assembly line A. Later, a statistical bar chart is plotted to monitor and analyse the problems. These methods help the authors to identify the main contributor to high time loss in the battery assembly line A and help to visualise and better understand the root cause of problems and finding possible solutions to the problems.

2.2 *SMED Techniques*

The SMED method investigated in this study consists of eight techniques (1) separate internal from external setup operations; (2) convert internal to external setup; (3) standardise function, not shape; (4) use functional clamps or eliminate fasteners altogether; (5) use intermediate jigs; (6) adopt parallel operations; (7) eliminate adjustments and (8) mechanisation.

2.3 *Data Analysis*

The analysis of data and information gathered that led to significant improvement to be carried out in three different categories such as mechanical improvement, electrical improvement and organisational improvement. Results comparison before and after SMED implementations are extensively reviewed.

3 Result & Discussion

Basically, there are nine processes and machines involved in mould setup activities in assembly lines A. Processes and machines involved are enveloping, cast on strap, polarity tester, spot welding, short circuit, shear tester, heat seal, post burning and air leak tester. The current setup time in all nine processes in Assembly line A were collected and analysed thoroughly to investigate the bottleneck process. This data analysis is vital to observe the current setup time activities and performance and to

identify which current setup processes need to be focused on this study before SMED can be implemented on mould setup in the assembly line A. The current setup time of nine processes involved in mould setup collected are shown in Table 1. From Table 1, it is apparent that the cast on straps process and heat seal machines takes longer setup times compared to other processes. Over the past 2 months, with an average of 52 minutes were used to perform the cast on strap machine setups and an average of 32 minutes were used to perform the heat seal machine setups. From this analysis, cast on strap and heat seal machines were identified as major bottlenecks. These two setup processes were approximately spent about 59% of the total average minutes to complete the tasks.

3.1 *Cast On Strap*

There are 13 tasks involved in the cast on strap setups on mould changing at the assembly line A. Data analysis on setup data was used to identify which current cast on strap activities delay the setups processes and contributing to longer setup times. The eight SMED techniques have been applied to the cast on strap setup operations. A thorough time study analysis of the cast on strap and heat seal setup activities were conducted in order to evaluate the setup performance for each setup activity after the implementation of the eight SMED techniques. Figure 1 shows the decreasing trend in the overall machine setup times after the implementation of SMED. This trend is due to the changes and improvements that have been made to setup activities in the production line which had reduced the total number of tasks from 13 to only 7 tasks as shown in Figure 2. After successful implementation of SMED and a few improvements that have been made in cast on strap setup activities, the overall setup time reduced from 52 minutes to 24 minutes. A total of 28 minutes or 54% of setup time were reduced in the cast on strap setup operations.

3.2 *Heat Seal*

There are 12 tasks involved in heat seal setups which are currently done by a single worker. In current practise, all the internal activities involved during the setup for a battery heat sealing machine are performed while the machine is not running or internally. Setup time data for each activity involved in battery heat sealing setups were collected and analysed. The same SMED techniques used in the cast on strap setup were applied in the heat seal machine setup. The collected data shows significant improvement in all bottlenecks activities after SMED techniques were applied in assembly line A. Figure 3 shows the decreasing trend in the overall machine setup times after the implementation of SMED. This trend was due to the changes and improvements that have been made to setup activities in the production line which had reduced the total number of tasks from 12 to only 5 tasks as shown in Figure 4. After successful implementation of SMED and a few improvements had been made in heat sealing machine setup activities, the overall setup time were reduced from 36 minutes to 19 minutes. A total of 17 minutes or 47% were reduced in the heat seal setup operations.

Table 1: Current setup time of nine processes involved in mould setup

No	Process/Task (mins)	Time (minute)										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
1	Enveloping machine	13.5	10.2	11.3	11.5	14.2	12.1	12.9	12.3	13.3	11.1	12.24
2	Cast on strap machine	52.2	50.1	55.2	51.3	53.6	59.2	51.2	53.6	50.2	49.5	52.61
3	Polarity tester machine	9.4	7.2	7.5	7.3	7.1	7.9	9.1	8.3	8.5	8.1	8.04
4	Spot weld machine	11.2	13.5	10.1	15.7	12.4	12.3	11.8	13.1	12.2	12.9	12.52
5	Short circuit machine	8.1	6.6	7.4	8.3	8.8	9.2	6.7	7.2	7.3	7.5	7.71
6	Shear tester machine	9.3	10.1	10.5	11.3	10.3	10.2	11.2	12.6	10.6	10.2	10.63
7	Heat seal machine	36.2	31.1	35.2	29.6	33.1	35.3	31.7	31.4	34.4	33	32.7
8	Post burning	406	5.1	5.8	4.3	5.9	4.6	4.1	4.7	4.5	5	4.86
9	Air leak tester	3.9	4.5	3.5	3.7	3.3	3.8	3.2	3.6	3.7	5	3.82

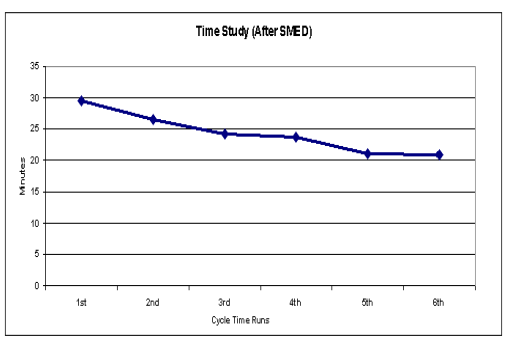

Figure 1: Time data study after the implementation of SMED in cast on strap

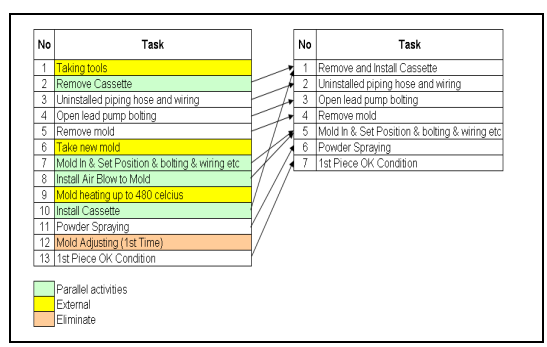

Figure 2: Tasks after SMED implementation in cast on strap

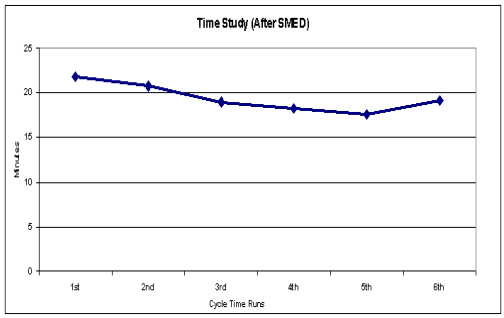

Figure 3: Setup time data after SMED implementation in heat seal

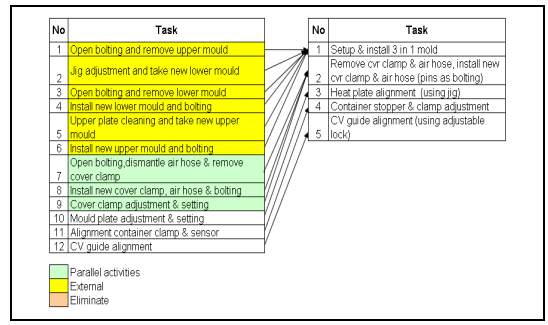

Figure 4: Tasks after SMED implementation in heat seal setup process

4 Conclusions

The SMED techniques were implemented in the two bottleneck processes, in cast on strap and heat seal. The goal to reduce machine downtime during the setup operations and reduction in setup times makes it possible to increase manufacturing system flexibility to manufacture a variety of products. An increased of manufacturing flexibility will lead to improve production performance. From the current setup time process data collected that have been shows that the bottleneck problem is at the cast on strap and heat seal machines. In general, these two setup processes spent approximately 59% of the total average minutes to complete the tasks in assembly line A. By implementing the eight SMED techniques, the total time taken to perform cast on strap setup activities at assembly line A was decreased by 54% or from 52 minutes to 24 minutes. Meanwhile the heat seal machine setup was reduced from 36 minutes to 19 minutes, resulting in a 47% reduction in setup process time. In other words, SMED is an effective tool that can be used to reduce machine downtime. However, the results from this study need to be treated with caution because the SMED techniques were not applied to the other three main assembly lines, B, C and D. Therefore, the authors recommend the company strongly the SMED techniques in main assembly lines B, C and D, so that the total assembly loss time due to setup or mould change over could be reduced and thus improves their production efficiencies.

References

[1] Chase, R.B., Aquilano, N.J., and Jacobs, F.R. 2001. Operations Management for Competitive Advantage, (9th Edition). New York: McGraw Hill/Irwin.

[2] Gest, G., Culley, R.I., Mileham, A.R., Owen, G.W. 1995. Review of Fast Tools Change Systems. Computer Integrated Manufacturing System 8(3): 205-210.

[3] Keberdle, C.F. 2008. Reducing Machine Setup and Changeover Times http://w3.manuvis.com/wp-content/uploads/2009/05/reducing-machine-setup-white-paper.pdf

[4] Roy, R.N. 2005. A Modern Approach To Operations Management. New Delhi : New Age international (P) Limited.

[5] Shingo, S. 1985. A Revolution in Manufacturing, The SMED System. Cambridge, MA: Productivity Press.

[6] Trovinger, S.C. and Bohn, R.E. 2005. Setup Time Reduction for Electonics Assembly: Combining Simple (SMED) and IT-based Methods. Production and Operations Management. 14(2): 205-217.

[7] Cakmakci, M. 2009. Process Improvement: Performance Analysis of The Setup Time Reduction-SMED in The Automobile Industry. The International Journal of Advanced Manufacturing Technology. 41(1-2): 168-179.