ANNALS OF FACULTY ENGINEERING HUNEDOARA
– INTERNATIONAL JOURNAL OF ENGINEERING
Tome X (Year 2012) – FASCICULE 1 (ISSN 1584 – 2665)

1. B. Suresh KUMAR, 2. S. Syath ABUTHAKEER

PRODUCTIVITY ENHANCEMENT BY IMPLEMENTING LEAN TOOLS AND TECHNIQUES IN AN AUTOMOTIVE INDUSTRY

1-2. DEPARTMENT OF MECHANICAL ENGINEERING, PSG COLLEGE OF TECHNOLOGY, COIMBATORE, INDIA

ABSTRACT: *Nowadays, automotive industries are adopting new tools and techniques to increase productivity, operational availability and better overall efficiency of the production line. This paper describes the productivity enhancement by set-up time reduction in a fagor press involved in the machining of evaporator plates. The well-known Single Minute Exchange of Die technique (SMED) was applied. 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. It is also often referred to as Quick Changeover (QCO). Using SMED technique, the result shows that tool change over time was reduced from 40 minutes to 12 minutes i.e. 28 minutes reduced and production rate has been increased from 92200 pieces to 98080 pieces i.e. 5800 pieces increased.*
KEYWORDS: *Lean manufacturing, Quick Changeover, Single Minute Exchange of Die (SMED)*

INTRODUCTION AND LITERATURE REVIEW

In recent years, companies have become increasingly focused on market demand and customers responsiveness. This has led to the implementation and adoption of lean manufacturing techniques in the automotive industry. Lean manufacturing is known as a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination [1]. For many, lean manufacturing is the set of "tools" that assist in the identification and steady elimination of waste (muda). The main tools of a manufacturing program are value stream mapping, 5S, TPM, SMED, and Six Sigma. These tools focus on certain aspects and areas of the manufacturing process to eliminate waste and improve quality while production time and cost are reduced. The waste reduction philosophy considers the change over time as a non-value added activity. Change over time that is illustrated in Figure 1 is defined as a method of analyzing and reducing the time needed to change a process from producing one good part to producing the next good part [2].

In the scope of lean manufacturing, an important problem needed to be solved. Because lean manufacturing requires small batch sizes and high product variation a new method had to be developed to reduce the setup times. In 1985 Dr. Shigeo Shingo introduced his methodology called Single Minute Exchange of Die (SMED) [3]. SMED is a scientific approach to setup time reduction that can be applied in any factory and also to any machine [4]. The ultimate goal of SMED is to perform machine setup and changeover operations in less than ten minutes. Several practitioners have proved that this method really works in practice and in some situations reductions of higher than 90 percent setup time are achievable [5]. With the application of SMED, improvements were substantial with initial data showing reduction of setup time ranging from 25% to as high as 85%. With the reduced setup time, production flexibility expanded as it was able to afford more frequent product mix changes. In addition, machine utilization and equipment went up with the reduced setup [6-8].

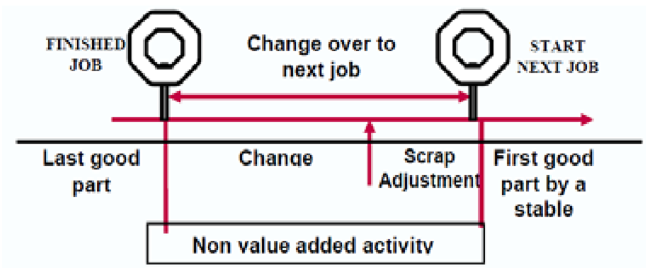

Figure 1. Representation of change over time

The SMED technique is used as an element of "TPM" and "continuous improvement process" in efforts of reaching lean manufacturing [9–14]. Case studies about setup reduction at different manufacturing environments take place in some texts [15, 16]. In addition, the technique is evaluated about its sequential implementation approach [17]. In light of the literature survey, the present study is *the first attempt that explores the degree of use of lean practices in the manufacturing of evaporator core in an automotive industry and provides direction for future research.*

METHODOLOGY

This study concentrates on the evaporator core building of the model car -PA. The evaporator coil in an air conditioning system is responsible for absorbing heat. As air (can also be water in a chiller) passes over the evaporator coils a heat exchange process takes place between the air and the refrigerant. The refrigerant absorbs the heat and as it absorbs heat is flashed to a vapour. The air conditioner evaporator conditions the air in two ways why it is typically operating below the dew point. It causes sensible cooling and it causes latent heat removal. The latent heat removal is the process of drawing moisture out of the air and the sensible cooling is dropping the temperature of the air.

Figure 2 shows the Evaporator core process flow, starts from the press and fin mill to the susring unit, from where it is made to pass to the furnace then to the brazing and gauging section finally to the inspection area. Completed evaporator core is shown in Figure 3, after the entire process is over it is sent to the storage where it will be retrieved latter to form a part of the Heating, Ventilating, and Air Conditioning unit (HVAC).

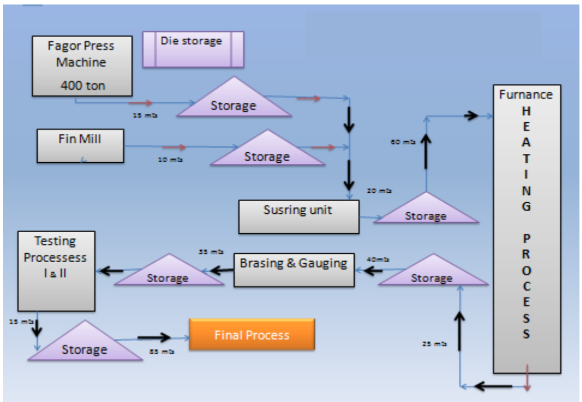

Figure 2. Evaporator core process flow

A. Data Collection

A statistical data collection method for measuring fagor press operation setup time was used in this study to summarise and describe the data. Standard operation procedure is reviewed briefly before setting up the data collection table. The next step is to create a data collection table prior to collecting data and the time taken was measured using a stopwatch. Based on the actual production, data was collected and recorded on a shift basis by different types of time loss from the fagor press operation. These methods helps to identify the main contributor to high time loss in the fagor press and help to visualize and better understand the root causes and finding possible solutions to the problems.

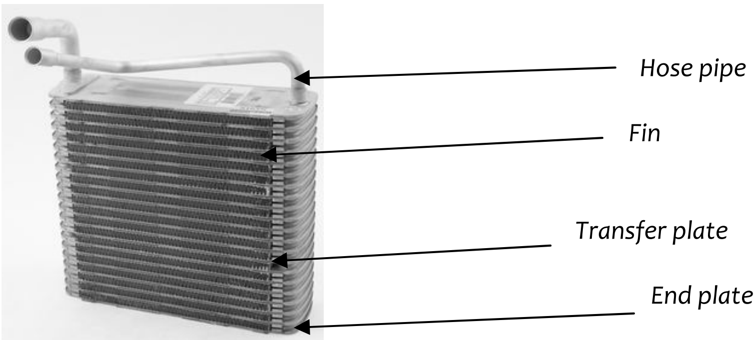

Figure 3. Evaporator core

B. Application of SMED techniques

Setup operation is defined as the preparation or post adjustment that is performed once before and once after each lot is processed [4]. Shingo divides the setup operation into two parts:

Internal setup: The setup operation that can be done only when the machine is shut down (attaching or removing the dies).

External setup: The setup operation that can be done when the machine is still running.

These operations can be performed either before or after the machine is shut down; for example, getting the equipment ready for the setup operation can be done before the machine is shut down. The three main steps of SMED, also given in Figure4, can be summarized as follows:

Step 1: Separating internal and external setup
Step 2: Converting internal setup to external setup
Step 3: Streamlining all aspects of the setup operation

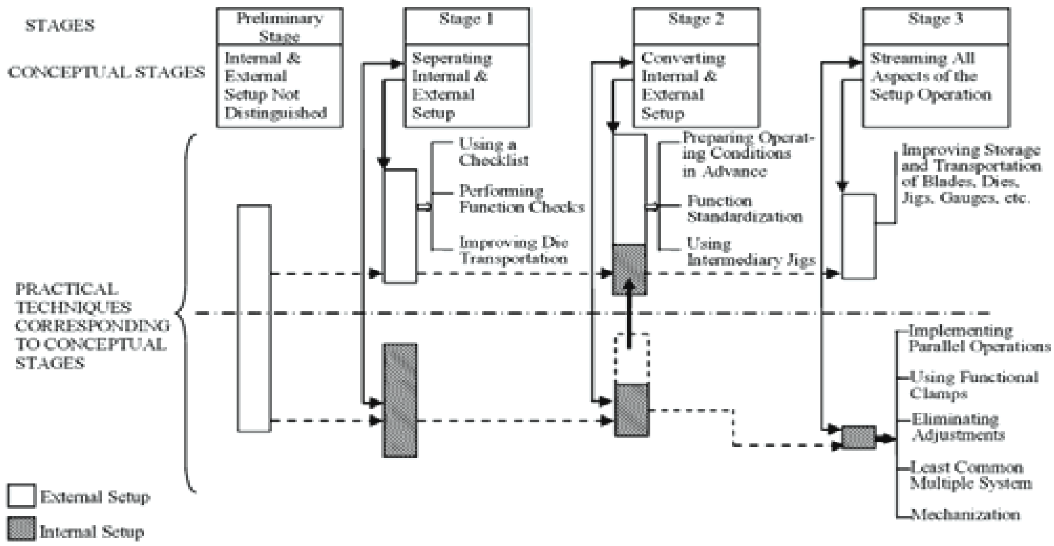

Figure 4. SMED conceptual stages and practical techniques

C. Data Analysis

The analysis of data and information gathered led to significant improvement carried out in mechanical improvement, and organizational improvement. Comparison result before and after SMED implementation was extensively reviewed. The operation of removing a die will be further split in to this format as listed in the Table 1.

Table 1. Current Percent Of Setup Steps

Operation	Proportion of time
Preparation, after-process adjustment, and checking of raw materials, blades, dies, jigs, gauges, etc.	30%
Mounting and removing blades, etc.	5%
Centering, dimensioning and setting of conditions.	15%
Trial runs and adjustments.	50%

RESULTS & DISCUSSION

Basically, Fagor Press is used to manufacture the evaporator plates from aluminium sheets. This press is about 400 ton, 34 feet high and 18 feet long. The tool die comprises of two parts the upper die and the lower die. The upper die has the projected part and the lower die has the receiving part. Usually the tool die consist of the various process, as the aluminum sheet is made to pass through the fagor press there is a series of various shape forming and cutting so that finally when the process is over a complete and a finished evaporator plate will come and fall, Figure5 shows the different types of evaporator plates.

Figure 5. Evaporator plates

A. Analysing setup time

The regular tool changing procedure of 400 ton fagor press took about 12 steps and 40 minutes to set the die in proper position and start out the process. Hence through literature survey, have put in forth the advanced technique of lean Manufacturing called the SMED to simplify the tool changing process and also increase the production size of the fagor press. After all the process is over, the regular production process starts from here.

Task operation = the task been performed by the operator to perform the tool changeover process.
Actual time = the time that is been noted while the operation is been performed (In– Internal time, Ex– External time).
Improvement = after the necessary changes the tasks performed.
Target time = the time noted with the implementation of the improvement. (In – Internal time, Ex – External time).

Table 2. Current changeover time

S. no	Task Operation	Actual Time	
		Internal (In)	External (Ex)
1	Removal of bolts (8 Bolts, 4 up, 4 down) (In)	45 sec	
2	Pushing the die to external Rail using chain drive (In)	2.50	
3	Using Overhead fixtures to place the die on to the ground (Ex)		8.47
4	Lifting the new die to the external Rail (Ex)		15.32
5	Positioning the die in the press using chain drive (Ex)		17.41
6	Calibrating using locator (In)	19.09	
7	Tightening the bolts (8 Bolts, 4 up, 4 down) (In)	21.35	
8	Calibrating and inspection (In)	23.29	
9	Adjustment of aluminum foil mills (Ex)		31.17
10	Insertion of aluminum foil and checking the completion of 1 full process (In)	36.49	
11	If errors calibrate (In)	37.03	
12	Regular process starts	40 min	

Table 3. Change over time after first SMED attempt

Improvement	Target Time	
	Internal (In)	External (Ex)
1. We use two operators to remove bolts on two sides	20 sec	
2. Pushing the die to external Rail using chain drive (In)	2.25	
3. Overhead fixtures in position and ready remove the die		4.32
4. New die in position & placed on external rail		6.45
5. Positioning the die in the press using chain drive (Ex)		7.55
6. Calibrating using locator (In)	8.15	
7. We use two operators to tighten bolts on two sides	8.35	
8. Calibrating and inspection (In)		9.30
9. 1 operator already do this procedure and is ready	8 min, NULL Done before	
10. Insertion of aluminum foil and checking the completion of 1 full process (In)	14.31	
11. If errors calibrate (In)	16.39	
12. Regular process starts	18.01 min	

Table 2 shows the actual change over time practiced in the industry. Then after the 1st SMED attempt, the time is reduced from 40min to 18min and is shown in table III. Then took another chance and planned to further decrease the tool changeover time. In step 3, increased the overhead fixture speed and did the same procedure, the time further got reduced from 2.07min to 1.10min. In step 4 the new die is placed in position, this cancelled out the new die search time and old die change time. The time further got reduced from 2.13min to 1.17min.In step 6, proper positioning of tool die using chain drive nullified locator checking process. In step 9, told the operator operating on the aluminium mill to work a little faster. They cut down the time from 8min to 5min, though this step is not taken for consideration, because this process has been started when the tool changeover process starts. Rest of the procedure is the same as that of the first time. In this 2nd SMED attempt, the time is reduced from 18min to 12min. The tool changeover time for an actual process was about 40 min which after implementing the 1st SMED got reduced to about 18 min and after the 2nd SMED got further reduced to 12 min.

The following Table 4 shows us in detail about the 3 different shifts and there working time period in minutes. In this case consider 1 shift is 480 min of work time period but in which 36 min will be for tool die changing procedure and 444 min of press run time. This will be a normal procedure which industry follows. After implementing 1st SMED, changes the tool changeover time to 18 min and press run time to 462 min. which further got reduced to 12 min of tool changeover time and 468 min of press run time after implementing 2nd SMED, shown in Figure 6.

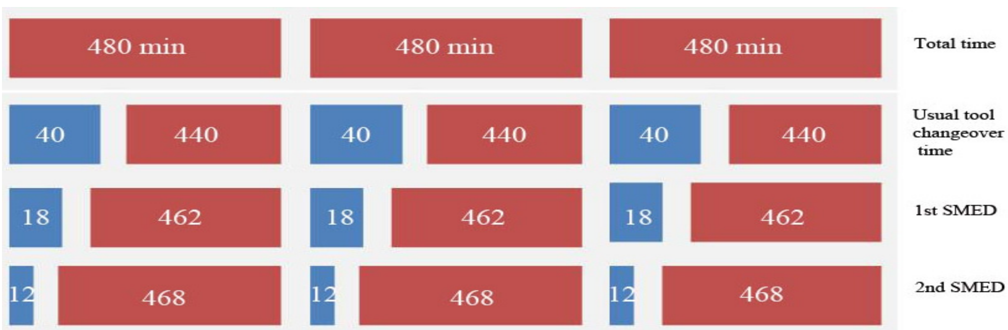

Figure 6. SMED after implementation

B. Basic Calculation and Tabulation

Basic Calculation and Tabulation:

- *Total no of shifts = 3.*
- *Each shift = 8 hours = 480 min.*
- *No of components produced in 1 min = 70 pieces.*
- *No of components produced in 1 shift = 440 pieces.*
- *No of defective pieces in 1 shift = 65*

Table 4. The Completed SMED Table

Process	Working time for 1 shift (min)	Working time for 3 shifts (min)	Number of pieces produced per shift	Number of pieces produced in 3 shifts	Number of defects in 3 shift	Total number of pieces produced in 3 shifts
Normal Process	440	1320	30800	92400	200	92200
SMED 1	462	1386	32340	97020	200	96820
SMED 2	468	1404	32760	98280	200	98080

CONCLUSIONS

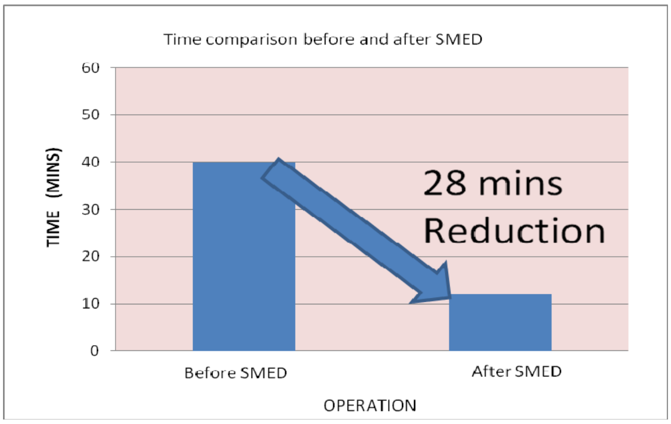

Figure 7. Time comparison before and after SMED implementation

The lean technique, SMED, was implemented and a significant result was achieved. SMED methodology was applied to prepare an optimal standard procedure for changeover operations on fagor press. Based on a series of time study data collected during the setup activities in the fagor press, a comparison of results and achievements before and after the SMED implementation was made to measure the effectiveness of SMED to reduce setup time. The goal to reduce machine downtime during the setup operations and reduction in setup time makes it possible to increase manufacturing system flexibility to manufacture a variety of products. By implementing the SMED techniques, the total time taken to perform setup activities at fagor press was reduced by from 40 minutes to 12 minutes i.e. 28 minutes reduced and production rate has been increased from 92200 pieces to 98080 pieces i.e. 5800 pieces increased. Other benefits achieved from SMED implementation are quick response to customers demand, increases workers' motivation, improved workers' safety and health and parallel operation system. Further studies in the facility may include 5S and Kaizen studies for internal setup. Alternative ways to shorten internal setups can be searched in detail. In order to eliminate adjustment steps, trial and errors should be minimized. Finally, the complete success of the application of lean viewpoint in the long run will depend on close teamwork between the shop floor personnel and the management.

REFERENCES

[1.] Johnson,A and Miller,J and A.M. Deif: A Lean Approach to Improve Reconfigurable Manufacturing Systems, In Proceedings of the Industrial Engineering Research Conference, 7 pages, 2010.

[2.] Ulutas,B.: An application of SMED Methodology, World Academy of Science, Engineering and Technology 79, 2011.

[3.] Cakmakci.M. and Karasu,M.K.: Set-up time reduction process and integrated predetermined time system MTM-UAS: A study of application in a large size company of automobile industry Int J Adv Manuf Technol 33: 334–344DOI 10.1007/s00170-006-0466-x, 2002.

[4.] Shingo,S. 1985. A revolution in manufacturing "The SMED system" Cambridge, MA: Productivity Press.

[5.] Van Goubergen, D. and Van Landeghem, H: Reducing Setup Times of Manufactuing Lines. International Conference on Flexible Automation and Intelligent Manufacturing, 2002.

[6.] Gilmore,M. and Smith,D.J.: Set-up reduction in pharmaceutical manufacturing: an action research study, Int J Oper Prod Man, vol. 16, no. 3, pp. 4–17, 1996.

[7.] Tharisheneprem,S: Achieving Full Fungibility and Quick Changeover By Turning Knobs In Tape and Reel Machine By Applying SMED Theory, In Proceedings of 33rd International Electronics Manufacturing Technology Conference, 5 pages, 2008.

[8.] Moxham,C. and Greatbanks,R.: Prerequisites for the implementation of the SMED methodology: A study in a textile processing environment, Int J Qual Reliab Man, vol. 18, no. 4, pp. 404–414, 2001.
[9.] Eti,M.C., Ogaji,S.O.T. and Robert,S.D.: Implementing total productive maintenance in Nigerian manufacturing industries. Appl Energy 79:385–401, 2004.
[10.] Chand, G and Shirvani, B: Implementation of TPM in cellular manufacture. J Mater Process Technol. 103,149–154, 2000.
[11.] Sun,H., Yam,R. and Wai-Keung,N.G.: The implementation and evaluation of Total Productive Maintenance (TPM)—an action case study in a Hong Kong manufacturing company. Int J Adv. Manuf. Technol. 22:224–228, 2003.
[12.] Prado, JC : Beyond quality circles and improvement teams. TQM 12(6):789–798, 2001.
[13.] Bamber, L and Dale, BG: Lean production: A study of application in a traditional manufacturing environment. Prod Plan Control 11(3):291–298, 2000.
[14.] McAdam, R and McGeough, F: Implementing total productive maintenance in multi-union manufacturing organizations: overcoming job demarcation. TQM 11(2):187–197, 2000.
[15.] Gilmore,M and Smith, DJ: Set-up reduction in pharmaceutical manufacturing: an action research study. Int J Oper Prod Man 16(3):4–17, 1996.
[16.] Moxham,C. and Greatbanks,R.: Prerequisites for the implementation of the SMED methodology: A study in a textile processing environment. Int J Qual Reliab Man 18(4):404– 414, 2001.
[17.] Cakmakci,M. :Process improvement: performance analysis of the setup time reduction-SMED in the automobile industry Int J Adv Manuf Technol 41:168–179 DOI 0.1007/s00170 008- 1434-4, 2009