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PROCESS IMPROVEMENT AND SETUP TIME REDUCTION IN MANUFACTURING INDUSTRY: A CASE STUDY

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Abstract: Nowadays, due to varying customer demands and demand of shorter delivery periods of the products, there is a need for the forging industries to adopt the lean manufacturing techniques over traditional methods to increase productivity, operational availability and better overall efficiency of the production line. The present study is aimed at studying the results derived after the Single Minute Exchange of Die (SMED) implementation at ABC Company. The Study consisted of a pilot study followed by the data collection then the data was analyzed for the losses and the possible solutions for the successful implementation of SMED. During the study it was observed there were 130 setups done in a month on a forging hammer and average setup time was 160 minutes. SMED methodology and other Lean Production tools were applied to reduce the setup times observed at the beginning of the project. With the developed solutions it is possible to reduce setup times, several changeover activities can be converted from internal to external and some of the activities can be streamlined. Application of the SMED on forging hammer reduced time per changeover from average of 160 minutes to 124 minutes 40 seconds and proposed saving of ₹ 1, 79,712 per year.

Keywords: Lean Manufacturing, SMED, Water Spider

1. INTRODUCTION

The modern manufacturing industries these days are facing lot of competition due to the concept of globalization, the industries are required to create the product that are available at competitive prices and with less lead time. Accordingly, to compete at the global level with global industries in terms of delivery time, quality and price, lean manufacturing techniques are being adopted by the manufacturing industries for every process. "Product differentiation implies the manufacture of a wider variety of goods in smaller batch quantities, the pursuit of which should be achieved without compromising overall productivity" [6]. However, producing products in smaller batch size result in more changeovers. A rapid changeover capability is critical for producing small quantities of a large diversity of products. SMED is one of many lean production methods for reducing waste, mainly in changeover time, in a manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from the current product to the next product. Fig.1 clarifies changeover time pictorially.

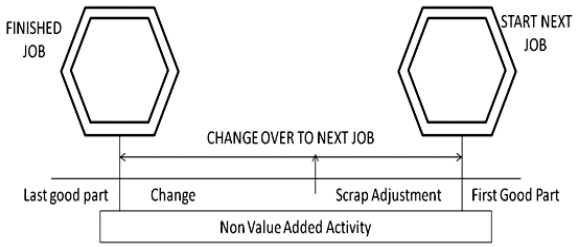

Figure 1: Changeover time

SMED changes the assumption that set ups can be done quickly, they can be done as often as needed. This means companies can make products in smaller lots, which has many advantages such as flexibility, quicker delivery, better quality and higher productivity.

2. LITERATURE REVIEW

Globalization has created the need to produce small lots, causing a significant increase in the

frequency of setup, causing the reduction of times production for each lot. For this reason it is important that changeovers are quick, so that the flexibility of respond to demand is not affected [8]. Single minute exchange of dies is one important lean tool to reduce waste and improve flexibility in manufacturing processes allowing lot size reduction and manufacturing flow improvements. SMED reduces the non-productive time by streamlining and standardizing the operations for exchange tools, using simple techniques and easy applications [1].The relation between both the setup time reduction and product design efficiency through quality control technique, and process capability analysis, it was also showed that SMED is still a suitable method not only for manufacturing improvement but also for equipment/die design development [3]. SMED was implemented on CNC machines. PDCA and ECRS techniques were used in addition to the SMED. In the study a reduction of 28% was observed in the changeover and productivity was increased by 11.5%[2].A study was conducted on bore grinding machine in a bearing manufacturing company. The SMED philosophy along with Eliminate, Combine, Reduce, and Simplify (ECRS) concept was adopted to achieve reduction in setup change time. The implementation of SMED and ECRS reduced the total setup time from an initial time of 195 minutes to 114 minutes, saving 81 minutes i.e. 41.53% of total time [12].In another study setup time of forging machine in fasteners manufacturing organization by using the technique of SMED was reduced. The total time of setup activity was reduced from 175 min. to 140 min. i.e. 35 min. were reduced by per changeover. So in a month by an average 20 changeovers are done on one machine which saves 700 minutes per month. Production rate had increased from 2664693 pieces to 2731193 pieces which means 66500 pieces increased per month. As a result Rs.2, 23,440 per month were saved in one machine [7].

3. CASE STUDY

3.1. Company Profile

ABC Company is a medium scale industry situated in Ludhiana. They have been dealing with manufacturing all types of hand tools, agricultural tools, construction tools, automotive tools, and plumbing tools etc for last 25 years.

3.2. Problems in Existing System

The Single Minute Exchange of Die (SMED), a process-based improvement formerly published in the mid 1980s, was first and foremost applicable in metal forging and forming industry involving the separation and conversion of internal setup operations into external ones. Although very important in increasing productivity SMED experiences are not very widespread in India and there is lack of consciousness and inspiration amongst operational personnel to reduce set-up times and knowledge of SMED is limited to a small group of individuals

So the present research work focuses on application of SMED in metal forging and forming industry as there are many losses in the process. The goal of applying SMED method to the changeover process at ABC Company is to develop a system so that setup time is reduced to minimum and the process of setup and changeover gets streamlined and all types of wastes can be eliminated from the production process.

3.3. Objectives

On the basis of the literature review, it can be said that although many companies have implemented SMED and have performed various activities to improve a setup process but still work can be extended the following objectives.

1. To identify internal and external activities in the changeover process of forging hammer.
2. To decrease changeover time of the forging hammer.
3. To suggest value adding practices by standardizing the process.

4. RESEARCH METHODOLOGY

Flow chart of research methodology is shown in Fig. 2 below:

A Pilot study was conducted to recognize the problems in current state. This study introduces us to the problems being faced at place of work. In the next step the focused area was determined where study is to be conducted and pre SMED data was collected to recognize existing practices and record current activity time/changeover time. Observed activities were classified into internal/

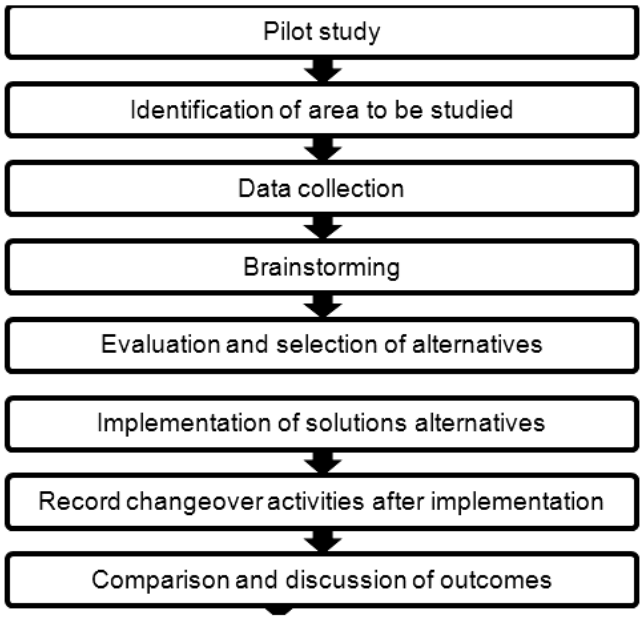

Figure 2: Research Methodology

external activities and were separated from each other. Then after that SMED activities were recorded.

4.1. Pilot Study

The process of production of a spanner was studied at ABC Company at present process parts on six separate forging hammers having capacity from 0.75 to 1.5 tons. To suit current manufacturing system and demand, the part is to be processed on one out of the 80 different die sets. On an average there were 13 changeovers processes that were performed on the machines in forging shop and machine shop in a day. Out of the these 13 changeovers, 6 changeovers are done on the forging hammers and rest on the trimming and blanking machines per day to suit achievement of daily orders.

4.2. Identification of Area to be Studied

The identification of area to be studied was done by studying the process flow chart of the spanner production and present time taken for changeover of various machines in different shops. The changeovers which were done in the forging and machine shops were more time consuming than in the other shops, changeover time of various machines in the machine and forging shops were noted down from the production reports of both the shops is given below in Table I.

Table 1
Average Setup Time Of Various Machines

Machine	*Setup Time (min)*
Forging Hammer	160
Trimming Press	87
Blanking Press	75

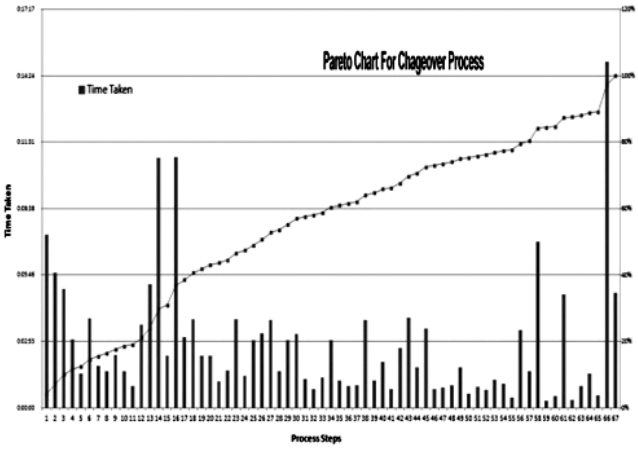

Figure 3: Pareto Chart for Changeover Process

Because of its high setup time the forging hammer was chosen for further study.

4.3. Data Collection

Collection of the data for the study is basically based on the time study as it plays a fundamental role in the collection of data. The data was collected for the changeover of 1.25 ton hammer. Four operators usually carry out changeover this may increase or decrease depending upon the labor availability and the operation being carried out. The data used in this study was collected by recording the entire changeover operation. Total number of people required performing various functions at various stages of the changeover process and the distance traveled by the workers and the fork lift operator to take back and put the die sets in position during the changeover process. Following the methodology of SMED, a usual changeover was taken into the consideration for study and recorded to evaluate and measure the changeover time in total for the present state. For the study, the data of the last cycle of the previous production run is taken into consideration.

4.4. Data Analysis

The analysis of collected data revealed the problems, inefficiencies, various wastes which were present

in the changeover process in current state. Critical analysis of the above data gave us a clear view of the time consuming activities show in Table II and to identify that a Pareto Chart was plotted to get the clear view of the time taken by each activity.

The following are the observations during set-up:-

- Nonexistence of regular policy procedures/ process scheduling/process planning.
- Too much outside movement to get hand tools and other things.
- Movements were not organized.
- The activities which are compulsory can be carried out concurrently. These activities include transport of the raw material to the machine; inform the quality department for inspection of the first piece.
- There was insufficient material handling equipments resulting in consumption of excessive time during material handling of dies.
- Offline activities such cleaning of dies, cutting of packing can be done prior to the start of the setup in order to save time when actual setup of the die is started.
- Too much adjustment time for die, due to trial and error method.

4.5. Brainstorming

After analysis of the changeover process a session was conducted with operators and shift supervisor the activities related with the changeover were discussed and understood thoroughly. There were notable numbers of waste elements in the process, improvement can be made to these elements for the more efficient changeover process. The elements which contributed in the increase of changeover time are shown in a fishbone diagram to identify the problems clearly.

The following ideas were generated for the improvements in the changeover process:

Short Term Ideas for Improvement

- Single Minute Exchange of Dies.
- Applying 5s to workplace.
- Standardizing the changeover process.

Long Term Ideas for Improvement

- Employing Water Spider.
- Erection of Die Racks Near the machines.
- Creating a specialized team for the changeovers.

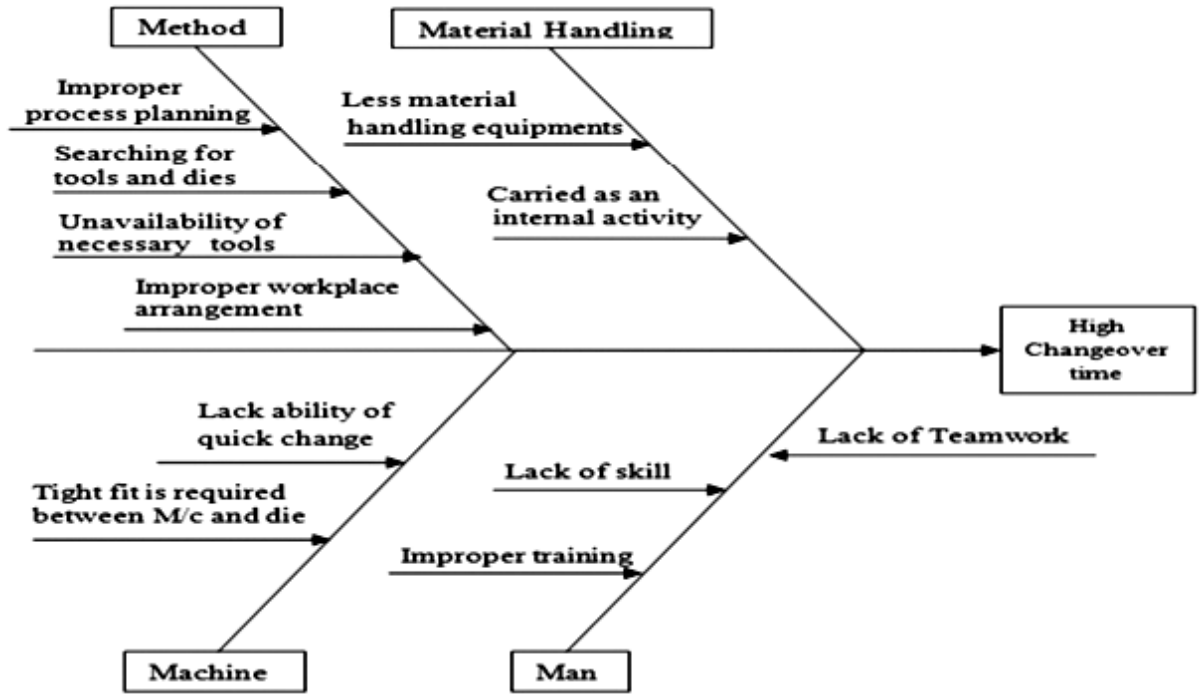

Figure 4: Fish Bone Diagram

4.6. Evaluation And Selection of Alternatives

After the generation of list of alternatives , the short term alternatives appears to be more reliable and efficient for the changeover process, on the other hand if the long term alternatives are fulfilled then the productivity and efficiency will be increased. Both the short and long term alternatives will help in creating a better working environment, better flow of working, well-organized process for the changeovers and increased productivity. Implementation of SMED and Water Spider was selected from the generated alternatives.

4.7. Application of the SMED methodology

The reduction of the setup time required for the changeover in forging hammer operations in the forging department at ABC Company. In order to accomplish this, the methodology of Single Minute Exchange of Dies (SMED) is adopted as the short term solution for analyzing the setup fundamentals and was useful to find out the which element can be eliminated, reduced or simplified for the achievement of the goal of setup time reduction. The reduction in the setup time was achieved through the application of the five step process.

First Step - The total setup time was measured in the current state.

Second Step - Study of setup elements that were being performed so as to identify the external and internal element, as well as recording of individual time of all elements in the process.

Third Step - Converting of the internal elements to external elements was done to the elements as many as possible.

Fourth Step - To reduce the total time required to perform the remaining internal elements

Fifth Step - Focused on standardization and reduction of the time for all external elements.

Table 2
Conversion Table For Internal And External Activities

S. No.	*Process Steps*	*Internal (mm:ss)*	*Improving Idea*	*Proposed*	
				Internal (mm:ss)	*External (mm:ss)*
1	Removal of forged pieces and collecting them in the bin	07:30	The furnace operator will perform these duties		07:30
2	Waiting for the fork lift to transport bin	05:51			05:51
3	Cleaning of the Machine and Surroundings	05:10			05:10
4	Operator Free	02:59	Duties assigned		02:59
5	Adjustment of slide sledge	01:29		01:29	
6	Removal of Die Key 3	03:53		03:53	
7	Adjustment of sledge	01:50		01:50	
8	Removal of Die Key 2	01:36		01:36	
9	Searching for additional tool key to remove keys	02:18	Shadow Board to be introduced	02:18	
10	Removal of Die Key 1	01:36		01:36	
11	Removal of Die Key 4	00:57		00:57	
12	Removal of Die From the locating pin	03:36		03:36	
13	Unloading of upper and lower dies from the machine	05:21		05:21	
14	Waiting for the fork lifter	08:50	Introduction of water spider		08:50
15	To store for new die	02:15			02:15
16	Searching for the new die and inspection	10:52			10:52
17	Loading the die set on the fork lift	03:04			03:04

(*contd...Table 2*)

S. No.	*Process Steps*	*Internal (mm:ss)*	*Improving Idea*	*Proposed*	
				Internal (mm:ss)	*External (mm:ss)*
18	Unloading of upper and lower dies from the store rack	03:50			03:50
19	From store to Machine	02:15			02:15
20	Operator Free	02:15			02:15
21	Loading of lower die on machine	01:08		01:08	
22	Loading of upper die on machine	01:37		01:37	
23	Cleaning of Dies	03:51	This process to be done in store		03:51
24	Adjustment of Air Hose Pipe	01:23		01:23	
25	Adjustment of Machine Base	02:56		02:56	
26	Finding packing for the key 3	03:15	SMED Trolley to be introduced		03:15
27	Placing of packing and inserting the locking pin in upper die	03:48		03:48	
28	Inserting Die key 2	01:35		01:35	
29	Sledging of key 2	02:56		02:56	
30	Finding packing for the key 3	03:12	SMED Trolley to be introduced		03:12
31	Inserting Die key 3 with packing	01:16		01:16	
32	Sledging of key 3	00:48		00:48	
33	Inserting Die key 4	01:20		01:20	
34	Finding die key 1	02:56	SMED Trolley to be introduced		02:56
35	Inserting Die key 1	01:10		01:10	
36	Removal of Die Key 1 and 4	00:56		00:56	
37	Re-Inserting the die key 1 with packing	00:58		00:58	
38	Grinding ends of key 4	03:48	More die keys are need		
39	Inserting die key 4	01:12		01:12	
40	Adjustment of slide sledge	01:59		01:59	
41	Removal of key 3 and 4	00:48		00:48	
42	Finding packing to be placed between die and machine base	02:36	SMED Trolley to be introduced		02:36
43	Cutting of packing to the size of the die	03:54	Must be done in the preparation phase		03:54
44	Placing of packing between lower die and machine base	01:45		01:45	
45	Operator Free	03:26		03:26	
46	Re-Inserting the die key 3	00:49		00:49	
47	Sledging of key 3	00:53		00:53	
48	Re-Inserting the die key 4	00:59		00:59	
49	Sledging of key 4	01:46		01:46	
50	Inspection of die position	00:37		00:37	
51	Adjustment of slide sledge	00:54		00:54	
52	Re-sledging of key 3	00:46		00:46	
53	Checking die position	01:14		01:14	

(*contd...Table 2*)

S. No.	*Process Steps*	*Internal (mm:ss)*	*Improving Idea*	*Proposed*	
				Internal (mm:ss)	*External (mm:ss)*
54	Adjustment of slide sledge	01:02		01:02	
55	Inspection of die position	00:26		00:26	
56	Adjustment of Machine Base	03:22		03:22	
57	Adjustment of Air Hose Pipe	01:35		01:35	
58	Placing of test piece in furnace and heating	07:12	Blank Must Be Placed Before Hand		07:12
59	First test piece	00:18		00:18	
60	Inspection of the forged piece	00:30		00:30	
61	Adjustment of machine base	04:56		04:56	
62	Forging of 2nd test piece	00:20		00:20	
63	Inspection of the forged piece	00:56		00:56	
64	Re-sledging of key 3	01:29		01:29	
65	Forging 3rd test piece	00:33		00:33	
66	Pre - Heating of die	15:00		15:00	
67	Final Trail run and inspection	05:00		05:00	
68	Setup Completed				
69	Total time taken	182.37		89.44	87.53

When the data was collected all the activities were internal to the setup but they can be converted to the external activities SMED methodology. The conversion table shows that there are various activities which can be converted from internal to external. The activities which can be converted from internal to external consist of activities such as dies from the store room when the press is in operation instead of getting them when the press is vacant from the previous setup. The searching time for the tools and equipments can be reduced by the introduction of shadow board and specialized trolley for carrying tools need in the setup known as SMED trolley.

4.8. Employment of Water Spider

A water spider or 'mizusumashi' in Japanese refers to a person who is assigned with standard set of tasks for maintaining the stock of materials in production areas. Water spider has different ways of working than a material handler because of specified operations sequence and the way of performing the tasks. The job of the water spider in the production system is to replenish material, removal of trash and storage bins between the work stations to decrease the amount work-in-process inventories. Due to these machines can be placed closer to each other, and the operator is spared from spending his time for transportation tasks, thus minimizing transportation waste [11]. Experienced workers usually are chosen as water spiders as they know about the needed parts and raw materials and the place where they are stored, and can serve up several workstations. Along with this managerial task such as updating record of the production, observing the workers and the process and provide training wherever needed can also be assigned to the water spider. Proposed Working/duties of the Water Spider

- Getting information from the production planning and control department about the changeover proposed for that particular day.
- Delivering the information to the store manager so that he could find the required dies and inspect them and the cleaning of the die set will be done by him in the store with the help of the store manager.
- Collection of dies from the store room and store them in die storage racks near the hammers according to the production plan.

Transport the raw material to the trimming machines and after the trimming process transporting it to required workstation.

- Transport the forged parts to the storage area and then to further operations.
- Collection of the dies from the machine storage rack and delivering them back to the store room.
- Assisting the operators during the changeover in case of shortage or need of any part or material he should get that as quickly as possible.
- Making a check that all the items which are needed for the changeover process are available when the setup starts.
- If there is any problem during the setup of die such as rejection after inspection, etc., immediately water spider will be informed and next changeover will take place with new die set and according to the production plan the next die set will be delivered by the water spider to the operator.

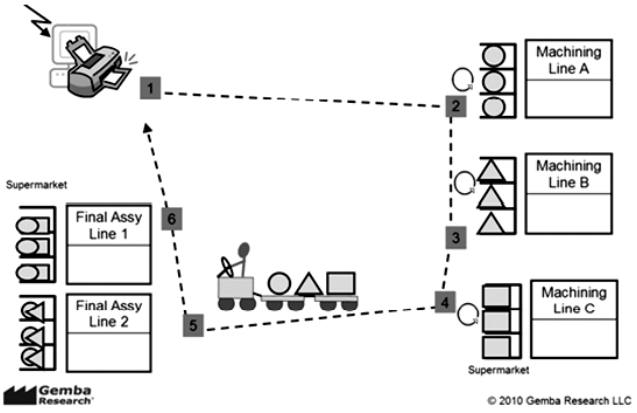

Figure 5: Concept of Water Spider

5. RESULTS

Before this study the activities related with the changeover of dies took an average time of 160 minutes. Use of problem solving lean tools such as fish-bone diagrams, 5S, Pareto chart etc. helped in getting the clear view of the problems encountered during the changeover. After applying the SMED methodology, the time related with changeover of dies was reduced to 124.40 minutes against the proposed time of 89.44 minutes and saving of 36 minutes was observed. Figure shows comparison between various setup

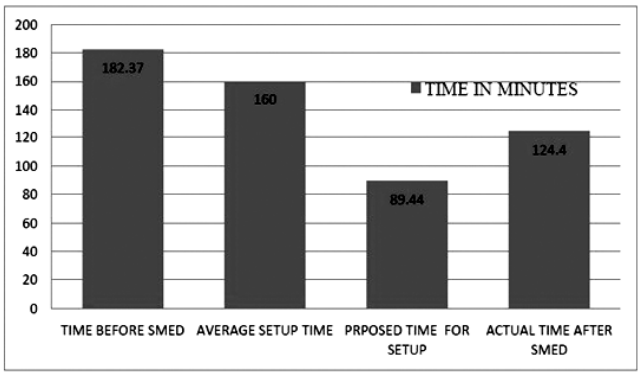

Figure 6: Comparison between various setup times

times. When the changeover was studied after the implementation, the required tools were checked and were placed on the special trolley. The shift supervisor acted as the water spider and performed the duty. Several operations were performed externally. All the activities were done internal to the setup when the study started but after the completion of the study the internal and external activities were distinguished and were separated from each other resulting in less time required for the changeover by 36 minutes. Changeover time was reduced by 22.5%.With the application of SMED methodology gains of approx [1] 1, 79,712 per year will be accomplished.

6. CONCLUSIONS

Standardizing the workspace and properly organized tools and equipment helps to reduce setup time. It is evidenced by study results which revealed that tool search time was abridged by 7.5%. SMED spectacle ways to reduce the changeover time and alter it into production time.

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