INTERNAL SETUP TIME REDUCTION BY INCULCATED SMED METHODOLOGY FOR PROCESS IMPROVEMENT

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Abstract
In manufacturing world we find many typical situation in industries due to which we are lacking in competition globally i.e. immediate customer order has received for a product but company is not able to cater that due to limitation in manufacturing inability. This paper presents the improvement illustration of the internal setup process of the water jet cutting machine by using Single Minute exchange of die in a project industry. Five month was the time duration for accomplishing the industrial project for master thesis. The implementation of SMED methodology counters the abnormalities of the process to increase efficiency, waste reduction and cycle time reduction. The objectives of the project has been achieved by reducing the setup time up to 23%, more than 90% reduction of recurring cost for slurry removal and 72% reduction of operators movements. The improvement of slurry removal corresponds to gain of approximately 6 lakh (605600/-). The approach to implement SMED methodology eliminates 7 deadly wastes and increase output efficiency.

Keywords— Lean manufacturing, SMED, Internal & External setup, Setup time

1. INTRODUCTION
Globalization of the market brought the need of cutthroat competition between the companies to produce and deliver the product on time to fulfill the requirement of the customer. In project based industries fabricating and delivering process of complex heavy objects require the expert to reduce the setup time to the best possible extent. In traditional manufacturing every company strive to increase the productivity without noticing the effect of increasing inventory but in engineering to order company inventory level is near negligible. It takes approx. minimum six month to complete the project. So, here setup time reduction, reduction of recurring cost and delivering the processed product on time is the main bottleneck to be focused. The most efficient ways to counter all manufacturing demerits is to implement SMED methodology. Single Minute Exchange of Die focuses on reducing the changeover time by converting internal tasks into external tasks and stimulates the output efficiency. Dr. Shingo classified the activities into two sub-categories internal setup and external setup. Internal Setup: All the setups which have to be carried out by stopping the ongoing operation is known as internal operation e.g. removal of the previous tool. Placing and positioning of new tool. External Setup: The activities are carried out when the machine is running or during producing parts is termed as external setup e.g. fetching raw material, returning the old die etc.

This paper illustrate a SMED implementation in an engineering to order company, more specifically in a water jet cutting machine, developed in the context of a master thesis in Total Quality Management. The objectives defined for the project were: (i) implement a methodology to reduce setup times, (ii) reduction in recurring cost and (iii) standardize setup activities. Lean manufacturing consists of large bunch of supplement tools and technique for reduction of waste including 5S, Poka Yoke, Standard Work, and SMED).

2. SCOPE OF THE STUDY
To understanding the detailed analysis of current situation the most crucial need is to get a full preparation about the present circumstance. Lead times were not sufficiently effective. It was showed that the machine availability was currently at an approximated 60%, meaning that the machine is not manufacturing almost a fourth of the time. Some of the vacant time is intended for maintenance and the rest is for setup time. Early in the project one suggestion is given to the company that to implement total productive maintenance (TPM) for all the machines to lower repair and overall maintenance time. Implementing some of the quality tools are also suggested including Pareto analysis, cause and effect analysis etc. After studying the detailed aspects of SMED methodology, the company felt that during that time they weren’t ready for this kind of project but now they feel a lot more prepared.

3. PROBLEM STATEMENT
It is observed from the study there should be no breakdown in water jet machining during operation. Each machine has an operator assigned to it. There are some major problems identified during the study of the machine in a company. Recurring cost is very high for slurry removal. Total efficiency of machine is 70% which is very less for water jet cutting machine. After problem informed, company asked for reduce the recurring cost and increase the efficiency of machine. It is observed by analyzing the machine recurring cost is caused due to slurry removal and time taken for internal setup of machine is more than its actual time.

4. LITERATURE REVIEW
In today’s scenario, customer satisfaction is a key way to remain in competition. To fulfill the need and expectation of the customer, companies have to produce products with high quality, less cost and with short cycle time. Changeover or setup is defined as an amount of time taken to change a piece of equipment or machine from producing the last good piece of a production lot to the first good piece of the next production lot. The essence of the SMED system is to convert as many changeover steps as possible to “external”. The principle of Single Minute Exchange of Die is pioneered by Dr. Shigeo Shingo while consulting variety of companies including Toyota, also known as Quick Changeover. This methodology came into existence when Mr. Ohno implemented SMED at car body molding press and reduce the changeover time from a day to 3 minutes. There are some steps are defined to strive for quick changeover or SMED: a) Document reality for identifying the suitable way to document the process reality, b) Separate
internal and external setup, c) Convert the internal setup into external setup, d) streamline the internal and external setup. Huge number of instance found during exploration of SMED methodology and proved that SMED methodology is applicable in various type industries. An example of garment industry is present in ref. [7] where case study reveals that there are 5 main factors affecting style change over time in garment manufacturing units in India. A case study on Elevator Company reveals the main results that obtained a reduction of 64% in setup time, 50% in work-in-process amount and 99% in the distance traveled by the operator during the internal period.

5. METHODOLOGY
To understanding the detailed analysis of current situation the most crucial need is to get a full preparation about the present circumstance. This project is carried on water jet cutting machine in engineer to order company to improve the setup process. The strategy adopted for implementing SMED methodology is to identify hindrance or abnormalities factors during ongoing processes. The water jet cutting machine consists of connected abrasive tank which takes 2½ days shutdown for washout of waste slurry from the tank and also comprise wastage of setup time for some activities. The study is carried out on water jet cutting machine for reduction of internal setup time and convert it to an external setup. There are four major steps which are prerequisite steps for implementation of SMED methodology.

Document Reality and Data Collected: Reducing changeover time depends on understanding the current process. To analyzing the exact time for changeover we used the most powerful tool i.e. video camera for document the reality. Time and motion study is observed for the particular task, using a timekeeping device (e.g., decimal minute stopwatch) to record the time taken to accomplish a task and it is often used when repetitive work cycle changes short to long duration. Water jet cutting machine having specification:

a) Water consumption: 3.79L/min
b) Abrasive consumption: 340-360 g/min
c) Nozzle size: - Diameter 0.35mm, Diameter 1mm (abrasive)
d) Below cutting pressure: - 3200 bar
e) Above cutting pressure: - 3800 bar

Machine bed size: - 1000mmL×4000mmW

Before begin the study is carried out which involve the meeting and interview with the machine operator and supervisor to collect the qualitative data. In sequence to understand the issues that is the long changeover times it will be necessary to analyze current changeover processes. The systematic structure for changeovers will be analyzed using a Changeover Analysis Sheet which records the work elements, finish times, internal activities, external activities, and the main function of the activity.

Table 1: Machine setup and time duration

<table>
<thead>
<tr>
<th>No</th>
<th>Tasks / Operation</th>
<th>Task Time</th>
<th>Category (Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Positioning of the metal piece on a bed</td>
<td>0.10:00</td>
<td>0.10:00</td>
</tr>
<tr>
<td>2</td>
<td>Alignment of the plate with X&amp;Y axis for positioning</td>
<td>0.25:00</td>
<td>0.15:00</td>
</tr>
<tr>
<td>3</td>
<td>Plate positioning at a right place where both nozzles will not collide</td>
<td>0.45:00</td>
<td>0.20:00</td>
</tr>
<tr>
<td>4</td>
<td>CNC setting on plate for cutting process</td>
<td>0.49:00</td>
<td>0.04:00</td>
</tr>
<tr>
<td>5</td>
<td>Trail on a plate</td>
<td>1.05:00</td>
<td>1.06:00</td>
</tr>
<tr>
<td>6</td>
<td>Walking to ware house to collect the plate &amp; bring it near to machine with the help of EOT crane</td>
<td>1.55:00</td>
<td>0.30:00</td>
</tr>
<tr>
<td>7</td>
<td>Fill-up of abrasive tank with abrasive material</td>
<td>2.01:00</td>
<td>0.06:00</td>
</tr>
<tr>
<td>8</td>
<td>Oil adding in a pressurized zone</td>
<td>2.11:00</td>
<td>0.10:00</td>
</tr>
<tr>
<td>9</td>
<td>Shutdown due to damage of grid</td>
<td>2.33:00</td>
<td>0.20:00</td>
</tr>
<tr>
<td>10</td>
<td>Shutdown of the machine for shurry removal</td>
<td>65:11:00</td>
<td>63:00:00</td>
</tr>
</tbody>
</table>

Fig2: Initial movement of operator (Spaghetti diagram)

It basically helps to eliminate the motion flow or unnecessarily movement of operator in unsystematic way of working.

a) Separate Internal and External Setup: The operation process of water jet cutting machine is fully automatic...
instead of lifting of metal plate or some non-value added activities. It was observed while studying activities that some activities are the biggest bottleneck in the machine which strongly affecting productivity of the machine. During the analysis of all activities the some activity found to be internal and very few are external. However, there are still many crucial and cost saving improvements that can be made. It is understood that all preparation and aftercare activities should be done externally and that some of the measurements, calibration tasks settings, can also be done externally. After analyzing, it was found that maximum activities are done while machine is stopped. Considering those activities are internal activities, the main aim is to reduce the internal setup time or convert internal setup into external setup to see the significant improvement by inculcating SMED methodology. Water jet machine changeover analysis sheet is employed which involves the activities, cumulative time, changeover time before improvement. Time study is replicated for many times for accurate identification of time duration. After identifying activities and measuring the changeover time of particular activity the priority matrix is generated for further prioritization and identified the main constraint of water jet cutting machine.

![Fig 3: Prioritized major problems](image)

b) Convert internal into external task: The purpose of this phase is to get a better perspective of the current situation and check if they can be in some way forced the internal setup into external setup. Study is carried out for four major problems demonstrated in previous stage. Firstly different concepts are generated for slurry removal system.

**Concept 1**
First concept created is slurry removal by water and air pressure with over flow to drain system and closed loop polishing system.

![Fig 4: Slurry removal by air and water pressure](image)

Pressurized water is flowed from nozzle with a high pressure speed for drain out of slurry and some air blowers are used for stirring of settled slurry but due to high pressure of nozzle up to 3800bar & fine particles of slurry will damage the air blower completely.

**Concept 2**
Second concept generated is abrasive removal by using hydraulic jack. Hydraulic jack in an abrasive bed made an agitation in bed foundation which affects the machining process and new fixture for hydraulic jack employed will increase the maintenance cost.
Concept 3
Third Concept is created using agricultural equipment for slurry removal by uploading auger. For slurry removal system auger will not applicable for load of slurry or collect and drain out but more applicable of stirring of slurry inside the bed.

Applicable concept for slurry removal system
The study is carried out to examine the applicability of the concept and concluded some results by executing the trail on slurry pump for removal of slurry. Removal of water and abrasive particle using slurry pump concept consists of slurry pump which will attach either side or both side of the abrasive tank. A slurry pump is a type of centrifugal pump which increases the pressure of liquid and solid particle mixture through centrifugal force and converts electrical energy into slurry potential and kinetic energy.

Concept 4
Slurry removal by using slurry pump is appropriate concept including some stringent standard work for its applicability. Basically slurry is any flow able suspension of small particles in liquid but here the constraint is with the time duration. With the time duration the abrasive fine particle get settled in bottom of the slurry tank and get convert into solid sludge. The most imperative solution to drain out this slurry is to pump the slurry in weekly basis. It consists of some integrated components show in below Fig.

In past scenario, recurring cost for water jet cutting machine slurry removal is very high and also included damage of grid fixture. Slurry is collected in tank for a long time which leads to make the slurry harder in bottom. So, during washout of tank harder slurry damages the grid as well as bed due to backhoe loader. Concept for grid is induced in water jet cutting machine in below fig.
Grid replacement system is generated by small prototype box of plastic. Finalizing the grid concept make one more alteration to increase the grid plate thickness 7mm to 12mm. Joined grid fixture is altered to removable grid system. Alteration of grid fixture helps to replace the grid plates during ongoing process or in less time interval. Implementing removable grid system lead to decrease the replacement time duration and grid plate can be replaced during ongoing process.

Some remedy for position of metal plate on a bed and waiting for crane is induced by employing the checklist to perceive before positioning.

c) Streamline of internal and external: In last stage of SMED methodology, the external improvements directly act on the setup time reduction and support the operator in improving his tasks. One of the water jet cutting machine’s major problems is the absence of a standard method to perform the setup process. In this study it was found that lots of money and manpower needed for slurry removal system. Another problem with this is damage of grid in slurry bed. To improve the process of slurry removal different concepts are suggested for it in which slurry removal using slurry pump is identified the best. Regarding the external improvements, some aspects influencing the motion of operator have been improved. Standard Work established for a positioning of metal plate by inducing the checklist.

Result and Discussion

To implement the SMED methodology in the water jet cutting machine, the longest setup process was analyzed. Internal activities time duration identified and valuable activities are converted into external tasks. Time study shows total time duration for internal activities including 106 min and 63 hours waste of time is identified for shutdown of machine for slurry removal as per half yearly.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Operation Description</th>
<th>Time</th>
<th>Improvement</th>
<th>Time saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Positioning of the metal piece on a bed</td>
<td>0:25:00</td>
<td>Checklist implement</td>
<td>8 min</td>
</tr>
<tr>
<td>2</td>
<td>Alignment of the plate with X&amp;Y axis for positioning</td>
<td>0:15:00</td>
<td>Poka Yoke</td>
<td>5min</td>
</tr>
<tr>
<td>3</td>
<td>CNC setting on plate for cutting process</td>
<td>0:04:00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Trail on a plate</td>
<td>0:16:00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Waiting for crane (Walking to warehouse to collect the plate &amp; bring it near to machine with the help of EOT crane)</td>
<td>0:30:00</td>
<td>Daily crane activities list implement</td>
<td>7min</td>
</tr>
<tr>
<td>6</td>
<td>Fill-up of abrasive tank with abrasive material</td>
<td>0:06:00</td>
<td>Checklist implement</td>
<td>5min</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>106 min</td>
<td></td>
<td>25 min</td>
</tr>
</tbody>
</table>

Table 2: Time saved after improvement

The main solution concluded for slurry removal is to washout the slurry on weekly basis because with the duration of time abrasive particle in tank become harder and difficult to washout or handle out. Cost is counted for this slurry removal and new concept for grid plates. Fixed cost is saved including different aspects like labor cost, vendor machining cost and transportation cost. Saving of the fixed cost of amount 605600/- or approximately 6 lakhs. Throughout the each phase of the project the total distance traveled is decreased significantly from an initial distance of 452 meters to a final distance of only 125 meters. Previously there was a lot of unorganized movement of operator to different places. Now it is possible to verify that just a few movements are performed during the internal setup, allowing a reduction in the machine downtime. The movement that the operator has to do (during the internal setup period) is to abrasive tank and tool box showed in (spaghetti diagram) figure.
Comparison between before SMED and After SMED: After the SMED technique was applied to the bottle neck Operation, the total time taken to perform the operation was decreased by 23% from 106 minute to 81 minute. The company started cutting the plate form 9 plates to 12 plates.

CONCLUSION
This study of SMED methodology on water jet cutting machine is a well-organized industrial application. A Comparison of results and achievements before and after SMED implementation were made to measure the effectiveness of SMED to reduce cycle time. The implementation of SMED methodology led to significant improvement, specifically reduction of 23% of setup time and cost saved for slurry removal system is amount of 605600/-. 72% reduction of operator movement. It was possible to verify that relatively simple solutions can bring great improvements at low cost. The maintenance of machine becomes more efficient by implementing new concepts for slurry removal and grid. The application of poka yoke helped a lot to eliminate error on some stages. The Elimination of waste in the entire operation improves equipment productivity, reduces the recurring cost with the continuous improvement approach, TQM team will take over one or more SMED Projects for analysis and improvement of the company’s setup processes.

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REFERENCES

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