OEE Improvement on a Bottleneck Process
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Abstract— The manufacturing industry has undergone a massive change in last few decades. Consumers are now focusing on reduction in cost with improved quality. There are various management methods that are adopted by mass production industries to ensure the desired quality with minimizing the cost, waste and time. Lean Manufacturing is one of the most popular management techniques adopted by popular industries to compete in this fast growing industry. The aim of this paper is to see how improvement in OEE can be brought by implementing the methods of lean manufacturing to an automobile components manufacturing company. Through this study, the increase in productivity and Overall Equipment Effectiveness (OEE) in an automobile components manufacturing industry is discussed.

Key words: Overall Equipment Effectiveness; Cycle Time; losses; bottleneck; production

I. INTRODUCTION

Maintenance has become one of the key departments in any of the industries all over the world. Recent study (Mobley, 1990) shows that 25-30% of total production cost is attributed to maintenance activities in the factory. Various activities are undertaken to ensure the productivity and quality is maintained inside the industries. A tremendous amount of work is done so that the job can be completed within the time desired by the consumer. In this automobile component manufacturing company, mass production of nozzle is done. The project has been undertaken to improve the Overall Equipment Effectiveness (OEE) for a bottleneck process in the manufacturing line.

- Lean Manufacturing: It is a systematic method for eliminating the waste (“Muda”) within a manufacturing process. Essentially, lean is centered on making obvious what adds value by reducing everything else. Lean Manufacturing is adopted from Toyota Production System (TPS)
- Overall Equipment Effectiveness (OEE): The overall equipment effectiveness is basically the total useful time per available production time. In practice, the OEE is a product of three quantities.

OEE = Availability x Performance x Quality
- Bottleneck Process: In simple terms, a bottleneck process is the process which obstructs the flow of manufacturing line. Due to bottleneck, there is a delay in material flow and in worse cases the customer machines remain idle due to bottleneck.

II. LITERATURE REVIEW

The literature has revealed that there are many challenges faced by manufacturing industries considering the maintenance of the machines. Till 1950s, the maintenance which used to be carried out was breakdown maintenance.

From the last few decades, the industries have started to carry out various maintenance programs and build the quality culture within the organization. Toyota has implemented its famous Lean Manufacturing technique to reduce the waste which in turn increases the productivity. The quality tools and modern equipments have been useful in the journey of lean manufacturing. Industries nowadays are using Pareto Charts, Poka-Yoke in manufacturing processes.

Overall Equipment Effectiveness comes into picture when the losses are to be considered while calculating the productivity of the machine. The losses are the main responsible factors for the reduction in quality, reduction in productivity and formation of the bottleneck process in the manufacturing processes.

The calculations of Overall Equipment Effectiveness for each machine on various processes are done in large scale industries to monitor the losses and the quality of the products manufactured. The industries try to match the world class OEE percentage every day in each shift. For this, the method of Lean Manufacturing is adopted by many large scale industries with mass production including automobile components manufacturing company. The Continuous improvement Program also focuses on improving the Overall Equipment Effectiveness. Modern equipment management began with preventive maintenance (PM) and evolved into productive maintenance.

III. ABOUT BOTTLENECK PROCESS

It is a process which obstructs the flow of material or parts in a manufacturing process line. To understand this, let us consider an example,

- Say, the customer demand is 10,00,000 components required in 25 working days, so the target is 40,000 components per day (44,000 after consideration of process flow errors)
- Planned Operation Time (POT) per day is actual working time of the day

\[ \text{POT} = \text{Total Time} - \text{Recess} \]

\[
\begin{align*}
\text{POT} &= (1440 - 135) \text{ min} \\
&= 1305 \text{ min (78300 sec)}
\end{align*}
\]

- Consumer Takt Time (T) is a time required to manufacture one piece,

\[
T = \frac{\text{Planned Operation time}}{\text{Consumer Demand per day}}
\]

\[
T = \frac{78300}{44000}
\]
Consider, there are various operations to be performed with different cycle time,

For Process 1, Cycle time = 8 sec
No. of Machines = 4
Process Time = \( \frac{8}{4} = 2 \) sec

For Process 2, Cycle Time = 30 sec
No. of Machines = 20
Process Time = \( \frac{30}{20} = 1.5 \) sec

If we plot a graph,

It is evident that, Process 1 takes more time than Consumer Takt time, so it delays the production, this is a bottleneck process. The OEE of that process needs to be improved.

In our observations and continuous monitoring of Cycle Time, we found out such a bottleneck process.

IV. FACTORS AFFECTING OEE
There are various losses which have a direct impact on OEE, let us see them one by one,

1. Organizational losses
   - Such as unavailability of oil, parts etc
2. Technical Losses
   - Such as Spindle malfunction, mandrel not working etc
3. Quality losses
   - Such as bad surface finish, improper dimensions etc
4. Changeover Losses
   - Such as Dia roll change, grinding Wheel change etc
5. Performance Losses
   - These losses occur due to machine’s internal aspects such as cycle time.

We did the Pareto Analysis of above losses over a period of three months, the results were.

<table>
<thead>
<tr>
<th>Types of Losses</th>
<th>Losses in percentage (over a period of three months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational losses</td>
<td>4.83 %</td>
</tr>
<tr>
<td>Technical Losses</td>
<td>3.25 %</td>
</tr>
</tbody>
</table>

Table 1: Pareto Analysis of Losses

Based on above mentioned data, it can be seen that the maximum number of losses were performance losses. Due to which we focused on reducing the cycle time of the bottleneck process in order to improve the OEE.

V. REDUCTION IN CYCLE TIME
We studied and monitored the machine from a bottleneck process and took some measures so that we can bring out the change in cycle time in order to improve the OEE.

Based on a comparison study of two different machines of different generations but with same sequence of operations, we found out some yield times which can be minimized to reduce cycle time.

Initial Cycle Time of the machine was 20.54 sec.

The comparison study was as follows:

<table>
<thead>
<tr>
<th>Operations</th>
<th>Time (sec)</th>
<th>Machine 1</th>
<th>Machine 2</th>
<th>Yield (Achievable reduction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tailstock Forward Movement</td>
<td>1.222</td>
<td>0.348</td>
<td>0.874</td>
<td></td>
</tr>
<tr>
<td>Indexing</td>
<td>3.562</td>
<td>2.928</td>
<td>0.634</td>
<td></td>
</tr>
<tr>
<td>Tailstock return Movement</td>
<td>1.26</td>
<td>0.386</td>
<td>0.874</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Comparison Study

After the above results, we found out the reasons behind increased cycle time. So we took following actions to reduce the timings of tailstock movement:

1. Increase the pressure limit of pressure relief valve (as tailstock movement is controlled by hydraulics)
   - The pressure was increased from 13 bar to 17 bar
2. Change the flow control valve
   - Due to improper maintenance of flow control valve, it was difficult to obtain maximum flow of hydraulic fluid

After the implementation of above changes, we carried out the thorough quality inspection including visual inspection and dimension measurements to make sure that there were no quality issues with the finished parts.

The results from quality inspection were very good and satisfactory.

The cycle time obtained was 18.24 sec.

<table>
<thead>
<tr>
<th>Cycle Time</th>
<th>Cycle Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial CT</td>
<td>20.54</td>
</tr>
<tr>
<td>Final CT</td>
<td>18.24</td>
</tr>
</tbody>
</table>

Table 3: Reduction in Cycle Time
VI. IMPROVEMENT IN OEE

OEE is calculated as follows:

\[
OEE = \frac{\text{good pieces produced per shift} \times 3 \times \text{Cycle Time}}{\text{Planned Operation Time}}
\]

(1.3)

(1) For CT of 20.54 sec,

\[
OEE = \frac{(935 \times 3) \times 20.54}{78300} = 0.7358 = 73.58\%
\]

(2) For CT of 18.24 sec,

\[
OEE = \frac{(1098 \times 3) \times 18.24}{78300} = 0.7676 = 76.76\%
\]

% Increase in OEE = \[
= \frac{\text{Final OEE} - \text{initial OEE}}{\text{Initial OEE}}
\]

(1.4)

\[
= \frac{(76.76 - 73.58)}{73.58} = 4.32\%
\]

VII. RESULTS AND CONCLUSIONS

After successful implementation of lean manufacturing techniques, we have managed to increase the OEE of a bottleneck process by 4.32%.

Lean Manufacturing has proven to be one of the best methods in improving the Overall Equipment Effectiveness of a bottleneck process. The mass production industries can use these methods to significantly increase their productivity.

VIII. FUTURE RECOMMENDATIONS

The indexing process can be improved a little further. The time can be reduced by increasing the pneumatic pressure to a certain value.

IX. SCOPE OF THE STUDY

Lean Manufacturing can be easily applied to a mass production industry such as automobile components manufacturing industry. This can be very helpful in getting rid of the bottleneck processes. The productivity increases substantially with these techniques.

REFERENCES


