OPTIMIZING TIME WITH INCREASING PRODUCTIVITY USING LEAN MANUFACTURING AND OVERALL EQUIPMENT EFFECTIVENESS

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ABSTRACT

Lean Manufacturing is the production control technique for eliminating the waste from manufacturing. Lean is concentrated on preserving value with less work. Lean manufacturing is a theme of efficiency based on optimizing flow; it is a present-day instance of the recurring theme in human history toward increasing efficiency, decreasing waste, and using empirical methods to decide what matters, rather than uncritically accepting pre-existing ideas. Manufacturers are under tremendous pressure to improve productivity and quality while reducing costs. It’s also known Toyota Production System (TPS). Lean manufacturing saves time of company with production. So, it can save labor time and cost. Also, it can save time on total production of Company. OEE is a "best practices" way to monitor and improve the effectiveness of your manufacturing processes. OEE is simple and practical. It takes the most common and important sources of manufacturing productivity loss, places them into three primary categories and distills them into metrics. OEE is frequently used as a key metric in TPM (Total Productive Maintenance) and Lean Manufacturing programs and gives a consistent way to measure the effectiveness of TPM and other initiatives by providing an overall framework for measuring production efficiency. At the end of paper we can achieve maximum production with decreasing time.

Keywords: OEE, Lean Manufacturing, TPM.

1. INTRODUCTION

1.1 Lean Manufacturing

“Lean manufacturing is a management philosophy that pursues the continuous elimination of waste in all business processes though kaizen, also known as small and incremental
improvement." By contrast, lean manufacturing is based on the concept that production can, and should, be operated by real customer demand. Instead of producing what we hope to sell, or as much as we can make, lean manufacturing produces what customer wants with much shorter lead times. Instead of pushing product through the factory and on to the market, it’s pulled through a system set up to respond quickly to actual customer demand.

1.1.1 Single Piece Flow

Single piece flow can be described as an ideal state of efficient operations, where batch sizes and lot production are replaced by working on one product at a time. While not practical for operations which very low processing times and correspondingly high change-over times (both values defined by takt time), it is nevertheless a Lean Manufacturing goal to achieve single piece flow in every operation possible.

Achieving one-piece flow requires the elimination of waste. We remind the reader of the seven wastes:
1. Labor
2. Overproduction
3. Space
4. Defects
5. Unnecessary human motion
6. Inventory
7. Transportation

As a company reduces these wastes and strives for single piece flow, many other benefits will follow. Some of these benefits include (1) improved quality and fewer defects (2) reduced inventory (3) less space required to build product, (4) enhancement to overall manufacturing flexibility, (5) identification of future kaizen workshops, (6) ensures a safer work environment and (7) improves employee morale.

Lean manufacturing involves identifying and eliminating non-value-adding activities in design, production, supply chain management, and order processing by developing a Future State Implementation Plan. The idea of lean is founded on the following principles:
• Specify value in the eyes of the customer
• Identify the value stream and eliminate waste
• Make value flow at the pull of the customer
• Involve and empower employees
• Continuously improve in pursuit of perfection

Reducing types of waste is another purpose to use Lean manufacturing in industry.

1.1.2 Principles of lean production

The five-step thought process for guiding the implementation of lean techniques is easy to remember, but not always easy to achieve:
1. Specify value from the standpoint of the end customer by product family.
2. Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
3. Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer.
4. As flow is introduced, let customers pull value from the next upstream activity.
5. As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste.
1.2 Overall Equipment Effectiveness

Overall equipment effectiveness (OEE) is a hierarchy of metrics developed by Seiichi Nakajima in the 1960s to evaluate how effectively a manufacturing operation is utilized. It is based on the Harrington Emerson way of thinking regarding labor efficiency. The results are stated in a generic form which allows comparison between manufacturing units in differing industries. It is not however an absolute measure and is best used to identify scope for process performance improvement, and how to get the improvement. If for example the cycle time is reduced, the OEE will increase i.e. more products is produced for less resource. Another example is if one enterprise serves a high volume, low variety market, and another enterprise serves a low volume, high variety market. More changeovers (set-ups) will lower the OEE in comparison, but if the product is sold at a premium, there could be more margins with a lower OEE. OEE measurement is also commonly used as a key performance indicator (KPI) in conjunction with lean manufacturing efforts to provide an indicator of success. OEE can be illustrated by a brief discussion of the six metrics that comprise the system. The hierarchy consists of two top-level measures and four underlying measures.

2. METHODOLOGY

This research is a case study in which we followed a systemic way to reach the solution of research problems. After a few primary visits an idea is generated and literature is studied according to it. Then data is collected and analyzed from the field according to the literature. Finally, the result is obtained. The methodology we followed can be represented by the following flowchart:

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**Figure 1: Action Plan of the Project**
3. OVERVIEW OF PRODUCTION IN ABM INTERNATIONAL

![Diagram of process layout in ABM International]

4. OVERALL EQUIPMENT EFFECTIVENESS (OEE)

Overall Equipment Effectiveness (OEE) is a way to monitor and improve the efficiency of a manufacturing process. Developed in the mid-1990’s, OEE has become an accepted management tool to measure and evaluate plant floor productivity. OEE is broken down into three measuring metrics of Availability, Performance, and Quality. These metrics help gauge plant’s efficiency and effectiveness and categorize key productivity losses that occur within the manufacturing process. OEE empowers manufacturing companies to improve their processes and in turn ensure quality, consistency, and productivity measured at the bottom line. By definition, OEE is the multiplication of Availability, Performance, and Quality.
5. TERMS USED

5.1 Availability
The previous diagram indicates that the availability is a measure for the down time losses.

The definition is as follows:

\[
\text{Availability} = \frac{\text{Available production time}}{\text{Gross operating time}}
\]

When down time losses are zero, the availability is 1 or 100%, the gross operating time equals the available time for production. In other words, the installation throughput equals zero in no point of time, during the available time for production. At the end of the installation, there is continuously an output and this without interruption.

5.2 Performance
The performance only concerns the gross operating time. A property of the gross operating time is that the speed exceeds zero at any time. There are no down time losses in the gross operational time.

\[
\text{Performance} = \frac{\text{Net operating time}}{\text{Gross operating time}}
\]

5.3 Quality factor
During the net operational time, no down time or speed losses occur. In other words, the output related to the net operational time is the product of the reference throughput (units per time unit) x the number of time units of the net operational time. However it is not certain that the total produced output is conform quality specifications. To gain insight into this, the quality factor is defined:

\[
\text{Quality factor} = \frac{\text{Valuable operating time}}{\text{Net operating time}}
\]

Finally, per class the total size of the loss should be quantified. For example, when producing a product of a certain quality class, 14% of the produced volume/numbers are losses because they do not live up to the quality specifications of that class.

5.4 OEE
OEE is defined as the valuable operating time over the available production time. The three effectiveness factors offer a second way to quantify the OEE:

\[
\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality factor}
\]
6. CALCULATION BASED ON EXPERIMENTAL DATA

The table below contains a original shift data from ABM INTERNATIONAL, to be used for a complete OEE calculation, starting with the calculation of the OEE Factors of Availability, Performance, and Quality. Note that the same units of measurement (in this case minutes and pieces) are consistently used throughout the calculations.

Table 1: OEE Calculation of Experimental Data

<table>
<thead>
<tr>
<th>Item</th>
<th>Data(shift1)</th>
<th>Total(shift 1,2 &amp;3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift Length</td>
<td>8 hours = 480 min.</td>
<td>24 hours =1440 min.</td>
</tr>
<tr>
<td>Short Breaks</td>
<td>1 @ 15 min. = 15 min.</td>
<td>3 @ 15 min. = 45 min.</td>
</tr>
<tr>
<td>Meal Break</td>
<td>1 @ 30 min. = 30 min.</td>
<td>3 @ 30 min. = 90 min.</td>
</tr>
<tr>
<td>Down Time</td>
<td>70 minutes</td>
<td>210 minutes</td>
</tr>
<tr>
<td>Ideal Run Rate</td>
<td>30 pieces per minute</td>
<td>30 pieces per minute</td>
</tr>
<tr>
<td>Total Pieces</td>
<td>9,600 pieces</td>
<td>28,800 pieces</td>
</tr>
<tr>
<td>Reject Pieces</td>
<td>192 pieces</td>
<td>1440 pieces</td>
</tr>
</tbody>
</table>

6.1 Calculation for Total shift (Shift 1, 2 & 3)

- **Planned Production Time** = [Shift Length - Breaks] = [1440 - 135] = **1305 minutes**
- **Operating Time** = [Planned Production Time - Down Time] = [1305 - 210] = **1095 minutes**
- **Good Pieces** = [Total Pieces - Reject Pieces] = [28800 - 1440] = **27,360 pieces**

<table>
<thead>
<tr>
<th>Availability</th>
<th>=</th>
<th>Operating Time / Planned Production Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>=</td>
<td>1095 minutes / 1305 minutes</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>0.8390 (83.90%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance</th>
<th>=</th>
<th>(Total Pieces / Operating Time) / Ideal Run Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>=</td>
<td>(28,800 pieces / 1095 minutes) / 30pieces per minute</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>0.8767 (87.67%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality</th>
<th>=</th>
<th>Good Pieces / Total Pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>=</td>
<td>27,360 / 28,800 pieces</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>0.95 (95.00%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OEE</th>
<th>=</th>
<th>Availability x Performance x Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>=</td>
<td>0.8390 x 0.8767 x 0.9500</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>0.6987 (69.87%)</td>
</tr>
</tbody>
</table>

6.2 Calculation based on the theoretical data

- **Theoretical production time**
  The examined period is January to December. This means that the theoretical production time is 365 days. This corresponds to 365 X 24 = 8760 hours.

- **Available production time**
  Consider there is 365 days a year, out of 365 works was not planned on some days, for the following reasons,
Staggering days 52
Holidays 10
Leave/vacation 12
--------------------------
Total 74 days

There are three shifts of 8 hours per day. In total there were \((365-74) \times 3 \times 8 = 6984\) hours of work during shifts. There are also work stoppages/pauses: 2.25 hour every day, total working day \(365-74 = 291\) days.

- **Total pause time** \(291\) days \(\times 2.25\) hours \(= 655\) hours
- This leaves Total hours of working \(6984-655 = 6329\) hours.

The lack of personnel or raw materials caused the rest of the time losses. Because there was no direct data available, an estimate had to be made. The production leader decided upon 5%, leaving the available production time \(6329 \times 0.95 = 6012\) hours.

The previous results are summarized as follows:

- **Theoretical production time** = 8760 hours
- **Available production time** = 6012 hours
- **Valuable operating time** = 5310 hours

- **OEE (Overall Equipment Effectiveness)**
  \[
  \text{OEE} = \frac{\text{Valuable operating time}}{\text{Available production time}}
  = \frac{5310}{6012}
  = 0.8832 (88.32%)
  
  - Planning factor
  \[
  \text{Planning factor} = \frac{\text{Available production time}}{\text{Theoretical production time}}
  = \frac{6012}{8760}
  = 0.6863 (68.63%)
  
  - Total OEE
  \[
  \text{Total OEE} = \frac{\text{Valuable operating time}}{\text{Theoretical production time}}
  = \frac{5310}{8760}
  = 0.6061 (60.61%)
  
  Note that the result can be obtained by multiplying the OEE by the planning factor.
Availability, performance and quality factor
The previous calculations do not give insight as to the different types of losses. Calculating the different effectiveness factors below can do this.

Availability
- Lead time during working period = 145.5 hours in 291 days
- Break Down time during one month = 8 hours
- 291 days = 9.7 months
- For 291 days total break down time = 8 hours × 9.7 months = 77.5 hours
- Total down time = lead time + break down time = 145.5 + 77.5 = 223 hours

Company ABM kept record of its down time - 223 hours during the examined period. Therefore the **Gross operating** time is 6012 - 223 = 5789 hours.

\[
\text{Availability} = \frac{\text{Gross operating time}}{\text{Available production time}}
\]
\[
= \frac{5789}{6012}
\]
\[
= 0.9629 (96.29%)
\]

Quality
From all produced tablets, 95% is transferred to the warehouse (Company ABM INTERNATIONAL works on stock), in other words 5% is rejected. The quality factor is thus 95%. Due to the available data, the quality factor had to be calculated before the performance factor.

Performance
The net operating time is the valuable operating time divided by the quality factor: 5310/0.95 = 5589 hours.

The gross operating time is 5789 hours.

\[
\text{Performance} = \frac{\text{Net operating time}}{\text{Gross operating time}}
\]
\[
= \frac{5310}{5789}
\]
\[
= 0.9355 (93.55%)
\]

OEE = Availability × Performance × Quality factor = 96.29% × 96.55% × 95% = 88.41%

7. CONCLUSION
After applying Lean manufacturing, ABM Private Limited can reduce the waste, can increase customer’s satisfaction. By implementing Lean Manufacturing we can achieve less idle time, reduce break downs, minimized waste, less production defects. By applying Lean manufacturing company can significantly reduce inventory and it will help to reduce inventory cost. When implementing lean within our organizations, equipment reliability is the predominant foundational element that enables lean operational performance.
Figure 3: Experimental and theoretical subdivision of plant operating time

From, the above graphs more production time can be achieved. In above graphs we can reduce the down time and break time up to 9% and can increase production time up to 9%

Table 2: Comparison of Theoretical and Experimental OEE

<table>
<thead>
<tr>
<th>OEE Factor</th>
<th>Theoretical</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>96.29%</td>
<td>83.90%</td>
</tr>
<tr>
<td>Performance</td>
<td>96.55%</td>
<td>87.67%</td>
</tr>
<tr>
<td>Quality</td>
<td>95.00%</td>
<td>95.00%</td>
</tr>
<tr>
<td>OEE</td>
<td>88.41%</td>
<td>69.87%</td>
</tr>
</tbody>
</table>

From calculation of OEE we are getting values for theoretical and experimental calculation. We can see that we can still achieve more production rate and effectiveness in the company’s production by comparing theoretical and experimental results. By implementing OEE in day to day task it will eliminate down time and lead time which this company have and by achieving more productive time company can increase it availability and performance. Also, company can implement the routine maintenance and maintenance on the working machines. Which will help them to reduce the break down losses; Speed losses, down time losses and more OEE can be achieved. So, overall equipment effectiveness can be increased. Implementation and working with these on daily bases can result in positive improvement of industry and lead to good position. Applying the Lean manufacturing and over all equipment effectiveness company can its production with decreasing time loss.

8. ACKNOWLEDGEMENTS

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