Improving Production Performance with Overall Equipment Effectiveness (OEE)

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Abstract – **Under current economic conditions and global competition, senior manufacturing executives are increasingly interested in all aspects performance management of equipments including effectiveness, cost, opportunities for increased production capacity, improved competitiveness leading to increases in bottom line profitability. In this environment, it pays to consider proven methods of Lean Manufacturing that can be used to improve competitiveness without the need to invest in additional resources. "Overall Equipment Effectiveness", or OEE as it is more commonly known, is a method that meets this objective.**

Based on the theoretical analysis and a case study in Plastic Injection Moulding unit, challenges associated with implementation of OEE are identified and analysed. Further paper discuses how OEE can be used as key performance indicator of the production performance and how OEE relates to overall performance of the organization.

Keywords- OEE, Production Performance Improvement

1. INTRODUCTION

The accurate estimation of the equipment utilization is very important in capital-intensive industries (e.g. semiconductor and automobile) since managers in these industries want to utilize their equipment as effectively as possible to get an early return on their investment. Based on the utilization estimated, managers can identify the causes of the time losses and attempt to reduce these losses.

Every factory attempts to be an effective, low-cost producer. This effort is required in today's challenging environment when customers demand "quality product at the best value". Few factories attain and maintain high level productivity and low costs. Many of these use a disciplined approach to identify the best improvements to make. They use teams to eliminate the root problems that otherwise keep the factory from driving toward continuously higher levels of effectiveness. In short, they have found the power of OEE: Overall Equipment Effectiveness. By recognizing the 'hidden factory' within, they have made improvements that contribute directly to the bottom line.

Nearly every industry has multiple manufacturers, each competing for its share of the market. Even a company with the best product may not stay in business if its expenses for getting the product to the customer are excessive. Fierce competition usually exists. Companies with the most effective factories will have the staying power to be the long-term survivors, assuming that the need for the product is continuous. [1]

2. LITERATURE REVIEW

Overall Equipment Effectiveness (OEE) is a hierarchy of metrics developed by Seiichi Nakajima in 1960's (based on Harrington Emerson way of thinking regarding to labor efficiency) which evaluates and indicates how effectively a manufacturing operation is utilized. 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 can also reduce, even though more products are 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. [2]

Knowing the complete OEE breakdown, the opportunities for improvement become apparent. The largest opportunities should be improved first, working down the list until all opportunities are improved. The improvement opportunities are always in one of the following "buckets".

- Breakdown
- Setup
- Downtime
- Speed loss
- Small stops
- Quality

OEE is an excellent way of communicating the improvement opportunities to everyone, including operators, maintenance technicians, sales representatives, engineers and managers. Most lean manufacturing tools work together to create value in the system and eliminate "waste". OEE is a prime example of this integration of tools. Many lean implementations begin with a concept called "5-S" and value stream mapping. The value stream map shows where the waste occurs in the system. OEE analysis can be applied at the point where the waste occurs. The improvement in the OEE number will take the use of other lean applications, such as SMED (setup reduction), TPM (Total Productive Maintenance), standardized operations and "kaizen events" targeting specific areas. OEE is a powerful lean manufacturing tool, especially when combined with other tools using an integrated approach. [3]

3. METHODOLOGY

3.1 Introduction

The purpose of the case study was to implement OEE as an operative tool for driving performance improvement. The definition of OEE combines six big losses in to three performance parameters. The initiative was to identify different downtime losses and quality defects of the process.

Data collection and experiments were carried at M/s Mitali enterprises S-1, MIDC Waluj Aurangabad. Mitali enterprise is an ISO 9001:2008 certified organization engaged in manufacturing and supply of plastic moulded components.

3. 2 Defining the Six Big Losses

One of the major goals of TPM and OEE programs is to reduce and/or eliminate what are called the Six Big Losses – the most common causes of efficiency loss in manufacturing. The following table lists the Six Big Losses, and shows how they relate to the OEE Loss categories. [4]

Table 3.1. Details of Six big losses

Six Big Loss Category	OEE Loss Category	Event Example	Comment
Breakdowns	Down Time Loss	Tooling Failures. Unplanned Maintenance. General Breakdowns. Equipment Failure	There is flexibility on where to set the threshold between a Breakdown (Down Time Loss) and a Small Stop (Speed Loss).
Setup and Adjustments	Down Time Loss	Setup/Changeover Major Adjustments Warm-Up Time.	This loss is often addressed through setup time reduction programs.
Small Stops	Speed Loss	Obstructed Product Flow. Component Jams, Misfeeds, Sensor Blocked, Delivery Blocked Cleaning/Checking	Typically only includes stops that are under five minutes and that do not require maintenance personnel.
Reduced Speed	Speed Loss	Rough Running Under Nameplate Capacity Under Design Capacity Equipment Wear Operator Inefficiency	Anything that keeps the process from running at its theoretical maximum speed (a.k.a. Ideal Run Rate or Nameplate Capacity).
Startup Rejects	Quality Loss	Scrap, Rework In-Process Damage In-Process Expiration	Rejects during warm-up, startup or other early production. May be due to improper setup, warm-up period, etc.
Production Rejects	Quality Loss	Scrap Rework In-Process Damage	Rejects during steady-state product

3.3 Selection of various tools for the present work

Various management tools are used to address the losses. These can be listed as below.

5s
Single minute exchange of die (SMED)
Root cause analysis
Cycle time analysis
Jishu Hozen (JH) / Autonomous maintenance

4. Results and Discussions

4.1 Data Collection

The OEE calculations should be based on correct data input. OEE calculations were done using MS Excel template. The initial data was collected from production output reports filled up by machine operators. Data like total production quantity, defects observed, down time details including machine breakdown, set up change time, planned and unplanned maintenance time was received from operators through these production reports. Inputs were filled up in MS excel sheet of OEE by production supervisor to facilitate OEE number and analyse the losses for further actions.

4.2 Implementation

4.2.1 Workplace organization 5S

The system implementation and analysis started with 5S. A detailed survey of the whole factory was performed.

It was observed that there was a lot of mixed class of material lying around the shop and factory. It comprised of finished goods, raw material, rejected material, old broken crates, customer returned rejected material, good as well as bad packing material.

1S SEIRI -through red tag movement all unwanted material was identified and disposed of by selling to scrap vendor or shifted to scrap yard.

This created free space of 150 sq ft, the sale scrap brought Rs 3000/-

The material and tools required on daily basis were kept closed to machine.

Less frequently required material, were assigned a location distant from operation area.

2S SEITON-

Machine operator who required tools like Allen key or spanner had to spent considerable time from few seconds to few minutes in searching the tools.

The location of spanners tools were fixed and indentified. The hand tools were stored and fixed in such a way that it now takes minimum time to pick the tool of required size.

The trolley used for material transportation had no fixed location. To prevent wastage of time in searching trolley, a specific location was assigned to trolley. It was made known to all workmen. After material transportation work is over, it was instructed to keep the trolley at identified location.

All other consumables like, oil can, Greece, cotton, were assigned fixed locations. The locations were identified and were made known to all workmen.

3S SEISO-

It was tried to create dust free zone. Shop floor, office floor, glass windows, machines were cleaned on daily basis. This improved the morale of the employees, illumination conditions. The clean machine surfaces helps to detect the small cracks, oil leakages at much earlier stage.

4.2.2 Single minute exchange of die (SMED)

The major loss that comes under set up and adjustment was change of Mould.

There are at least 10 mould changes in a Month per machine. The average time for mould change was 90 minutes. Production loss in term of machine hours per month was 900 machine hours.

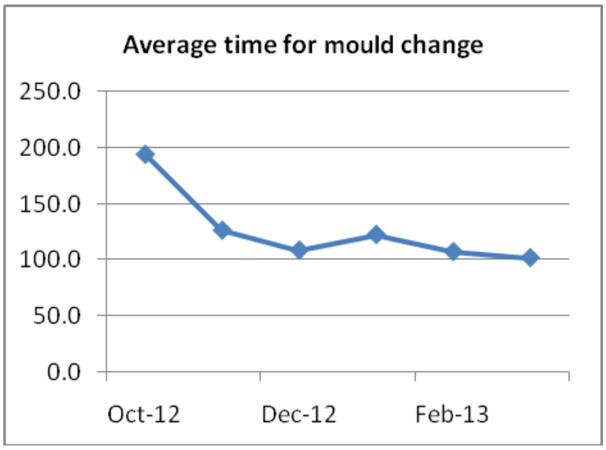
It was immense need to implement SMED techniques.

The first stage of SMED was recording data. All the data of mould change was recorded on a specific recording sheet. Appropriate actions were taken to minimize mould change time.

Table 4.1 Analysis of Mould change

Month	Mould Change loss in Minutes	No of Mould change	Average time for mould change
Oct-12	1750	9	194.4
Nov-12	1390	11	126.4
Dec-12	1193	11	108.5
Jan- 13	490	4	122.5
Feb-13	1178	11	107.1
Mar-13	1119	11	101.7

Graph 4.1 Average time for mould change



4.2.3 Root cause analysis

Defects observed during production were analysed for root causes. Based on causes, corrective actions were planned and taken to eliminate recurrence of the defects. The details of the rejections, its causes and action take are summerised as below.

Table 4.2 Details of Quality defects

Sr No	Quality Defect	Root cause of defect	Corrective actions taken to eliminate root cause
1	Short mould (battery tray)	Machine nozzle was blocked, due to foreign metal particle mixed with recycled runner material during grinding.	Recycled material is inspected before feeding to hopper. A magnet is placed in hopper to restrict Iron material entry in machine barrel.
2	Warpage	Cooling during moulding is insufficient due to large area	Additional fixtures provided to arrest warpage.
3	Hole blockage	Insert in mould was missing.	New insert fitted in place of missing insert.
4	Shrinkage	Cooling period in process cycle time fell short	Cooling period changed
5	Silver mark	Poor preheating of raw material.	Pre heating done to elevated temperature.
6	Flow mark	Process parameters injection speed and pressure not appropriate	Process parameters reset. Trials taken.

4.2.4 Cycle time analysis and Jishu Hozen (JH) / Autonomous maintenance

Cycle time analysis was performed to identify non value adding activities in production cycle.

Appropriate actions were taken to eliminate non value adding activities and shorten cycle time.

Another bigger contributor to down time losses was equipment breakdown and minor stoppages.

Jishu Hozen (JH) was introduced which helped to reduce minor stoppages and bring down major breakdown as well. While implementing 1st stage of Jishu hozen, the motto was –

- All round clean up of dust and dirt on machine
- Finding and restoration of abnormalities
- Oiling and retightening of bolts.

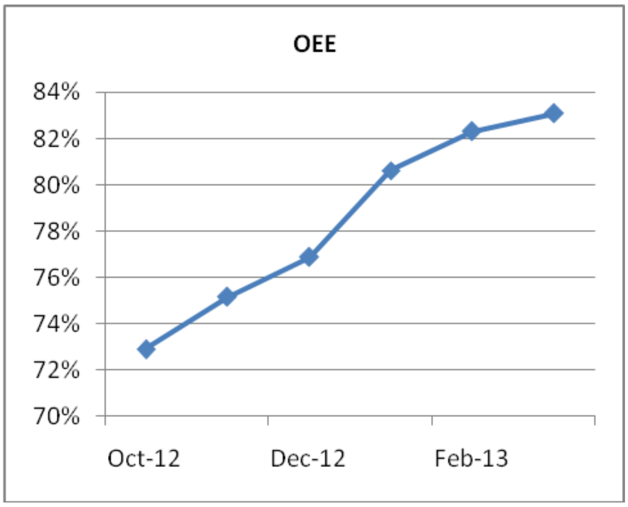
4.3 OEE performance

We witnessed a gradual improvement in OEE number after implementing various actions in all areas to reduce down time , defects and performance losses,

Table 4.3 OEE performance

Month	OEE
Oct-12	72.90%
Nov-12	75.17%
Dec-12	76.88%
Jan-13	80.62%
Feb-13	82.31%
Mar-13	83.09%

Graph 4.2 OEE performance



4.4 Benefits of implementing OEE

Favorable changes in OEE directly lead to gains in profitability. The linkage between OEE results and financial performance is a function of Reduced Variable Manufacturing Cost (Direct Cost) resulting from Increased Uptime (Availability), Higher Speed (Performance) Minimized material waste (Quality)

Better Asset Utilization, leading to, Lower Overhead Cost (Fixed Cost), Additional Sales Capacity - at no cost, Reduced Inventory as the Manufacturing Processes become more reliable, Rational basis for more effective capital management and spending [5]

OEE should be viewed as a 'Continuous Improvement Engine' that provides a robust framework for the Lean Manufacturing journey, Triggers and monitors Six Sigma projects and Kaizen events and provides basis for Total Productive Maintenance (TPM) [6]

5. CONCLUSIONS

The paper discusses various aspects of Overall Equipment Effectiveness. Understanding theory of OEE is simple. Improving OEE figure is also easy. OEE is an important measure of efficiency. Improvements done in an industry can result in greater return on investments (ROI). OEE also gives valid comparative measurement across the plant, across sites, and potentially against competitors of the organisation.

OEE is applicable to both manufacturing and non-manufacturing operations. OEE can be used to save companies from making inappropriate purchases, and help them focus on improving performance of machinery and plant they already own.

In future, OEE should be implemented at micro and small scale industries. By continuously measuring and comparing results from day to day or week to week, industry will see its performance improving. Some OEE improvements will happen due to the increased attention and focus on asset management. We expect this tool will be used by all engineering industries across all scales.

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