ISSN: 0974-5823 Vol. 6 No. 3 October-December, 2021

International Journal of Mechanical Engineering

Enhancement of Overall Equipment Effectiveness in Automotive Parts Manufacturing Industry

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ABSTRACT

Injection moulding is the most commonly used manufacturing process for the fabrication of plastic parts which are primarily used in automotive industries. A significant improvement has taken place in the management of equipment and productive systems to reduce the wastage of energy resources and time. Overall equipment effectiveness (OEE) is a technique to measure the effectiveness of the machines. It helps in systematically analysing the process and identifying the potential problem areas affecting the utilization of the machines. Thus a maintenance program should be implemented to improve and increase the quality and productivity. Total productive maintenance (TPM) is a system of maintain and improving the integrity of production and quality systems through the machines, equipment, processes and employees rather than new investments. TPM aims at increasing the availability of the existing equipment and improve its performance. In the case study on the OEE of injection moulding process is measured and increased through availability, TPM, better utilization of resources and a maintenance program.

Keywords: Lean Manufacturing (LM), lean tools, Total productive maintenance, kaizen sheet.

1. INTRODUCTION

LM is a process that aims at consistent elimination of waste through continuous improvement in pursuit of perfection. LM initiatives use less resources as compared with traditional mass production approaches namely, less on site inventory, less product development engineering hours and so forth. LM is a systematic method of waste elimination within a manufacturing system without sacrificing productivity. Lean also takes into account waste created through overburden and waste created through unevenness in workloads.

The ultimate aims of LM are

- Improve quality
- Increase productivity
- Eliminate waste
- Reduce cost

There are seven types of waste to be eliminated

- Transportation
- Inventory
- Motion
- Waiting
- Over production
- Over processing
- Defects

1.1 Overall Equipment Effectiveness (OEE)

OEE is a hierarchy of metrics to evaluate how effectively a manufacturing operation is utilized or shows how effectively an equipment is utilized. Calculating the OEE is a crucial element of any serious commitment to reduce equipment and process related wastes.

Elements of OEE

1. Availability losses
   - Setup
   - Breakdown
2. Performance losses
   - Minor stoppages
   - Speed losses
3. Quality losses
   - Start-up losses
   - In-process losses

OEE identifies the percentage of manufacturing time that is truly productive or to simply put it measures the gap between the actual performance and the potential performance of a manufacturing unit. By measuring OEE and the underlying losses we will gain insights on how to systematically improve the manufacturing process.

OEE is the product of Availability, Performance and Quality, it takes into account all losses resulting in a measure of truly productive manufacturing time.

Availability- it is the ratio of operating or run time and planned production time. Operating time is planned production time minus down time.

Performance- it takes into account all that causes the manufacturing process to perform at less than maximum possible speed.
Quality- takes into account parts that do not meet the standards including the parts that need rework. It is the ratio of accepted parts to total parts produced.

$\text{OEE} = \text{AVAILABILTY} \times \text{PERFORMANCE} \times \text{QUALITY}$ (World class = 85%)

$\text{Availabilty} = \frac{\text{Actual operating Time}}{\text{Planned production time}} \times 100$ (World class = 90%)

$\text{Performance} = \frac{\text{Design cycle time} \times \text{Output}}{\text{Operating time}} \times 100$ (World class = 95%)

$\text{Quality} = \frac{\text{Good parts produced}}{\text{Total parts produced}} \times 100$ (World class = 99%)

1.2 Total Productive Maintenance (TPM)

TPM is a plant improvement methodology which enable continuous and rapid improvement of the manufacturing process through use of employee involvement, employee empowerment and closed-loop measurement of results. There are eight pillars of TPM and each pillar has their own task to perform. The eight pillars are

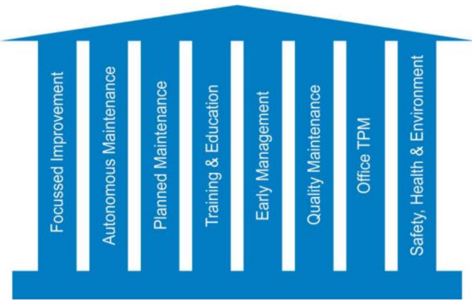

Fig. 1: 8 pillars of TPM

5S Tool
5S is the foundation of TPM. It describes how to organize a workplace for efficiency. 5S as a broader construct as visual control, visual workplace or visual factory.
Seiri (sort) - separate the necessary and unnecessary items from the workplace and discard what is not required.
Seiton (set in order) - arrange the items or tools in order that can be easily selected for use. It reduces the waiting and searching time.
Seiso (sweep) - its cleaning the workplace systematically and uses cleaning as inspection. It helps the operator become more involved in the work and aware about the condition of the equipment.
Seketsu (standardize) - to standardize and schedule the first three 'S' practices. Develop a work structure that supports the new practice.
Shitsuke (sustain) - it translates to "do without being told" sustain the practices, conduct regular audits, implement training and self-discipline.
Autonomous maintenance, in this pillar independent maintenance is carried out by the operator. The operators are educated and trained in basic maintenance activities such as cleaning, lubricating, calibration of equipment etc. so that maintenance department can concentrate on more serious problems like break downs. This pillar is a basic preventive maintenance activity to reduce or eliminate break downs and empowers the operator makes him more involved in the work and increases the lifetime of the equipment.
Focused improvement, cross functional teams are formed to solve problems of critical or crucial machines by doing large number of small improvements. Right tools are used for solving problems and to find the root cause of the problems. Focussed improvements involves activities that maximize the OEE through elimination of losses.
Planned maintenance, the objective of this pillar is to maintain the equipment at optimal process conditions and improve the service life of the equipment. Planned maintenance is scheduling of maintenance in advance based on the frequency of breakdowns and failures of equipment.
Quality maintenance, the objective of this pillar is to detect, prevent and eliminate errors during production. It focusses on providing right quantity at the right time. Defects lead to reworks, reworks lead to more usage of energy and resources, thus quality maintenance is crucial as it aims at preventing defects.
Early equipment maintenance, it is to ensure that the new machinery is used at its optimal level earlier than usual after the installation through the knowledge gained from the maintenance and management of the previous machines. It uses input from the operator and other individual going to use the equipment before installation for better utilizing the equipment.
Education and training, this pillar bridges the gap that exists when it comes to TPM. Lack of education and training leads to improper application of tools and wrong results. Without proper education and training the roles of the employee and tools can be misunderstood which may lead to more problems than solution.
Healthy safety and environment, this pillar aims at providing a working environment free of harmful elements that is environment which safe and healthy for his wellbeing. All the health and safety risks are to be eliminated.
Office TPM, it concentrates on all area that provides administrative and support functions in the organization. Its work is eliminating losses and waste from these departments. This pillar ensures that all process support the optimisation of manufacturing process.

1.3 Lean tools and techniques

LM tools and techniques used are

- 5S
- TPM
- Kaizen

2. LITERATURE REVIEW

[1] Vijay lahri et al, (2015) has given a case study on implementation of OEE on CNC table type boring and milling machine. The inefficiency losses were classified into three categories for better understanding of the manufacturing process. Through the implementation of OEE

the bottleneck and hidden losses were found thus enabling to reduce them and improve the effectiveness of the machines.

[2] Raghavendrakasyap K. et al, (2014) has done a case study on various defects that occur in an injection moulding process. The author found the effect of machine process parameters on wall thickness variation defects. Through design of experiments the process parameters were optimized and wall thickness variation defects were reduced.

[3] Ranteshwarsingh et al, (2012) has done a study on automation of OEE calculation through hardware and software development. Based on different machine parameters and flow chart, algorithm and software was developed to automatically measure the OEE. Hardware controller was developed to overcome the problem using stopwatch. OEE calculation was made automatic and the losses can be identified and analysed using the software.

[4] Vijaykumar S.R. et al, (2014) has given a case study on improving the OEE in injection moulding process industry, the paper implies that maintenance management of the productive system is important to reduce wastage of energy and resource. In this work, the OEE of the injection moulding process was increased from 61% to 81% through the implementation availability, better utilization of resources, high quality products and also raised employee morale and confidence.

[5] Jitendrakumar (2016) has done a case study on OEE improvement by TPM implementation. In this paper TPM was implemented in a thermal power plant and its effectiveness after the TPM implementation was increased which is measured from the OEE calculation after TPM implementation.

[6] Khedkar S.B. et al, (2012) has given a case study on implementation of 5S in plastic moulding industry. The objective of the paper is to improve the utilization of the storage space of raw material and finished goods through 5S implementation. Layout of the plant was studied and 5S was implemented and there were significant improvements to productivity, efficiency and housekeeping.

[7] Vikashdwivedi et al, (2014) has given a case study on injection moulding process to improve the quality. Six sigma DMAIC methodology and root cause analysis were used to identify the causes for the black speck on the part surface and through TPM implementation improvements were made to reduce the defects.

3. DATA ANALYSIS

Production data

- Shift length
- Tea breaks
- Meal breaks
- Down time
- Idle run rate
- Total quantity produced
- Total quantity rejected

Support variables

Down time = waiting time + setup and changeover time + material flow or shortage time + failure or breakdown time + meeting time.

4. DETAILED WORK

OEE Calculation for machine-1 before TPM implementation

Design cycle time = 45 seconds
Number of shifts per day = 2
Number of days in a month = 26
Total down time = 162 hours
Planned production time = 572 hours
Actual operating time = Planned production time – Total down time

$$\text{Availabilty} = \frac{\text{Actual operating Time}}{\text{Planned production time}} \times 100$$

Availability = 71.6/%
Total quantity produced = 27546

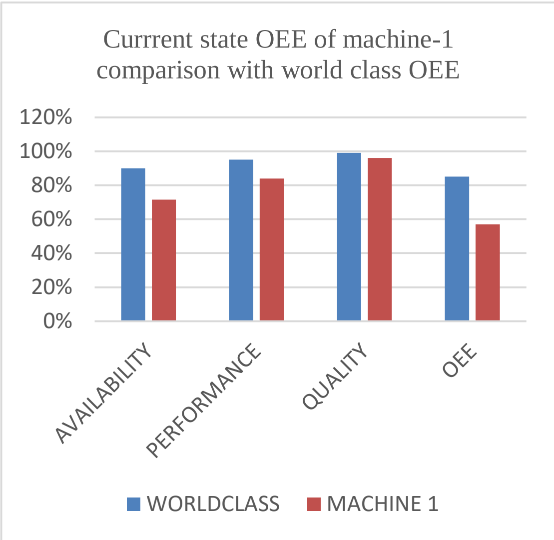

Fig. 2: OEE of machine-1

Total quantity rejected = 915

$$\text{Performance} = \frac{\text{Design cycle time} \times \text{Output}}{\text{Operating time}} \times 100$$

Performance =83.9%

$$\text{Quality} = \frac{\text{Good parts produced}}{\text{Total parts produced}} \times 100$$

Quality = 96%

$$\text{OEE} = \text{Availabilty} \times \text{Performance} \times \text{Quality}$$

OEE = 57%

OEE calculation for machine-2 before TPM implementation

Design cycle time = 40 seconds
Number of shifts per day = 2
Number of days in a month = 26
Total downtime = 177 hours
Total quantity produced = 23055
Total quantity rejected = 340
Planned production time = 572 hours
Actual operating time = Planned production time – Total down time

$$\text{Availabilty} = \frac{\text{Actual operating Time}}{\text{Planned production time}} \times 100$$

Availability = 69%

$$\text{Performance} = \frac{\text{Design cycle time} \times \text{Output}}{\text{Operating time}} \times 100$$

Performance = 64.8%

$$\text{Quality} = \frac{\text{Good parts produced}}{\text{Total parts produced}} \times 100$$

Quality = 98.5%

$$\text{OEE} = \text{Availabilty} \times \text{Performance} \times \text{Quality}$$

OEE = 44.1%

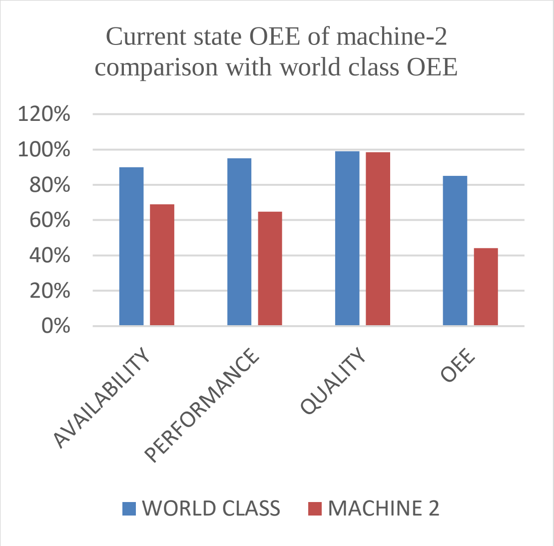

Fig. 3: OEE of machine-2

OEE calculation of machine-1 after TPM implementation

Design cycle time = 45 seconds
Number of shifts per day = 2
Number of days in a month = 26
Total downtime = 121 hours
Total quantity produced = 32049
Total quantity rejected = 676
Planned production time = 572 hours
Actual operating time = Planned production time – Total down time

$$\text{Availabilty} = \frac{\text{Actual operating Time}}{\text{Planned production time}} \times 100$$

Availability = 78.6%

$$\text{Performance} = \frac{\text{Design cycle time} \times \text{Output}}{\text{Operating time}} \times 100$$

Performance = 88.8%

$$\text{Quality} = \frac{\text{Good parts produced}}{\text{Total parts produced}} \times 100$$

Quality = 68.43%

$$\text{OEE} = \text{Availabilty} \times \text{Performance} \times \text{Quality}$$

OEE = 68.43%

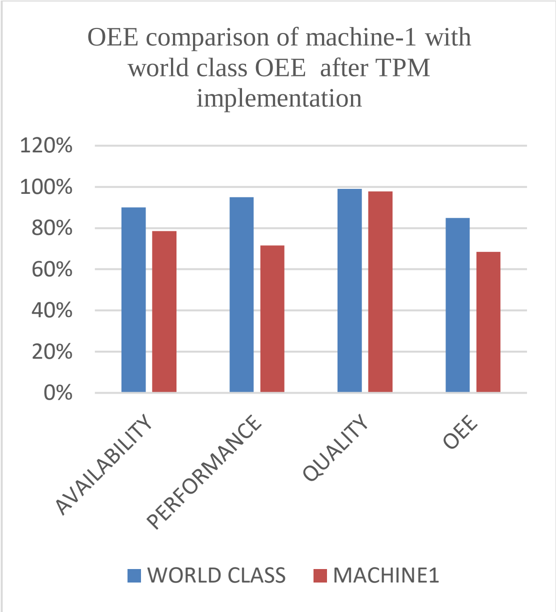

Fig. 4: OEE of machine-1 after TPM implementation

OEE calculation of machine-2 after TPM implementation

Design cycle time = 40 seconds
Number of shifts per day = 2
Number of days in a month = 26
Total down time = 139 hours
Total quantity produced = 27908
Total quantity rejected = 388
Planned production time = 572 hours
Actual operating time = Planned production time – Total down time

$$\text{Availabilty} = \frac{\text{Actual operating Time}}{\text{Planned production time}} \times 100$$

Availability = 75.6%

$$\text{Performance} = \frac{\text{Design cycle time} \times \text{Output}}{\text{Operating time}} \times 100$$

Performance = 71.6%

$$\text{Quality} = \frac{\text{Good parts produced}}{\text{Total parts produced}} \times 100$$

Quality = 98.5%

$$\text{Oee} = \text{Availabilty} \times \text{Performance} \times \text{Quality}$$

OEE = 53.3%

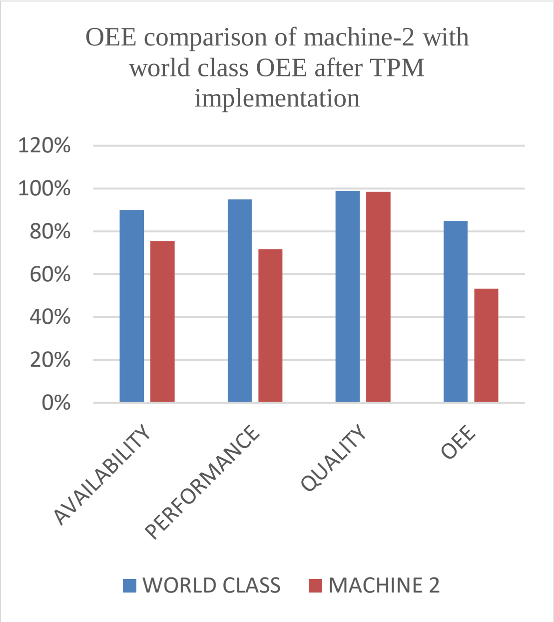

Fig. 5: OEE of machine-2 after TPM implementation

Table 1: OEE of machine-1 and machine-2 after TPM implementation

	Availab ility	Perfor mance	Quality	OEE
World class	90%	95%	99%	85%
Machi ne-1	78.6%	88.8%	97.8%	68.43 %
Machi ne-2	75.6%	71.6%	98.5%	53.3%

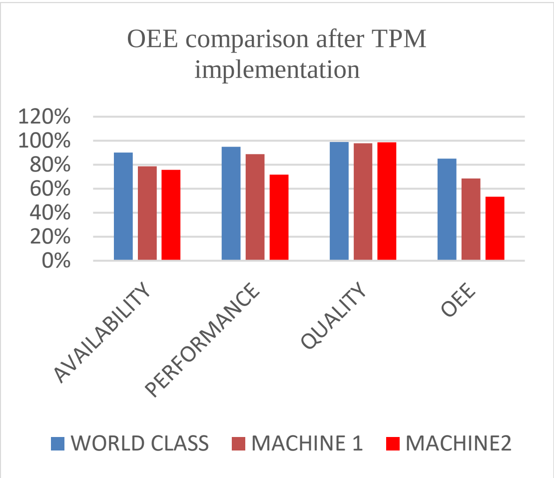

Fig. 6: OEE comparison after TPM implementation

5. RESULT

After the implementation of TPM and 5S techniques the OEE of machine 1 was increased from 57% to 68.3% and OEE of machine 2 was increased from 44.1% to 53.3%.

6. CONCLUSION

Manufacturing process and the resources for producing the plastic parts have been studied and the breakdowns such as mechanical, electrical and other which occur during operation have been analysed. It is evident that TPM increases the service life of the equipment and improve men and machine utilization. Therefore, it is very much important to implement TPM so as to increase the availability, performance, quality and effectiveness of the machines.

ACKNOWLEDGEMENT

We are sincerely grateful to the General Manager, Maintenance Head, Facilitator and the operators who helped as to conclude the study.

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