IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 32-45
www.iosrjournals.org

Improvement of Overall Equipment Effectiveness (OEE) in Plastic Injection Moulding Industry

S.R.Vijayakumar[1] , Dr.S.Gajendran[2]
[1](PG student- Department of Production Technology, MIT Campus, Anna University, Chennai)
[2](Associate Professor- Department of Production Technology, MIT Campus, Anna University, Chennai)

ABSTRACT:- *Injection moulding is a plastic-forming process used in the production of most of the plastic parts (about 70%) in automobile industries.The manufacturing industry has gone through significant changes in the recent years. For a good manufacturing plant, the most recommended thing is quality, efficiency and operating cost. These parameters depend on the function of the equipments used in the industry. Nowadays a remarkable improvement has taken place in the maintenance management of the physical assets and productive systems to reduce the wastage of energy and resources. Because of this, the organization should introduce a maintenance system to improve and increase both the quality and productivity continuously.OEE is one of the performance evaluation methods that are most common and popular in the production industries. In this work, the OEE of the injection moulding process was increased from 61% to 81% through the implementation of availability, better utilization of resources, high quality products and also raised employee morale and confidence.*

Keywords:- *Focused quality improvement , Major Losses, Maintenance, , Manufacturing performance, Overall Equipment Effectiveness improvement, Planning, Training etc.,*

I. INTRODUCTION

Management is the process of getting things done, effectively and efficiently, through and with other people.

- *Objective:* to attain the organizational goals.
- *Efficiency:* doing things right.
- *Effectiveness:* doing the right things!

In most of the automotive parts manufacturing units lack of higher rate of quality defects in produced parts and minor stops due to workforce, planning and unskilled operators for their competitive. So that it is required to keep proper observation for reducing product rejection and wastage, producing parts without defect, proper training for workers and reducing equipments breakdown and down time. The term Total productive maintenance (TPM) is originated in Japan in the year 1971 as a method for improved machine availability through better utilization of maintenance and production resources. In most production settings the operator is not viewed as a member of the maintenance team, in TPM. The machine operator is trained to perform many of the day-to-day tasks of simple maintenance and fault-finding. Teams are created that include a technical expert (often an engineer or maintenance technician) as well as operators [1]. The concept of overall equipment effectiveness was originated from Japan in 1971.The Japan Institute of Plant Maintenance promoted the total productive maintenance (TPM) which includes overall equipment efficiency. The OEE calculation is quite general and can be applied to any manufacturing organization [2]. It is closely tied to JIT (Just in Time) and TQM (Total Quality Management) and it is extension of PM (preventive maintenance), where the machines work at high productivity and efficiency, and where the maintenance is all employee responsibility, and focus to prevent the problem before it may occurs [3]. The aim of TPM to reduce the six major equipment losses, to zero, has been recognized as necessary for corporate survival. TPM is a unique Japanese system of plant management, developed from preventive maintenance concept. This approach emphasizes the role of team work, small group activities, and the participation of all employees to accomplish equipment improvement objectives [4]. It challenges a sense of joint responsibility between operators and maintenance workers, not only to keep the machines running smoothly, but also to extend and optimize their overall performance [5] TPM is intended to bring both functions (production and maintenance) together by a combination of good working practices, team working and continuous improvement [6]. This work focus on improving the Overall Equipment Effectiveness of the Injection Moulding machine through the implementation of availability, better utilization of resources, high quality products and also raised employee morale and confidence.

1.1 Injection Moulding

The Process of manufacturing by shaping pliable raw material using a rigid frame is called *Molding* (American English) or *Moulding* (British English). It is also known as *Coving* (UK, Australia). *Injection moulding* is the most widely used polymeric fabrication process. It evolved from metal die casting, however, unlike molten metals, polymer melts have a high viscosity and cannot simply be poured into a mould. Injection moulding process is a dynamic process known for its speed and preciseness when compared to other moulding processes. Injection moulding is a process of forming an article by forcing molten plastic material under pressure into a mould where it is cooled, solidified and subsequently released by opening the two halves of the mould. Injection Moulding is used for the formation of intricate plastic parts with excellent dimensional accuracy. A large number of items associated with our daily life are produced by the way of Injection Moulding.

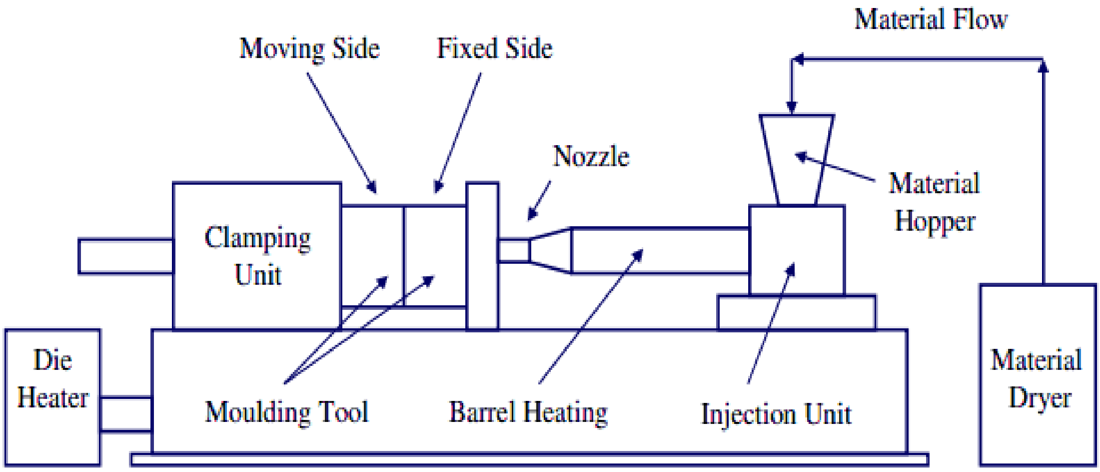

Fig.1.Injection Moulding Machine

- **Manufacturing Process**
  - ✓ Pellets placed in hopper
  - ✓ Pellets fall into barrel through throat
  - ✓ Pellets packed to form solid bed. (air forced out through hopper)
  - ✓ Pellets melted by mechanical shear between barrel and screw
  - ✓ Melted plastic form shot in front of screw (screw moves back as plastic moves forward –reciprocating screw)
  - ✓ Screw moves forward to inject plastic into mould cavity
  - ✓ Part cooled and solidifies (next shot is made)
  - ✓ Mould opens
  - ✓ Ejection pins move forward to eject part
  - ✓ Mould closes and Process starts again

Note:-

- Injection Pressure typically – 15,000 psi.(3000 ~ 40,000 psi)
- Hydraulic pressure is about 10x less

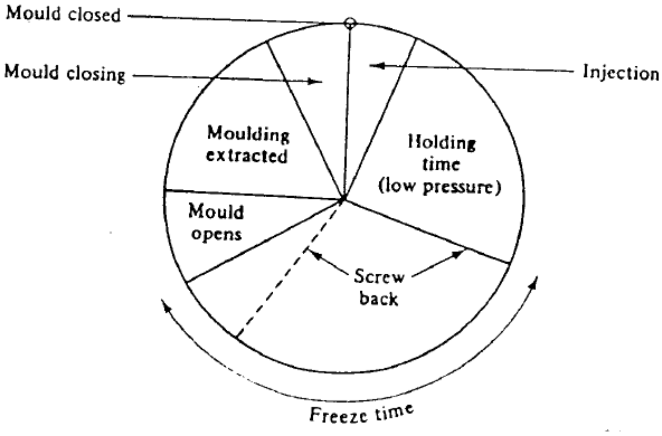

Fig.2. Cycle of Operations

- **Application**

- Injection moulding is a manufacture technique for making parts from plastic material. (polystyrene, nylon, polypropylene and polythene)
- Heated, fluid plastic is injected at high pressure into a mould, which is the inverse of the desired shape.
- Injection moulding is used to create a variety of parts, like plastic milk cartons, containers, bottle caps, automotive dashboards, pocket combs, and most other plastic products available today.
- Injection moulding is extensively used in automobile manufacturing industry.

1.2 Polymers

Polymer (poly-many; mer-unit or parts) is defined as a substance composed or molecules characterized by the multiple repetition or one or more species of atoms or groups or atoms linked to each other in amounts sufficient to provide a set or properties that do not vary markedly with the addition or removal or one or a few or the constitutional units. Oligomer is a substance composed or molecules containing a few or one or more species or atoms or groups or atoms (constitutional units) repetitively linked to each other. Constitutional unit is a species or atoms or group or atoms present in a chain or polymer or oligomer molecule. Monomer is a compound consisting of molecules each or which can provide one or more constitutional units. When the polymer is formed by polymerization of two or more than two types of monomers together the polymer is called Copolymer. Polymerization is the process of converting a monomer or a mixture of monomers into a polymer.

- **Plastics:** A polymeric material with the ability to flow into a desired shape when heat and pressure are applied to it.
- **Polymeric material -** A chemical compound formed by linking many monomer units to form larger molecules that contain repeating structural units.

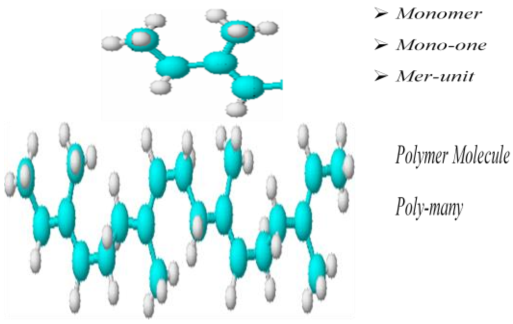

Fig.3 Molecular structure of Polymer

- **Thermoplastics:** The polymer is softened by heating, shaped and then cooled to retain shape. This process is repeatable as no chemical change occurs in the polymer.
  - Molecular structure - chain is liner able to break chain, so easily remelt.

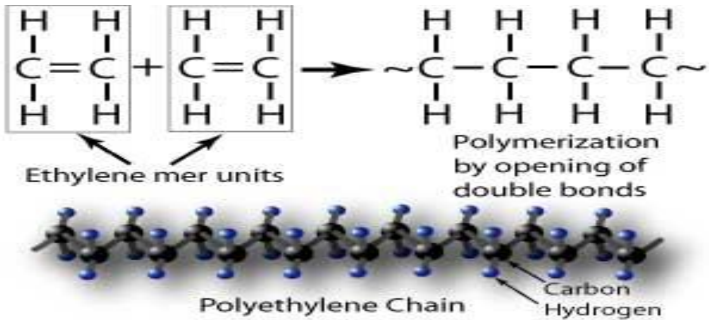

Fig.4. Molecular structure of PE

- **Thermosetting:** The polymer is softened by heating, shaped and then further heated to produce a chemical change which gives permanence of shape. This process is irreversible therefore the material cannot be reprocessed.
  - Molecular structure - Networked structure, not able to break the structure.

Fig.5. Molecular structure of Thermosetting

- **Environment, Safety, Recycling**

The Customer has an objective of minimizing the negative effects of products on humans and the environment while taking account of technical/ economic factors according to ecological criteria. Adherence to valid laws and directives therefore represents a minimum requirement for the supplier. The materials used and their components must conform to the legal regulation relating to the environment, safety and recycling as well as to agreed customer standards.

Recommendation: Identification of materials in accordance with relevant standards and regulations. Identifications must be easily visible and easily legible after the used phase

Advantage: Manual fractionation possible, avoidance of complicated subsequent process steps.

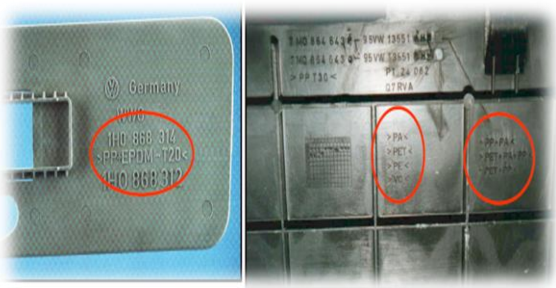

Fig.6. Material marking

Note :- The component on the left side is clearly labelled polymer blend PP + EPDM-T20 (Polypropylene + Ethylene propylene diene monomer–Talc20). On the right side, there are several marks within to cover all equipment variants. This information is useless for a recycling process; the material cannot be clearly assigned.

- **Recycling of Plastic**
  - State and Federal Regulation
  - Codes for Plastics

- 1 PET (Polyethylene terepthalate)
- 2 HDPE (High Density Polyethylene)
- 3 Vinyl / PVC (Poly Vinyl Chloride)
- 4 LDPE (Low Density Polyethylene)
- 5 PP (Polypropylene)
- 6 PS (Polystyrene)
- 7 Others

It was developed by the Society of the Plastics Industry (SPI) in 1988, and is used internationally. The primary purpose of the code is to allow efficient separation of different polymer types for recycling. Separation must be efficient because the plastics must be recycled, even one item of the wrong type of resin was found.

II. OVERALL EQUIPMENT EFFECTIVENESS

The *Effectiveness* of the equipment is the Actual Output over the Reference Output.
Equipment Effectiveness shows how effectively an equipment is utilized.
Overall Equipment Effectiveness shows the effectiveness of a machine compared to the ideal machine as a percentage.

OEE is essentially the ratio of Fully Productive Time to Planned Production Time. In practice, however, OEE is calculated as the product of Availability, Performance and Quality.

OEE = Availability X Performance Rate X Quality Rate
Availability – is enhanced by eliminating equipments breakdowns, setup/adjustment losses and other stoppages. It measure "Productivity Losses" from Breakdown times and remaining time is called "Operating Time". Availability is the ratio of Operating Time to Planned Production time. It represents the percentage of schedule time that the equipment is available to operate. It takes into account Down Time Losses.
Availability = (Available Time – Unplanned Downtime) / Available Time

- Available Time = Total Available Time – Planned Downtime
- Planned Downtime – Excess Capacity, Planed breaks, Planned maintenance, Communication break, Team meetings.
- Unplanned Downtime – Breakdowns, Setup and Adjustment, Late material delivers, Operator availability

Performance Rate – is enhanced by eliminating equipment idling and minor stoppage and reduced speed losses. It measure "Productivity Losses" from slow cycles and remaining time is called "Net Operating Time". Performance is the ratio of Net Operating Time to Operating Time. It represents the speed at which the equipment runs as a percentage of its designed (Ideal) speed. It takes into account Speed Losses.
Performance = (Total Production Parts / Operating Time) / Idle run rate

- Operating Time = Available Time – Unplanned Downtime
- Idle run rate = Number of parts per minute
- Output (Quantity of Product) = Operating Time / Actual Cycle Time
- Net Operating Time (Productivity) = (Output x Actual Cycle Time) / Actual Operating Time
- Rate Efficiency = Processed Amount x (Actual Cycle Time / Actual Operating Time)
- Speed Efficiency = Design (Ideal) Cycle Time / Actual Cycle Time

Quality Rate – is enhanced by eliminating quality defects and rework, and start up losses. It takes into account Quality Losses and remaining time is called "Fully Productive Time". Quality is the ratio of Fully Productive Time to Net Operating Time. It represents the Good units produced as a percentage of the Total units produced.
Quality Rate = (Total Produced Parts – Defects Parts) / Total Produced parts

III. PILLARS OF TPM

1. Autonomous maintenance:

- Fostering operator ownership.
- Perform Mould cleaning – water flow – material flow – adjustment – inspection – readjustment on production equipment.

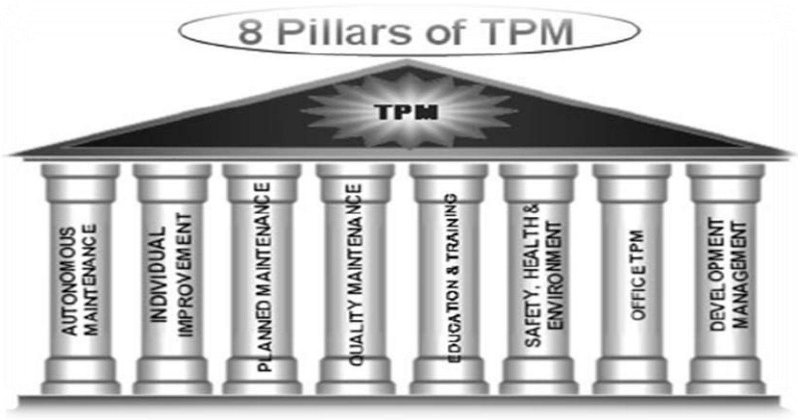

Fig.7. Eight Pillars of TPM

2. Focused improvement:
- Systematic identification and elimination of 16 losses.
- Working out loss structure and loss mitigation through.
- Structured why-why analysis, FMEA (Failure Mode Effective Analysis).
- Achieve improved system efficiency.
- Improved OEE on production systems.

3. Planned maintenance:
- Planning efficient and effective PM, PdM and TBM systems over equipment life cycle.
- Establishing PM check sheets.
- Improving Mean Time Between Failure (MTBR), Mean Time To Repair (MTTR).

4. Quality maintenance:
- Achieving zero defects.
- Tracking and addressing equipment problems and root causes.
- Setting3M(machine/man/material) conditions.

5. Education and training:
- Imparting technological, quality control, interpersonal skills.
- Multi-skilling of employees.
- Aligning employees to organizational goals.
- Periodic skill evaluation and updating

6. Safety, health and environment:
- Ensure safe working environment.
- Provide appropriate work environment.
- Eliminate incidents of injuries and accidents.
- Provide standard operating procedures.

7. Office TPM:
- Improve synergy between various business functions.
- Remove procedural hassles.
- Focus on addressing cost-related issues.
- Apply 5S in office and working areas.

8. Development Management:
- Minimal problems and running in time on new equipment
- Utilize learning from existing systems to new systems Maintenance improvement initiatives

IV. MAINTENANCE MANAGEMENT

In modern industry, equipment and machinery are a very important part of the total productive effort. Therefore, their idleness or downtime becomes very expensive. Hence, it is very important that the plant machinery should be properly maintained

- Preventive Maintenance (PM)
- Breakdown Maintenance (BM)
- Corrective Maintenance (CM)
- Maintenance Prevention (MP)
- Predictive Maintenance (PdM)

❑ ***The main objective***

- ✓ To achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost.
- ✓ To keep the machine and other facilities in such a condition that permits them to be used at their optimal capacity without interruption.
- ✓ To ensure the availability of the machines, building and service required by other sections of the factory for the performance of their functions at optimal return on investment.

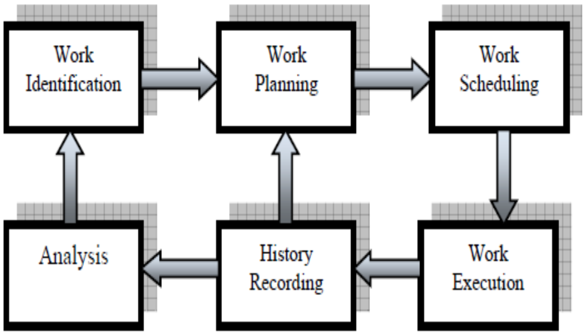

Fig.8. Maintenance Process

❑ **Maintenance Strategies:**

Maintenance actions can be divided into four general categories or strategies. The maintenance plan for a company's assets will be a combination of these four strategies (Fig.9), often they could all be used on the same machine.

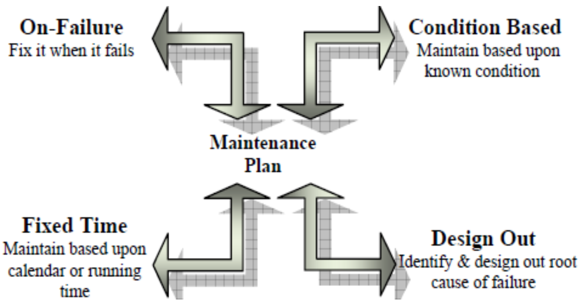

Fig.9. Maintenance Strategies

V. SIX LOSS CATEGORIES

To achieve Overall Equipment Effectiveness, elimination of "Six Big Losses" from the Injection Moulding that are formidable obstacles to equipment effectiveness is required. (Refer Table.1)

- **Break down losses:** These are losses of quantity via defective products and losses of time due to decreased productivity from equipment breakdowns.
- **Setup and adjustment losses:** These losses stem from defective units and downtime that may be incurred when equipment is adjusted to shift from producing one kind of product to another.
- **Idling and minor stoppage losses:** Typically, these kinds of small losses are relatively frequent. They result from brief periods of idleness when between units in a job or when easy to clear jams occur.
- **Reduced speed losses:** These losses occur when equipment is run at less than its design speed.
- **Quality defects and rework:** These are product related defects and corrections by malfunctioning equipment.

- **Startup losses:** These are yield losses incurred during early production, from machine startup to steady state.

Table.1.Six Big Losses

Six Big Loss	OEE Loss Category	OEE Metric	Loss Category Examples	Comment
Breakdown	Downtime Losses	**Availability**	Equipment Failure Unplanned Maintenance General Maintenance Tooling Damage	Loss due to Breakdown of Equipments (more than 10 min)
Setup and Adjustment			Setup/Changeover Material Shortage Operator Shortage Mould warm up Time	Time lost due to adjustments in the Equipments (less than 10 min)
Idling & Minor Stoppage	Speed Losses	**Performance**	Material Flow Stoppage Components Jams Material mis-feeds	Small stops losses occur when equipments stops for a short time as a result of temporary problem
Reduced Speed			Mould Life/Wear Operator inefficiency Under Design Capacity	Reduced speed refers to the difference between Design speed and Actual Operating speed
Startup Rejects	Quality Losses	**Quality**	Material warm up Lumps Material unfilled	Some equipment require warm up time and certain adjustments to obtain optimum output (Startup Rejection occurs during this startup time)
Production Rejects			Scrap / Rework Undercutting Child part mis-feeds	These losses occurs when products produced are not conforming to the specification (Reject during steady state production)

VI. DATA ANALYSIS

- *Plant Operating Time* = Fully Productive Time + Quality Losses + Speed Losses + Downtime Losses + Planned Shutdown
- *Planned Shutdown* = Tea Break + Lunch/Dinner/Supper Break
- *Down Time* = Waiting Time for Operator + Setups & Changeover Time + Material Flow Shortage Time + Failure or Breakdown Time + Meeting Time

Production Data:

- Shift Length (Plant Operating Time)
- Tea Breaks
- Meals Break
- Down Time
- Idle(Design) Run Rate
- Total number of Production Quantity
- Total number of Rejected Quantity

Support Variable:

- Planned Production Time = Shift Length – Breaks
- Operating Time = Planned Production Time – Downtimes
- Good Quantity = Total Production Quantity – Total Rejected Quantity

VII. CASE STUDY

This study is done in the Automobile parts manufacturing sector using Injection Molding at M/s. **Unitech Plasto Components Pvt. Ltd.,** Mugalivakkam, Chennai. The values chosen are meant for justifying the research initiatives only. Finally, to evaluate the effectiveness of TPM implementation steps, OEE value in the plant was calculated and analyzed before and after the implementation of TPM in industry. In the process industry it is very much essential to maximize the production effectiveness; the effectiveness of the plant's production depends on the effectiveness with which it uses equipments, materials, peoples and methods. This is done by examining the inputs to the production process and identifying and eliminating the losses associated with each other to maximize the production. Major industry losses were identified as shut down (planned maintenance), production adjustment, equipment failure, process failures, normal production loss, abnormal production loss, quality defects, and reprocessing.

The company was facing some problems due to break downs, equipment defects and poor working condition. The management of company took a decision to overcome these problems by implementing TPM concept. The management also took a decision if there is an improvement in the overall equipment efficiency, and then this method will be extended to other machines.

The objectives of this case study were,

- ✓ To improve equipment reliability and maintainability.
- ✓ To cultivate the equipment-related expertise among operators.
- ✓ To maximize OEE, through total employee involvement.
- ✓ To create an enthusiastic work environment.
- ✓ To pick up the weakening in the production system those do not allow the company to achieve its full capacity and meet the set goals.
- ✓ To suggest the ways to improve the situation.
- ✓ To upgrade each operator's skills.
- ✓ To improve problem solving by the team members.

❑ Problem Statement

The bottle neck machines are selected for the implementation of TPM in the Injection Molding Machine for the following reasons.

- Poor performance among other machines
- Material Refilling Problem
- Oil leakage and Temperature problem
- Machine Relay and Thermocouple Problem
- Ejection and Clamping problems
- Internal Parts Damages
- Poor Housekeeping
- Heater Zone problem
- Quality Problems (Part Shrinkage, Catching, etc.,)

❑ Bottleneck Machine

A bottleneck is a phenomenon, where the performance or capacity of an entire system is limited by a single or limited number of components or resources. In engineering, a bottleneck is a phenomenon by which the performance or capacity of an entire system is severely limited by a single component. Formally, a bottleneck lies on a system's critical path and provides the lowest throughput. A bottleneck in project management is one process in a chain of processes, such that its limited capacity reduces the capacity of the whole chain. The bottle neck machine is due to which productivity is going down most of the time and this plant was selected as equipment for OEE calculation.

Table.2. List of Bottleneck Machines

Sl.No	Capacity	Machine Number	No. of Machine	Remarks
1	40 T	IMM-01, IMM-07	2	Hydraulic Cylinder
2	50 T	IMM-03, IMM-15	2	Single Toggle
3	60 T	IMM-09, IMM-14	2	Hydraulic Cylinder
4	80 T	IMM-04, IMM-06	2	Hydraulic Cylinder
5	100 T	IMM-08	1	Double Toggle
6	150 T	IMM-13	1	Double Toggle
7	200 T	IMM-12	1	Double Toggle
		TOTAL	**11**	

OEE – Calculation

- ❑ **Production Data**
  - Plant Operating Time
    = Shift length x 60 min
    = 24 x 60 = 1440 min/day
  - Working days in a month
    = 25 x 1440 = 36000 min/month
  - Planned Down Time
    = Cleaning+ Break+ Meeting Time
    = 30 +150 + 15 = 195 min/day

Table.3. Shift Times

Shift	Timing	Planned Downtime	Remarks
I	**08.00 am to 04.30 pm**	**Lunch- 12.30 ~ 01.00** **Tea Break- 10.30 ~ 10.40 & 02.30 ~ 02.40**	**Downtime : 50 min**
II	**04.30 pm to 01.00 am**	**Dinner- 08.00 ~ 08.30** **Tea break- 06.20 ~ 06.30 & 10.40 ~ 10.50**	**Downtime : 50 min**
III	**01.00 am to 08.00 am**	**Supper- 04.30 ~ 5.00** **Tea Break- 02.30 ~ 02.40 & 0630 ~ 06.40**	**Downtime : 50 min**

A sample calculation for the bottleneck machine IMM-06 is given below and for all other machines; the values were directly mentioned in the tabular column given below (Refer Table.4).

- ❑ **IMM-06 Machine:**
  - ✓ Planned Down Time = Setup & Mould Change Time + Break Time
    = 300 min + 195 min = 495 min/day
    = 495 min x 25 = 12375 min/month
  - ✓ Unplanned Down Time = Mechanical Breakdown + Electrical Breakdown + Electrical/Safety device Breakdown
    = 52.40 Hrs + 18.40 Hrs + 19.40 Hrs
    = 90.20 x 60 = 5412 min/month
  - ✓ Total Production Parts= 1,95,500 Nos.
  - ✓ Total Rejection Parts = 21,600 Nos.
  - ✓ Good Parts = Total Production Parts – Total Rejection Parts
    = 1,95,500 – 21,600 = 1,73,900 Nos.
  - ✓ Ideal Run Rate = 12 parts/min
  - ✓ Planned Production Time = Plant Operating Time – Planned Down Time
    = 36000 – 12375 = 23625 min
  - ✓ Operating Time = Planned Production Time – Unplanned Down Time
    = 23625 – 5412 = 18213 min

- **OEE Factors**
  - ✓ Availability = (23625 / 18213) x 100 = 77.09%
  - ✓ Performance = (195500 / 18213) /12 x 100 = 89.45%
  - ✓ Quality = (173900 / 195500) x 100 = 88.95%

  OEE=77.09x 89.45x 88.95 = 61.34%

Table.4. Initial OEE Calculation

Sl.No.	Machine No.	Availability	Performance	Quality	OEE
1	IMM-O1	78.50%	88.97%	87.93%	61.41%
2	IMM-03	76.72%	89.37%	88.98%	61.02%
3	IMM-04	79.23%	85.67%	90.58%	61.48%
4	IMM-06	77.09%	89.45%	88.95%	61.34%
5	IMM-07	77.40%	88.41%	89.54%	61.27%
6	IMM-08	76.15%	89.21%	89.91%	61.08%
7	IMM-09	75.92%	89.48%	90.16%	61.25%
8	IMM-12	75.90%	89.93%	89.38%	61.01%
9	IMM-13	76.71%	88.20%	90.74%	61.40%
10	IMM-14	78.01%	86.68%	90.49%	61.19%
11	IMM-15	77.42%	87.93%	90.15%	61.55%

VIII. METHODOLOGY

The methodology for OEE is based on the study of the steps used in the implementation of TPM in an organization. This method is divided into various steps, whose aims are bring forth improved maintenance policies of the mechanical equipment. Also, the continuous and through inspection of the production process is achieved through measurements of the overall equipment effectiveness (OEE). The goal of developing this methodology is to bring the competitive advantages, such as increasing the productivity, improving the quality of the products and this project gives an idea about the outcomes of the industry such as productivity, quality, profit etc., by introducing the new framework.

5S: 5S is the foundation program for TPM. It is a Japanese Nomenclature used for the implementation of TPM.

- Seiri – Sort / Organisation
- Seiton – Systematise / Tidiness
- Seiso – Sweep / Clean
- Seiketsu – Standardise
- Shitsuke – Self Discipline

It is a systematic process of housekeeping to identify and rectify the problems. If the 5S process is not done in a systematic order, then it leads to more problem in production and quality. In this work the 5S audit was done and it was finalized with few modifications. Such as, the rejection parts if found, it has to be separated at the spot itself and sent to rework process. All the moulds and machines should be cleaned before starting the production in every shift, etc.

Jishu Hozen: Jishu Hozen also called autonomous maintenance is a team based approach to maintenance activities. The goal of autonomous maintenance is to prepare operators to do some equipment care independently of the maintenance staff. Jishu Hozen implementation lays the foundation for other maintenance activities by establishing the basic condition for a machine’s operation.

Kaizen: “Kai” means change, and “zen” means good (for the better). Kaizen refers to continuous improvements in the production process to achieve better quality. Here the continuous improvement was done in 5M (Man, Machine, Mould, Method, Material).

The workers are provided additional training and awareness program. Based on the tonnage, the moulds and machines are listed and separated accordingly. Some required modifications in the mould to achieve the parts in proper shape and clean surface is done. The raw material grades are varied and some improved properties in less cost was obtained. Optimization of process parameters were done by trial and error method.

By doing these works, the 5 evils such as defects, mistakes, delay, wastage and accidents can be avoided or neglected. After successful implementation of TPM, it is found that OEE is increased (Refer Table.6) upto 20%.

Table.5. Quality Improvements

Sl.No	Problem	Root Cause	Corrective Action	Benefits
Category : Mould			*Part Name : Glove Box Lens*	
1	Piece Catching	Rust formation core side	Cleaned & Check list was added	8% ↑
Category : Mould			*Part Name : 2 way Connector*	
2	Flap Broken	Due to less holding strength in joint area	Material to be add in flap joint area	12% ↑
Category : Machine			*Part Name : 2 Lower Cover*	
3	Over Trimming	Mould Plastizing area wear & tear	Rectified to get rid of flash issues	23% ↑
Category : Method			*Part Name : 7967-Box*	
4	Shrinkage	Cooling Line blocked	Mould core & cavity temp.-check list was added	10% ↑
Category : Mould			*Part Name : 90S2 way male*	
5	Terminal Backout	Uneven filled in tough area, Air vent blocked	Air vent has been cleaned – check list was added	27% ↑
Category : Material			*Part Name : Bezel*	
6	Noise Problem	Small gap between Bezel & Lens	Rib size increased 0.30 mm & Material grade changed	42% ↑ (Rs.4.8 laks/yr.)

Classification of Abnormalities: After setting up of standards for all machines, abnormalities are found in all machine, which is noted during the initial cleanup. It is systematic method to organize, order, clean and standardize a work place and keep it that way. In this activity

Table.6.Abnormalities in IMM

Sl.No	M/c No.	Problem	Corrective Action	Benefits
1	5 & 8	Nozzle Heater Problem	Heater replaced	6% ↑
2	7,8 & 10	Oil Leakage Problem in Pump side	New Hydraulic Hose replaced	8% ↑
3	1,4,5 & 9	Nozzle Temp. variation	New Thermocouple replaced	16% ↑
4	3,8 & 7	Zone-01 Heater problem	New Heater replaced	6% ↑
5	11	Machine SMPS Problem	New one replaced	12% ↑
6	9	Ejection Cylinder Problem	Serviced	21% ↑

❑ **Production Data**

- Plant Operating Time
  = Shift length x 60 min
  = 24 x 60 = 1440 min/day
- Working days in a month
  = 25 x 1440 = 36000 min/month
- Planned Down Time
  = Cleaning+ Break+ Meeting Tim
  = 30 + 70 + 15 = 105 min/day

Table.7.Modified Shift Times

Shift	Timing	Planned Downtime	Remarks
I	06.00 am to 02.00 pm	Breakfast- 08.30 ~ 09.00 Tea Break- 11.00 ~ 11.10	Downtime : 40 min
II	02.00 pm to 10.00 pm	Tea Break- 03.45 ~ 04.00	Downtime : 10 min
III	10.00 pm to 06.00 am	Tea Break- 03.45 ~ 04.00	Downtime : 10 min

A sample OEE calculation for the bottleneck machine IMM-06 is given below and for all other machines; the values were directly mentioned in the tabular column given below. From this we can see the dramatic improvement in OEE (Refer Table.6).

- **IMM-06 Machine:**
  - ✓Planned Down Time = Setup & Mould Change Time + Break Time
    = 180 min + 100 min = 280 min/day
    = 280 min x 25 = 7000 min/month
  - ✓Unplanned Down Time = Mechanical Breakdown + Electrical Breakdown + Electrical/Safety device Breakdown
    = 26.20 Hrs + 10.30 Hrs + 9.40 Hrs
    = 45.90 x 60 = 2754 min/month
  - ✓Total Production Parts= 2, 90,000 Nos.
  - ✓Total Rejection Parts = 7,400 Nos.
  - ✓Good Parts = Total Production Parts – Total Rejection Parts
    = 2,90,000 – 7,400 = 2,82,600 Nos.
  - ✓Ideal Run Rate = 12 parts/min
  - ✓Planned Production Time =Plant Operating Time – Planned Down Time
    = 36000 – 7000 = 29000 min
  - ✓Operating Time = Planned Production Time – Unplanned Down Time

    = 29000 – 2754 = 26246 min
- **OEE Factors**

  - ✓ Availability = (26246 / 29000) x 100 = 90.50%
  - ✓ Performance = (290000 / 26246) / 12 x 100 = 92.08%
  - ✓ Quality = (282600 / 290000) x 100 = 97.45%

  OEE=90.50x 92.08x 97.45 = 81.21%

Table.8. Final OEE Calculation

Sl.No.	Machine No.	Availability	Performance	Quality	OEE
1	**IMM-O1**	**89.28%**	**93.58%**	**97.51%**	**81.47%**
2	**IMM-03**	**90.73%**	**91.59%**	**97.86%**	**81.33%**
3	**IMM-04**	**90.15%**	**91.39%**	**98.46%**	**81.12%**
4	**IMM-06**	**90.50%**	**92.08%**	**97.45%**	**81.21%**
5	**IMM-07**	**90.09%**	**92.74%**	**97.70%**	**81.62%**
6	**IMM-08**	**90.59%**	**93.26%**	**97.53%**	**82.40%**
7	**IMM-09**	**90.77%**	**91.97%**	**97.54%**	**81.43%**
8	**IMM-12**	**91.56%**	**92.51%**	**96.54%**	**81.77%**
9	**IMM-13**	**90.73%**	**93.30%**	**96.82%**	**81.97%**
10	**IMM-14**	**91.17%**	**91.06%**	**97.88%**	**81.26%**
11	**IMM-15**	**90.50%**	**91.60%**	**98.23%**	**81.44%**

IX. CONCLUSION

It is essential for a company to improve the production rate and quality of the products. In order to achieve this, the Overall Equipment Effectiveness was improved with low machine breakdown, less idling and minor stops time, less quality defects, reduced accident in plants, increased the productivity rate, optimised process parameters, worker involvement, improved profits through cost saving method, increased customer satisfaction and increasing sales. The Overall Equipment Effectiveness of the Injection Moulding machine was increased from 61% to 81% through the implementation of availability, better utilization of resources, high quality products and also raised employee morale and confidence.

REFERENCES

[1] Abhishek Jain, Rajbir Bhatti, Harwinder Singh Deep and hiv kumar Sharma, "Implementation of TPM for Enhancing OEE of Small Scale Industry", International Journal of IT, Engineering and Applied Science Research, 2012, Volume 1 No 1.

[2] Philip Godfrey, "Overall Equipment Effectiveness" Manufacturing Engineering, 2002, Vol, 81(3), 109-112.

[3] Islam H. Afefy "Implementation of Total Productive Maintenance and Overall Equipment Effectiveness Evaluation", International Journal of Mechanical & Mechatronics Engineering, 2013, Vol:13.

[4] Bulent Dal, Phil Tugwell, and Richard Greatbanks, "Overall equipment effectiveness as a measure of operational improvement A practical analysis", International Journal of Operations & Production Management, 2000, 20(12), 1488-1502.

[5] Debadyuti Das. "Total Productive maintenance (TPM): A comprehensive tool for achieving excellence in operations system – A case study", Industrial Engineering Journal 2001, 30 (10), 15.

[6] Cooke, F. L., "Implementing TPM in plant maintenance: some organizational barriers", International Journal of Quality and Reliability Management, 2000,17(9), 1003-1016.

[7] Thomas R. Pomorski, "Total Productive Maintenance (TPM) Concepts and Literature Review", Brooks Automation, Inc.2004.

[8] Melesse Worknesh Wakjira, Ajit Pal Singh "Total Productive Maintenance: A Case Study in Manufacturing" Global Journal of Researches in Engineering Industrial Engineering, 2012, Volume 12.

[9] Amit Kumar Gupta, R.K.Garg "OEE Improvement by TPM Implementation: A Case Study", International Journal of IT, Engineering and Applied Sciences Research, 2012, Volume 1.

[10] Gaurav Gera, Gurpreet Saini, Rajender Kumar, S.K.Gupta "Improvement of Operational Efficiency of Equipment through TPM: A Case Study", International Journal of Industrial Engineering Research and Development, 2012, Volume 3.