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Improvement of Overall Equipment Effectiveness In a Plastic Injection Moulding Industry

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ABSTRACT: - *In the present scenario, the world is highly competitive. Many industries compete in this competitive world by giving their best productivity. Productivity can be improved in many ways. In this paper the details of application of overall equipment effectiveness (OEE) to a plastic industry are presented. Using overall equipment effectiveness calculations one can determine the present situation in the production system, effectiveness of the maintenance system, conditions of the machines, worker's skill and utilization of the machines. Five bottleneck machines which affect productivity have been identified and studied and the results are presented.*

Keywords:- *OEE,TPM,Maintenance,Downtime,Breakdown*

I. INTRODUCTION

In this challenging environment, industries are facing the critical situation that it must use latest technologies to improve their productivity with minimal raw materials. Manufacturers must be able to give their products with high quality in a cost effective manner to their customers. This can be obtained by measuring all productive activities and analyzing it to identify the areas of improvement. Industry which has capability to well- manage all departments can survive in this leading market.

II. BACKGROUND

The present scenario of the company was studied. The usage of available equipments, the difficulties faced by the company in their production equipment and its measurement, the possibilities to overcome the problems were studied. Company must use their maximum abilities to get desired output. For the growth of production, it has to satisfy expectations of customers with minimal cost and maximum output. Though the problems are unexpected, it must be able to solve it within a short period. Company may not be able to achieve its goals due to the problems of service and on time delivery.

The study was carried out in the following order.

- Investigation of the present scenario of the plastic industry
- Identification of bottleneck machines in the plastic industry
- Action plan for the improvement of bottleneck machines
- Measurement of the total output once again
- Modifications if needed for obtaining the world class OEE

III. TOTAL PRODUCTIVE MAINTENANCE

The Japanese introduced the concept of Total Productive Maintenance (TPM), in 1971 to overcome the maintenance problems. TPM is defined by Nakajima (Nakajima 1988) in Japan. Its main objectives are obtaining ideal performance, enhancing product quality, minimizing losses, and improving effectiveness of equipment. It consists of eight pillars: Autonomous Maintenance, Planned Maintenance, Quality Maintenance, Focused Improvement, Early Equipment Management, Education and Training, Safety, Health and Environment, and TPM in Administration.

IV. OVERALL EQUIPMENT EFFECTIVENESS

OEE can be expressed as the ratio of the actual output of the equipment divided by the maximum output of the equipment under the best performance condition.(OEE) is used to measure the overall performance of the equipment and to determine how efficiently a machine is running. OEE depends on the basic three components: Availability, Performance and Quality.

A. SIX BIG LOSSES

OEE is a simple tool that will help to measure the effectiveness of their equipment. It takes the most common and important sources of productivity loss, which are called six big losses and given in **Table I.**

TABLE I. SIX BIG LOSSES

Major Loss event	OEE Metric	Loss category	Example of Loss category
Machine breakdowns	Availability	Down time	Equipment failures, Tooling damage, Unplanned maintenance
Machine adjustments/setups	Availability	Down time	Process warm-up, Machine change over's, material shortage
Machine stops	Performance	Speed	Product misdeeds, component jam, product flow stoppage
Machine reduced speeds	Performance	Speed	Level of machine operator training, Equipment age, Tool wear
Machine bad parts	Quality	Quality	Tolerance adjustments, worm up process, damage,
Machine production bad parts	quality	quality	Assembled incorrectly, rejects, rework

These losses are quantified as availability, performance rate and quality rate in order to estimate OEE as given in equation (1).

$$OEE = Availability \times Performance \times Quality \quad (1)$$

B. OEE CALCULATION METHOD

Planned production time = Shift length – break
Operating time = Planned production time - downtime loss
Availability = (Operating time / Planned production time)
Actual cycle time = (Operating time / No of products produced)
Performance = (Standard cycle time / Actual cycle time)
Quality=(Good product / Total product)
OEE = Availability × Performance × Quality
World Class OEE found to be 85% for the manufacturing industries.
Shortcut method to calculate OEE is shown below. But where problem occurs exactly is not found out.
OEE=(Good Parts ×standard cycle time) / Planned production time

C. CASE STUDY

The case study was carried out in a plastic industry which is situated near Chennai. The overall equipment effectiveness has been measured to know the present situation of the plastic industry. Five bottleneck machines have been identified and studied using overall equipment effectiveness calculations. OEE of various kinds of machines gives the best understanding of the issues.
Calculation of availability of plastic industry denotes how effectively the machine is operating. Ability of workers and machines can be given by performance efficiency. Quality rate gives how efficiently the machine is utilized.

D. IDENTIFICATION OF BOTTLENECK MACHINES

There are many methods to find out the bottleneck machine. Some of the commonly used methods are shown below

- Grading of Machines.
- Most Rejection(or) High Breakdown
- Time Over (More Setup Time)/Tool Changeover
- Cycle Time is greater than Takt Time.
- More Cycle Time
- Lowest Output.

- Oldest Machine and.
- Employee Suggestion

E. GRADING OF MACHINES

The six factors which are used to categorize the machine are number of shifts, spare machinery, failure, quality, safety and age factor.

TABLE I. CRITICAL MACHINES

S.No	Type	Points	Ranks
1	Critical machines	24&above	15
2	Rank 2 machines	21-23	57
3	Rank 3 machines	18-20	53
4	Rank 4 machines	15-17	20
5	Rank 5 machines	Below 14	10

The average points of four and above in each criteria is considered as having a significant effect in deciding the criticality of the machinery which is shown in Table II and 15 bottle neck machines were found out and shown in Table III. 5 bottleneck machines were selected based on criteria, all of which comes under the grading of machines criterion.

TABLE II. CRITICAL MACHINES

S.No	Machine Name	1	2	3	4	5	6	Total	Rank
1	Capsule Injection Moulding	4	5	4	5	4	4	26	1
2	Injection Moulding Machine	4	5	4	5	4	4	26	1
3	Injection Moulding Machine	4	5	4	5	4	4	26	1
4	Injection Moulding Machine	4	5	4	5	4	4	26	1
5	Injection Moulding Machine	4	5	4	5	4	4	26	1
6	Injection Moulding Machine	4	5	4	5	4	4	26	1
7	Injection Moulding Machine	4	5	4	5	4	4	26	1
8	160 T Hydraulic Press	4	3	4	5	4	5	25	1
9	Shaft Injection Moulding	4	3	4	5	4	5	25	1
10	Ultrasonic Welding Machine	4	3	4	5	4	5	25	1
11	Compressor 204 Cfm	4	3	4	3	4	5	23	2
12	Final Inspection Table	4	3	3	3	4	5	22	2
13	Generator-320 Kva	4	3	3	4	3	5	22	2
14	Drilling&Tapping(Manual)	3	3	3	3	3	3	18	3
15	Crack Detector	2	3	1	1	3	5	15	4

F. Bottleneck Machines list

Among the 136 machines, 5 machines are selected based on the bottleneck machines which is shown in Table IV

TABLE III. BOTTLENECK MACHINES LIST

S. No	Machine Name	Machine no	Reason for Selection
1	Capsule injection moulding	CIM 112	Most Rejection
2	Shaft injection moulding	SIM 1098	More cycle time
3	Hydraulic press	HP 40T	Employee suggestion
4	Ultrasonic welding machine	UWM C3	Less production
5	Injection moulding machine	IMM RF2	More cycle time

G. OEE Calculation of Injection Moulding Machine

Production Data For Injection Moulding Machine - 1				
Shift Length	8 Hr = 480 Min	480 Min		
Short Breaks	2 @ 15 Min	30 Min		
Meal Break	1 @ 30 Min	30 Min		
Down Time		62 Min		
Ideal Run Rate	10 Pieces Per Min	10 p/m		
Total Pieces	2812	2812		
Reject Pieces	23	23		
Support Variables		**Calculation**	**Calculated Data**	**Result**
Planned Production Time		Shift Length - Breaks	420	420
Operating Time		Planned Production Time - Down Time	358	358
Good Pieces		Total Pieces - Reject Pieces	2789	2789
OEE Factor		**Calculation**	**Calculated Data**	**OEE %**
Availability		Operating Time / Planned Prodction Time	0.8524	85.24%
Performance		Total Pieces / Operating Time/Ideal Run Rate	0.7855	78.55%
Quality		Good Pieces / Total Pieces	0.9918	99.18%
Overall OEE		Availability X Performance X Quality	0.6640	66.40%

Checking
OEE= (Good Parts * standard cycle time) / Planned production time
= (2789*10) / (420) =66.40%

H. OEE Calculation of Bottleneck Machines

The overall equipment effectiveness of the bottleneck machines are calculated.The OEE of the five bottleneck machines are i.e. Capsule injection moulding machine , shaft injection moulding machine, Hydraulic press, Ultrasonic welding machine and Injection moulding machine are 66.40%,63.17%, 65.75%, 67.64% and 69.07% are shown in table below.

S.NO	M/C Name	Availability (%)	Performance (%)	Quality (%)	OEE (%)
1	Capsule Injection Moulding	85.24	78.55	99.18	66.40
2	Shaft Injection Moulding	85.24	7.54	99.43	63.17
3	Hydraulic Press	86.29	76.53	99.56	65.75
4	Ultrasonic Welding Machine	87.12	78.30	99.16	67.64
5	Injection Moulding Machine	87.86	79.08	99.42	69.07

V. RESULTS & DISCUSSION

All industries are in the situation to improve their productivity. Every company is facing many challenging problems to produce better production rate. Manufacturers should be able to identify even the small factors affecting production growth. Clear identification of problem at the right time will help to increase quality as well as productivity rate. The OEE of the five bottleneck machines i.e. Capsule injection moulding machine, shaft injection moulding machine, Hydraulic press, Ultrasonic welding machine and Injection moulding machine are shown. Calculated OEE is compared with world class OEE shown in figure 2.

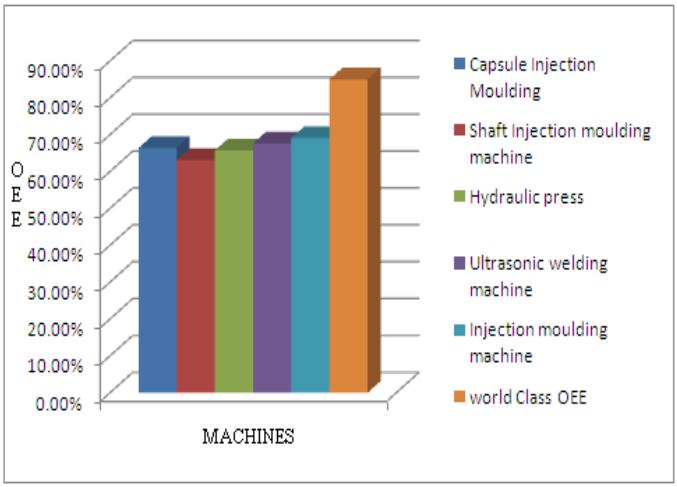

Fig 2 OEE World Class Comparison

VI. CONCLUSION

Utilization of equipment can only be improved and controlled successfully if an appropriate performance measurement system is used. OEE is a known method to measure performance of production equipment in manufacturing industries and adapted for steering column manufacturing industry in this paper. It aims to identify unproductive time losses within the system and these time losses affect availability, performance and quality.

It was found in this work that when a group formed with members each department the company got a chance to see how the team work is important in solving the problem. Another benefit that was realized is to give them the chance to know what best techniques they can apply which will improve their performance. Calculating the OEE also give the company where they are and where is the weakness point and how to improve. From the calculated OEE high cycle time, more waiting time and Low productivity were identified.

The importance of proper data collecting system to estimate OEE is also emphasized. If data are not properly collected then the resulting OEE will not be meaningful. Most of the equipment producers provide data collecting system for their equipments and the manager just needs to classify them according to definitions.

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