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Implemented the Overall Equipment Effectiveness (OEE) by the techniques of Total Productive Maintenance (TPM) in MSE's- A case study

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ABSTRACT

In this era of globalization and open knowledge-based economy, the overall focus converges through Total Productive Maintenance concept applied in industries. For the Indian organization, TPM is a new concept. In Total Productive Maintenance, various types of maintenance are analyzed viz. Total Predictive Maintenance, Total Preventive Maintenance. TPM has the objective of zero breakdowns and zero defects. This thesis impacts on the TPM approach in an MSE's where the existing overall equipment efficiency is low. The implementation of TPM takes about three to four years for reaching to a certain level and the success depends upon how the whole structure is defined and systematically worked out. Various data acquisition techniques and TPM analysis techniques like Pareto analysis and why-why analysis, make data tables has done to know the different reasons and their contribution to total downtime. In this case study analysis of break down, TPM implementation and OEE improvement after TPM implementation are presented. The problems related to safety, machine maintenance and breakdowns were referred to management for further action. A study on the breakdown of different machines was also conducted and submitted to the management to improve the quality. The study helps the management to decide some concrete action plans to improve the overall equipment efficiency by adopting TPM in their plant.

Keywords— *Overall Equipment Effectiveness, Total Productive Maintenance, Why-Why analysis, Gooseneck failure data, Pareto chart*

1. INTRODUCTION

Maintenance is kind of activity necessary for retaining or restoring a piece of equipment, machine, or system to the specified operable condition to achieve its maximum useful life. The maintenance is a very important part of all industries. By maintaining plant equipment we may quality and quantity of product.

The calculation of equipment's effectiveness is one of the most critical aspects for operators, maintenance personnel, process engineers, quality engineers and management since it identifies the inefficiencies determining where to focus improvement actions. Many 'Lean Thinking' companies have found that OEE (Overall Equipment Effectiveness) is the metric that best correlates to continuous improvement success. An OEE model measures three critical components of equipment utilization, the rate of quality, availability and performance efficiency. Our investigation spanned over a time period of six months on the shop floor for determining the OEE and suggesting ways for improving it. After analyzing various reasons for low OEE, we have given various solutions for improving it. As a result, the OEE of the organization increased from a meagre 23% to 56%.

TPM is an innovative Japanese concept. The practice of TPM started in 1951 when preventive maintenance was introduced in Asia. The concept of preventive maintenance originated in the USA. Nippondenso was the company who introduced the plant-wide preventive maintenance in the year 1960. This is a technique where, operation group produced goods using machines and maintenance group used to work of maintaining those machines, however with the automation of Nippondenso, maintenance became a problem, as more maintenance personnel were required. Hence management decided that the workers would carry out the routine maintenance of equipment and this Company added in-house maintenance done by the production workers. The modifications lead to prevention from maintenance. Thus preventive maintenance along with Maintenance prevention and Maintainability Improvement gave birth to Productive maintenance. The aim of such maintenance was to improve overall effectiveness to achieve optimum life cycle cost of production equipment. TPM is a philosophy, which focuses on the aspect of equipment availability and efficiency to:

- Make maximum utilization of the existing facility.
- Enhance the rate of output.
- Reduce the cost of production.
- Total participation of all the employees from top-level management to lower level to achieve the goal of zero breakdowns and zero defect.

2. REVIEW OF PAST RESEARCH

TPM combines the best features of productive and PM procedures with innovative management strategies and encourages total employee involvement. TPM focuses attention on the reasons for energy losses from, and failures of equipment due to design weaknesses that the associated personnel previously thought they had to tolerate.

Swapnil Raut and Niyati Raut (2017) shows, machine maintenance and in particular, implementing an appropriate maintenance strategy has become increasingly important for manufacturing industries. Total Productive Maintenance (TPM) is an excellent approach for maintaining plants and equipment's which optimizes the equipment effectiveness, eliminates breakdown and promotes autonomous operator maintenance through day-to-day activities, which involves the total workforce. This paper presents the study and overview of the implementation of TPM in an automobile spare parts MSE'S to enhance OEE. For this purpose, the current OEE of machines are analyzed and the critical machine is selected for implementation of TPM. The methodology includes stepwise implementation of 5S, Autonomous maintenance, Kaizen and Planned maintenance. After implementation of TPM on the critical machine increase in availability, performance and quality are achieved thereby enhancing overall equipment effectiveness. Comparison of OEE before and after TPM implementation validates the success of TPM implementation in the industry.

Meghraj and Dr Sridhar K (2016) to evaluate the contributions of total productive maintenance (TPM) initiatives to improve manufacturing performance in the machine shop. Due to frequent failures and breakdowns occurred in the machine, require more investment on maintenance due to which increased in maintenance cost and this results into different losses at the workplace which cause low availability, poor performance and low quality of the output ultimately cause low OEE of the machine. The correlations between various TPM implementation factors and manufacturing performance improvements have been evaluated and validated by employing overall equipment effectiveness (OEE) in a machine shop. OEE of a machine plays an important role in the present scenario because it provides information about the effectiveness of the equipment. Results obtained through the detailed study reveals the varying trends in the Overall Equipment Effectiveness (OEE) and Total Productivity of the machines taken up for the study. The average values of OEE were found to lay between the ranges of 49% to 61%against world-class standards of 85%. The results highlight the major causes resulting in the downtime and decrease in productivity. In this paper, a comparative study between World Class industries where TPM has been implemented and industry which does not follow TPM identifies the various problems leading to decrease in the overall efficiency of the industry and provides valuable suggestions for the improvement and methodology for implementing TPM pillars in industry.

Sarang G. Katkamwar, Sadashiv K. Wadatkar and Ravikant V. Paropate (2013) Presents the study and overview for the implementing approach of Total Productive Maintenance in Indian spinning industries. The study is carried out in medium scale cotton spinning industry using the observations coupled with documents collection. The TPM implementation methodology is suggested for improvement in the availability, performance efficiency and the quality rate results in improvement of the overall equipment effectiveness of the equipment. The aim of this paper is to suggest and study the implementation of the TPM program in the spinning industry. Using a See-through, JH-Check sheet, PM-Check sheet, One Point Lessons, empirical and comprehensive approach toward the methodology results in the proper implementation of TPM. After implementation of TPM on the model machine, both direct and indirect benefits are shown to be obtained for equipment and employees respectively.

3. PROBLEM IDENTIFICATION

By Observing the Company work process cycle, we have observed the following losses:

OEE combines the operation, maintenance and management of manufacturing equipment and resources. The six major losses which affect the overall performance of the equipment are:

(a) Breakdown losses: These are the time and quantity losses caused by defective products.
(b) Set-up and adjustment losses: These are the time losses resulting from downtime and defective outputs that occur when production of one item ends and the machine is adjusted to meet the requirements of another item.
(c) The above two losses are termed as downtime losses and they are used to calculate availability of a machine.
(d) Idling and minor stop losses: They occur when a machine is idling or the production is interrupted by a temporary malfunction.
(e) Reduced speed losses: It is the difference between the designed speed of the machine and actual operating speed.
(f) The third and fourth loses are termed as are speed losses and they are used to calculate the performance rate.
(g) Start-up losses: These losses occur from the machine start-up stage to the stabilization stage.

4. METHODOLOGY AND EXPERIMENTAL PLAN

OEE (Overall Equipment Effectiveness) is the gold standard for measuring manufacturing productivity. Simply put it identifies the percentage of manufacturing time that is truly productive. An OEE score of 100% means you are manufacturing only Good Parts, as fast as possible, with no Stop Time. In the language of OEE that means 100% Quality (only Good Parts), 100% Performance (as fast as possible), and 100% Availability (no Stop Time).

"OEE=Availability rate X Performance efficiency X Quality rate"

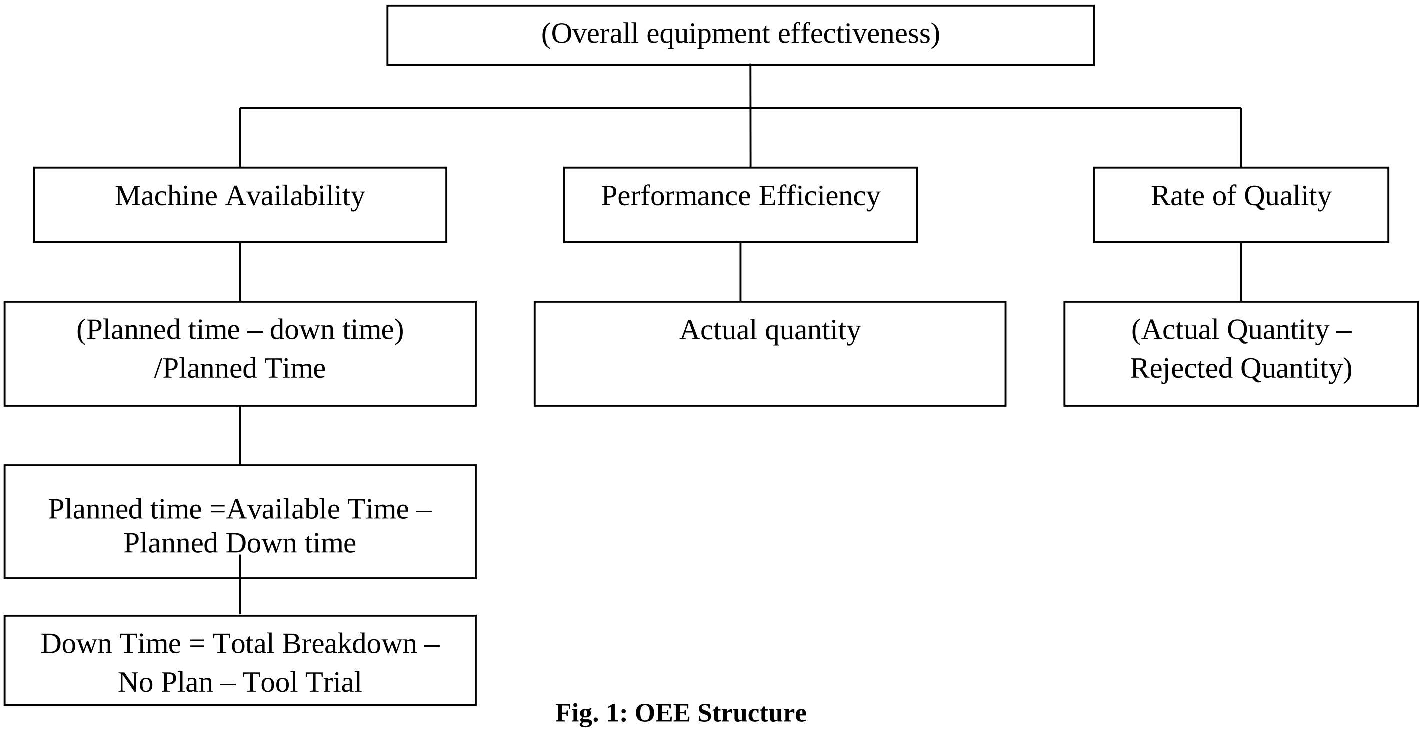

Fig. 1: OEE Structure

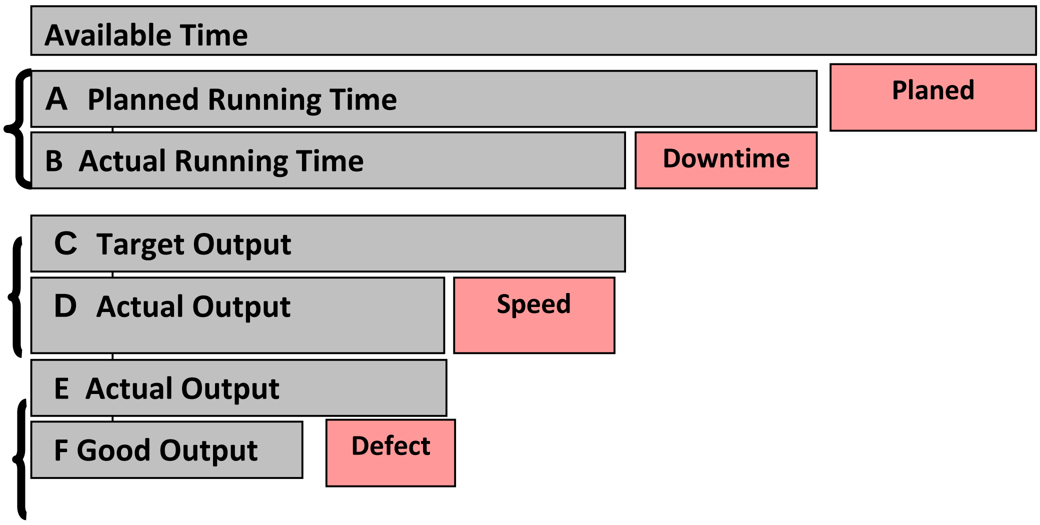

Fig. 2: Time distribution in OEE

The OEE can be improved by increasing any of the factors from above three. Here emphasis on Machine Availability Rate is made in order to increase the availability rate so as to improve the OEE.

$$A.R. = \frac{Actual\ Running\ Time}{Planned\ Running\ Time} = \frac{Planned\ Running\ Time - Downtime}{Available\ Time - Planned\ Downtime}$$

The machine availability can be measured in terms of availability rate and can be increased by following two ways:
(1) Increasing the actual running time
(2) Decreasing the planned running time

Planned running time is fixed so we can increase the OEE by increasing the actual running time. In this way, we can increase the actual running time by decreasing the downtime due to machine breakdown. So it is necessary to analyze the breakdown. The only efficiency is not sufficient to analyse the process. It is simply a ratio of output over input but what happens with the losses in terms of Equipment, machine, tooling. To calculate these losses OEE is measured.

1. Reduce breakdown
2. A frequent response to equipment
3. Eliminate quality defects
4. Improve productivity
5. Reduce fatigue
6. Reduce unnecessary follow-ups
7. Eliminate the six losses
8. Eliminate line stoppage
9. Reduce rework and rejection

Measuring OEE is not an approach for criticizing people. It is strictly about improving the equipment or process. When we measure OEE, we look at how well the equipment or process is working. Unlike some uses of the efficiency measure, OEE monitors the machine or process that adds the value, not the operator's productivity. Used as an impartial daily snapshot of equipment conditions, OEE promotes openness in information sharing and a no-blame approach in handling equipment – related issues.

5. DATA COLLECTION

5.1 OEE Analysis

5.1.1 OEE calculation for September 2017

Availability rate = Actual running time / Planned Running time

Planned running time = Available time - Planned Breakdown time

Available Time = 8 x 3x 31 = 744 hrs

Planned Breakdown time = 50 x 3 x 31 / 60 = 77 .5 hrs

Planned running time = 744 – 77.5 = 666.5 Hrs.

Breakdown Time = 159 hrs

Actual Running time = Planned Running time - Breakdown time

Actual Running time = 666.5 – 159 = 507.5 Hrs.

Availability rate = 5.7.5 / 666.5 x 100 = 76.14 %

Performance Efficiency = Actual Output / Target Output

Cycle time = 20 – 25 sec.

Target / hrs = 180 nos.

Target / month = 180 x 8 x 3 x 31 =133920 nos.

Actual Output = 117823 nos.

Performance Efficiency = 117823 /133920 x 100 = 87.98 %

Quality rate = output / Actual Output = 113086 / 117823 x 100 = 95.98 %

(OEE) September 2017 = 0 .7614 x.8798 x .9598 x100 = 64.295 %

5.1.2 OEE calculation for October 2017

Availability rate = Actual running time / Planned running time

Planned running time = Available time - Planned Breakdown time

= 720-75 = 645 Hrs.

Breakdown Time = 148 hrs

Availability rate = 645 – 148 / 645 x 100 = 77.05 %

Performance Efficiency= 93 %

Quality rate = 98 %

(OEE) October 2017 = 0.7705 x .93 x.98 x100 = 70.17 %

5.1.3 OEE calculation for November 2017

Availability rate = Actual running time / Planned running time

Planned running time = Available time - Planned Breakdown time

Planned running time = 744-77.5 = 666.5 Hrs.

Breakdown Time = 120 hrs

Availability rate = 666.5 – 120/ 666.5 x 100 = 81.99 %

Performance Efficiency = 97 %

Quality rate = 98 %

(OEE) November 2017 = 0.8199 x .97 x.98 x100 = 77.93%

5.2. Breakdown Analysis

5.2.1. Five months machine breakdown data for Pareto calculation

Table 1: Month Machine Breakdown data for Pareto calculation

S. no.	Cause of B/d	B/D hours	Cumulative hours	% Contribution
1	Gooseneck Failure	206.91	206.91	28
2	Nozzle Heater	131.08	337.91	45.75
3	Burner	76.1	414.09	56.05
4	Injection	69.66	483.75	65.48
5	Gooseneck heater	53.6	537.35	72.73
6	Die Bar	51.75	589.1	79.74
7	Sweep and Striker	41.75	630.85	85.39
8	Toggle unit	39.82	670.67	90.78
9	Power problem	20	690.67	93.49
10	Spray gun	18.5	709.17	95.99
11	Thermocouple	15	724.17	98.02
12	Hydraulic Motor	14.6	738.77	100

5.2.2. Pareto Chart for 5 months Breakdown data

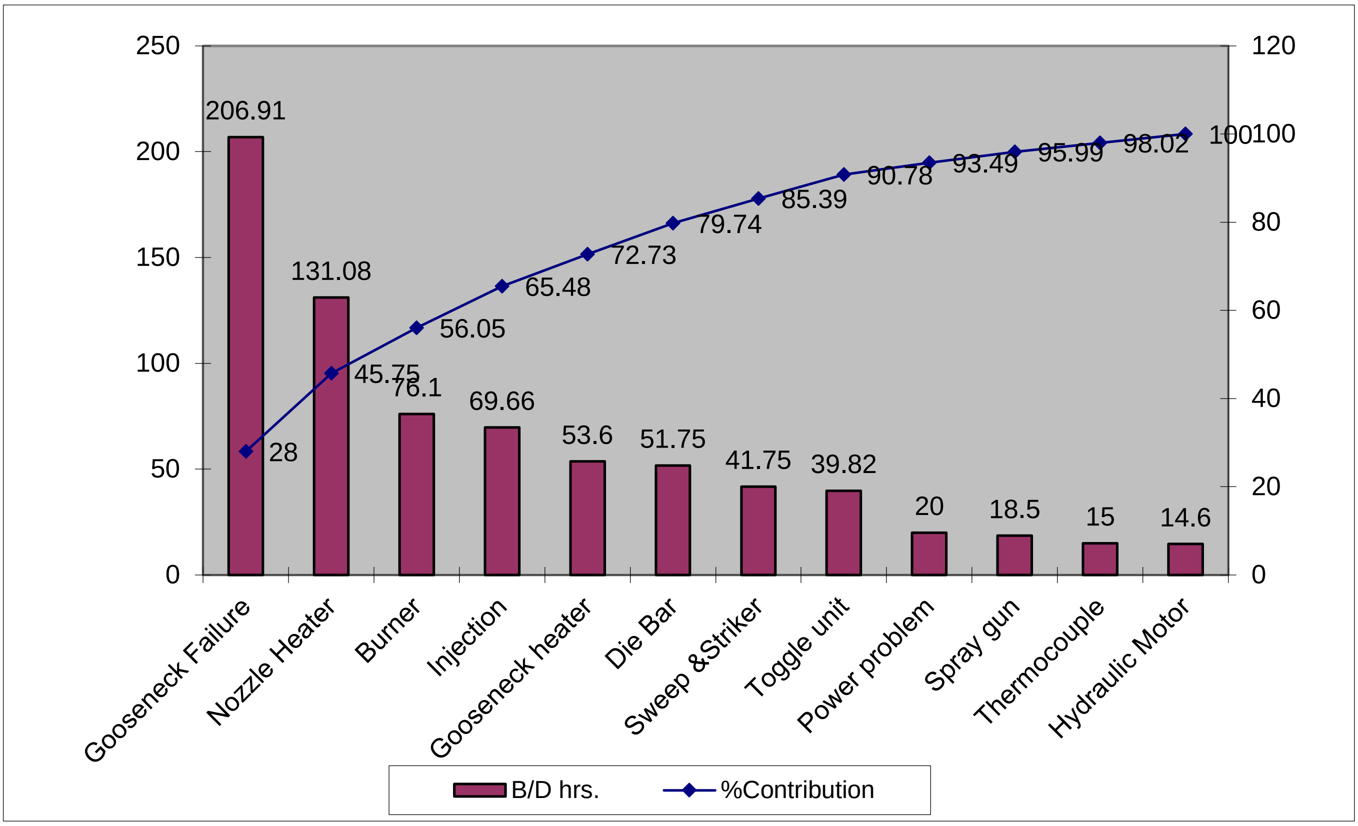

Fig. 3: Pareto Chart for 5 months of breakdown data

5.2.3. Gooseneck Failure analysis

Among of all breakdowns of machines breakdown due to gooseneck failure is maximum so we will first analyze the gooseneck failure.

Table 2: Gooseneck failure data for Pareto calculation

S. no.	Type of B/D	B/D hours	Cum.B/D hours	% Contribution
1	Alignment	134.08	134.08	64.80
2	Sleeve oversize	58.83	192.91	93.23
3	Leakage	14	206.91	100.00

5.2.4. Pareto chart for Gooseneck failure

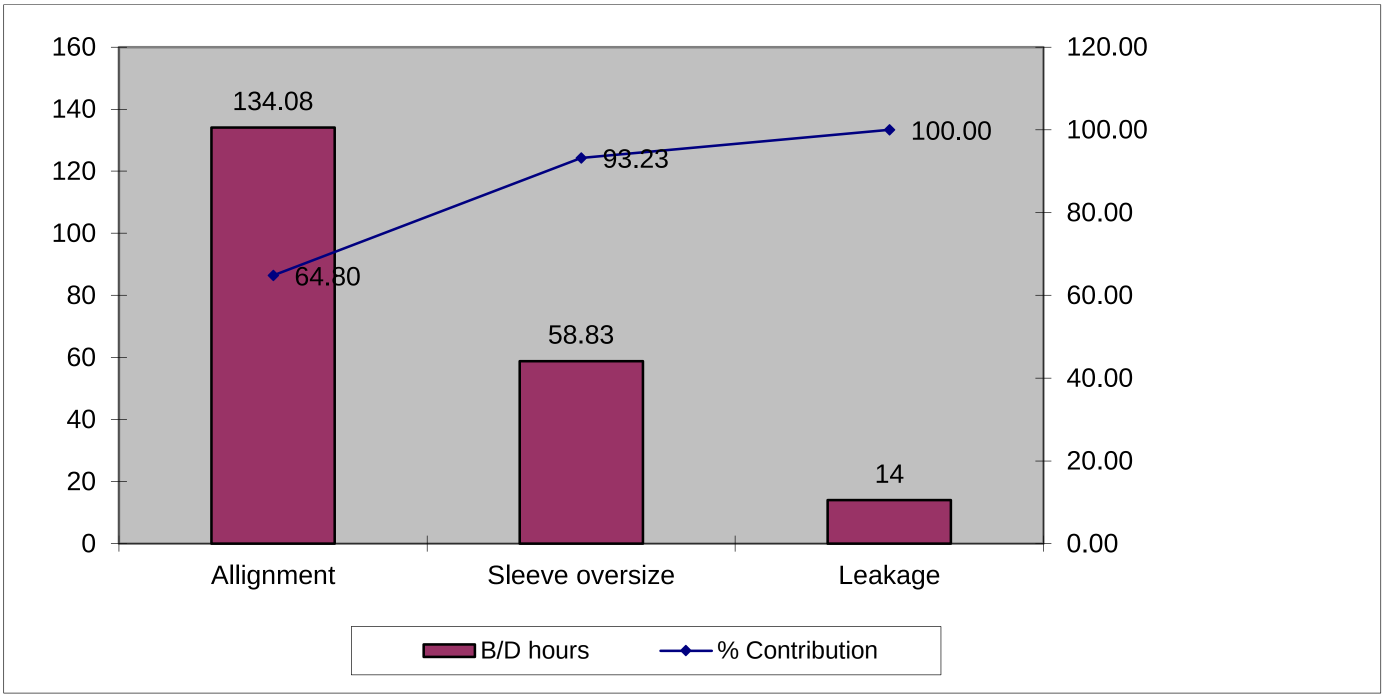

Fig. 4: Pareto Chart for Gooseneck failure

5.2.5 Machine wise Gooseneck failure data for Pareto calculation

Table 3: Machine wise Gooseneck failure data for Pareto calculation

S.no.	M/C Name	Capacity	Manufacture	B/D min.	B/D hrs.	Cumulative B/D hrs.	% Contribution in B/D
1	DC-15	30T	JF	2970	49.5	49.5	23.35
2	DC-09	75T	PROD	2250	37.5	87	41.05
3	DC-11	50T	JF	1590	26.5	113.5	53.56
4	DC-02	30T	JF	1225	20.41	133.91	63.19
5	DC-14	30T	JF	1010	16.83	150.74	71.13
6	DC-04	30T	JF	950	15.83	166.57	78.6
7	DC-08	50T	PROD	790	13.16	179.73	84.82
8	DC-07	125T	PROD	540	9	188.73	89.07
9	DC-12	30T	JF	480	8	196.73	92.84
10	DC-10	50T	JF	440	7.33	204.06	96.3
11	DC-03	30T	JF	240	4	208.06	98.19
12	DC-05	30T	JF	230	3.83	211.89	100
13	DC-01	30T	JF	0	0	0	0
14	DC-06	90T	FRECH	0	0	0	0
15	DC-13	75T	PROD	0	0	0	0
16	DC-16	75T	PROD	0	0	0	0
17	DC-17	250T	PROD	0	0	0	0
18	DC-18	50T	PROD	0	0	0	0

5.2.6 Pareto chart for machine wise Gooseneck failure data

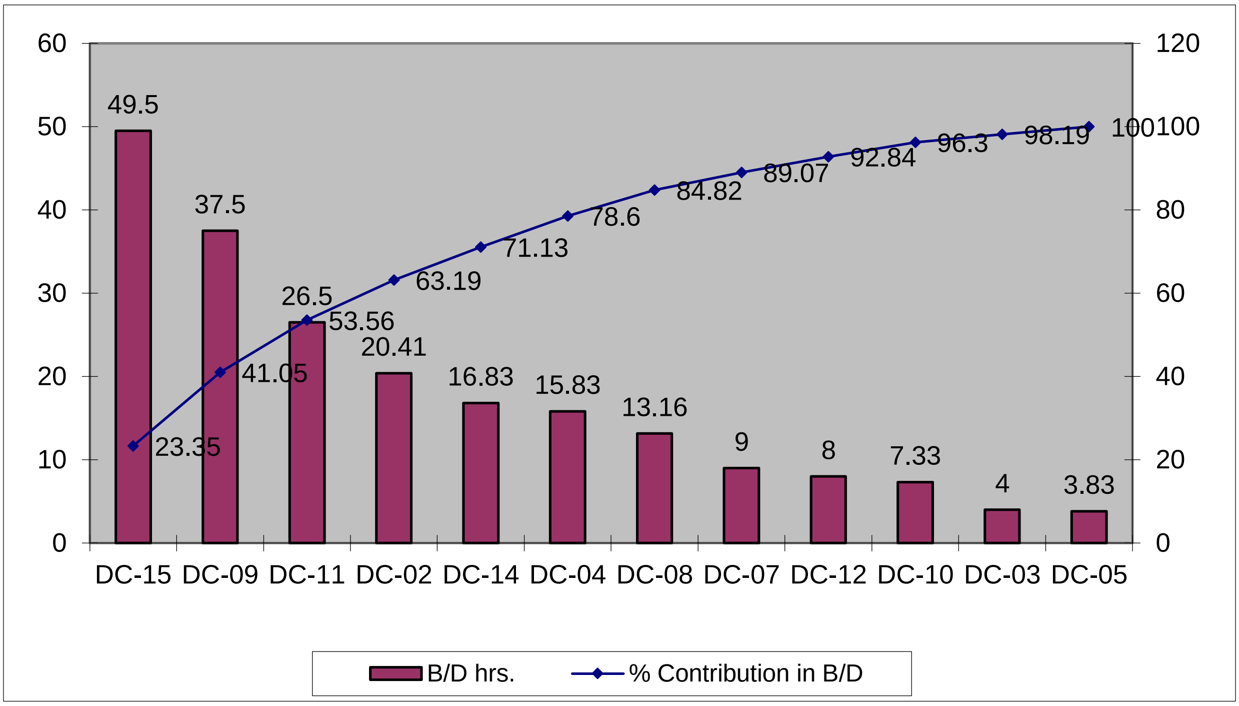

Fig. 5: Pareto Chart for Machine wise Gooseneck failure data

5.3. OEE Analysis for DC-15

Table 4: Machine No- 15 Breakdown data for Pareto calculation

S. no.	Cause of B/d	B/D hrs.	Cumulative hrs.	%Contribution
1	Gooseneck Failure	49.5	49.5	51.14
2	Nozzle Heater	20.4	69.9	72.21
3	Burner	15.3	85.2	88.02
4	Injection	11.6	96.8	100.00

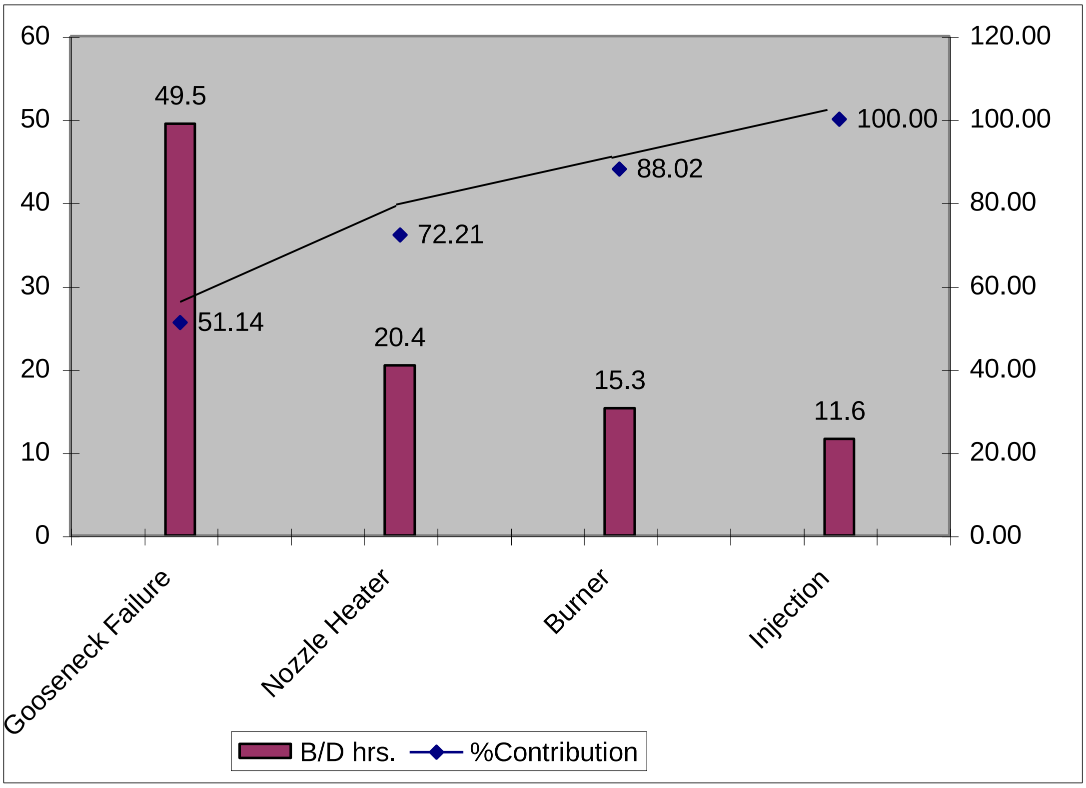

Fig. 6: Pareto chart for machine No- 15 breakdown data

5.3.1 OEE calculation for December 2017

Availability rate = Actual running time / Planned running time
Planned running time = Available time - Planned Breakdown Time
Available Time = 8 x 3x 30 = 720 hrs
Planned Breakdown time = 50 x 3 x 30 / 60 = 75 hrs
Planned running time = 720-75 = 645 Hrs.
Total Breakdown Time = 96.8 hrs
Breakdown due to Gooseneck failure = 49.5 hrs.
Breakdown due to nozzle heater failure = 20.4 hrs.
Breakdown due to Burner failure = 15.3 hrs.
Breakdown due to Injection unit failure = 11.6 hrs.
Actual Running time = Planned Running time - Breakdown time
Actual Running time = 645 – 96.8 = 548.2 Hrs.
Availability rate = 548.2 / 645 x 100 = 84.99 %
Performance Efficiency = Actual Output / Target Output
Cycle time = 20 – 25 sec.
Target / hrs = 180
Target / month = 180 x 8 x 3 x 30 =129600
Actual Output = 125660
Performance Efficiency = 125660 /129600 x 100 = 96.96 %
Quality rate = OK output / Actual Output
= 123147 / 125660 x 100 = 98 %
OEE Dec'17 = 0 .8499 x.9696 x .98 x100 = 80.8 %

6. RESULTS AND DISCUSSIONS

6.1. OEE of DC-15

Table 5: OEE of DC-15

	M/c Availability (%)	Performance Efficiency (%)	Quality (%)	OEE (%)
Sep'17	76.14	87.98	95.98	64.29
Oct'17	77.05	93	98	70.17
Nov'17	81.99	97	98	77.93
Dec'17	84.99	97	98	80.8

With reference to the above table, we may conclude that the machine availability in the month of September 2017 was 76.14%, while the performance efficiency, quality and overall equipment effectiveness was 87.98%, 95.98% and 64.29% respectively. By the continual Implementation of Total Productive Maintenance, the availability, performance efficiency, quality and Overall Equipment Effectiveness are improving month by month. OEE is increased by 16.51%.

6.2. Benefits of TPM on DC – 15

Before the implementation of TPM the OEE was 64.29% and after application of TPM, it increased to 80.80%. The average shots increased by 21nos per hour. The machine breakdown reduced to 3.2 Hrs/ day. Since due to the reduction of daily breakdown hours, the monthly breakdown occurrence reduced to 4nos/ month. Accordingly, the minor stoppages, burn injuries and mean time between failures are also improved.

Table 6: Benefits of TPM on DC – 15

S. no.	Parameter of Performance	UOM	Before TPM	After TPM
1	OEE	% age	64.29	80.8
2	Average no. of Shots/hours	Nos.	70	91
3	Total Machine Breakdown/ day	Hrs.	5.3	3.2
4	Machine B/D occurrence / month	Nos.	18	4
5	Minor stoppages / month	Hrs.	30	6
6	Burn injuries / month (minor)	Nos.	1	0
7	Mean Time between failure	Hrs.	5	13

6.3. Benefits derived from TPM

- Operator’s Awareness and Morale Improved.
- Daily checks through CLIT standards.
- Detection of HTAA(Hard To Access Area)
- Abnormalities have removed by making Abnormality list
- MTBF and MTTR Monitoring Started.
- Focus on Striation of spares parts like nozzle, nozzle tip, ejector rod etc.
- Spare Management System under progress.
- Increase machine availability.
- Reduce breakdowns of machines through Why-Why analysis of M/C Breakdowns.

7.CONCLUSION AND FUTURE WORK

7.1 Conclusion

A manufacturing facility has been studied and analyzed to study TPM implementation issues, the roadmap followed and the key benefits achieved from OEE as a result of TPM implementation.

It can be seen that OEE on boiler plant has shown a progressive growth, which is an indication of an increase in equipment availability, a decrease in rework, rejection and increase in the rate of performance. As a result of the overall productivity of the industry also increased. OEE value is encouraging and with the passage of time results will be quite good and may reach a world-class OEE value of 85% - 90%.

TPM has been widely known in the manufacturing environment. This proactive maintenance strategy contributed to manufacturing performance improvements are highlighted by various researchers Through TPM process focus, the cost and quality were improved significantly by reducing and minimizing equipment deterioration and failures. Cost of rework and repairs reduced due to very limited products rejected due to equipment failure. Thus, the overall effectiveness of equipment also improved significantly.

Additionally, equipment deterioration was eliminated as the equipment operated efficiently. Autonomous maintenance activities were carried out with total employee participation. The investment in training and education managed to boost the operator’s morale and the commitment towards the company’s goals.

7.2 Future work

Apparently, successful TPM implementation can achieve a better and lasting result as compared to another isolated program because there is an ultimate change in people (knowledge, skills, and behaviour) during the progress.

This research is aimed at measuring contributions of successful implementation of TPM initiatives in the automobile industry. However, as future researches work the contributions with other lean manufacturing philosophies like six sigma, TQM, Just-in-time (JIT) manufacturing, Quality function deployment (QFD), etc. can also be undertaken for assessing the overall plant efficiency.

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