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Study and Implementation of Total Productive Maintenance in Turbocharger Plant

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***Abstract* – Production System has undergone the major changes in recent years. In the highly competitive environment, to be successful and to achieve world class manufacturing, organizations must possess both effective maintenance and efficient manufacturing strategies. Overall Equipment Effectiveness (OEE) quantifies how well a manufacturing unit performs relative to its designed capacity, during the periods when it is scheduled to run. The data and the behavior of the machines in the cell were analysed and the bottleneck points were identified. The Overall Equipment Effectiveness (OEE) of NU-600 turning centre, MGT-50 turning centre and S-66 milling centre was found to be 60%, 43% and 65% respectively from the data collected in the month of December 2013, January and February 2014.**
The techniques of 5S, Poka yoke, Preventive Maintenance and Kaizen which are elements of Total Productive Maintenance are applied effectively on the machines in the cell. The result obtained from the TPM approach showed that the Overall Equipment Effectiveness (OEE) of NU – 600 turning centre, MGT – 50 turning centre and S – 66 milling centre are increased to 71.95%, 69.55% and 75.05% respectively. To sum up, there was an increase in income of Rs.353 per hour from the cell due to effective implementation of TPM technique.

Key Words -- Overall Equipment Effectiveness (OEE); Total Productive Maintenance (TPM); Kaizen; Poka yoke; 5S.

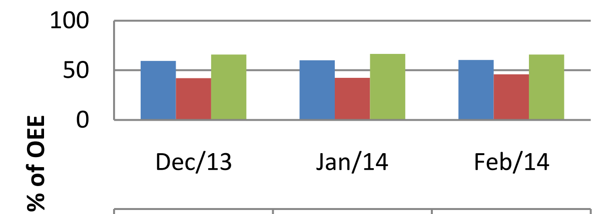
I. INTRODUCTION

The study is focusing on the machining process of shaft before it is assembled with the turbowheel through auto assembly process. The shafts with two different diameters are machined in the plant that is 50.mm and 60.mm for turbocharger. The tools and products are to be changed frequently due to which the setup time is getting larger.

There are five machines in the cell and the turbo shaft machining process is described as follows. NU – 600 turning centre is performing the operations of Turning, Taper turning and facing on one side of the shaft where turbo wheel is assembled. MGT – 50 turning centre is performing Threading on other side where compressor wheel is assembled. The end milling and peripheral milling is performed on the S – 66 milling centre. The holes on the shaft to place the fasteners are drilled using conventional drilling machine. The burrs on the surface of the shaft are finally removed by deburring machine.

II. PROBLEM STATEMENT

The data collected for the 3.months period of December 2013, January 2014 and February 2014 revealed that the Overall Equipment Effectiveness (OEE) value of the machines in the cell are 60%, 43%, 66% which are very low compared to the general manufacturing scenario(OEE – 85%). Due to the low OEE, the machines are not effectively utilized. Hence the production is affected and in turn not able to reach the requirements of customer.



	Dec/13	Jan/14	Feb/14
NU 600	59.355	60.195	60.555
MGT-50	42	42.395	45.955
S-66	66	66.5	66

Figure 2.1 OEE of the machines from data collected for 3.months

The bar chart in the figure 2.1 clearly represents the OEE values of the machines for the data collected for 3.months of December 2013, January 2014 and February 2014. The NU-600 turning centre has OEE value of around 60%, MGT-50 turning centre has OEE value of around 43% and S-66 milling centre has OEE value of around 66%. The world class performance of machines has the OEE value of 85% which is far away from any of the machines in the cell. The project focuses on improving the

OEE of each machine to around 70%, which increases the productivity and improves the delivery time.

A. Defining the problem

To study and implement the Total Productive Maintenance (TPM) and 5S techniques in order to improve the Overall Equipment Effectiveness (OEE) of the CNC machining cell present in the turbocharger plant. [1] describes the TPM as a Lean tool to optimize the effectiveness of manufacturing equipment and tooling.

B. Objectives

1. To review the literature on TPM related activities and case studies implemented in companies for improving the productivity.
2. To find out the bottleneck machines in the cell.
3. To analyse the breakdown data and to identify the critical components.
4. To form the TPM team to resolve the issues.
5. To turn around the bottleneck machines into the model machines.
6. To standardize 5S activities in the cell.
7. To validate and report the TPM and 5S practices performed.

III. METHODOLOGY

A. Data collection

The data for measuring the performance of the cell was collected for the period of three months from December 2013 to February 2014 for all 3.shifts. The data pertaining to breakdown, setup time, speed loss, minor stoppages, scrap and rework rate were collected and analysed.

The project focuses on an improving the Overall Equipment Effectiveness (OEE) of the machines as it is the major concern for lower productions and loss of time and money.

The breakdown details of the three machines for the month of December 2013, January 2014 and February 2014 is as shown in the figure 3.1.

The total breakdown time in minutes of each machine for three months in total is given below:
NU-600 turning centre is 7159 minutes.
MGT-50 turning centre is 16255.minutes.
S-66 milling centre is 6115.minutes.

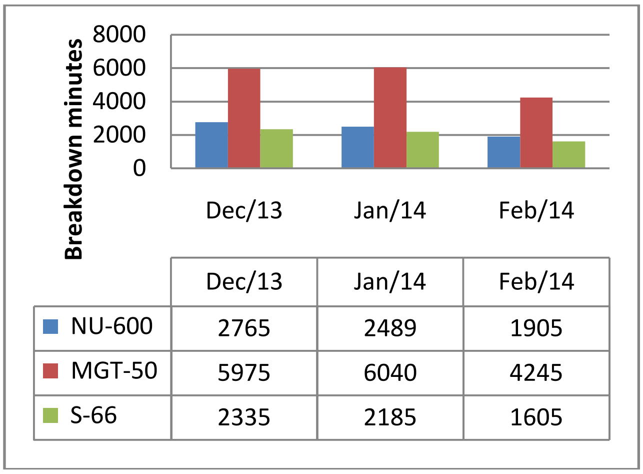


Figure 3.1 Break down data from data collected for 3. months

B. Setup details of 3.machines for a lot of 450 units.

The total setup time for NU- 600 turning centre, MGT – 50 turning centre and S – 66 milling centre for machining a lot of 450.units was found to be 185.minutes, 410.minutes and 155. minutes respectively as shown in the figure 3.2. In all the machines second setup was taking more time than first setup.

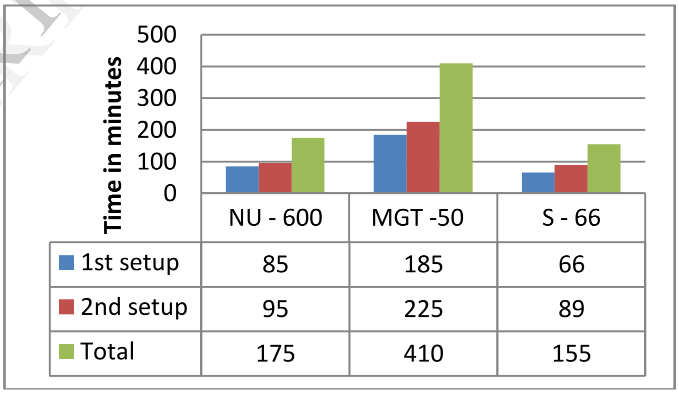


Figure 3.2 Setup details for the period of 3.months

Table 3.1 represents the parameters of OEE which are critical and need to be focused on each machine in order to increase the Effectiveness. The parameters which are represented in colored blocks are to be focused in order to bring the operations to the normal conditions.

Table 3.1 Comparison of critical parameters of 3.machines

Machine	Parameters to be focused (%)			
	Availability	Performance	Quality	OEE
NU – 600	84	75	96	60
MGT- 50	66	66	95	43
S – 66	86	77	96	65

C. System Analysis through Simulation

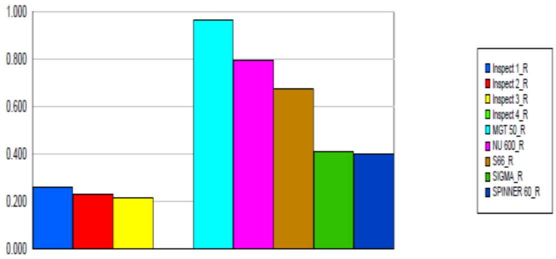


Figure 3.3 Utilisation factor of different machines in the cell through simulation

From the simulation Analysis of the system as shown in the figure 3.3, it is clear that the MGT – 50 turning centre is the bottleneck because of its high cycle time and breakdowns. There is a queue of 2.parts on an average all the time before MGT – 50 turning centre and waiting time is around 7.minutes/part. We can conclude that MGT – 50 turning centre needs more focus and necessary actions to be taken to bring it to the normal conditions.

D. Capacity and existing condition of cell

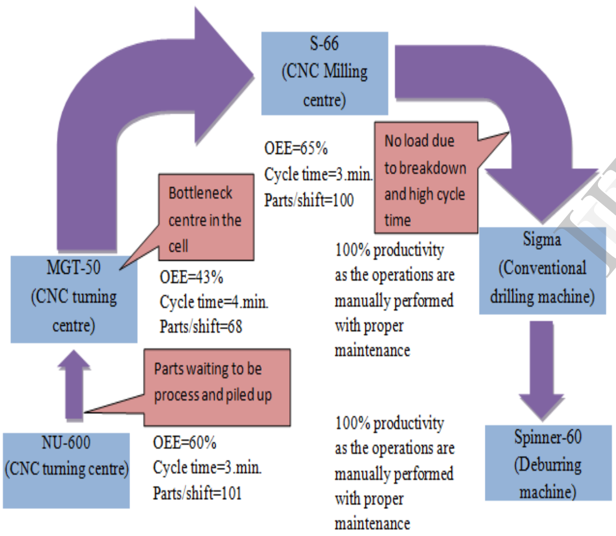


Figure 3.4 Process parameters of all machines in the cell

As it can be observed in the flow chart in figure 3.4, the MGT – 50 turning centre is in the middle of the cell. The parts processed from the NU_ 600 turning centre were piled up before MGT- 50 as the cycle time of NU- 600 is 3.minutes and MGT – 50 is 4.minutes. Due to slow cycle rate and breakdowns, the parts are not sufficiently passed on to the next centre for processing and therefore causing the stoppage of line. Thus, hindering the production and reduces the effectiveness and efficiency of the line.

E. Implementation phase

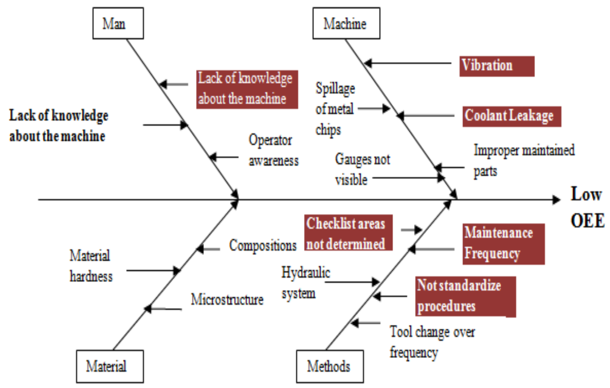


Figure 3.5 Cause and Effect Diagram for low OEE of the machines

The figure 3.5 shows how the 4M – Man, Machine, Material and Method are affecting the OEE of the machine. The causes which are highlighted in the diagram are found to be major causes from the analysis. The cleaning kit was effectively used by each team and necessary cleaning actions were taken to efficiently perform 5S activities and to identify the abnormalities in and around the machines. After the cleaning was completely performed on the machines, the abnormalities identified and it was recorded in a pareto for an observation and an analysis. It is observed that around 80% of occurrences of abnormalities are due to Coolant leakage, Chipping problems, Loosed fasteners and screws, unwanted materials and dirt. [2] The primary goal of the technique is to determine the root cause of a defect or problem.

The checklist which involved daily activities such as greasing chuck, checking the oil level, cleaning AC filter etc. was provided so the machine was maintained after the cleaning activity was performed and all the spare parts were replaced and repaired. Few Kaizen approaches were also performed in and around the cell. In Japan, the concept of Kaizen is so deeply engrained in the minds of both managers and workers that they often do not even realize they are thinking Kaizen as a customer-driven strategy for improvement [3].

1. *To eliminate the extra setting by providing a rigid clamping in the first setup*

The idea was incorporated as the processing time was more due to the second setting taking long time due to low parameters. A revised process plan was made for single setup with holding at the bigger ends of the parts so that the pressure applied can be high and the cutting area could be increased. The second setup causes the higher cycle time due to low parameters specified in the process. The idea was to eliminate the second setup as it could be done in the first setup itself with some clamping alterations. The setting time is reduced from 410.minutes to 90.minutes. The above clamping modification helped in decreasing the cycle time from an average of 4 minutes to around 3.3minutes.

F. Quality Approach

The quality aspect of the machine had no problems as the quality was maintained at 95%. To improve the quality level, the TPM team decided to implement Poka yoke on all the three .machines of interest which would fool proof the process. The team implemented poka yoke on each centres which is discussed in common to all the three machines.

Poka yoke - 1

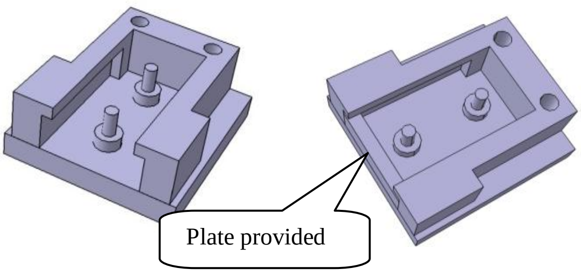


Figure 3.6 Poka yoke modifications

Parts were placed with wrong orientation, which caused the parts to fell down from the storage space and become scraped. In order to avoid this, the TPM team provided the side plate with the fixtures is as shown in the figure 3.6 which blocks the space if the parts are placed wrongly. It avoids the slipping of parts placed in the space provided.

Poka yoke – 2

Pre machined parts length is not controlled, which resulted in tool breakage while turning in MGT - 50 turning centre. This problem was occurred 6.times in 3.months. In order to avoid the tool breakage, the height guage is placed next to the machine and was made part of the inspection, where the operators had to inspect the piece and if oversize parts are there, they must be machined to required size and then turn it.

G. Improving OEE of NU– 600 turning centre and S- 66 milling centre

As we incorporated the tagging system for MGT- 50 machine, the tags were hanged to NU – 600 turning centre and S- 66 milling centre similarly. The white tags and red tags were hanged based on the normal techniques as done in the MGT- 50 turning centre. All the data was recorded and then analysed, action was taken to see that it was rectified. The missing parts were replaced and the faulty parts were repaired based on the tagging system. All the steps are followed similar to that followed on MGT- 50 turning centre.

H. Design modifications in NU – 600 turning centre

Quick Change Jaw Concept Design

The traditional jaws were used initially and the replacement time of the jaw is considerably high. Due to the high number of part count, also trial and error alignment of bolts and tightening and loosening the bolt time was more. To avoid the trial and errors and to eliminate the whole chuck replacement theory the new quick change jaws were designed. And the jaws were designed to accommodate both the products on to the single chuck.

Earlier the operator had load two different chucks to run both products due to the product geometry variation and now the larger existing chuck is used and only the top soft jaws are going to be changed. The figure 3.7 shows the schematic arrangement of changeover process on turning centers. The special jaws arrangement is shown in figure 3.8 for individual products which were designed to reduce the Change Over Time.

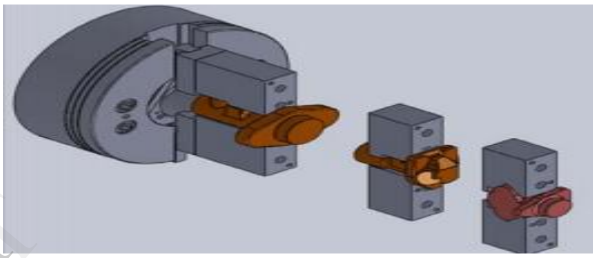


Figure 3.7 Quick change jaw Concept

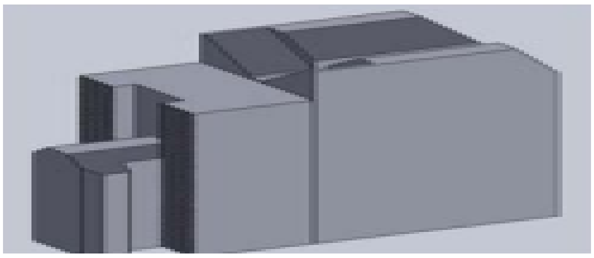


Figure 3.8 Quick change jaw Process

IV. RESULTS AND DISCUSSION

The results obtained by implementing the TPM methods are explained step wise, the individual improvements obtained are shown on the three parameters separately.

A. Availability results

The major problems of coolant leakage and the chip fall out due to which hydraulic motor was failing regularly and the lead screw getting damaged frequently from the chips accumulation was avoided. The above parts are replaced immediately which reduced the breakdown by 3.hours per day. The breakdown details after the implementation of TPM techniques are as shown in the figure 4.1.

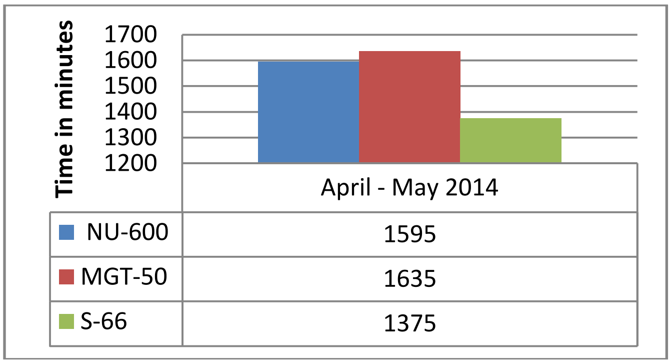


Figure 4.1 Breakdown details of machines after TPM implementation

Total available production time per month = 410* 25 = 30,750 minutes. (Considering 25.days working and 410.minutes per shift excluding the breaks)
Breakdown per month on an average is given in the table 4.1.

Table 4.1 Breakdown time in minutes of 3.machines

Machine	Before TPM		After TPM	
	Time in minutes	% breakdown	Time in minutes	% breakdown
NU – 600	2500	8.15	1595	5.15
MGT – 50	5500	17.85	1635	5.35
S - 66	1900	6.15	1375	4.45

Note: % breakdown is calculated by,

$$(\%\ \text{breakdown}) = \frac{Breakdown\ \ time}{Total\ \ time\ \ available}$$

1. Setup time reduction for a lot of 450units.

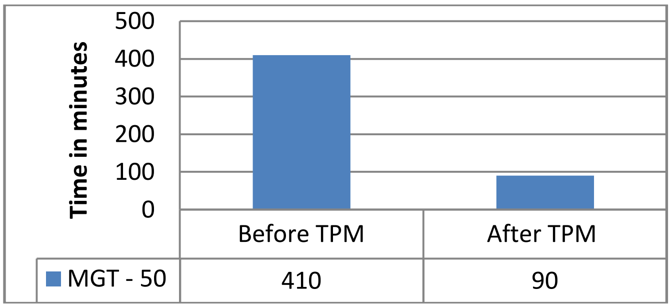


Figure 4.2 CNC setup details of machine for lot of 450.units

Figure 4.2 shows that the reduction in the setup time after the implementation of the TPM techniques. Earlier there was a long second setup time due to part dimension changes and increases the process time because of insufficient cutting area and pressure. The modifications in the clamping process and fixtures were made because of which the setup was combined. As a result, the availability (%) of the MGT – 50 turning centre, NU – 600 turning centre and the S – 66 milling centre were increased as in table 4.2.

Table 4.2 Comparison of % Availability for 3.machines

Machine	Before TPM	After TPM
	% Availability	% Availability
NU – 600	83	86
MGT – 50	66	88
S - 66	83	88

B. Performance Results

The improvements and results of modifications are shown below.

1. The balancing of the man and machine working time was achieved by proper training to operators.
2. The operator movements to pick and place the tools were reduced by providing the shadow board to each machine and in turn reduce the cycle time.
3. The combining of tools which resulted in saving of 1.minute between each parts and the cycle time was reduced from 4.minutes to 3.minutes.

Table 4.3 Comparison of % Performance before and after implementation of TPM

Machine	Before TPM	After TPM
	% Performance	% Performance
NU – 600	75	84
MGT – 50	66	90
S - 66	77	91

C. Quality Results

The machines were producing quality products with the rejection rate of 5%. The quality level did not demand any improvement. However, it was necessary to sustain the current level of quality. Further, the team decided to monitor current level effectiveness with some additional fool proof methods which are already discussed earlier.

D. OEE improvement

Due to the systematic approach in implementation of TPM, the OEE of the bottle neck machine MGT – 50 turning centre, NU – 600 turning centre and S – 66 milling centre are increased to 69.55%, 71.95% and 75.075% respectively. The chart of the OEE (%) values before and after implementation of TPM techniques is as shown in the figure 4.3.

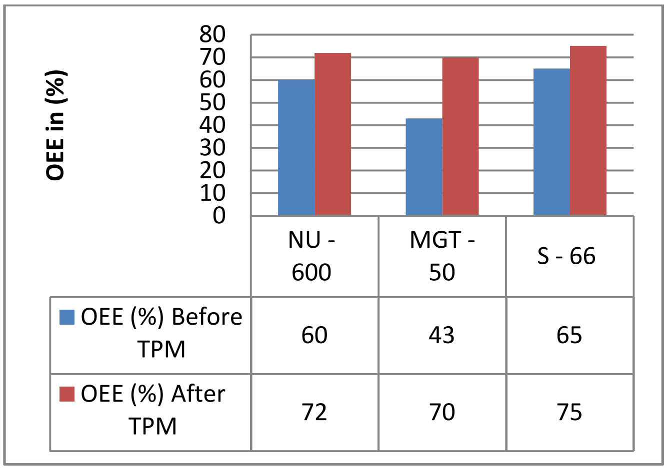


Figure 4.3 OEE (%) before and after implementation of TPM techniques

E. Cost aspects

The income to the company relative to the increase in the OEE of the machines in the cell is as shown in the table 4.4. Total increase in the income of Rs. 2825/ shift was achieved due to the effective implementation of TPM techniques in and around the cell.

Table 4.4 Comparison of income from the cell before and after TPM implementation

Machines	Income from the cell in Rs./shift		Increase in income in Rs./shift
	Before TPM implementation	After TPM implementation	
NU – 600	2700	3250	550
MGT – 50	2900	4725	1825
S – 66	2925	3375	450
Total	8525	11350	2825

V. CONCLUSION

In general the focus of almost all the industries is on downtime losses especially breakdowns. Many losses are not targeted enough today i.e, planned downtime, cycle time losses and minor stoppages. It is beneficial to change the focus and use a comprehensive model of losses. In order to utilize the OEE measure effectively, it must be convincing and credible to production management. In order to achieve the target performance, efficient maintenance was installed in the workplace, Autonomous maintenance teams were developed and the better communication with team work was promoted. Efficient data recording system was installed in order to provide the upto date and accurate information to the management. The increase in an income of Rs. 353 per hour was achieved because of the effective implementation of the TPM and the 5S techniques in the plant.

AKNOWLEDGMENT

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