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## TPM Review in a Sheet Metal Parts Manufacturing Company

R.S. Mhetre

*Vishwakarma Institute of Technology, Pune, Maharashtra, India, rsmhetre15@gmail.com*

R.J. Dhake

*Vishwakarma Institute of Technology, Pune, Maharashtra, India, R.J.Dhake@gmail.com*

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# TPM Review in a Sheet Metal Parts Manufacturing Company

R.S.Mhetre & R.J.Dhake

Vishwakarma Institute of Technology, Pune, Maharashtra, India  
E-mail : rsmhetre15@gmail.com

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**Abstract** - In all manufacturing plants the machines and equipment's are influenced by deterioration in performance due to its age and use, obsolescence due to improvement in technology and failure due to unplanned maintenance. Improper maintenance leads to unavailability of machine. Hence the effective maintenance becomes useful in improving equipment life, reducing manufacturing cost, improving quality and minimizing the many unforeseen losses which are responsible for reducing the potential of the manufacturing plant.

This paper addresses the issue by taking a case study of a manufacturing company. Detailed analysis and calculations are carried out on data collected through discussion, interview and observations.

The overall equipment effectiveness (OEE) calculation is used to find out the current situation of the production system of the case company. It calculates the availability of the production system which shows that maintenance system's effectiveness. The quality rate calculations of the work stations show the conditions of the machines and the worker's skill and the calculations of the performance efficiency of the work stations show the utilization of the machines.

The result of analysis is presented here with recommendations to the company.

**Keywords** - Total Productive maintenance(TPM), Overall equipment effectiveness(OEE), Quality Rate, Availability, Performance Efficiency.

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## I. INTRODUCTION

Now a days there is a large competition among companies. Companies are trying their best to provide the products in a innovative, exciting, cost effective way in the present globalize and competitive market [1]. They should be at the best competitive prizes with quality and service. For this the company's operating cost should be minimum and all its departments are performing well. Many companies are making use of techniques like JIT, TQM, TEl, Etc. for their production process. They are now focusing on optimizing their available assets. Maintenance department and people responsible for maintenance has the greatest influence on the company assets. Without the support of the Quality and Maintenance it is not possible to meet the requirements of manufacturing plants by the techniques described above. For example the JIT technique demands efficient and effective maintenance of the machines to ensure smooth and uninterrupted flow of production with cent percent quality rate ideally. The maintenance adds to customer value in terms of profit, quality, time and service.

Without effectively maintained equipment; it will not be possible to deliver the products in the competitive

market that requires low cost products at a high quality to be delivered quickly [2].

Thus maintenance has become a competitive weapon for the companies to survive in the competitive market. The companies are using Upsizing, Downsizing, change reporting system, changing organizational structure, contracting to outside parties, employing empowered teams, etc. for better control over the maintenance. The machine are not made up of only mechanical components but also electronic components, software, hydraulic, electromechanical and the human beings are also involved in it. So it has become important to concentrate on quality of bought out spares, manufacturing process control and human errors and the failure of the important parts to avoid the stoppage in production flow.

In all manufacturing plants the machines and equipment's are influenced by deterioration in performance due to its age and use, obsolescence due to improvement in technology and failure due to unplanned maintenance. Improper maintenance leads to unavailability of machine. Hence the effective maintenance becomes useful in improving equipment life, reducing manufacturing cost, improving quality and minimizing the many unforeseen losses which

are responsible for reducing the potential of the manufacturing plant [3].

## II. PURPOSE

To see the current status or situation of the company and to suggest the ways to improve the current situation is the theme of this project. Whether the company is using all its assets in an efficient way to stand in a competitive market? If it is not so then find out the kind of problem is there in availability, quality or performance. And influence of these on the goals of the company.

## III. RESEARCH METHOD

The research strategy used in project is the case study. The case study consists of the interviews and the observations. That is the reason that the both qualitative and quantitative methods are used in the project [4]. The qualitative method is used when interviews are conducted and the quantitative method is used when the data is collected and analyzed [5]. The author has collected the data by himself and received from the company employees. In other words, the primary and secondary data will be used. The deduction approach will be used in this case study project. This approach is helpful when comparing the collected data with the theory. The purpose of the data collection is explained to the persons involved in the information so that a valid and reliable data can be used in the project.

## IV. BRIEF ABOUT CASE COMPANY

The case company is located in Pune. It is a medium scaled company and is involved in manufacturing of precision sheet metal parts as per the orders of the customers. More than 2500 different parts are produced per annum. Machinery like CNC Laser Cutting, CNC Punching and Press Brakes imported from Germany (purchased in March 1997). It has full fledged in-house Powder Coating and Robotic Welding facilities so as to give its customers fully ready-to-use products. Number of customers are more than 50 but 12 number of customers are the major one.

## V. DETAILS OF PRODUCTION ACTIVITIES

The company is working in shifts and it produces different products as per the requirement of their customers. The production system is having flexibility to accommodate and capability to process different sizes. The most important activities are Laser cutting bending, punching, welding, powder coating and assemblies.

### A. Laser cutting:

There are four laser cutting machines which are computerized and work according to the program fed to the machines. The set up time for each machine is determined from the past year data and verified by stop watch method. There are twelve number of workers who work in two shifts (six workers in one shift). Each shift consists of 8 hrs plus 4hrs of over time. There are 6 working days in a week. And weekly off is on every Thursday. Two workers are kept in spare. The number of failures is found from the Daily production report and maintenance record. The short stoppages are due to many reasons like dirt on sheet, nozzle found loose, blank coming up etc. The average set up time of each machine per day is 10.10 minutes. The number of failures per year for each machine is 2. Time required to recover one time failure is 10 days. The short stoppages for each machine are 841 per year and time to recover each stoppage is 15 minutes. The output of this work station is 216 products per week. The machine can cut 1 meter in 2.8 minutes but actual cutting speed is 3.5 minutes for 1 meter cutting. The number of rejected products per year is 56 per month. There are two lunch breaks of 30 minutes and six tea breaks each of 10 minutes in two shifts (each shift of 12 hours).

### B. Bending:

There are six bending machines of different specifications and capacities. Ten workers are working in this work station for 1.5 shift (12 hours). Four workers are stand by. The ideal cycle time is 6 second i.e. it can make one bend in 6 seconds. The average time between two strokes is 35 seconds. The average set up time of each machine is 20 minutes per day. The machine runs for one shift (12 hour shift) per day. Preventive maintenance is done every after three months and time required to do PM is 3 hours per machine. Each machine stops twice in a year and time required to recover the failure is 2 weeks. The number of short stoppages to each machine is 353 per year. The time required to recover each stoppage is 2.3 minutes per day. There is one lunch break of 30 minutes and three tea breaks each of 10 minutes in 12 hour shift. The number of products produced in this work station are 22 per day and rejection is 80 per month.

### C. Punching:

There is only one punching machine which is computerized and work according to the program fed to it. Twenty tooling can be hold by the machine and 10 tooling can be hold at a time. There are seventeen stations and three numbers of clamps are provided. One worker operates the machine for 8 hours. The average time to punch 2500mm x 1250 mm is 10.2 minutes. The ideal cutting speed stated by the manufacturer is 7

minutes. The set up time for this machine is 32 minutes per day. The machine fails 4 times in a year. The time required to restart the machine is 2 weeks after each failure. The short stoppages for this machine are 119 per year. Time required to cover each stoppage is 9.8 minutes. The numbers of products produced on this machine are 12 per week and products rejected per month are 2.

*D. Welding:*

There are two robotic welding machines which work according to the instructions and programme fed to it. This work station works in one shift (8 hours). Nine employees are involved in this work station. Semi welded objects are made before making the full welding. The average time taken to weld 1000 mm is 134 sec. The number of product produced per week is 48 and products rejected are 110 per month. The ideal speed to weld 1000mm length is 34 seconds. The set up time for each machine is 28 minutes per day. Break time is 40 minutes. Each machine fails twice a year and time required to recover each failure is 10 days.

*E. Painting:*

There are two automatic powder coating plants. One is in unit no I with 55 meter conveyor length. The time taken to reach the spray chamber is 90 minutes. The time taken to cure in the oven is 15 minutes at temperature of 220 degree centigrade. Another unit no II with conveyor length of 35 meter length. The time taken by a component to reach the spray chamber is 70 minutes. Phosphating is done with help of tanks. This work station work for 8 hours. The numbers of workers working on this work station are 12. The parts are hanged to the conveyor which moves to the spray chamber. Two painters with spray guns, spray the paint on two surfaces opposite to each other. After spray painting the parts moves into the oven where the parts are cured in 220 degree centigrade temperature for 15 minutes. The average set up time is 2.10 hours. More than 100 shades are used for painting. The average powder change time is 16 minutes. Preventive maintenance is done twice a month and 5 hours are spending at each time of preventive maintenance. Each plant fails twice a year and time required to recover is 5 days for each failure. The short stoppages observed are 16 and time required to recover one stoppage is 45 minutes. The short stoppages are due to manpower shortage, power off, compressor not working, trolley jam, filter jam, material not ready, burner failure, etc. The paint station is painting 73 products per week and 9 parts have quality problems per week.

*F. Assembly and Packing:*

There are 3 workers in this last workstation. It works for 8 hours. Different tools like pneumatic gun,

screwdrivers, hammers, etc. are used by the assembly workers. But the worker do mistake while assembling the parts. The final product is then packed for dispatch. The numbers of parts rejected during assembly are 20 in 923 for the whole year.

We are not able to study all the machines individually in selected work stations. We use the average value of all the machines at a work station. All the calculations are based on one year's data (2011). The data is collected for the year 2011 gives us a foundation to recommendations to the case company under study for improvements. For this purpose two production lines are selected. These production lines are the main production lines through which majority of the products flow and workstations of these lines participate in the whole production of the case company. The line 1 consists of laser cutting, punching, welding and powder coating and line 2 consists of laser cutting, bending, welding, and powder coating operations. The current situation of these two lines and each work stations can be determined by calculating OEE of each.

**VI. OEE COMPUTATION [6]**

1) *OEE calculation for Laser Cutting work station:*

The laser cutting machine is working for two shifts (12+12=24 hours) and 6 days a week.

TABLE I : DIFFERENT TIMINGS FOR LASER CUTTING STATION

Set up time per day	10.10 min
Break time per day	120 min
Preventive maintenance per year	5 days
Short stoppages per year	2 nos
Time for one short stoppage	10 days
No of failures per year	841
Time for recovering one failure	15 min

Planned down time = set up time for machine + break time + preventive maintenance (1)

$$= 10.10 + 120 + (5 * 24 * 60 / 300)$$

$$= 154.10 \text{ min/day}$$

Unplanned down time due to failures/day = failures per year / working days

$$= 2 * 10 * 24 * 60 / 300$$

$$= 96 \text{ min/day}$$

Unplanned down time due to short stoppages

$$=841 \times 15 / 30$$

$$=42.05 \text{ min/day}$$

Loading time = total time - planned down time

$$=1440 - 154.10 = 1285.9$$

Operation time = loading time - planned down time

$$=1285.9 - (96 + 42.05) = 1147.85 \text{ min/day}$$

Availability

Availability = operating time / loading time

$$=1147.85 / 1285.9 = 89.26$$

Quality rate

No. of products per day =  $216 / 6 = 36$

Rejection per day of products =  $56 / 25 = 2.24$  nos

Quality rate = processed amount - rejection amount / processed amount

$$= (36 - 2.24) / 36$$

$$= 93.77$$

Performance rate

Machine cutting speed

1 meter = 2.8 minutes

Machine actual speed

1 meter = 3.5 minutes

Process amount =  $(1 / 3.5) \times 1147.85 = 327.95$  meters

Performance efficiency = process amount x ideal cycle time / operation time

$$= 327.92 \times 2.8 / 1147.85$$

$$= 80$$

**OEE = Availability x Quality rate x performance efficiency**

$$= 89.26 \times 93.77 \times 80$$

$$= 66.95$$

*Similar calculations are done for bending, welding, punching and powder coating workstations to determine their OEE values..*

From Table II

OEE of Line 1 = Laser cutting OEE x Bending x Welding station OEE x OEE powder coating station [7]

$$= 0.6695 \times 0.1512 \times 0.2067 \times 0.4797$$

$$= 1.00$$

OEE of Line 2 = OEE of punching x OEE of welding x OEE of powder coating (9)

$$= 0.5279 \times 0.2067 \times 0.4797$$

$$= 5.23$$

TABLE II : VALUES OF OEE FOR DIFFERENT WORKSTATIONS

Workstation	Availability	Performance Efficiency	Quality Rate	OEE
Laser cutting	89.26	80.00	93.77	66.95
Bending	90.54	18.63	85.45	15.12
Punching	80.14	68.62	96.00	52.79
Welding	91.90	24.77	90.83	20.67
Powder coating	88.13	62.10	87.66	47.97

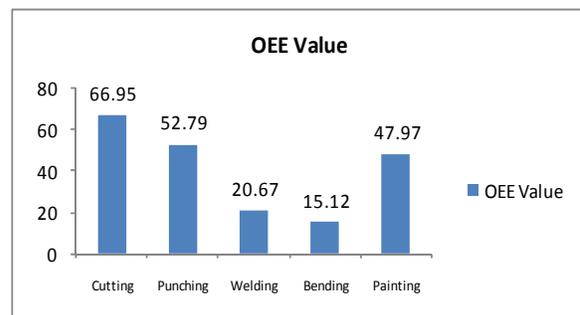


Fig.1.OEE values of different workstations

## VII.DISCUSSION ON THE OUTCOMES

Fig.2 shows OEE of production line-1 is 1.00 and it is smaller than the OEE of production line-2 which is 5.23. This difference in OEE of two lines is due to the bending work station's OEE which is 15.12%. From Fig.1, the welding work station and powder coating work station comes with 20.67% and 47.97% O.E.E. But the bending work station is the main cause of the lower O.E.E. of the production line 1. This work station is needed to be focused on the first priority to increase the OEE of the production line 1. The welding work station and the powder coating work station are the common work stations of the selected production lines 1 and 2. Hence it has the impact on both the selected production lines.

There are different views to see the satisfactory level of the O.E.E. but the target of the best satisfactory level of the value of O.E.E. is 85% with the availability more than 90%, performance efficiency more than 95% and quality rate more than 99% [8]. In the case company the O.E.E. of bending, robot welding, punching and laser cutting and powder coating work stations are 15.12%, 20.67%, 52.79%, 66.95 and 47.97% respectively and are not at the satisfactory level. It

means lot of work is required to achieve the satisfactory level of the O.E.E.

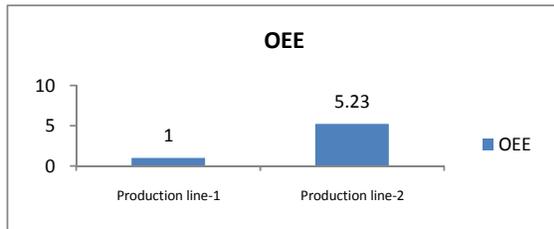


Fig. 2 : OEE values for production line 1 and 2

### VIII. CONCLUSION

The value of O.E.E. shows that the company has the production system to produce the products in more quantity in the same production time by improving the current situation i.e by improving the availability, quality rate and performance efficiency. These three factors indicate all flaws in the production system. The O.E.E. of the bending work station is the lowest as compared to the others. So to increase the production, the O.E.E. values of all work stations indicate the bending work station is the key point to start the improvements. Future, the performance efficiency value of this work station is the lowest as compare to the other factors i.e. availability and quality rate. This indicates the exact point to start the improvements in the current production system of the company. The improvement of the performance efficiency of the bending machine will increase the value of the O.E.E. of the bending work station. This increase of the value of the O.E.E. of the bending work station will increase the O.E.E. value of the production line 1. Then the robot welding and powder coating work station's value of O.E.E. will become important for the both selected production lines. This way of improvements in the current system will lead the company's production system towards the satisfactory level slowly and slowly and to develop a good production systems. The role of the maintenance to develop a good production system and to improve the O.E.E. value of the production machines cannot be ignored but it is not the main problem of the case company. The lower performance efficiency of the work stations shows that there is a problem of the man power management. The machines are waiting for the work in the production time. This is because of the more than one responsibility of the operators. Most of their time is wasted in quality checking and material handling. During this time machines are available for the production but remain idle as the operator is busy doing something else.

The maintenance is the parts of the production system. Every system needs maintenance for attaining

its best position for the production otherwise the problems of quality, short stops and failures become more and more which lead the company towards the losses. The maintenance has the direct contact with the production system to keep the production machines as much as possible to the best conditions to minimize the disturbance in the production and as a result the production will be more with high quality. The other advantage of the maintenance will be appearing in the form to establish a more reliable and stable production system. Then the production of the orders and delivery to customers will be on time which will increase the satisfaction level of the customer. This more production and the satisfaction of the customers are the benefits for the company to increase the sales of the products and to make the more profits for the company.

Thus the O.E.E. is the tool for the company to assess the current situation and to start to make the improvements from particular point. The maintenance is the sporting activity which helps to make the improvements in the current condition and to improve the value of O.E.E. The start of the improvement in the value of O.E.E. and the development of the preventive maintenance plan for the machines will be the first step for the company towards the implementation of the TPM. Because these factors are the main objectives of the TPM.

### IX RECOMMENDATIONS

Some recommendations to the case company are given which will be helpful for the company to develop a good and reliable production system to get the competitive advantages. Our recommendations for the case company as follows:

- The company should use the O.E.E. as the tool to assess the current situation and to find out the starting point for the improvement process.
- The company should have to modify the current preventive maintenance plan for all the machines which will be able to decrease the failures and short stoppages and keeping the machines in the best conditions for production.
- Sometimes, the time is wasted due to the spare parts i.e. the time is consumed in importing of the spare parts. So the company should keep the frequently problem creative parts in the store so that they can be used in the case of need.
- The company has the quality problems in the last year and much of money wasted due to the quality problems. So the company should go into detailed analysis to finding out root causes of problems and

activate its quality system to reduce these problems. At present only operator is checking the quality of the products and wasted the time which gives its impact in form of lower performance efficiency. The company has the quality system and the department for to insure the quality. The need is to make it active and make a plan for that system.

- The operators are the key persons in the production system. So to get the maximum output with high quality products, it is necessary that they have the good skills as according to their job. So our suggestion is that the company should arrange quality training for them time to time to keep them updated and motivated.

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