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TPM Methodology: A Way of Improving Overall Equipment Efficiency

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ABSTRACT : The integration of the world economy and the resultant growth in competition has made quality one of the most important factors in an organization's survival and success. Successful companies understand that the customer-defined quality can have the powerful impact their business. Due to this reason many competitive firms continually increase their quality standards. Competitive firms believe that the way to rebound is through improvements in quality, and each has outlined specific changes to their operations. Most of the automotive manufacturing industries are focusing on strict quality standards in their production process and implementing a quality program called Total Productive Maintenance. The aim of the study is to implement the TPM program in Sheet Metal industry to increase the OEE of Laser Cutting Workstation. The Overall Equipment Effectiveness (O.E.E.) of the Laser Cutting Workstation for the financial year 2010-11 has been calculated. The OEE value for the lathe machine generates a clear view of the problems. Along with the other factors, improper utilization of resources is an important factor, which reduces the OEE of the plant. TPM methodology is implemented in the company in the financial year 2011-12. Thus there is an improvement have been noticed in the overall results.

Keyword : Total productive Maintenance (T.P.M.), Overall Equipment Effectiveness (O.E.E.), Availability, Maintainability, and Quality rate.

I. INTRODUCTION

Quality, as a concept, does not easily fit into any given timeframe. Human understanding for quality lays a long way back in history, perhaps even a million years ago, or when humans first began constructing tools. The concept of quality rests on its management, so before delving deeper into quality management measures and systems we should first familiarize ourselves with definitions of quality. The concept of quality has long been analyzed by numerous representatives from many academic and business backgrounds. Despite this, one universal and common definition of quality is yet to be agreed on. The reason for this is the complexity and breadth of quality as a concept which is due to the great variance in quality, in terms of all the factors and issues that affect it. In other words, quality is not a static, but a dynamic concept that, over time, is treated differently depending on current specifications and the particular object concerned. Quality may be defined as meeting certain set standards and specification requirements, being suitable for use, or the degree of customer/client satisfaction. Most of the people may evaluate quality according to which particular aspect of consumer needs a given product satisfies. In this approach, the product's functionality, reliability, and how it meets various social, ergonomic, aesthetic, environmental and economic requirements etc may be evaluated. One of quality guru suggests that the quality is defined in terms of the total sum of a product's features that ascribe its suitability to meet all expressed and implied consumer needs as determined by the product's conditions of use and its purpose. Quality also incorporates product's defectives and its impact on the environment. In business practice the concept of quality is often interpreted more narrowly, that is, how product's features satisfy standards, technical regulations, specifications, legal acts, and commercial contract requirements. Quality is important not only as a measure of how competitive a business is, it also determines the efficacy of sciences, technologies, state governance and other public sector organizations, the stability of a nation's economy, and the quality of life of its citizens. This is why it is necessary to broaden our understanding of quality. Technologies and quality are the integrating and maintaining factors of the engineering, economics, and management systems. There is no doubt that the maintenance has a vital role in the companies. Now a day's most of the companies are giving attention to this important function, which is considered as the necessary evil for the companies, i.e. an expense to the companies and a non-value addition function. The companies cannot survive for long time without considering the maintenance as an important function because the companies that are considering the maintenance as a competitive weapon will put them out of the business. Now the companies are looking it as a way to reduce the cost of producing their products. There is no doubt that it is another main area of cost. Fig. 1 shows the history of TPM.

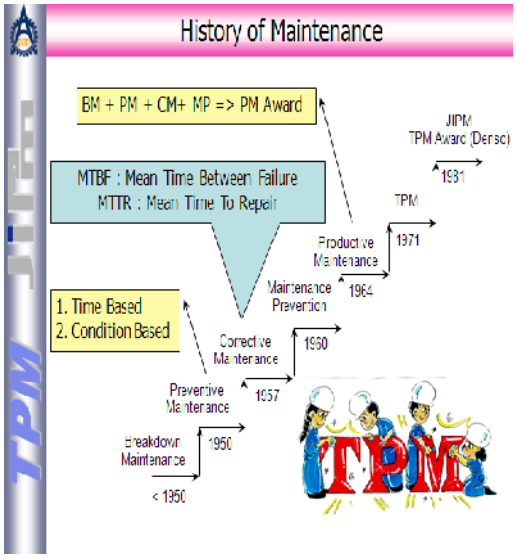

Fig. 1. History of TPM.

In this research work, TPM methodology is implemented in the industry. It was started in Japan in 1971. The concept of this methodology was come from USA. In those days the Japanese's industry was in critical economic situation due to the oil crises and was searching the effective measures to survive in the worldwide market. They took the basic idea of the productive maintenance (PM) from united state and modified it by the Japan institute of plant maintenance to TPM system. This system was developing step by step in small group activities. Therefore, TPM is an American style of productive maintenance, which has been modified and improved to fit it in the Japanese industrial environment. How TPM covers all the company activity used in this work shown in Fig. 2.

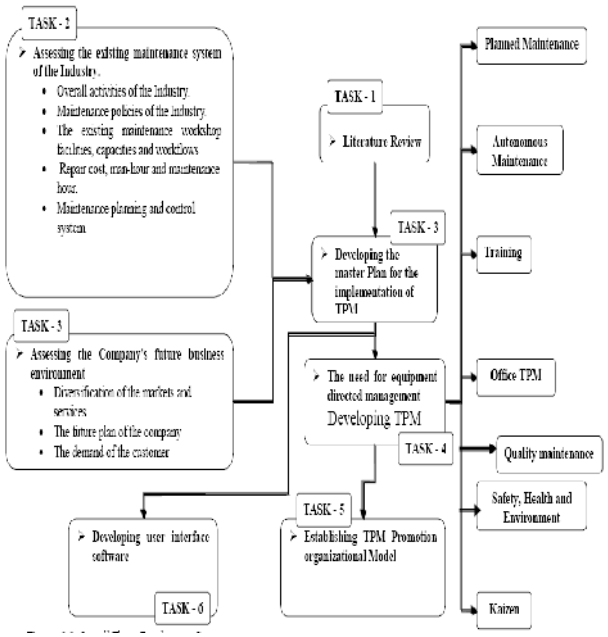

Fig. 2. Overall Thesis Development Strategies.

A. Difficulties Faced in TPM Implementation

Implementing TPM is not an easy task as it seems to be. A great infrastructure and commitment of all personnel from top level management to bottom level is required. A lot of problems have to be faced, while implementing it. Some of them are as follows:

(*i*) Sufficient resources like people, money, time, etc. and assistance are not provided.

(*ii*) TPM is not a "quick fix" approach, it involve cultural change to the ways to do the things.

(*iii*) Incomplete understanding of the methodology and philosophy by middle management.

(*iv*) Many people treat it just another "program of the month" without paying any focus and also doubt about its effectiveness.

(*v*) Workers show strong resistance to any change.

(*vi*) Many people considered TPM activities as additional work or threat.

II. PROBLEM FORMULATION

The idea with this case study is to optimize the current situation of the company. Is the company using its manufacturing equipments in a proper way to get the competitive advantages ? If not, then find out the main reason for that. Which kind of problem is there i.e. availability, quality or performance efficiency ? And what is the influence of these problems to achieve the goals of the company. The company cannot compete in the competitive market unless it uses it resource and capabilities to the maximum level. The company must have to work to get rid of the problems to get the competitive advantages with respect to cost, service, quality and on time delivery. These issues do not allow the company to achieve its set goals.

(*i*) To investigate the current situation of the production of the case company.

(*ii*) 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.

(*iii*) To suggest the ways to improve the situation.

All the calculations are based on two financial year's data that is financial year 2010-11 and financial year 2011-12. The main problem is associated with the Laser Cutting Workstation in the Company. A study is carried out on the production system of Laser Cutting Workstation. The current situation of the production lines will be cleared through the O.E.E., which is calculated below:

To find the overall equipment efficiency of the Metal Industry, identifying the six major losses of the machines was the first stride by organizing under three key factors. And then data pertinent to those losses was collected for Laser Cutting Workstation. The major losses that are identified for the Laser Cutting Workstation machineries presented as follows:

1. Equipment failure loss
2. Setup and adjustment loss
3. Startup loss
4. Minor stoppage and idling loss
5. Speed Loss
6. Defect and rework loss

A. O.E.E. calculation of Laser Cutting Workstation

Some of the data pertinent to the above loss are difficult to obtain, since the company doesn't apply the overall equipment efficiency concepts in evaluating the performance of the machines at the individual level. It has been attempted to gather some relevant data to estimate the OEE of the typical machinery. From the observations and few recorded data to calculate the availability of the machine, the researcher has treated the workstations as a whole as one machine and considered the available machines in that departments. Therefore accordingly the available machines on the days are collected and recorded in the following table.

For the calculation purpose, all the relative data collected for Laser Cutting Workstation. The Laser cutting machine is working 24 hour a day and 7 days a week.

Table 1: Data for O.E.E calculation of Laser cutting Workstation.

S. No.	*Description*	*Time*
1.	Setup time per day	8.57 min.
2.	Break down time per day	120 min.
3.	Preventive maintenance per day	7 days (App. 27.6 min./day)
4.	No. of failure per month	2
5.	Time to cover failure	34 hrs. App.
6.	Short stoppages per years	975
7.	Time for one short stoppage	20 min.
8.	Number of product produced	491 per week

(*i*) Planned down time = Setup time for machine + Break time (coffee) + preventive mtn.

= 8.57 + 120 + 27.6 = 156.17 min/day

(*ii*) Unplanned down time, due to failures/day = Failures per month Working days/month

= (2 × 34 × 60)/30 =136 min/day

(*iii*) Unplanned down time, due to short stoppages = (975 × 20)/365 =53.4 min/day

(*iv*) Loading time = Total time – planned down time

= 1440 – 156.17 = 1283.83 min/day

(*v*) Operation time = Loading time – Unplanned down time

= 1283.83 – (136 + 53.4) = 1094.43 min/day

(*vi*) Availability = Operation time/Loading time

= 1094.43/1283.83 = 0.8524 × 100 = 85.24%

(*vii*) Quality rate = (Input – Quality defects) × 100/Production Input

Number of products per day = 491/7 = 70.14 products Per day

Rejection per day of products = 3.65 products Per day (App.)

= 70.14 – 3.65/70.14 = 0.9516*100 = 95.16%

(*viii*) Performance efficiency

Machine cutting capacity = 1 m in 2.8 min

Machine actual speed = 1 m in 3.2 min

Process amount = (1m/3.2 min) × 1094 min = 341.875 m

P.R. = Processed amount × Ideal cycle time/Operation time

= 341.875 × 2.8/1094.43 = 0.875 × 100 = 87.5%.

(*ix*) O. E. E. = Availability × Quality rate × Performance efficiency

= 0.8524 × 0.9516*0.875 = 0.7097 × 100 = 70.97%

III. IMPLEMENTATION OF TPM METHODOLOGY

TPM focuses on optimizing planning and scheduling, Availability, performance and yield are other factors that affect productivity. Availability losses arise from breakdowns and change-over, *i.e.*, the situation in which the line is not running when it should be. Performance losses arise from speed losses and small stops or idling or empty positions. Yield losses consist of losses due to rejects and poor start-up behavior in the line producing the products. These losses lead to low values of the overall equipment effectiveness (OEE), which provides an indication of how effective the production process is. TPM helps to raise the value of the OEE by supplying a structure to facilitate the assessment of these losses. Application of TPM leads to both short- and long-term improvements. TPM entails having a

(*i*) Linear organizational structure.

(*ii*) Multi-skilled workforce.

(*iii*) Rigorous reappraisal of the way, the thing is done and so improvements are introduced, resulting in simplification and/ or standardization.

TPM seeks to encourage the setting of ambitious, but attainable, goals for raising the value of the OEE. The

importance of maintenance has been increased than before, due to its role in maintaining and improving availability, performance efficiency, and quality products, on time deliveries, the environment, safety requirements and overall plant productivity at a high level. These are all the key factors of TPM methodology. Now, the TPM is implemented in the industry. For implementing the TPM in industry, it is very important to study the TPM Pillars and requisites, which are mentioned in Section 1.0 (Introduction).

A. TPM Success Measurement

Now again finding the O.E.E. value for all the workstations and finding the current situation of the production process by utilizing the data. This time data considered for calculation purpose is of Financial Year 2011-12.

Table 2: Data for O.E.E calculation of Laser cutting Workstation.

S. No.	*Description*	*Time*
1.	Setup time per day	8.37 min.
2.	Break down time per day	120 min.
3.	Preventive maintenance per year	5 days (App. 19.7 min./day)
4.	No. of failure per month	2
5.	Time to cover failure	27 hrs. (App.)
6.	Short stoppages per years	814
7.	Time for one short stoppage	17 min. App.
8.	No. of product produced	521 per week

(*i*) Planned down time = 8.37 + 120 + 19.7

= 148.07 min/day.

(*ii*) Unplanned down time, due to failures/day

= (2*27*60)/30 =108 min/day.

(*iii*) Unplanned down time, due to short stoppages

= 814*17/365 =37.91 min/day.

(*iv*) Loading time = Total time – planned down time

= 1440 – 148.07 = 1291.93 min/day.

(*v*) Operation time = Loading time – Unplanned down time

= 1291.93 – (108 + 37.91) = 1146.02 min/day.

(*vi*) Availability = Operation time = 1146.02/1291.93 = 0.8870 = 88.70% Loading time.

(*vii*) Quality rate

Number of products per day = 521/7 = 74.42 products Per day.

Rejection per day of products = 3.04 products Per day (App.)

Q.R. = Processed amount – Defective amount/Processed amount

= 74.42 – 3.04/74.42 = 0.9591 × 100 = 95.91%.

(*viii*) Performance efficiency

Machine cutting capacity = 1 m in 2.8 min

Machine actual speed = 1 m in 3.2 min

Process amount = (1 m/3.2min) × 1146.02 min = 358.13m

P. R. = Processed amount × Ideal cycle time/Operation time

= 358.13 × 2.8/1146.02 = 0.875 × 100 = 87.5%

(*ix*) O. E. E. = Availability × Quality rate × Performance efficiency

= 0.8870 × 0.9591 × 0.875 = 0.7443 = 74.43%.

IV. RECOMMENDATIONS

This research work propose that the operator should participate in simple restoration and also give emphasis to involve the operators on activities to prevent and measure deterioration as they are always near to the machine. Since these activities are vital, it should be one of the necessary parts of daily work of the operator. The proposed activities that the operators and the maintenance division should do are revealed as follows.

A. Duties for operators

(*i*) Restoration of minor deterioration of the machineries.

(*ii*) Restoration of some mechanical part failure.

(*iii*) Restoration of oil, mechanical drive and electrical system deterioration.

(*iv*) Establishing basic conditions for all the machines in the department.

(*v*) Cleaning for milling, lathe and other machines they operate.

(*vi*) Retightening of loose parts on the above mentioned machineries.

(*vii*) Operating properly.

(*viii*) Proper loading based on the capacity of the machines.

(*ix*) Accomplishing minor inspection for the equipments and machines.

(*x*) Appearance inspection for the machines listed above.

(*xi*) Noise, Vibration etc. tracking while operating by understanding irregularities for internal deterioration by the five senses.

(*xii*) Reporting the condition of the equipment immediately for further investigation if it is required.

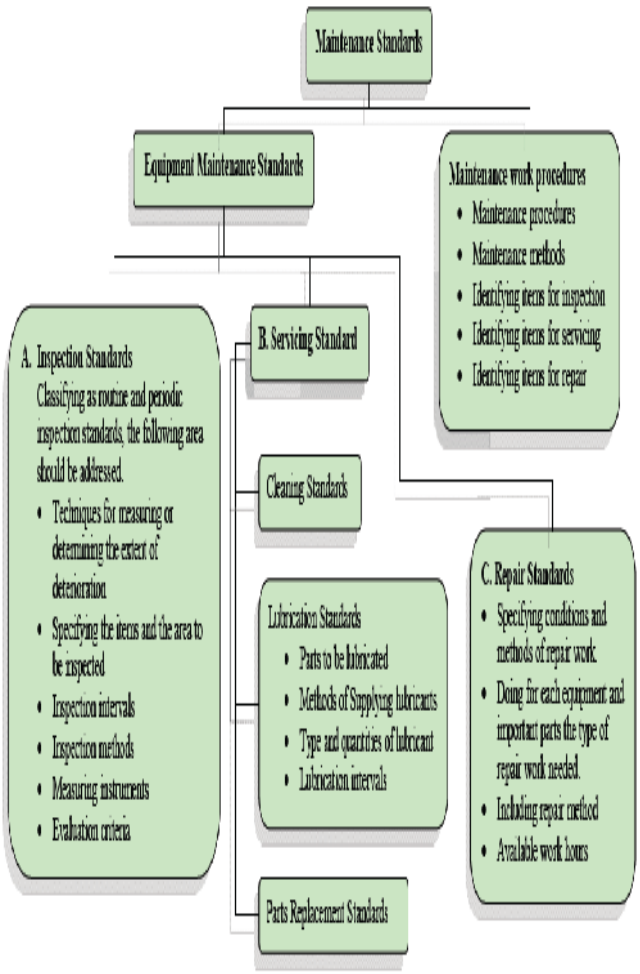

Fig. 3. Proposed Area of Standardization for the Industry.

B. Duties for the Maintenance Personnel's

(*i*) Execution of time based maintenance for all the machines in the industry

(*ii*) Prepare annual, monthly and weekly maintenance plan for the all machineries in the industry.

(*iii*) Perform the above plans accordingly

(*iv*) Standardization of replacement for every machinery in the industry

(*v*) Standardization of maintenance activities and methods for every machinery in the industry

(*vi*) Standardization of inspection methods for all machines

(*vii*) Providing training to the operators

(*viii*) Diagnosing the failure mode effect analysis, when failure occurs in any machine in the industry.

(*ix*) Prevent recurrence of failure that has occurred in routine operation.

(*x*) Discover potential failures (fatigue, faults and equipment weaknesses) of priority equipment.

V. CONCLUSION

In this case industry, all maintenance activities are only done by maintenance division which encompasses maintenance foreman. Deterioration prevention based on fixed interval of time and restoration of the equipment are the basic activities of the maintenance division of the industry. As the study shows, breakdown of the machines is getting far above the ground. One of the main factors is that operators are not involved in minor restoration, prevention and deterioration measurement. In the industry, it is the technician's duty to investigate the problems encountered. The operators may be interviewed what he has observed for further investigation which is rarely practiced in the industry.

Now, from analyzing the data it is concluded that the overall equipment effectiveness of the Laser Cutting Workstation is improved by implementing TPM. The basic reason of this improvement is due to reducing in the setup time for workstation and reduction in no. of short stoppages. The current status of O.E.E. of Laser Cutting Workstation is 74.43% earlier it was 70.97%.

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