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ENHANCEMENT OF OVERALL EQUIPMENT EFFECTIVENESS THROUGH IMPLEMENTATION OF TOTAL PRODUCTIVE MAINTENANCE

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Abstract

In the present competitive world most of the manufacturing industries are skirmishing by providing their best productivity. In this research article an attempt was made to analyse and implement the total productive maintenance system to improve the overall equipment effectiveness in a manufacturing industry. The details of application of overall equipment effectiveness of the industry are also presented. The current position in the production system, effectiveness of the maintenance system, condition of the machines, workers skill and utilization of the machines can be determined by the calculations of overall equipment effectiveness. Down time of machines which affects the overall productivity have been identified and the results are presented. From the results, after implementation of total productive maintenance cycle time for the identified operation has been decreased from 15 hours to 11 hours. Saving of 4 hours it means by using OEE performance and productivity is improved about 5%. Similarly, the availability of the machines has also been increased up to 90%.

Keywords: OEE, TPM, 5S, Productivity, Cycle Time, Breakdown

1. Introduction

In the current production scenario, most of the manufacturing companies are facing the recurring problems like breakdown of machines, frequent repair and quality defects. In this research, a case study has been conducted in a textile yarn manufacturing industry. Due to regular machine breakdowns, the industry currently encounters low availability and performance efficiency of the machines. Overall Equipment Effectiveness (OEE) is extensively used as a key performance indicator to measure the availability of machines. Total Productive Maintenance (TPM) eliminates breakdowns and promotes Autonomous Maintenance (AM) by operators through day to day activities involving total workforce thereby, maximizing the availability of a machine. This research work was carried out in heavy machinery manufacturing industry especially on CNC turret punching machine. Now a day's industries are depends on their timely production with effective machinery equipment with quality product. Manufacturing industries have undergone significant changes day by day, so it is necessary to conduct continues study of the existing machinery and production system to identify weather their system is working in right path with less lead time. OEE is a tool for benchmarking with world class rate and then optimizing the efficiency of the machines. OEE conveys how well our manufacturing facilities are performed relative to its full load capacity during the planned production time which

depends on the basic three components such as availability, performance and quality as shown in Figure 1. The objective of this research work is to increase the OEE of the manufacturing industry about 70% and also slowly brings up towards the level of world class manufacturing. TPM occupies OEE as a quantitative constraint for determining the performance of an existing manufacturing process and it is also the core metric for determining the TPM execution program for accomplishment. The ultimate aim of TPM is to enhance the OEE of the machines in the manufacturing industry. Normally, there are eight pillars in TPM as shown in Figure 2.

Figure 1 Basic Components of OEE

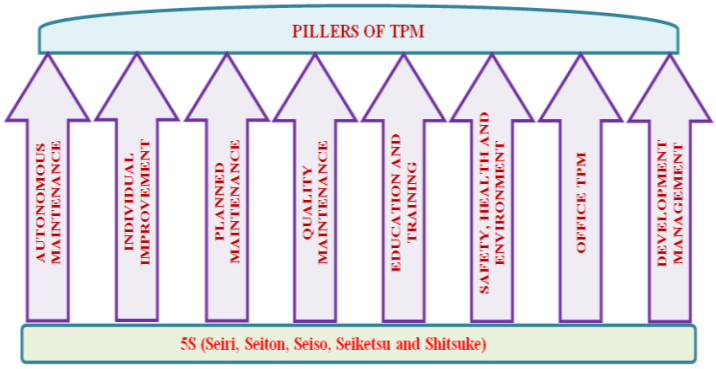

Figure 2 Main Pillars of TPM

2. Literature Review

The manufacturing industries have gone through significant changes for the past two decades. Global competition has increased dramatically and the customers focus on product quality, delivery time and cost of product. Total productive maintenance is a methodology that aims to increase the availability of existing equipments hence the further investment for the machines to be reduced. Different lean tools such as Kaizen, Kanban, 5S, Poka Yoke, JIT, etc is used to increase the overall performance in different manufacturing industries during implementation of lean manufacturing. Implementations of lean tools are closely attached to Just in Time (JIT) and Total Quality Management (TQM) and also it is an addition of Preventive Maintenance (PM). In general, lean tools are used to enhance the machines work with high productivity and efficiency, and to maintain all the employee responsibility to prevent the break downs before it occurs [1-3]. Normally, OEE was used to enhance with less breakdown of machines, a lesser amount of idle and stop time, lesser defects in quality, to reduce accidents in plants, to increase the overall productivity rate, to optimize process constraints, better involvement of workers, to improve profits through cost saving method, to increase the customer satisfaction, to increase sales and also to improve the morale and confidence of the workers [4-6]. The winning functions of time and motion study in manufacturing industries are mainly depend on the training of the individual worker who applies it and also places of interest to enhance the OEE of the autoclave practices by the implementation of TPM [7-9]. The measurement of Overall Performance Effectiveness (OPE) was an efficient method to analyze the overall efficiency of a single setup process [10-12]. Enhancement of productivity can be obtained by eliminating the unwanted movements through Standard Operating Procedure (SOP), minimizing the overall cycle time and affording the necessary suggestions for different troubles during the manufacturing of the components to enhance the OEE as well as the overall productivity [13-15]. Through the case study of implementing TPM in a thermal power plant it was found that, there is an increase in efficiency and productivity of plant in

terms of overall equipment effectiveness are discussed [16-18]. A case study examines the overall equipment effectiveness of CNC table type boring and milling machine in a heavy machinery manufacturing industry. OEE tool is a route map to boost the effectiveness of manufacturing process and equipment and from the results it was found that the utilization of machines has been increased about 95% [19-21]. The OEE of pressing equipment facing theoretical aspects and reality issues has been improved by investigating all the possibilities at the present working process. The tools involved are part of the content, but the way to support a company for the organizational change required to the success is another part of the content. The actual and theoretical OEE was calculated and improved according to the feasible chances in an industry [22-25]. The implementation of TPM is require full support of top level management to ensure its working conditions as well as the support of all employees from all the levels of escorting the TPM to be carried in proper way and practice. Based on the above literature, a case study was carried out in a heavy machines manufacturing industry especially in the CNC machine cell.

3. Problem Statement and Objective

The selected manufacturing industry is currently facing the excess down time is high due to improper machine setup and process changes with less availability of machines. This is mainly due to more breakdowns of machines and unplanned downtime. Also, more time involved in accommodating dimension variation in Computer Numerical Control (CNC) programming and machine tool setup as well as more defective parts resulting in CNC punching operation. Hence, the industry is unable to meet out the demand at the right time to satisfy the customer. The main objective of this study is to minimize the frequent machine breakdowns in the industry by implementing TPM concepts which increases the OEE. Consequently there will be a reduction in overall down time and set up time. The availability of tools should be increased and also the overall OEE to be increased by about 80% after implementation of TPM.

4. Data Collection and Analysis

The existing manufacturing process data were collected to analyze the present level of OEE for each machine and the necessary suggestions were implemented with different tools.

Overall Equipment Efficiency = Availability x Performance Efficiency x Rate of Quality

Where,

Availability - Available time required for producing a finished product

$$Availability = \frac{\text{Actual time taken for production}}{\text{Total planned time for production}}$$

$$\text{Actual time taken for production} = \text{Total planned time for production} - \left(\frac{Major\ losses}{60}\right)$$

Total planned time for production = Shift time - Planned down time

Performance - The design of cycle time to produce the product

$$Performance\ Efficiency = \left(\frac{Total\ production}{Planned\ production\ quantity}\right) * 100$$

Quality - It is the ratio of production output to the production input.

$$\text{Rate of quality} = \frac{(\text{Total items} - \text{Defects})}{\text{Total items}}$$

Based on the data collection the analysis was carried out to find out the OEE value before and after implementation of TPM.

4.1 Results before Implementation of TPM

The OEE results for different machines before implementation of TPM are as follows.

OEE for Old Coma Machine:

Availability (A) = Actual time taken for production / Total planned time for production

Actual time taken for production = Total planned time for production-(Major losses/60)
= 8.1 - (70/60) = 6.933 hours

Total planned time for production = Shift time - Planned down time
= 9.4 - 1.3 = 8.1 hours

Availability (A) = 7.033/8.1 = 86.83 %

Performance Efficiency = (Total production / Planned production quantity) × 100
= (130/210) ×100 = 61.90 %

Rate of Quality = (Total items - Defects) / (Total items)
= (130 - 8) / (130) = 93.84 %

OEE= Availability × Performance × Efficiency = 0.8683 × 0.619 × 0.938 = 50.41%

OEE for New Coma Machine:

Actual time taken for production = 8.1 - (48 / 60) = 7.3 hours
Total planned time for production = 9.5 - 1.3 = 8.2 hrs
Availability = 7.4/8.2= 89.02%

Performance efficiency = (155 / 230) × 100 = 67.39 %

Rate of quality = (155 - 8) / (155) =94.83 %

OEE= 0.8902 × 0.673 × 0.9483 = 56.89%

OEE for Pega 358 Machine

Actual time taken for production = 8.1 - (50/60) = 7.2667 hours
Total planned time for production = 9.5 - 1.3 = 8.2 hours
Availability (A) = 7.2667 / 8.1 = 88.62 %

Performance efficiency = (140 / 200) × 100 = 70.00 %

Rate of quality = (140 - 5) / (140) = 96.42 %

OEE= 0.8862 × 0.7 × 0.964 = 59.80%

The OEE results for different machines are compared with target level of OEE as shown in Figure 3.

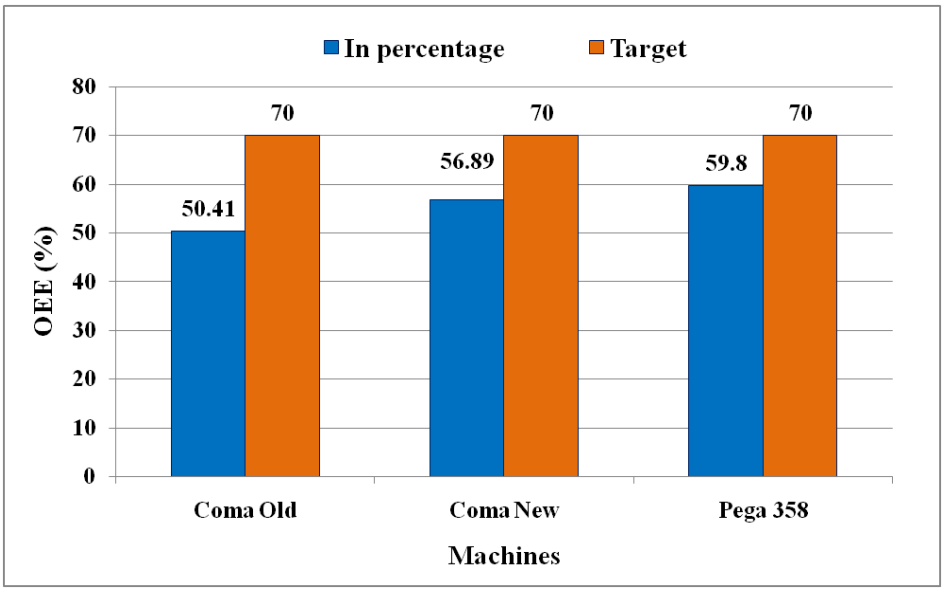

Figure 3 OEE before TPM Implementation

4.2 Fish Bone Diagram

The root cause analysis was carried out for one of the repeated defect of bulged hole which is as shown in Figure 4. Fish bone diagram is a visualization tool for categorizing the major causes of problem occurred in machine in order to identify the root causes of bulged hole.

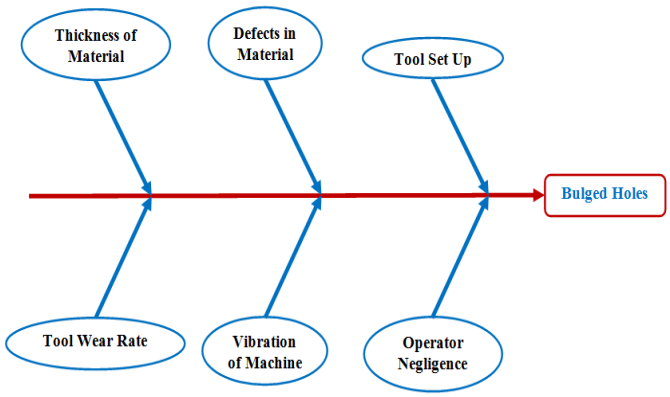

Figure 4 Root-Cause analysis for Bulged Hole

4.3 Action Plan for TPM

The action plan using 5S tool is given detail in Table 1.

Table 1 Action Plan using 5S

Description	Present Conditions in CNC Turret Punching Machine	Score 1-5	Action Plan for TPM
SEIRI			
Sorting out unnecessary items from the workplace and throw it	No items that are not needed in the production area	3	Control Seiri implementation on CNC Turret punching department.
SEITON			
Arranging goods according to the appointed place, so it is very easy to find when needed.	Layout the placement of goods available	3	Goods in accordance with a predetermine layout. Keeping the placement of production and immediately sent to the next process (Internal Customer)
SEISO			
Cleaning the workplace of dirt, dust and all	Cleaning schedule for each shift available	2	Cleaning schedule for each shift available
SEIKETSU			
Maintaining a high standard of cleanliness work so well maintained	SOP available	2	Control implementation of the SOP
SHITSUKE			
Train and Motivate employees to have discipline in cleanliness	Communication between the beginning of the shift and end shift	2	Briefing the beginning of each shift, and shift hand over and importance of 5S

4.4 Finding and Suggestions

After the current working position analysis it was found that, CNC turret punching machines of old coma, pega 358 and new coma is working with OEE value about 60% which is much below as compare to the world class standard OEE of 85%. Hence, there should be a need of improvement in working process to improve the OEE. After careful analysis and discussion with shop floor in-charge and top level management some feasible suggestions were found for improvement of OEE. These suggestions are based on the visual recorded data as follows.

- During observation it was found that, housekeeping of machine is carried out during machining hours which accounts for 30 minutes delay. So if housekeeping of machine is carried out during lunch time and in break time then delay can be reduced to 25 minutes compare to previous 30 minutes delay
- During observation Tool and Tool insert unavailability is a huge problem it usually takes huge time to find the tools from other machines so during this period machine is ideal. This delay can be reduced when company deployed experience manpower in tool crib room so the worker will ensure the availability of Tool and Tool insert for all machines. This will largely reduce the unplanned down time. Approximately 20 to 45 minutes for this machine during the machining of bottom balancer frame
- During observation it was found that at the time of loading and job setting proper arrangement of clams and fixture is not their prior to the job loading and also helpers are not enough trained. This increased the job setting and loading time, hence there must be prior arrangement of fixture clams and other necessary items prior to the job loading.

4.5 Results after Implementation of TPM

The OEE results for different machines after implementation of TPM are as follows.

OEE for Old Coma Machine:

Actual time taken for production = 8.1 - (55 / 60) = 7.183 hours
Total planned time for production = 9.5 - 1.3 = 8.2 hrs
Availability = 7.183 / 8.2= 87.59%

Performance efficiency = (160 / 210) × 100 = 76.19 %

Rate of quality = (160 - 8) / (160) = 95.00 %

OEE = 0.8759 × 0.761 × 0.95 = 63.32%

OEE for New Coma Machine:

Actual time taken for production= 8.1 - (40/60) = 7.433 hours
Total planned time for production = 9.5 - 1.3 = 8.2 hours
Availability = 7.433 / 8.2 = 90.65 %

Performance efficiency = (165 / 230) ×100 = 71.73 %

Rate of quality = (165 - 6) / (165) = 96.36 %

OEE = 0.9065 × 0.717 × 0.963 = 62.66%

OEE for Pega 358 Machine:

Actual time taken for production = 8.1 - (38 / 60) = 7.467 hours
Total planned time for production = 9.5 - 1.3 = 8.2 hours
Availability = 7.467/8.2 = 91.06 %

Performance efficiency = (155 / 200) × 100 = 77.50 %

Rate of quality = (155 - 5) / (155) = 96.77 %

OEE = 0.9106 × 0.775 × 0.9677 = 68.29%

5. Results and Discussion

The OEE value has been calculated after implementation of TPM and results are shown in Figure 5. From the graph it was found that, overall equipment effectiveness of CNC turret punching machines is increased from 60% to 70% after implementation of the appropriate suggestions developed. But still it is below the world class level of OEE and there is further need of improvement by enhancing the machine utilization with minimizing the down time of machines through identifying the micro level problems.

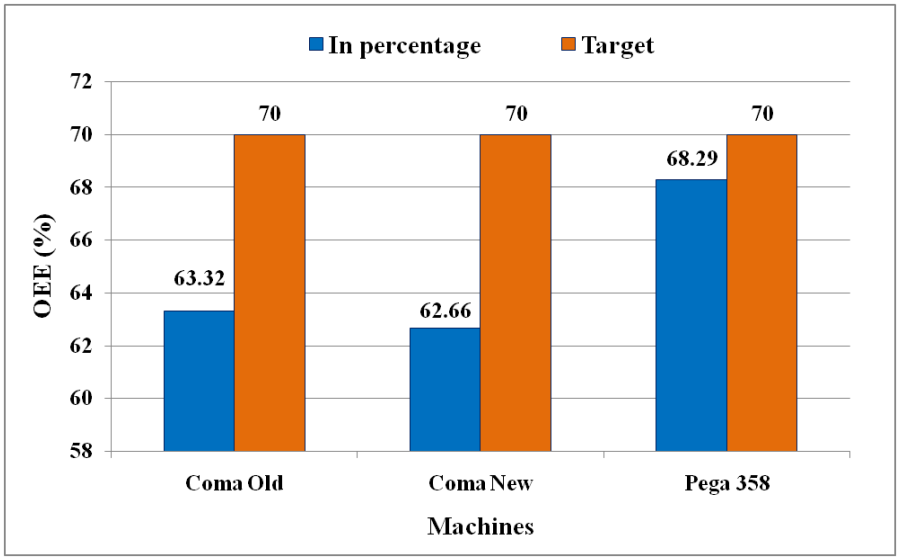

Figure 5 OEE after TPM Implementation

6. Conclusion

The objective of study and analyse the production system in a machine manufacturing industry was carried out. Based on the analysis and results the following conclusions were arrived. The CNC turret punching machines were continuously running before the case study but company production schedule delayed for every time. After finding out the root cause for the down time the necessary suggestions were developed. The suggestions were implemented in all the machines and the analysis was carried out after implementation. From the results it was found that, the OEE has been increased about 70% after implementation of TPM. Also the total cycle time for punching operation was decreased about 4 hours in turn the performance of OEE and the overall productivity was improved. Since, there is a future scope to improve the OEE up to the world class level of 85% by implementing some other lean tools with micro study of existing problems in the industry.

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