Improvement in the Overall Equipment and Effectiveness of wire cut CNC machine through the implementation of TPM

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ABSTRACT: Total Productive Maintenance (TPM) is a methodology that aims to increase the Overall Equipment and Effectiveness (OEE) of existing equipment. Total productive maintenance establishes a system of productive maintenance, covering the entire life cycle of equipment, covers all departments involves participation of all employees from top to bottom and promotes small group autonomous activities. The aim of this paper is to study the effectiveness and implementation of TPM program in a manufacturing organization. The process of TPM is applied on the Wire cut CNC machine (Robofill-240SL) of the Larsen and Toubro organization. The result obtained from the TPM approach showed that the OEE was improved from 43 % to 65%.

Keywords: OEE (Overall Equipment and Effectiveness**,** TPM, Kaizen, Autonomous Maintenance, Planed Maintenance.

1. INTRODUCTION

Nowadays Maintenance is a critical factor to improve productivity and quality in manufacturing industries. The manufacturing industry has experienced an unprecedented degree of change in the last three decades, involving drastic changes in management approaches, product and process technologies, customer expectations, supplier attitudes as well as competitive behaviour. Wire cut CNC machine named Robofill-240SL is used in the Larsen and Toubro organization. But there were many problems regarding the efficiency of the machine. There are various methods which are used in day to day practices for the increase in efficiency. But we decided to opt for Total Productive Maintenance for the increase in the Overall Equipment Effectiveness. TPM is a highly structured approach, which uses a number of tools and techniques to achieve highly effective plants and machinery. The main improvement we want is in the OEE which is increased due to TPM. OEE is measured in the terms of the Performance, Quality and Availability of the Equipment. OEE = Availability X Performance X Quality.

AVAILABILITY:

Availability takes in to account the down time losses and is calculated as :

Operating time/ planned production time.

i.e Percentage of the actual amount of production time the machine is running to the production time the machine is available.

PERFORMANCE:

Performance takes in to account the speed losses and is calculated as:Total count/target counter i.e Percentage of total parts produced on the machine to the production rate of machine

QUALITY:

It takes in to account the quality losses and is calculated as : Quality = Good Count / Total Count.

Percentage of good parts out of the total parts produced on the machine. The OEE measure is central to the formulation and execution of a TPM improvement strategy. This project aims in bringing the OEE near to 65% and gradually moves up towards world class manufacturing. TPM employs OEE as a quantitative parameter for measuring the performance of a production system. OEE is the core metric for measuring the success of TPM implementation program. The overall goal of TPM is to raise the overall equipment effectiveness. TPM is a program that “addresses equipment maintenance through a comprehensive productive- maintenance delivery system covering the entire life of the equipment and involving all employees from production and maintenance departments to top management. There are 8 pillars of TPM or we can say that there are 8 steps in the implementation of TPM which are shown in Fig1.We will now further see the objectives of these pillars and their respective implementation.

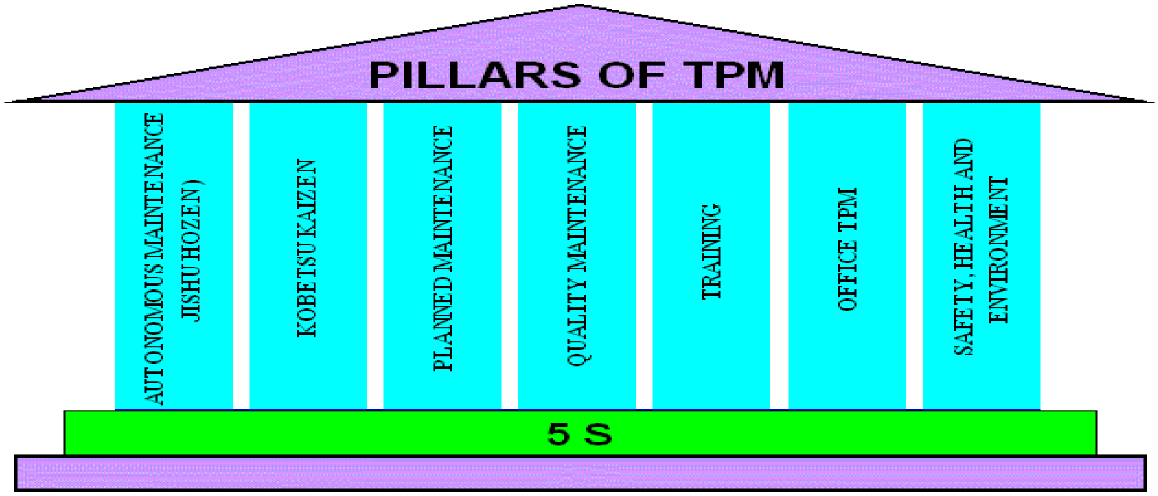


Fig1: Pillars of TPM.

2. PROBLEM DEFINITION

Historical data showed that the OEE of the wire cut CNC machine (Robofill-240SL) was very low compared to general manufacturing scenario. The following Figure2 shows the OEE of machine. The figure clearly shows that the OEE of the machine is very low. The average OEE shown is 43% in the three months. So our main aim is to increase the OEE of the machine.

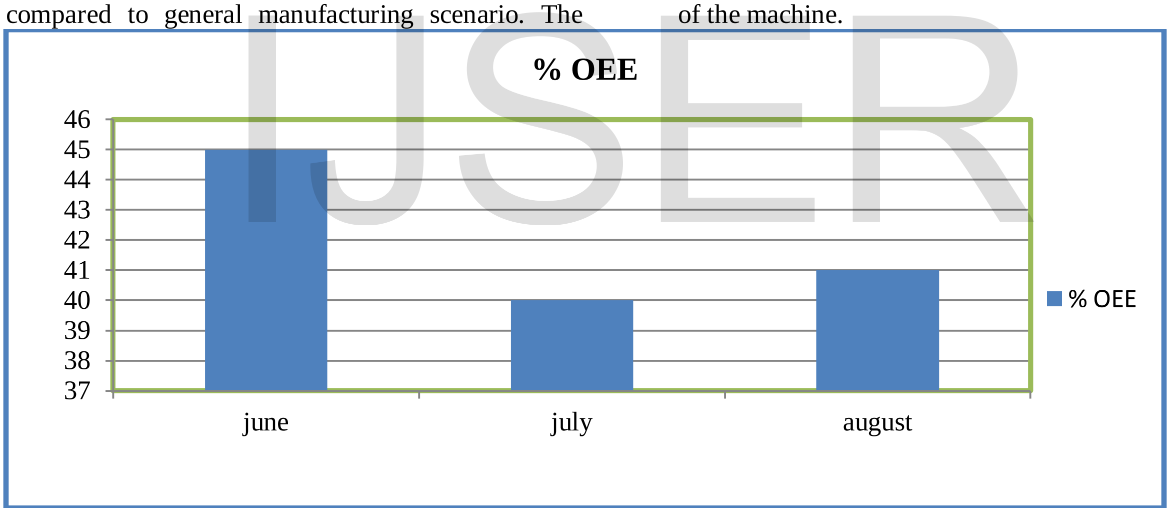


Fig2: OEE of machine in last 3 months

2.1 METHODOLGY FOLLOWED

1. Data collection, Machine history study.
2. Analysis the problems using Quality tools & evaluate them,
3. Training of employees to achieve autonomous maintenance of the machines.
4. Maintaining 5s in the machine surrounding.
5. Replicating success across the different machines in the cell layout.

3. IMPLEMENTATION OF TPM

We will now study the steps of TPM in detail and their implementation on the machine whose OEE has to be increased.

(i) Implementation of 5S on this Machine:

5S are defined as Sort, Set in Order, Shine, Standardize and Sustain. Because each of the five pillars begins with S, this method was appropriately named 5S. These 5S are implemented on TPM model section.

5S – Sort: The first pillar of 5S helps to clearly distinguish the items needed in a work area from those no longer needed. At work place, various items have been sorted out on the basis of priority of use. Low priority denotes the less frequency of use while high priority shows the items used daily/frequently.
5S - Set In Order: The second pillar of 5S helps to keep the needed items in the correct place to allow for easy and immediate retrieval. The correct place, position, or holder for every tool, item, or material must be chosen carefully in relation to how the work will be performed and who will use them easy identification. At company, for organizing activity, the components were stored according to their code number so assigned that the high priority items are located very near to the operator.
5S – Shine: The third pillar of 5S helps to keep work areas, all work surfaces and equipment clean and free from dirt, debris, oil, etc. At company, all the persons from managers to operators were engaged for cleaning their table, chair and cabin.
5S – Standardize: The fourth pillar of 5S defines the standard activities, procedures, schedules and the persons responsible for keeping the workplace in a clean and organized manner.
5S – Sustain: SUSTAIN is the last pillar of 5S and drives the organization to be disciplined in maintaining these new standards and procedures and in continuously improving the 5S state of the workplace.

(ii) Implementation of Autonomous Maintenance (Jishu Hozen)- Jishu Hozen also called autonomous maintenance is a team-based approach to maintenance activities. The goal of autonomous maintenance is to prepare operators to do some equipment care independently of the maintenance staff. Jishu Hozen implementation lays the foundation for other maintenance activities by establishing the basic conditions for a machine's operation. Various tentative standards for cleaning, inspection and lubrication are set for machine. Standards for cleaning are as follows.

Table 1: Standards for cleaning

Sr no	**Location**	**Method of cleaning**	**Standard**	**Time**	**Frequency**
1	Operator table	Dry cloth	No mist	1 min	Shift
2	Pedestal platform	Wire brush	No mist	2 min	Week
3	Work head	Dry cloth	No chips/oil	2 min	Daily
4	Hydraulic tank outside	Dry cloth	No mist	5 min	Week
5	Hydraulic pipe cleaning	Dry cloth	No dust/oil	5 min	Week
6	Machine back	Dry cloth	No oil	2 min	Daily
7	Electric panel	Dry cloth	No oil	2 min	Daily
8	Coolant tank	Dry cloth	No mist	10 min	Week
9	Electric motor	Dry cloth	No dust	2 min	Week

Table 2: Standards for Inspection

Sr no	Location	Method of inspection	Standard	Time	Frequency	Action if not OK
1	Hydraulic tank oil level	visual	Max and Min	20 sec	week	Fill oil
2	Chip collector	visual	Filled to top	10 sec	daily	Cleaning required
3	DC valve	visual	No leakage	15 sec	daily	Inform maintenance

Table 3: Standards for Lubrication

Sr no	Location	Method of Lubrication	Type of oil/greese	Frequency
1	X , Y , Z axis	Manual	Greese	Month
2	Ball screw	Manual	Greese	Week
3	Spindle	Manual	Greese	Month

(iii) Implementation of Kobetsu Kaizen.

This includes all activities that maximize the overall effectiveness of equipment, processes, and plants through uncompromising elimination of losses and improvement of performance (Suzuki 1994). Kaizen in Japanese context simply means change (kai) for the better (zen). Several Kaizens are performed on the machine. A proper kaizen sheet is filled for each kaizen, which contains all information like before and after ideas and benefits. A Kaizen sheet consists the problems detected and their solutions in short and the sheet is fed in to the input of the machine so that operator or the Engineer will have its solution without wasting the time thus increasing the availability of machine. Some of the Kaizens performed on machine are shown in below table.

Table 4: Problems and their solutions

Kaizen no	Kaizen theme	Problem	Idea	Results	Benefits
1	To provide Cover for machine head	Chips and oil split out while working	Design of proper covering system	Splitting of oil and chips is avoided	More clean space. Machine works properly
2	To provide plastic cover on control panel	Oil can go in to control panel which causes short circuit	Plastic cover should be provided	Panel looks more neat and clean more safe	Less cleaning is required and more safe
3	To change the design of the water tank	Oil comes with chip and is not seperated	To separate oil and chips in water tank by changing its design	Chips don’t get mixed with the oil	Wastage of oil is reduced
4	To fix filter	Oil becomes contaminated	Fix the filter	Contamination stopped	Clean oil
5	To replace glass of load pane	Looks bad	Provide glass	Easy to visualise	Looks good
6	To provide bolts on motor	Improper working	Provide bolts	Motor works properly	Motor safe

Kaizen no	Kaizen theme	Problem	Idea	Results	Benefits
7	To change the design of coolant nozzle	Difficult to operate	Design a new nozzle	Coolant directly falls on job	Wastage of coolant reduced
8	To replace the scale of worktable	Not properly visible, misadjustment	Replace it	Easy to take readings	Proper readings available
9	To provide bulb and cover on control panel	Indication is not achieved	Provide bulb and cover	Indication is received	Indication is received
10	To change the headstock scale	Scale no are totally damaged due to dust	Replace an old scale	Operators machine set up time reduced	Improved efficiency
11	To provide nut on column	Vibrations	Provide nut on right side of the column	Vibrations stopped	Easy to work
12	Clean and check nozzle size, check moisture.	Machine giving faulty edges on the job	Due to pressure, Moisture content in gases, or Movement of machine. X axis parallel movement not ok due to dirty	Machine not giving faulty edges	Quality product
13	Adjust the clearance between nozzle and plate.	Machine giving rough edges.	Clearance between nozzle and plate too high.	Machine giving smooth product	Quality product.
14	Control the feed rate and speed.	Incomplete cut and end not cut through.	Feed rate too high	Machine giving complete cut.	Quality product
15	Oxygen Pressure high	Adhering Slag, Slag burrs.	Cutting Oxygen Pressure too low.	No slags.	Cutting Nozzle safe.
16	Sufficient Preheating	Cracks in the cut surface.	Insufficient Preheating.	No Cracks.	Quality product.
17	Cutting Oxygen supply to be continous.	Cut surfaces undulating in the direction of the cut.	Cutting oxygen supply briefly interrupted	Clean cutting surfaces.	Cutting nozzle safe.

(iv)Planned Maintenance- The Planned Maintenance pillar activities are normally led by the maintenance team. The routine maintenance thus comes under the planned maintenance. For reducing the breakdown time of the machine, we weekly performed Routine Maintenance Operation on the machine. During preventive maintenance operation the most critical are cleaned or replaced if wear out. This pillar aimed toward to have a trouble free machine and equipments for improving the reliability and maintainability and also for total customer satisfaction for the products. Planned Maintenance are mainly divided into four categories:
(1) Preventive maintenance
(2) Breakdown maintenance
(3) Corrective maintenance
(4) Routine Maintenance.

(v) Quality Maintenance- Quality Maintenance is implemented in two phases. The first phase aims to eliminate quality issues by analysing the defects, so that optimum conditions can be defined that prevent defects occurring. Then, the current state is investigated and improvements are implemented. The second phase ensures that quality is sustained, by standardising the parameters and methods to achieve a zero defect system. This pillar aimed toward achieving the customer requirement through highest Quality through defect free manufacturing. Through focused improvement, defect the process after identifying the parameters of machine which mainly affect the products. QM activities are to set equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products.

The condition is checked and measure in time series to very that measure values are within standard values to prevent defects. The key is to prevent defects from being produced in the first place, rather than installing rigorous inspection systems to detect the defect after it has been produced.

(vi) Training- Training and Education is the sixth pillar of TPM. It ensures that operators are trained in the skills identified as essential both for their personal development and for the successful deployment of TPM in line with the organization's goals and objectives. Initially the knowledge and skills required for carrying out each job are defined,

in terms of both complexity of knowledge needed and the number of capable people required to support the business needs. A current state analysis assesses the current levels against the established requirements and a training plan is developed to close any gaps. This plan is implemented and evaluated to ensure that the activity generates the improved capabilities targeted. The pillar team then designs, implement and improve a 'Skill Development System' to enable on-going development of all employees. As the TPM program develops, the pillar will expand to cover broader roles and increasingly complex training needs. TPM education and training program has been prepared which is oriented towards three goals:

• Managers will learn to plan for higher equipment effectiveness and implement improvements aimed at achieving zero breakdowns and zero defects.

• Maintenance staff will study the basic principles and techniques of maintenance and develop specialized skills concerning the company's equipment.

• Equipment operators will learn how to recognize equipment abnormalities as such during their daily and periodic inspection activities.

(vii) Office TPM- Office TPM is the seventh pillar and concentrates on all areas that provide administrative and support functions in the organization. The pillar applies the key TPM principles in eliminating waste and losses from these departments. The pillar ensures that all processes support the optimization of manufacturing processes and that they are completed at optimal cost. This pillar should be started after its successful activating of four pillar of tpm which are JH, KK, QM, PM office tpm must be followed to improve productivity and efficiency of the administrative functions. Due analyzing process and procedures towards increasing in the office automation office TPM has some major losses such as processing loss, cost loss, idle loss, setup loss, office equipment breakdown.

(viii) Safety, Health and Environment- Safety, Health and Environment (SHE) is the final TPM pillar and implements a methodology to drive towards the achievement of zero accidents. It is important to note that this is not just safety related but covers zero accidents, zero overburden (physical and mental stress and strain on employees) and zero pollution. Although the SHE pillar is the eighth pillar of TPM, it should not be thought of as the last to be deployed. The implementation of SHE strategies occurs throughout the TPM deployment process and SHE activities are never complete. To create awareness among employees various safety slogans, posters, etc. related to safety were put. Special attention was paid regarding health by keeping first-aid box near the machine which could prove useful during emergency. After applying the 8 pillars of TPM for 6 months, we are now calculating the new OEE (Overall Equipment and Effectiveness) in the below table

Table 6: OEE Calculation sheet

A	Shift time(General)	480 min
B	Planned downtime	60 min
C	Running time(A-B)	420 min
D	Running time losses	58 min
E	Operating time(C-D)	362 min
F	Availability(E/C) x100	86.2
G	Output	207 pieces
H	Machine speed(no of components/min)	0.75
I	Expected output(H x E)	271 (No of pieces)
J	Performance(G x 100)/I	76.38
K	Rejection	3
L	Quality(G-K x 100)/G	98.5

Therefore, OEE= Availability X Performance X Quality
= 86.2 X 76.38 X 98.5 =65%.

4. RESULTS AND CONCLUSION

From the previous records the Efficiency was only 43%, the availability was 68%, Performance was 65% and Quality was 98%.After successful implementation of TPM, it is found that Overall Equipment Effectiveness is increased.

The Availability of the machine was increased to 86.2%.

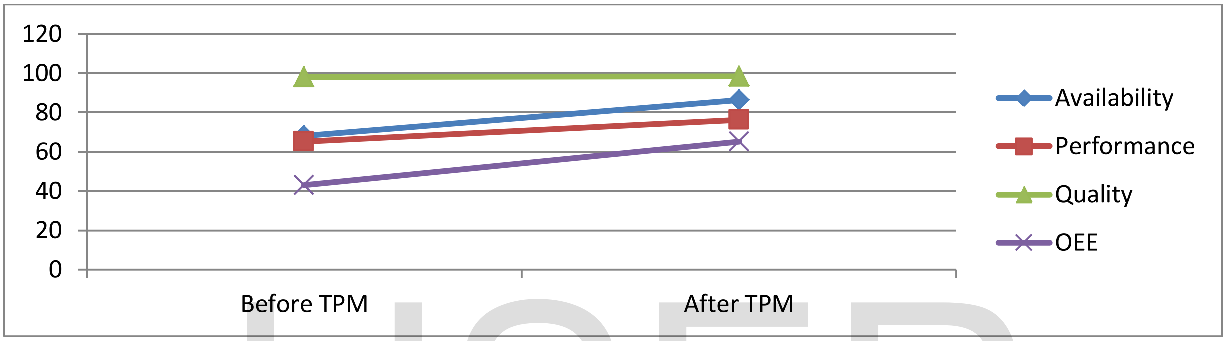
The Performance was increased to 76.38%

The Quality was increased to 98.5%.

The OEE was increased to 65%

The following graphs below give the availability, performance and OEE before TPM implementation and after TPM implementation.

Fig3: Comparison of OEE terms before and after the implementation of TPM



After the implementation of TPM we finally come to the conclusion that there are several direct and indirect benefits of TPM. The benefits are as given below.

Direct benefits of TPM

1) OEE is improved.
2) Customer complaint reduced.
3) reduction in manufacturing cost
4) Satisfying the customer need by 100%.
5) Reduced accidents.

Indirect benefits of TPM

1)Confidence of Employees increase.
2) A clean, neat and attractive Workplace.
3)Favorable change in the attitude of the operators.

The main thing about TPM is that it has to be carried out for year or more than one year. If we apply TPM for more than one year, it is sure that we will get the world class OEE of more than 80%.

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