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Experimental Investigation to Deploy Overall Equipment Effectiveness (OEE) In CNC Machining Line of an Automobile Component Production Industry Using TPM

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ABSTRACT

Productivity plays a vital role in real time industries in order to improve the output percentage in machining line. This Research complies with implementing Total Productive Maintenance in CNC Machining line in an automobile component manufacturing company. Industries in current scenario are spending huge amount in implementing new machines and equipments, but unfortunately concentration to improve productivity become less by achieving maximum productivity from a machine for which it is really designed for. Normal behaviour of machine is defined in an order, such as minor loses in time and deviations from actual designed capability. 5S Technique is implemented in order to implement the Total Productive Maintenance (TPM), which is part of implementing a cognitive maintenance plan with involvement of everyone from Top management to lower level employees throughout the production plan of equipments in an organization. Research comes up with neat and tidy work environment, improved morale of employees, creating maximum effectiveness of equipments which results in Overall Equipment Effectiveness (OEE). Previous results of the production line are compared with Research results and effectiveness of equipments. At the end of the report over all equipment effectiveness OEE is compared with previous results.

Keywords: 5S, Total productive maintenance (TPM), Overall equipment effectiveness (OEE), 5S, CNC Machining Line, Autonomous maintenance, Preventive maintenance.

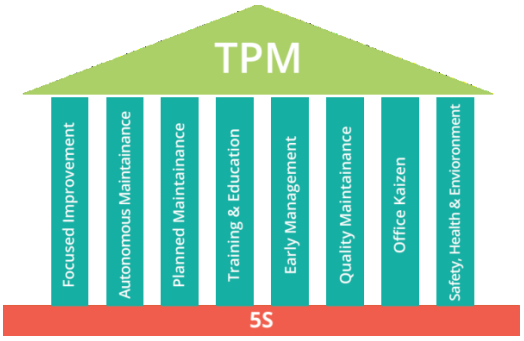
I. INTRODUCTION

In order to be successful in today's world-class manufacturing environment companies have to fulfil several requirements. Maintaining a reliable manufacturing process is a key success factor to satisfy these requirements which can be achieved through implementing a proper maintenance strategy. Any operation or process done on machine or its parts to enhance the efficiency of machine before or after the breakdown is called maintenance. In the recently released European Standards regarding maintenance, maintenance is defined as "the combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function". A manufacturing business is said to be prosperous over the years, when it runs non-interrupted and always maintains a stable and high productive production flow. Plant can achieve productivity up to a satisfactory level by proper maintenance work. An efficient maintenance strategy not only reduces the probability of breakage of machine elements or shutdown of machines which hinders the production's schedule, but also such a strategy enhances the efficiency and life-span of machines, process quality and labour force productivity. Total Productive Maintenance (TPM) has widely been accepted as an effective strategy for improving maintenance in the manufacturing companies. Especially in the last decades because of a growing competitive environment the importance of TPM has increased. Therefore in this paper by getting help from system dynamics which is a part of system thinking concept the effects of implementing TPM on machine breakdowns, machine reliability, process quality, machine and labour force

utilization for production in manufacturing companies is investigated.

The Japanese, based on the planned approach to preventive maintenance (PM), evolved the concept of total productive maintenance (TPM). Nakajima (1986) outlines how, in 1953, 20 Japanese companies formed a PM research group and, after a mission to the USA in 1962 to study equipment maintenance, the Japan Institute of Plant Engineers (JIPE) was formed in 1969, which was the predecessor to the Japan Institute of Plant Maintenance (JIPM). In 1969, JIPE started working closely with the automotive component manufacturer Nippondenso on the issue of PM, and when the company decided to change roles of operators to allow them to carry out routine maintenance this was the beginning of TPM. Tajiri and Gotah (1992) point out that whilst TPM was communicated throughout Japan only a small number of factories took up the challenge. It was the severe economic situation in the early 1970s that accelerated the adaptation of TPM, propagated by the seven-step programme developed by the Tokai Rubber Industries (see Nakajima, 1989). In the early 1990s, Western organisations started to show interest in TPM following on from their total quality management (TQM) interventions. The more academic papers focus on the relationship of TPM with other productivity.This paper examines how TPM was implemented at automobile manufacturing companies to improve overall equipment effectiveness.

II. PILLARS OF TPM



2.1 PILLAR 1 - 5S

TPM starts with 5S. Problems cannot be clearly seen when the work place is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement.

2.2 PILLAR 2 - JISHU HOZEN (Autonomous maintenance)

This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time on more value added activity and technical repairs. The operators are responsible for upkeep of their equipment to prevent it from deteriorating.

2.3 PILLAR 3 - KAIZEN

"Kai" means change, and "Zen" means good (for the better). Basically kaizen is for small improvements, but carried out on a continual basis and involve all people in the organization. Kaizen is opposite to big spectacular innovations. Kaizen requires no or little investment. The principle behind is that "a very large number of small improvements are move effective in an organizational environment than a few improvements of large value. This pillar is aimed at reducing losses in the workplace that affect our efficiencies. By using a detailed and thorough procedure we eliminate losses in a systematic method using various Kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

2.4 PILLAR 4 - PLANNED MAINTENANCE

It is aimed to have trouble free machines and equipments producing defect free products for total customer satisfaction. This breaks maintenance down into 4 "families" or groups which were defined earlier.

[1] Preventive Maintenance
[2] Breakdown Maintenance
[3] Corrective Maintenance
[4] Maintenance Prevention

With Planned Maintenance we evolve our efforts from a reactive to a proactive method and use trained maintenance staff to help train the operators to better maintain their equipment.

2.5 PILLAR 5 - QUALITY MAINTENANCE

It is aimed towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating non-conformances in a systematic manner, much like Focused Improvement. We gain understanding of what parts of the equipment affect product quality and begin to eliminate current quality

concerns, then move to potential quality concerns. Transition is from reactive to proactive (Quality Control to Quality Assurance).

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 conditions are checked and measure in time series to very that measure values are within standard values to prevent defects. The transition of measured values is watched to predict possibilities of defects occurring and to take counter measures before hand.

2.6 PILLAR 6 - TRAINING

It is aimed to have multi-skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient know only "Know-How" by they should also learn "Know-why". By experience they gain, "Know-How" to overcome a problem what to be done. This they do without knowing the root cause of the problem and why they are doing so. Hence it become necessary to train them on knowing "Know-why". The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phases of skills are

Phase 1 : Do not know.
Phase 2 : Know the theory but cannot do.
Phase 3 : Can do but cannot teach
Phase 4 : Can do and also teach.

2.7 PILLAR 7 - OFFICE TPM

Office TPM should be started after activating four other pillars of TPM (JH, KK, QM, PM). Office TPM must be followed to improve productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation. Office TPM addresses twelve major losses. They are

[1] Processing loss
[2] Cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories
[3] Communication loss
[4] Idle loss
[5] Set-up loss

2.8 PILLAR 8 - SAFETY, HEALTH AND ENVIRONMENT

In this area focus is on to create a safe workplace and a surrounding area that is not damaged by our process or procedures. This pillar will play an active role in each of the other pillars on a regular basis.

A committee is constituted for this pillar which comprises representative of officers as well as workers. The committee is headed by Senior vice President (Technical). Utmost importance to Safety is given in the plant. Manager (Safety) is looking after functions related to safety. To create awareness among employees various competitions like safety slogans, Quiz, Drama, Posters, etc. related to safety can be organized at regular intervals.

III. OVERALL EQUIPMENT EFFECTIVINESS

TPM initiatives in production help in streamlining the manufacturing and other business functions, and garnering sustained profits. The strategic outcome of TPM implementations is the reduced occurrence of unexpected machine breakdowns that disrupt production and lead to losses, which can exceed millions of dollars annually. Overall equipment effectiveness (OEE) methodology incorporates metrics from all equipment manufacturing states guidelines into a measurement system that helps manufacturing and operations teams improve equipment performance and, therefore, reduce equipment cost of ownership (COO). TPM initiatives are focused upon addressing major losses, and wastes associated with the production systems by affecting continuous and systematic evaluations of production system, thereby affecting significant improvements in production facilities. The evaluation of TPM efficiency can facilitate significantly enhanced organizational capabilities across a variety of dimensions. TPM employs OEE as a quantitative metric for measuring the performance of a productive 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. OEE is calculated by obtaining the product of availability of the equipment, performance efficiency of the process and rate of quality products.

3.1 OEE CALCULATION

OEE=Availability x Performance x quality

Availability= (shift time-losses)/shift time

Performance= (Cycle time x No of product processed)/Availability Time

Quality = (No of parts production-Rejection x 100)/No of parts production

OEE measurement is made up of three underlying elements, each one expressed as a percentage and accounting for a different kind of waste in the manufacturing process.

IV. PROBLEM DEFINITION

a) Due to improper arrangements there is high fatigue to operator to operate the machines.
b) Due to insufficient training materials rejection is high.
c) Manual inspection takes more time to check the quality of component.
d) Early equipment management is very low.
e) Tool setting time is comparatively high.
f) Safety precautions to the workers need to improve.

V. OBJECTIVE OF THE RESEARCH

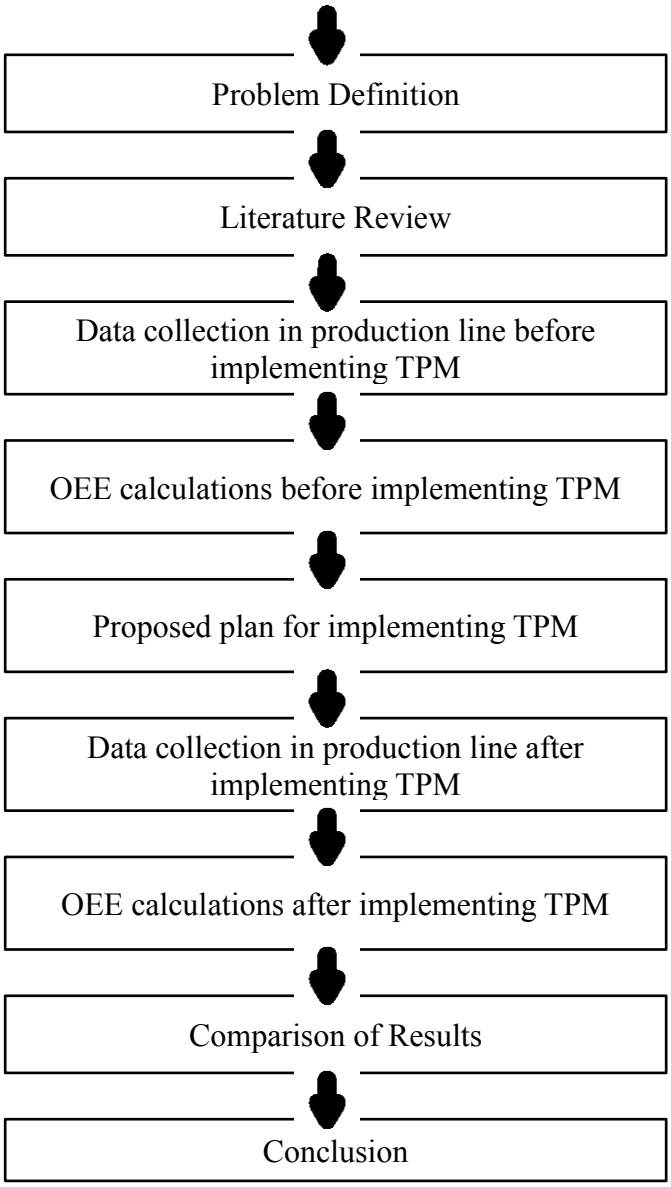
a) To reduce the operator fatigue.
b) To increase the productivity.
c) To minimize the rejection of materials.
d) To decrease the setting time.
e) To maximizes quality of inspection.
f) To give sufficient training to workers.
g) To ensure safety and health of workers.
h) To increase overall equipment effectiveness (OEE).

VI. SUMMARY OF LITERATURE REVIEW

a) TPM implementation methodologies to be discussed step by step and systematic approach to understand the equipment's function, the equipment's relationship to the product quality and the likely cause of failure of the critical equipment conditions is investigated. [1,7,8,9,10,15,16,]
b) TPM implementation success factors like top management leadership and involvement, traditional maintenance practices and holistic TPM implementation initiatives, towards affecting improvements in manufacturing performance in the Manufacturing industry. [3,12,14,]
c) This paper deals the effects of implementing TPM on machine breakdowns, machine reliability, process quality, machine and labor force utilization for production in manufacturing companies and small scale industries is investigated. [11,13,17]
d) Evaluation technique of TPM implementation and Global performance evaluation for continuous improving of the production process is investigated. [10]

VII. METHODOLOGY

The following are the basic steps need to be carried in the current project.



VIII. DATA COLLECTION AND OEE CALCULATION BEFORE IMPLEMENTING TPM

Data are collected and recorded for the actual production on a shift basis in the production machining line before implementing TPM. It helps to find out the overall equipment effectiveness of machining line before implementing TPM. It also helps to visualize the root causes and possible solution for the problem.

Table I.
Production machining line OEE before TPM

Month	No of Sets	Productivity	Availability	Performance	Quality	OEE
Dec	8125	81.25	82.95	89.04	99.44	73.44
Jan	8625	96.25	87.50	89.10	99.36	77.46
Feb	9150	91.50	90.72	91.66	99.64	82.85

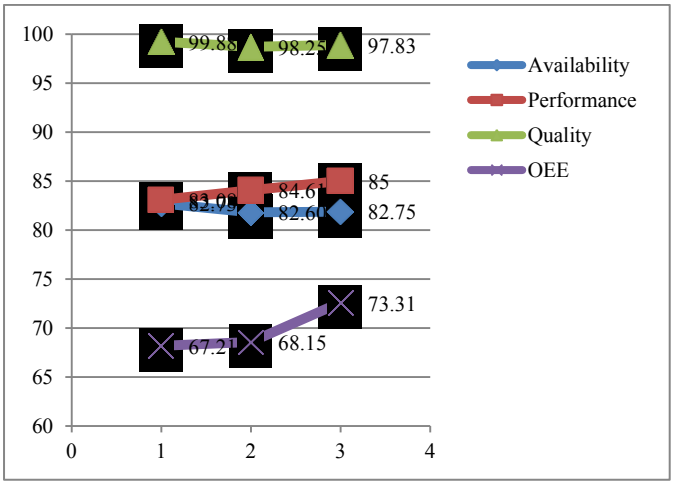


Fig.1: Production machining line OEE chart before TPM

8.1 PROPOSED PLAN FOR IMPLEMENTATING TPM

- Introductory education and propaganda
- Formation of TPM committee
- Development of master plan for TPM
- Stage by stage training to the employees
- Stake holders on eight pillars of TPM
- Implementation preparation process
- Establishing the TPM policies and goals

8.2 STEPS IN IMPLEMENTING TPM

Step 1: Announcement of TPM. Top management needs to create an environment that will support the introduction of TPM. Without the support of management, skepticism and resistance will kill the initiative.

Step 2: Launch a formal education program. This program will inform and educate everyone in the organization about TPM activities, benefits and the importance of contribution from everyone.

Step 3: Create an organizational support structure. This group will promote and sustain TPM activities once they begin. Team-based activities are essential to a TPM effort. This group needs to include members from every level of the organization – from management to the shop floor. This structure will promote communication and will guarantee everyone is working toward the same goals.

Step 4: Improve the effectiveness of each piece of equipment. Project teams will analyze each piece of equipment and make the necessary improvements.

Step 5: Develop an autonomous maintenance program for operators. Operators' routine cleaning and inspection will help stabilize conditions and stop accelerated deterioration.

Step 6: Develop a planned or preventive maintenance program. Create a schedule for preventive maintenance on each piece of equipment.

Step 7: Conduct training to improve operation and maintenance skills. The maintenance department will take on the role of teachers and guides to provide training, advice and equipment information to the teams.

Step 8: Develop an early equipment management program. Apply preventive maintenance principles during the design process of equipment.

Step 9: Continuous improvement. As in any lean initiative, the organization needs to develop a continuous improvement mind-set.

8.3 DATA COLLECTION AND OEE CALCULATION AFTER IMPLEMENTING TPM

Data are collected and recorded for the actual production on a shift basis in the production machining line after implementing TPM. It helps to find out the

overall equipment effectiveness of machining line after implementing TPM.

TABLE.II
Production machining line OEE after TPM

Month	No of Sets	Productivity	Availability	Performance	Quality	OEE
Sep	8101	81.01	82.73	83.08	99.21	68.18
Oct	8091	80.91	81.82	84.06	98.70	68.56
Nov	8500	85.00	81.88	85.00	98.88	72.58

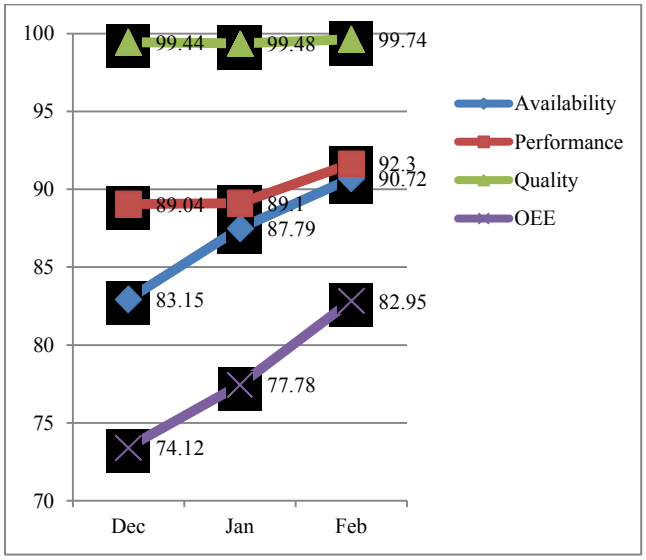


Fig.2: Production machining line OEE Chart after TPM

IX. RESULTS AND DISCUSSION

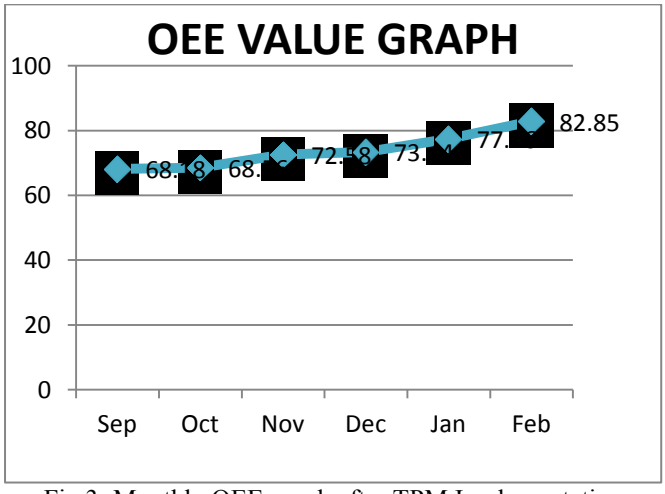


Fig.3: Monthly OEE graph after TPM Implementation

- As a result of TPM implementation OEE has improved from 72.58% to 82.85%, it indicates the improvement in productivity and improvement in quality of product.
- It is observed that better quality rate has been achieved as a result of implementing TPM.
- It improves customer satisfaction, inventory handling, production rate, quality and transportation of component.

9.1 BENEFITS OF TPM IMPLEMENTATION

- Increased rate of productivity and improved OEE value.
- Reduction of complaints from customer.
- Reducing manufacturing cost upto 30%.
- Satisfying the customer needs.
- Improved product quality.
- Increased employee morale.
- A clean, neat and attractive work place.
- Favorable change in the attitude of the operators.

X. CONCLUSION

Overall Equipment Effectiveness is achieved with implementation of TPM in a CNC production line of an automobile production industry. Key benefits with detailed analysis is reported with roadmap and benefits achieved with OEE. Research Emphasis on progressive growth in productivity in CNC line, which increases the rate of production with reduced defects and increase in availability of equipment. A manufacturing facility has been studied and analyzed to study TPM implementation issues, the roadmap followed and the key benefits achieved from OEE as a result of TPM implementation. OEE value is constantly increasing and with the comparative of time results will be quite good and may reach a world class OEE value of 86%-92%. TPM has been trending towards the key feature of manufacturing environment. TPM process focuses on minimizing the failures and deterioration of equipments with improvement in cost and quality of product. After enhancement of equipment standards the total Cost of repair and damages has been drastically reduced due to reductions in equipment failure. Thus, the overall effectiveness of equipment also improved significantly. Additionally, equipment deterioration was eliminated as the equipment operates in good condition and efficiently. To achieve organisation goal, improvements on operator's morale and

training can be provided with little towards training and education.

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