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Implementation of TPM in a Small Scale Industry through Fuzzy Logic Simulation Model

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Abstract—*In today's industrial scenario all industries are looking for their maximum growth by supplying best quality products with as much as possible low cost. In order to achieve maximum return on investments, company must think about to minimize plant downtime, increase productivity, improve quality and deliver orders to customers without fail. To achieve this success, company must have good maintenance practice in their company because huge amount of losses occur due to poor maintenance policy. In this work, we found the major losses as well as overall equipment effectiveness (OEE) of selective machines in industries. OEE calculation is very important for knowing the condition and performance of the machines in industry. Total productive maintenance (TPM) has been introduced in the industry which involves a concept for maintaining plants and equipment. In this work, past data has been collected from the industry which has been analysed and then the suggestion on the basic of the observation has been given. There are lots of problems which were identified during the study and among which the major problem were the slow production rate and unavailability of machine and manpower. 5's technique, preventive maintenance concepts in industry has also been implemented. After implementation of the TPM concepts lots of benefits like improved the overall equipment efficiency of the equipment, productivity and employees morale have been found. This paper shows how to optimise losses and OEE through application of TPM with the help of fuzzy logic simulation model.*

Keywords*: Total Productive Maintenance (TPM), 5'S Technique, Overall Equipment Effectiveness (OEE), Fuzzy Logic.*

1. INTRODUCTION

In today's industrial scenario all industries are looking for their maximum growth by supplying best quality products with as much as possible low cost, because to survive in global competitive market everyone thing about their customer satisfaction. In this scenario company must think about elimination of losses which are occurring in shop floor. Huge amounts of losses occur in the manufacturing shop floor due to operator's maintenance, tooling problems and non-availability of components, frequent machine breakdown in the time of work and quality related waste which is most important because its matter of the company in terms of time, materials and mainly reputation of the company. Most of the company are enabling to survive as a result they are shutdown their plant due to these losses. To survive in present situation company must think about zero defects, zero breakdown and zero accidents and as much as possible minimizing losses by the development of good maintenance practice. Total Productive Maintenance (TPM) is a unique Japanese philosophy combines with American preventive maintenance and total involvement of employees and also a program for fundamental improvement of the maintenance functions in an organization, which involves its entire human resources. A. Jain et al. [6] said that if any organization whether it is small or big or global after implementation or following the golden pillars of TPM, get guaranteed success but it is necessary that it is Implemented and follow completely and with believe. B.A. Najjar et al [1] have assessed the most popular maintenance approaches using a fuzzy multiple criteria decision making (MCDM) evaluation methodology. They describe that using fuzzy MCDM would be possible to select in advance, the most informative maintenance approach. They also discussed that this methodology lead to less planned replacement, and failures would be reduced to approximately zero and higher utilization of component life can be achieved. Z. Tahiret al [2] have used decision making grid (DMG) with fuzzy logic in maintenance decision support system (DSS) to carry out the computations for calculating frequency of failures and downtime as the maintenance data problems.

V.D. Kedaria et al [10] highlighted that TPM is day-to-day activity with involvement of all employees and commitment of top management.

The aim of this paper is to present the implementation methodology for the TPM and develop a maintenance policy to enhance the overall equipment efficiency (OEE) and established a maintenance practice by fuzzy logic.

2. PILLARS OF TPM

According to H.R.Rajputet al [4] TPM program is based on the implementation of a series of 8 pillars of TPM in a

systematic way to optimize plant and equipment efficiency by creating perfect relationship between man and equipment.

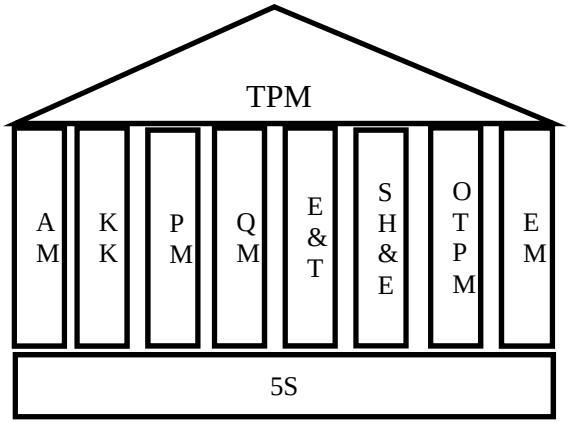

Fig. 1. Pillars of TPM

TPM starts with5'S. It is called as foundation of TPM. If any organisation follow 5's fully then few pillars of TPM automatically implemented. It is a way of housekeeping. Good housekeeping is the first step toward quality achievement in any organization. It boosts employee morale and inspires customer confidence. Good quality management practices can prosper only in clean and serene atmosphere. Poor workplace conditions may lead to rising of waste, accident, more time spent in searching for item needed. So it is very important tool for any industry. It is a systematic and rotational approach to work place organization and methodical housekeeping with a sense of purpose.

It is divided into five parts one is seiri, it means is sorting. It is an excellent way to free up valuable space. Few steps like Sort-out the necessary and unnecessary items and then put necessary items in assigned place, Use green tag and red tags on the place where necessary and unnecessary items are kept, repair those items which are currently not in the working condition but are useful and repairable etc. are have been taken.

The second part of 5's is seiton, it means organized. This is help to keep the needed items in the correct place to allow for easy identification and immediate retrieval. For seiton implementation few activities like Pre –fix a place for everything required and put everything in its place, name everything required and assign their location, plan storage based on frequency of use have been taken.

The third part of 5's is seiso, it means shine. Its keeps work stations and equipment clean and free from dirt, debris, oil, etc. The presence of dust on instruments and materials and equipment can cause scratches, blockage, leakage, electrical defects and quality defects. So everyone, right from top man to workers must do cleaning. It is not a one-time activity. Some sort of activities of cleaning needs to be developed and regular follow up is necessary to sustain this improvement. Few activities like clean machine before start and finish of operations, Remove scrap, clean shop floor daily, clean tools, Prepare schedule for cleaning have been developed.

The fourth part of 5's is seiketsu, it means standardised. Seiketsu is repeatedly following of 'seiri', 'seiton', 'seiso', for maintaining safe and hygienic condition.

The five part of 5's is shitsuke, it means sustain and Sustain also means 'Discipline'. It denotes commitment to maintain orderliness and to practice first 3S as a way of life. This also requires that employees show positive interest and overcome resistance to change. Few activities like, Create5'S Slogans, Work together on specific 5'S projects, Make friendly environment, Conduct good telephonic and communication exercise, Make good relationship with customers and suppliers, Follow housekeeping rule strictly, Maintain discipline have been developed and followed.

2. I. Autonomous Maintenance (AM):

It aims to create a scenario where all operators look after own equipment. Few activities like carrying out routine checks, oiling and greasing, replacing parts, doing repairs, checking precision and so on have been followed.

2. II. Kobestu Kaizen (KK):

Kobestu kaizen or Individual improvement is characterized by a drive for zero losses meaning continuous improvement effort to eliminate any effectiveness. For this major loss like machine breakdown, set-up time, quality defects etc. have been identified and respective solutions have been undertaken.

2. III. Planned maintenance (PM):

The purpose of Planned Maintenance is to ensure the equipment conditions at their best with the minimum maintenance cost, enabling equipment to function at an optimal level whenever operation is required and zero breakdown by improving the efficiency of traditional preventive maintenance activity. In order to achieve this purpose, for properly equipment maintenance, production department and the maintenance department have been involved.

2. IV. Quality Maintenance (QM):

The purpose of Quality Maintenance is to produce defect free products to maintain the product quality through eliminating non-conformance to satisfy the demand of the customer. The conditions are checked and measured in time series to verify that measured values are within standard values to prevent defects. The transition of measured values watched to predict possibilities of defects occurring and to take counter measures beforehand. Prepare check list, Verification of product quality etc. have been done.

2. V. Education &Training (E&T):

For eliminating operator maintenance related losses education has been provided to operators for upgrade their skill and training has been given by day-to-day teaching and coaching and assistance with self-study.

2. VI. Safety, Health & Environment (SH&E):

Safety is the most important thing in any industry. Safety, Health and Environment (SHE) 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. For this purpose one special team has been made and the team specially work on three key areas: people's behaviours, machine conditions and the management system and few problems has been detected which may affect safety or environment, Safety audits, Pollution control related activity also has been taken.

2. VII. Office TPM:

It should be started after activating four other pillars of TPM (Autonomous Maintenance, kobestu kaizen, Planned Maintenance and Quality Maintenance).Office TPM concentrates on all areas that provide administrative and support functions in the organization. For implementation of this pillar team are arranged and divided into few parts according to area basic for maintenance. Team not made by bottom management only it also involvement of top management. Few activities like all workers are writing daily report, computer system is proposed for maintenance department, daily check of inventory standards and control system by top management etc. have been implemented.

2. VIII. Early Management:

This pillars aims to implement new product and process. For this scenario we have been collected previous experience and then to some modification have been developed on equipment and process flow line.

OEE calculation methodology:

Overall equipment effectiveness (OEE) gives the idea about machine availability, performance rate, and quality rate. For calculation of OEE data has been collected on daily basis and a mean value is calculated at the month's end. Two machines were selected and then OEE was calculated. In table 1, OEE calculation methodology has been provided and then table2 and table 3are listed out similar way.

Table 1: OEE calculation methodology of milling machine

• loading time (TL)	480 min
• Idle time (TI)	306 min
• Operating time (TO)=(TL- TI)	174 min
• Availability(A)=(TO/TL)× 100%	36.25%
• Performance rate (P) =((cycle time × Number of products processed)/ production time))× 100%	76.67%
• Quality rate (Q)=((Production input– Quality defects) / Production input) ×100%	95.29%
• Overall equipment effectiveness (OEE)=(availability × performance rate× quality rate) ×100%[5]	26.76%

Table 2. OEE of milling machine

Month	A (%)	P (%)	Q (%)	OEE (%)
October, 15	36.25	76.67	95.29	26.76
november,15	46	79.99	96.24	35.41
december,15	59.32	81	97.25	46.72

Table.3. OEE of reciprocating sawing machine

Month	A (%)	P (%)	Q (%)	OEE (%)
October,15	69.95	79.70	96.29	53.68
November,15	72	78.50	95.10	53.75
December,15	74.20	79.60	97.90	57.82

Fuzzy system implementation methodology:

In present days decision making has become very important for any organisation. To develop a decision support we have been applied most effective tool that is fuzzy logic. Fuzzy system contains following five major steps.

i) Fuzzifier ii) Rule base iii) fuzzy inference engine iv) Defuzzifier and v) Output quantity.

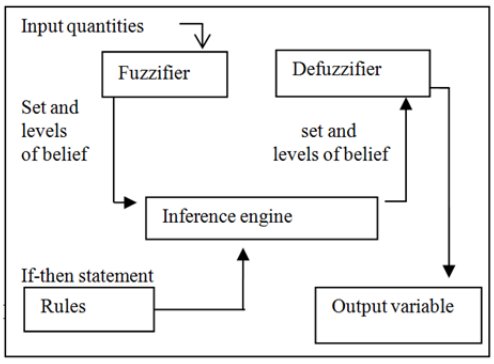

Fig. 2. Fuzzy system

For input quantities downtime, frequency and repairing cost of some machines and for output quantity maintenance practice have been taken. Centroid method has been taken for defuzzification.

- **Downtime:** It is periods of time that a system or machine are unavailable to perform or unscheduled stop periods. Downtime are categorised by range of day basis in month like if downtime in between 0-2 then it is considered as low, if in between 1-4 then it is considered as medium and in between 3-5 then it is considered as high. Three trapezoidal membership functions have been taken. Membership function for downtime has been shown in fig.3.

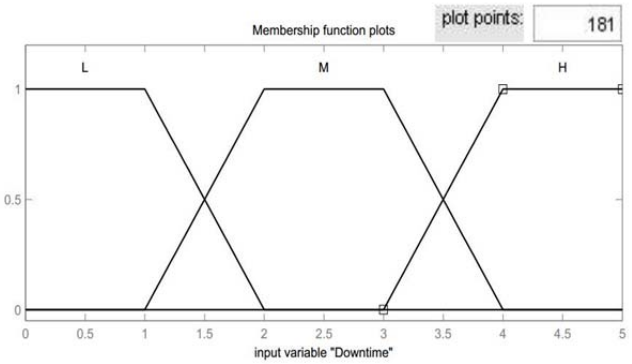

Fig. 3. Membership function for downtime

Frequency: Number of failures occurs per period. It also categorised by low for 0-2, medium for 1-4 and high for 3-5 monthly basis. Three triangular membership functions have been taken. Membership function for frequency has been shown fig.4.

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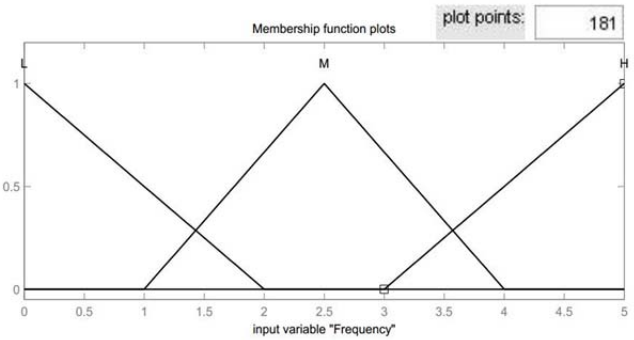

Fig. 4. Membership function for frequency

- **Cost**: Repairing cost are categorised by low, medium and high. For range of 0-20000 rupees is considered as low, for 5000-45000 rupees considered as medium and for 30000-50000 rupees considered as high. Three triangular membership functions have been taken. Membership function for cost has been shown in fig.5.

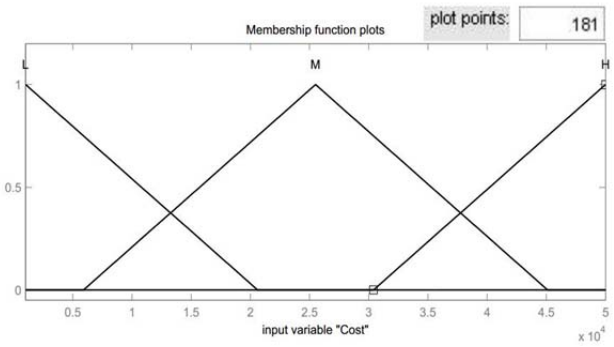

Fig. 5. Membership function for cost

- **Maintenance:** Three Gaussian membership functions have been taken and name of the membership function are breakdown maintenance which is denoted by BM, preventive maintenance which is denoted by PM and predictive maintenance which is denoted by PD. M. . Membership function for maintenance has been shown in fig.6.

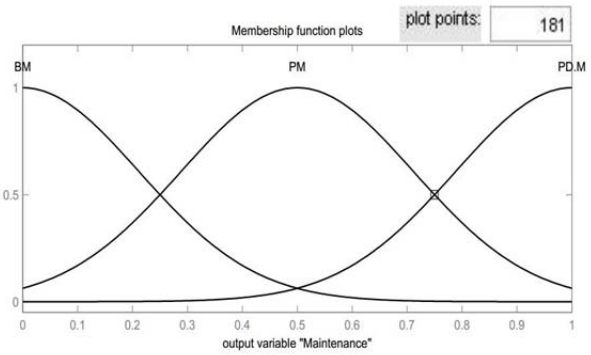

Fig.6. Membership function for maintenance

Type of maintenance with cost, frequency and downtime are shown in three dimensional plots in fig. 7, 8, and 9.

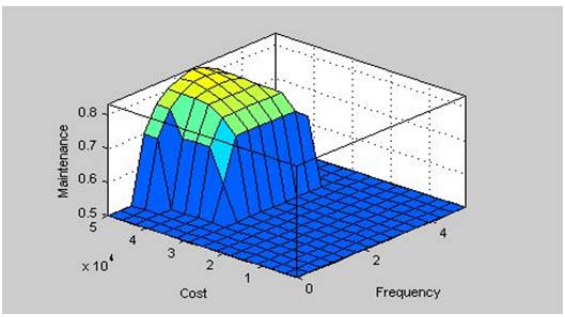

Fig. 7. Surface plot for cost, frequency and maintenance

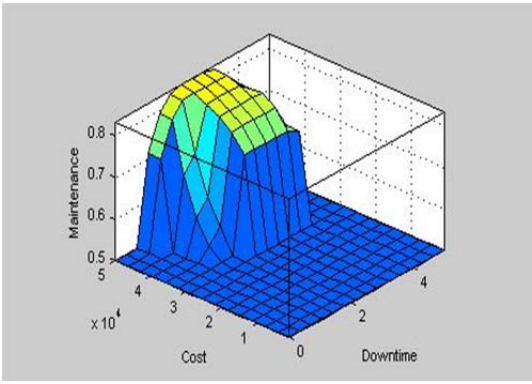

Fig. 8. Surface plot for cost, downtime and maintenance

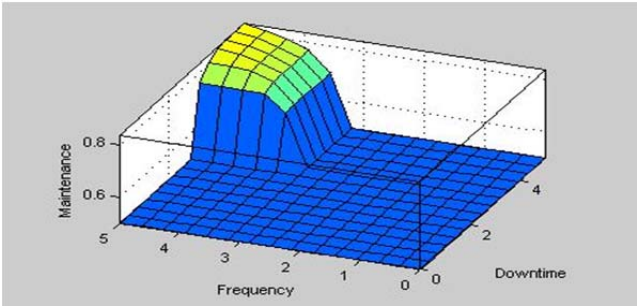

Fig. 9. Surface plot for frequency, downtime and maintenance

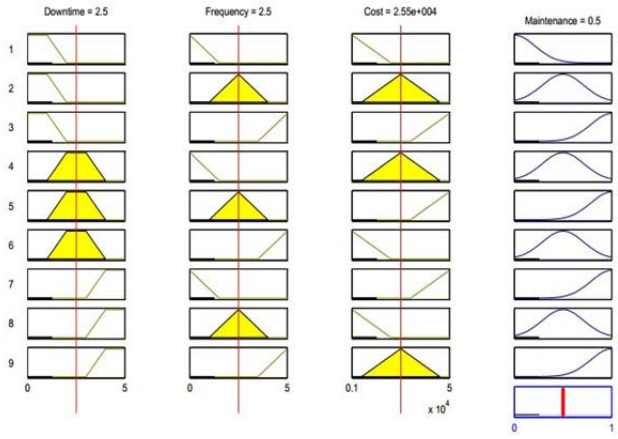

Fig. 10. Membership function rule viewer

Rule Evaluation: Fuzzy rules are the relation between input and output parameter which are made by the experience. Here there are three input and one output variable & for making relation among them we considered nine rules. The rules used are shown in fig.11

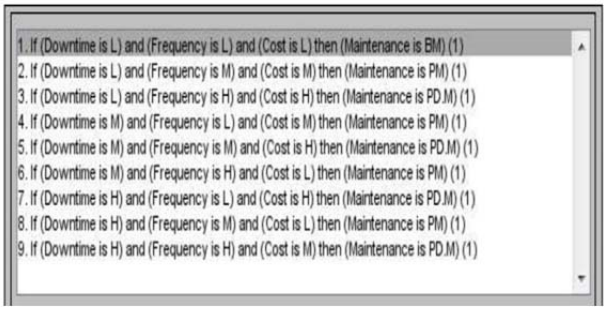

Fig. 11. Fuzzy rule

3. CONCLUSION

Throughout in this study it is found that total productive maintenance methodologies plays an important role for keeping the assets in good condition and also increase the overall efficiency. From the above analysis we found that to improve the efficiency of production line, maintenance of the machines or equipment's is very essential. OEE of machines are increased nothing but due to implementation of small small activities of TPM and this activities also minimize the major losses which is occur in industry. TPM is not a one day activity or maintenance; it is a daily based maintenance system. For finding most cost effective maintenance approach fuzzy evaluation methodology are very useful by which we can achieve most effective maintenance system.

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