IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 34-38
www.iosrjournals.org

Implementation of Total Productive Maintenance on Boiler

Amit Borikar[1], Ankit P. Shingare[1], Jay R. Sarnaik[1], Avinash G. Bhusari[1]
[1]*Mechanical, J.D.I.E.T. YAVATMAL/S.G.B.A.U., INDIA*

ABSTRACT: *The unit cost of thermal energy depends on the capital investment, operations and maintenance (O&M) costs, Availability, Performance and Quality. The capital costs are substantial but are incurred only at the inception of the power plant and can be optimized at the inception stage. The O&M costs are incurred throughout the life of the plant and determine the economic operation of the power plant. The greatest part of O&M costs goes to maintenance cost. To make thermal power plants (TPPs) economical, the maintenance functions should be optimized by carefully selecting and planning the maintenance strategies that will address the maintenance needs of the plant at the least cost. The objective of the study was to propose a methodology that can be used to compare the management methods and determine a method that can optimize maintenance of TPPs to make the plants operate economically by using TPM.*

I. INTRODUCTION

Boiler produces steam from water by heat of pulverized coal is air-blown into the furnace from fuel nozzles at the four corners and it rapidly burns, forming a large fireball at the center. The water circulation rate in the boiler is three to four times the throughput and is typically driven by pumps As the water in the boiler circulates it absorbs heat and changes into steam at 700 °F (370 °C) and 22,000 kPa. It is separated from the water inside a drum at the top of the furnace. The saturated steam is introduced into superheat pendant tubes that hang in the hottest part of the combustion gases as they exit the furnace. Here the steam is superheated to 1,000 °F (540 °C) to prepare it for the turbine.

TPM is a maintenance process developed for improving productivity by making processes more reliable and less wasteful.TPM is an extension of TQM(Total Quality Management). The objective of TPM is to maintain the plant or equipment in good condition without interfering with the daily process. To achieve this objective, preventive and predictive maintenance is required. By following the philosophy of TPM we can minimize the unexpected failure of the equipment. Original goal of total productive management:

"Continuously improve all operational conditions, within a production system; by stimulating the daily awareness of all employees"

II. PREVENTIVE MAINTENANCE

Preventive maintenance (PM) is a time based maintenance method in which the maintenance activities are planned and scheduled based on predetermined counter intervals in order to prevent breakdowns and failures from occurring. The book 'applied reliability centered maintenance' (Jim August, 1999) defines PM as any scheduled preventive tasks intended to reduce the probability of failure of equipment. The scheduling process can be done by a computer system, human memory, wall charts or other scheduling methods. The primary goal of PM is to preserve and enhance equipment performance and reliability by preventing failure of equipment before it failure occurs by such actions as replacing worn components.

PM is commonly used where equipment failure is age related or where the equipment failure rates follow what is called bath-tub curve (Figure 1). It is recommended that for new maintenance organizations, PM should be started in small steps and move to next step when the previous is successful. When building a PM system, equipment with high downtime, high number of repairs or repetitive breakdowns should be targeted. The PM should find root cause of common failures, review work order history, brainstorm with operation and maintenance (O&M) employees in order to develop PM procedures to address the root causes of failures.

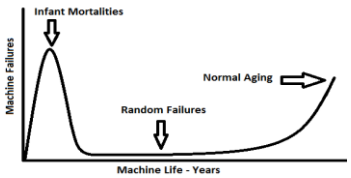


Figure 1: The bathtub curve for preventive maintenance.

Periodic replacement is where disposable parts and inexpensive but critical parts are replaced. The long term objectives and benefits of PM programs are:

Improved system reliability.
Decreased cost of replacement.
Decreased system downtime.
Better spares inventory management.
The requirements for a good PM procedure include the following:
A list of tools, spare parts and instruments required.
A form to record the measurements to be made.
Limits or ranges for the parameters to be measured.
Required safety procedures such as isolation and locking out.

2.1 Condition Based Maintenance

Condition Based Maintenance (CBM) is a set of maintenance actions based on the evidence of need for maintenance obtained from real time assessment of equipment condition obtained from embedded sensors and external tests and measurement taken by portable equipment.

Predictive maintenance (PdM) involves comparing the trends of measured physical parameters against known engineering limits for the purpose of detecting, analysing and correcting problems before failure occurs. Figure 16 shows a predictive maintenance cycle which includes measuring critical performance parameters periodically or online and when the measurements exceed an established limit, the condition must be analysed further and action taken to forestall failure. PdM is part of CBM practices because the maintenance actions are related to measured parameters.

2.2 The Key Elements of a Lean Maintenance Method:

Proactive maintenance means that lean maintenance uses PM and CBM strategies to prevent and predict failure instead of reacting to it.

Planned and scheduled means that the maintenance activities are documented in such a way that the required activities, labour needs, spare parts and time needed to complete the tasks are known in advance. By being scheduled, the maintenance activities are prioritized and assigned a designated action time.

Application of RCM decision logic means lean maintenance tasks are optimized.

Self empowered teams' means lean teams are designed so that a maintenance team has all the skills required to execute all the tasks within the team.

Application of 5S:
Sort (remove unwanted items).
Straighten (organize).
Scrub (clean).
Standardize (make routine).
Spread (expand to other areas).

Kaizen means that lean focuses on continuous evaluation and improvement of the maintenance processes in terms of time, resources use and quality of work.

2.3 Six sigma:

Six sigma is a comprehensive and flexible management system for achieving, sustaining and maximizing business success, a process driven by closely understanding customer needs, disciplined use of facts, data and statistical analysis and build on diligent attention to managing, improving and reinventing business processes.

2.3.1 Core elements of the six sigma method:

Close understanding of customer needs
Diligent use of statistical analysis for analysis and support decisions
Systematic, structured approach to issues affecting processes
Continuous and sustained improvement.

The term sigma (σ) refers to statistical standard deviation which is a measure of the degree of variation from the mean in a population. A deviation from the population mean represents a defect or nonconformity. A six sigma standard is equivalent to six standard deviations corresponding to 3.4 Defects per Million Opportunities (DPMO). It is seen that the level of variation from the mean represent the level of defects or the sigma level. It is seen that defect level reflects the spread of the variable (X) about the mean value. A narrow spread of population about the mean value is most desirable as it corresponds to fewer defects.

III. TPM IMPLEMENTATION

The following is the brief description of each of the TPM implementation activities:

(i) Master plan: The TPM team, along with manufacturing and maintenance management, and union representatives determines the scope/focus of the TPM program. The selected equipments and their implementation sequence are determined at this point. Baseline performance data is collected and the program's goals are established.

(ii) Autonomous maintenance: The TPM team is trained in the methods and tools of TPM and visual controls. The equipment operators assume responsibility for cleaning and inspecting their equipment and performing basic maintenance tasks. The maintenance staff trains the operators on how to perform the routine maintenance, and all are involved in developing safety procedures. The equipment operators start collecting data to determine equipment performance.

(iii) Planned maintenance:the maintenance staffs collects and analyzes data to determine
usage/need based maintenance requirements. A system for tracking equipment performance metrics and maintenance activities is created (if one is not currently available). Also, the maintenance schedules are integrated into the production schedule to avoid schedule conflicts.

(iv) Maintenance reduction: The data that has collected and the lessons learned from TPM implementation are shared with equipment suppliers. This 'design for maintenance' knowledge is incorporated into the next generation of equipment designs. The maintenance staff also develops plans and schedules for performing periodic equipment analysis (burner pump, fuel filter, rotary cup atomizer, furnace tube and valve, etc.). This data from analysis is also fed into the maintenance database to develop accurate estimates of equipment performance and repair requirements. These estimates are used to develop spare parts inventory policies and proactive replacement schedules.

(v) Holding the gains: The new TPM practices are incorporated into the organization's standard operating procedures. These new methods and data collection activities should be integrated with the other elements of the production system to avoid redundant or conflicting requirements. The new equipment management methods should also be continuously improved to simplify the tasks and minimize the effort required to sustain the TPM program.

3.1 TPM Implementations Stages

a) Stage A-Preparatory Stage

Step 1-Announcement by management to all about TPM introduction in the organization:

Proper understanding, commitment and active involvement of the top management in needed for this step. Senior management should have awareness programmes, after which announcement is made. Decision the implement TPM is published in the in house magazine, displayed on the notice boards and a letter informing the same is send to suppliers and customers.

Step 2-Initial education and propaganda for TPM:

Training is to be done based on the need. Some need intensive training and some just awareness
training based on the knowledge of employees in maintenance.

Step 3-Setting up TPM and departmental committees:

TPM includes improvement, autonomous maintenance, quality maintenance etc., as part of it.
When committees are set up it should take care of all those needs.

Step 4-Establishing the TPM working system and target:

Each area/work station is benchmarked and target is fixed up for achievement.

Step 5-A master plan for institutionalizing:

Next step is implementation leading to institutionalizing wherein TPM becomes an organizational culture. Achieving PM award is the proof of reaching a satisfactory level.

b) Stage B-Introduction Stage

A small get-together, which includes our suppliers and customer's participation, is conducted.

Suppliers as they should know that we want quality supply from them. People from related companies and affiliated companies who can be our customers, sisters concerns etc. are also invited. Some may learn from us and some can help us and customers will get the message from us that we care for quality output, cost and keeping to delivery schedules.

c) Stage C-TPM Implementation

In this stage eight activities are carried which are called eight pillars in the development of TPM
activity. Of these four activities are for establishing the system for production efficiency, one for initial control system of new products and equipment, one for improving the efficiency of administration and are for control of safety, sanitation as working environment.

d) Stage D-Institutionalizing Stage

By now the TPM implementation activities would have reached maturity stage. Now is the time to apply for preventive maintenance award.

3.2 The Common Maintenance problems related to the Physical and Chemical properties

Silica scaling on steam pipes, valves, separators and turbine nozzles.
H2S attacks on exposed copper material of switchgears, transformers, motors etc.
Extensive surface corrosion of ferrous metals of pipes, pipe supports, structural frames.
Blockage of drains due to deposits of suspended solids and silica in the fluids.
Sticking of valves as a result of scaling cement.
Leaking of valves due to worn valve discs.
Failure of steam traps and condensate drain devices.
Bursting of pressure safety discs due to pressure fluctuations.

3.3 Six Big Losses

One of the major goals of TPM and OEE is to reduce or eliminate what are called the six big losses which they are the most common causes of efficiency loss in manufacturing. The link of the losses and the effectiveness in TPM is defined in terms of both the quality of the product and the equipment availability. Any operation time may face losses and these losses can be visible like scrap, changeovers and breakdowns or invisibles such as the slow running, the frequent adjustment to maintain the production within tolerance, Nakajima summarised the loss in a six big losses as following:

Downtime Losses:

Breakdown losses this loss is due to parts failure where they cannot work anymore and they need either repair or replace. These losses are measured by how long it takes from labor or parts for fixing the problem.
Setup and adjustment time, These losses are due to the changes in the operating conditions, like the start of the production or the start of the different shifts, changes in products and condition of the operation. The main examples of this kind of losses are equipments changeovers, exchange of dies, jigs and tools. These losses consist of setup, start-up and adjustment down times.

Speed Losses:

When the output is smaller than the output at references speed these are called speed losses. When considering speed losses, one dose not check if the output conforms to quality specifications. This can be found in two forms:
Minor stoppage losses these losses are due to the reason of machine halting, jamming, and idling. Many companies are considering these minor stoppages as the breakdowns in order to give importance to this problem.
1. Speed losses :these losses are due to the reduction in speed of the equipment. In other words the machine is not working at the original or theoretical speed. If the quality defect and minor stoppages occurs regularly then the machine is run at low speed to cover the problems. It is measure by comparing the theoretical to actual working load.

Defect or quality losses:

Rework and quality defects; these losses are due to the defective products during the routine production. These products are not according to the specifications. So that rework is done to remove the defects or make a scrap of these products. Labor is required to make a rework which is the cost for the company and material become a scrap is also another loss for the company. The amount of these losses is calculated by the ratio of the quality products to the total production.
Yield losses: these losses are due to wasted raw materials .The yield losses are split into two groups. The first one is the raw materials losses which are due to the product design, manufacturing method etc. The other group is the adjustment losses due to the quality defects of the products which are produced at the start of the production process, changeovers etc.

3.4Requirements of Total Productive MaintenanceProgram

Good maintenance management department with experienced personnel
To firm up plan of PM in consultation with shop personnel
A good lubricating and cleaning schedule
Detail procedures on maintenance work
Proper records maintained along with manuals, parts list etc
Adequate stock of spare parts
Properly training maintenance crew
Adequate space around machinery for maintenance work

Previous data on failure etc of each machine/equipment
Systematic approach- a guide showing problems, probable causes, diagnosis system, repair procedures etc
Supplier's recommendations for up keep of machineries.

3.5 Steps involved in Total Productive Maintenance

Identifying the job to be taken & appropriate case register
Preparation of schedule of maintenance
Preparation of history card of all the repair work carried on such a machine.
Preparation of job specification
Preparation of maintenance schedule and detail program of work with time frame for completion
Preparation of inspection chart
Preparation of maintenance report on the work done
Feed back on the corrective action/ repair work done and its results.

Summary of Heat Balance for Coal Fired Boiler

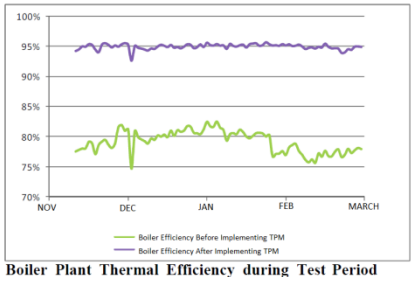
Input/Output Parameter		kCal / kg of coal	% loss
Heat Input	=	3501	100
Losses in boiler			
1. Dry flue gas, L_1	=	275.88	7.88
2. Loss due to hydrogen in fuel, L_2	=	120.43	3.44
3. Loss due to moisture in fuel, L_3	=	206.91	5.91
4. Loss due to moisture in air, L_4	=	10.15	0.29
5. Partial combustion of C to CO, L_5	=	90.32	2.58
6. Surface heat losses, L_6	=	8.75	0.25
7. Loss due to Unburnt in fly ash, L_7	=	3.85	0.11
8. Loss due to Unburnt in bottom ash, L_8	=	61.97	1.77
Boiler Efficiency = 100 – (L_1 + L_2+ L_3+ L_4+ L_5+ L_6+ L_7+ L_8) = **77.77 %**			

Summary of Heat Balance for the Boiler Using Furnace Oil

Input/Output Parameter		kCal / kg of furnace oil	%Loss
Heat Input	=	10000	100
Losses in boiler :			
1. Dry flue gas, L_1	=	786	7.86
2. Loss due to hydrogen in fuel, L_2	=	708	7.08
3. Loss due to Moisture in fuel, L_3	=	3.3	0.033
4. Loss due to Moisture in air, L_4	=	38	0.38
5. Partial combustion of C to CO, L_5	=	0	0
6. Surface heat losses, L_6	=	38	0.38
Boiler Efficiency = 100 – (L_1 + L_2+ L_3+ L_4+ L_6) = 84.27 %			

These two tablesshow the efficiency and various losses in coal fired and oil fired boiler.

IV.RESULT AND DISCUSSION-



Boiler Plant Thermal Efficiency during Test Period

Figure 2. Shows that efficiency of the thermal power plant is increased by implementing TPM.
In above figure 2. We are analyzing efficiency of a boiler during period of 4th months & we conclude that the efficiency of a boiler increases by implementing TPM on it.

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