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Total Productive Maintenance of a Thermal System (Steam Power Plant)

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Abstract— It is a well-known fact that TPM is an effective tool for the minimization of downtime of machines, production losses and material scraps. It also improves working efficiency and productivity of employees and equipments, and a positive inclination is registered in the overall environment of a company. The main aim of my work is to maximise the availability and Overall Equipment effectiveness (OEE) of the steam power plant by increasing the Power output and thermal efficiency of a steam power plant by implementation of TPM. In my work I have analysed various aspects of the implementation of the TPM in a Steam Power Plant. The practical aspects within and beyond basic TPM theory, difficulties in the adoption of TPM and problem encountered during implementation are discussed. I have done my work in Gwalior Alcobrew Pvt. Ltd, Rairu Gwalior (M.P.). Whereas in most of the production settings the operator is not viewed as a member of the maintenance team. In TPM, The machine operator is trained to perform many of the day-to-day tasks of simple maintenance and fault-finding. Teams are created that include a technical expert (often an engineer or maintenance technician) as well as operators.

Index Terms— **TPM, Steam, Power Plant, Efficiency**

I. INTRODUCTION

Kaizen introduced the idea that employee expertise generates improvements. TPM stands for Total productive Maintenance, is first developed in Japan, it is term-based preventives and productive maintenance and involves every level from top executives to shop floor operators. TPM has been proven to be successful for helping to increase the productivity and overall equipment effectiveness. 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 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. To implement TPM the production unit and maintenance unit should work jointly. TPM brings maintenance into focus as a necessary and vitally important part of the business: Maintenance should not be considered as a non-profit-making activity. Down time for maintenance is scheduled as an on-going activity of the manufacturing process making it imperative to carry out maintenance not solely when there is a failure in the production flow. The goal is to minimize the frequency and magnitude of emergency and unscheduled maintenance interruption. I have studied various changes in terms of availability of Steam Power Plant before and after implementation of TPM in **"Gwalior Alcobrew Private Ltd. Rairu"**, Gwalior. A comparison of the relevant data is presented in tabular form. Also graphical interpretation of the changes is interpreted. **TPM** can be considered as the medical science of machines. Total Productive Maintenance (TPM) is a maintenance program which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction. Total Productive Maintenance permanently improves the overall effectiveness of equipment with the active involvement of operators." The western approach moves the emphasis away from both maintenance and teamwork and towards Equipment Management and Utilization with operator participation

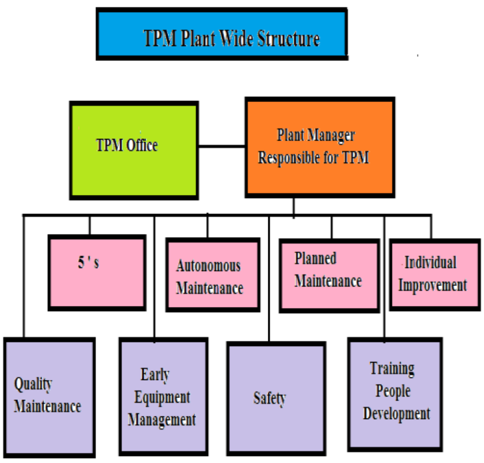

Fig-1: TPM Plant Wise Structure

II. TPM GOALS AND ATTITUDE

TPM try to minimize losses in the production and to operate machines with full design capacity. TPM also considered quality aspect by making zero product defect rate. Which means no production scrap or defect, no breakdown, no accident, no waste in the running production or changeover? This can be achieved by improving Overall Equipment Effectiveness (OEE), which can be improve by reducing Six Big Losses as shown in fig-2. It is aimed towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating

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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, and 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.

III. LITERATURE REVIEW

One Yoon Seng, MuhamadJantan, T. Ramayah [2] implemented TPM in a manufacturing organization and considered only two success factors as Human-oriented and Process oriented. Osama TaisirR.Almeanazel [3] has reviewed the goals and benefits of implementing TPM and also focussed on calculating the overall equipment Effectiveness (OEE) in steel company in Jordan. Sorabh Gupta , P.C. Tewari , Avadhesh Kumar Sharma [4] has presented TPM history, benefits, its strengths as a maintenance philosophy, its implementing approach, difficulties in its implementation and cost of implementing TPM. Ravikant V. Paropate ,Shrikant R. Jachak , Prasad A. Hatwalne [5] has discussed the implementation of the TPM program in an Indian Automobile manufacturing Industry. FarhanaAfreenproma, TaheraYesmin, and M. AhsanAkhtarHasin [7] has conducted the study in a pharmaceutical company to find out a relative scenario of these losses in different sections of the tablet manufacturing facility. MANU DOGRA, VSIHAL S. SHARMA, ANISH SACHDEVA, J.S. DUREJA [8] has emphasized on the fact that, TPM is promoted through a structure of overlapping small groups; in this system leaders of small group at each organizational level are members of small group at the next higher level. M.C. ETI, S.O.T. OGAJI and S.D. PROBERT [9]has a conceptual approach to the requirement for optimal preventive maintenance using JIT and TQM techniques. This study explores the ways in which Nigerian manufacturing industries can implement TPM as a strategy. The research of I.P.S. Ahuja and J.S.Khamba [10] focuses, upon the significant contributions of 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 Indian industry. TPM is a major departure from the “you operate, I maintain” philosophy [11]. In essence, TPM seeks to integrate the organization to recognize, liberate and utilize its own potential and skills [12].

IV. PROBLEM DEFINITION

The maintenance system of the company is according to the skill of the maintenance personnel. The maintenance department of the company has no manual. The researcher tried to find the problem that the company does not have the manuals, the answer found was the equipment vendor’s didn’t give enough material. The maintenance personnel just changes the items which failed by the operation after the failure occurs. There is no analysis done to find the causes and the effect of the failure. Some of the maintenance plan of the company contains cleaning and making minor inspection on the machineries. The plans are not based on the maintenance manuals. The figure below shows that the maintenance system the company uses is almost 85% breakdown type and very small percentage about 15% lubrication and change of oils. The maintenance systems of the company instruct the operators or maintenance person to wait for the failure of the items then change it. Until failure of the item, it should be run by preventive maintenance. This has an adverse effect on the productivity and growth rate of the company. Moreover, we have noticed that top level management as well as workers themselves are lacking in zeal and interest. Most of them have personal issues, objectives to be accomplished. This negligence has resulted in the frequent breakdowns. Consequently cost incurred does not justify the gain in productivity.

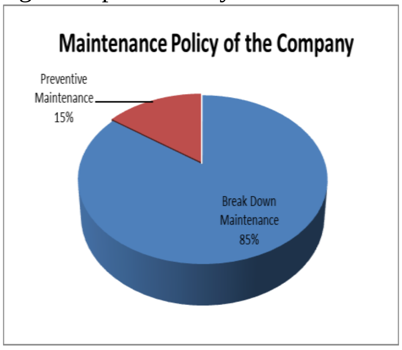

Fig-2.Maintenance Policy

V. INTRODUCTION OF COMPANY

The **Bapuna Group** is based in **Central India** with its liquor and beer manufacturing facilities at Gwalior (Madhya Pradesh) and blending and bottling units at Nagpur (Maharashtra).The Group’s main business is the manufacture of Rectified Spirit, Extra Neutral Alcohol and branded alcoholic beverages, with an installed capacity of 60, 00,000 Bulk Litres of Spirit per month at its facilities based in Gwalior. Gwalior Distillers Limited, (GDL), incorporated in 1987, is the flagship company of the Bapuna Group, a group with a rich history and strong track record in the Alcohol Industry. GDL is engaged in the manufacture of Rectified Spirit (RS) and Extra Neutral Alcohol (ENA) from molasses and grain. Apart from the Company s own brands, which are today well accepted and strongly entrenched in the market, the Company also blends and bottles popular brands of IMFL, for the UB Group, Seagram & other industry leaders. Following the success of GDL, Tripti Alcobrew Limited was set up at Morena (M.P.). A modern unit for manufacturing Beer, it manufactures its own brands as well

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as for leading labels like SKOL, Kingfisher and Sandpiper. The brewery has an installed capacity of 48, 00,000 cases per annum. The Group has a State-of-the-art Ice Cream factory at Nagpur, which is ISO 9001 & HACCP Certified. The popular Din Shaw brand of premium quality Ice Cream, Paneer& Ghee which is made here is sold in 14 States. Besides making 1, 25,000Litres of Ice Cream per day, it operates a Dairy which caters to the demand for best quality milk in and around Nagpur. It is one of the largest and oldest Ice Cream manufacturing units in India, celebrating its 75th Year of existence.

VI. STUDY AREA

This case study was conducted in a leading manufacturing industry “Gwalior Alcobrew Private Ltd. Rairu” of Madhya Pradesh, India. *Steam Power Plant* was chosen for the study. Mr. Rakesh Jain is the Head of Steam Power Plant. Boiler Section there are 48 employees working under Mr, Shahjad Khan DGM. 12 employees are there for Coal handling, 6 workers for ash handling and 30 employees for Boiler and Turbine operations. Mr. Achal Singh Chauhan Assistant Manager is the Head of Turbine and Heat exchanger section. 15 employees are working for smooth operation of turbine. Mr. Dharmendra Bhargava is the head of R.O. Plant. There are 7 employees in R.O. Plant. Full rated capacity of Steam Power plant is 3MWH, generally it operates with 2 – 2.1 MWH. After implementation of TPM there was a rise in Power output of Steam Power Plant. Various components of Steam power plant are shown in figure 3.

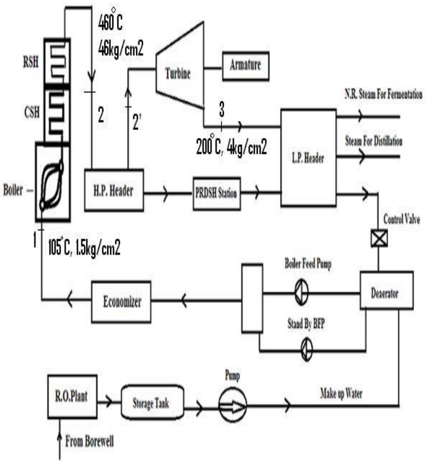

Fig-3 Steam Power Plant

BOILER:

THE **"CETHAR FLUIDIX"** IS A FLUIDISED BED BOILER WITH THE FOLLOWING FEATURES.

a) Compartmentalized combustion chamber

b) Under bed fuel feeding system

c) BI-drum water tube type.

The boiler is designed for **COAL & RICE HUSK** as main fuels with capacity of **30 TPH** at MCR. The outlet steam parameters are **46 kg/cm^2** pressure and **450 ±5°C** steam temperature.

VII. TURBINE

The turbine is a compact, back-pressure multi-stage turbine for driving purposes wherever high output under medium pressure and temperature steam conditions is required. Its construction allows for easy assembly and maintenance work. The upper and lower turbine housings, made of cast alloy steel, are horizontally split, thus allowing for disassembly of the upper part without removing the live steam and exhaust steam lines. The turbine has three nozzle chambers integrated to the lower housing casting, each connected to one of the control valves. The nozzles are of milled profiles, welded and bolted to the lower portion of the turbine housing. Diaphragms are fitted into the housing, and the stages are sealed with labyrinths and grooves on the shaft. The rotor is formed by a control wheel and stages with milled blades, made of high-temperature-resistant stainless steel. Shrouds, also in stainless steel, are riveted onto the blades. Both the control wheel and the stages have keyways and are interference-fitted onto the shaft. Steam sealing on the shaft is accomplished by means of labyrinths. The control valve is hydraulically actuated by a servo-motor. The emergency stop valve is independent and mechanically actuated. Bearings are made of steel lined with Babbitt metal and fitted inside independent casings bolted to the turbine; thus; it is not necessary to open the turbine housing for inspection or maintenance purposes. Axial thrust is reduced to a minimum, due to the balance piston principle adopted in its construction, which enables balancing the rotor under operation, thus compensating for axial loads of the blading.

VIII. METHODOLOGY&SUGGESTIONS

- The Steam Power Plant of Gwalior Alcobrew Private Limited Rairu was observed for few months working hours on the regular intervals. Time measurement for various losses was setup and adjustment; changes in process, Transportation, Inventory Management were suggested.
- Analytical interpretation and comparison of data.
- Identification & Quantification of significant losses.
- Frequent Maintenance and breakdown-prevention measures implemented.
- Training to improve the technical skills of all personnel.
- Higher effectiveness sought in newly-purchased equipments.
- We have also suggested implementing cleaning of machines and shop floor area before starting their lines so that rejection or rework can reduce.
- We also suggest Autonomous maintenance, which means that each operator is doing routine maintenance of his own machine like lubrication, tightening of nuts etc. One should not wait for maintenance personal for routine maintenance work. They may call maintenance personal when machine are prone to breakdown.

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- Prepare a proper maintenance schedule by maintenance department and always focus on preventive maintenance.
- Motivate each employee as well as engineers to take part actively in maintenance work also, either by giving incentives or by other means.
- Collaboration b/w industry and educational institute needs to be promoted. This is win-win situation for body the groups.
- Visual display of maintenance chart at suitable locations in the shop floor. Audit of maintenance department must be on regular basis.

IX. DATA OBSERVATION

Following important data were recorded and collected for Understanding the improvements in thermal efficiency of Steam Power Plant. Before Implementation of TPM, Plant was under continuous observation for three months and data related to steam generation rate, power output and fuel consumption are as follows:

X. CALCULATIONS

- **JANUARY 2012**

Average steam consumption per day,

$m_s = \frac{15317}{31} = 494.096$ Metric Tonne

Average Power Generation per day,

$P = \frac{1492.15}{31} = 48.13\ MWH$

Average Fuel (Coal) consumption per day,

$m_f = \frac{2823.17}{31} = 91.07$ Metric Tonne

Boiler

1. Inlet Temperature of water, $T_1 = 105$ °C
2. Inlet Pressure, $P_1 = 1.5$ kgf/cm^2
3. Outlet Temperature of steam, $T_2 = 460$ °C
4. Outlet Pressure, $P_2 = 46$ kgf/cm^2

Enthalpy at various points can be determine with mollier charts –

Now, Boiler Efficiency = $\frac{\text{Enthalpy of Steam at outlet of Boiler} - \text{Enthalpy of Water at inlet of Boiler}}{\text{Mass of Fuel} \times \text{Calorific Value of fuel}}$

$$\eta_b = \frac{m_s \times h_2 - m_w.S.\Delta t}{m_f \times C.V.}$$

$$\eta_b = \frac{494.096 \times 3360 - 494.096 \times 4.18 \times 105}{91.07 \times 4600 \times 4.18} = 0.8242$$

$\eta_b = 82.42\%$

Turbine

1. Inlet Temperature of Steam, $T_{2'} = 455$ °C
2. Inlet Pressure, $P = 46$ kgf/cm^2
3. Outlet Temperature of steam, $T_3 = 200$ °C
4. Outlet Pressure, $P_3 = 4$ kgf/cm^2
5. Speed of Turbine N = 6000 r.p.m.

Turbine Efficiency

$$\eta_T = \frac{\text{Enthalpy Drop in Turbine}}{\text{Enthalpy of Steam at the inlet of Turbine}}$$

$$\eta_T = \frac{3360 - 2850}{3360} = \frac{510}{3360} = 0.1518$$

$$\eta_T = 15.18\ \%$$

Alternator

1. Speed, N = 1500 r.p.m
2. Full Rated Power Output = 3 MWH
3. Operating load approximately = 2.2 MWH
4. Running Time = 24 Hrs.

Armature Efficiency,

$$\eta_A = \frac{\text{Power Output of Armature}}{\text{Work output of Turbine}}$$

$$\eta_A = \frac{48.13 \times 10^3 \times 3600}{494.096 \times 1000 \times 510} = 0.6876$$

$$\eta_A = 68.76\ \%$$

- **FEBRUARY 2012**

Average steam consumption per day,

$m_s = \frac{14314}{29} = 493.58$ Metric Tonne

Average Power Generation per day,

$P = \frac{1402.69}{29} = 48.36\ MWH$

Average Fuel (Coal) consumption per day,

$m_f = \frac{2633.69}{29} = 90.81$ Metric Tonne

Boiler

Now, Boiler Efficiency = $\frac{\text{Enthalpy of Steam at outlet of Boiler} - \text{Enthalpy of Water at inlet of Boiler}}{\text{Mass of Fuel} \times \text{Calorific Value of fuel}}$

$$\eta_b = \frac{m_s \times h_2 - m_w.S.\Delta t}{m_f \times C.V.}$$

$$\eta_b = \frac{493.58 \times 3360 - 493.58 \times 4.18 \times 105}{90.81 \times 4600 \times 4.18} = 0.828$$

$\eta_b = 82.8\%$

Turbine

Turbine Efficiency

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$$\eta_T = \frac{Enthalpy\ Drop\ in\ Turbine}{Enthalpy\ of\ Steam\ at\ the\ inlet\ of\ Turbine}$$

$$\eta_T = \frac{3360-2850}{3360} = \frac{510}{3360} = 0.1518$$

$$\eta_T = 15.18\ \%$$

Armature

Armature Efficiency,

$$\eta_A = \frac{Power\ Output\ of\ Armature}{Work\ output\ of\ Turbine}$$

$$\eta_A = \frac{48.36\times10^3\times3600}{493.58\times1000\times510} = 0.6915$$

$$\eta_A = 69.16\ \%$$

- **MARCH 2012**

Average steam consumption per day,

$m_s = \frac{15323}{31}$ = 494.29 Metric Tonne

Average Power Generation per day,

P = $\frac{1501.73}{31} = 48.44\ MWH$

Average Fuel (Coal) consumption per day,

$m_f = \frac{2818.33}{31} = 90.91$ Metric Tonne

Boiler

Now, Boiler Efficiency

$$= \frac{Enthalpy\ of\ Steam\ at\ outlet\ of\ Boiler - Enthalpy\ of\ Water\ at\ inlet\ of\ Boiler}{Mass\ of\ Fuel \times Calorific\ Value\ of\ fuel}$$

$$\eta_b = \frac{m_s \times h_2 - m_w.S.\Delta t}{m_f \times C.V.}$$

$$\eta_b = \frac{494.29\times3360 - 494.29\times4.18\times105}{90.91\times4600\times4.18} = 0.826$$

η_b = 82.6%

Turbine

Turbine Efficiency

$$\eta_T = \frac{Enthalpy\ Drop\ in\ Turbine}{Enthalpy\ of\ Steam\ at\ the\ inlet\ of\ Turbine}$$

$$\eta_T = \frac{3360-2850}{3360} = \frac{510}{3360} = 0.1518$$

$$\eta_T = 15.18\ \%$$

Alternator

Armature Efficiency,

$$\eta_A = \frac{Power\ Output\ of\ Armature}{Work\ output\ of\ Turbine}$$

$$\eta_A = \frac{48.44\times10^3\times3600}{494.29\times1000\times510} = 0.6918$$

$$\eta_A = 69.18\ \%$$

- **JUNE 2012**

Average steam consumption per day,

$m_s = \frac{15688}{30}$ = 522.93 Metric Tonne

Average Power Generation per day,

P = $\frac{1609.19}{30} = 53.63\ MWH$

Average Fuel (Coal) consumption per day,

$m_f = \frac{2845.88}{30} = 94.86$ Metric Tonne

Boiler

1. Inlet Temperature of water, T_1 = 105 °C
2. Inlet Pressure, P_1 = 1.5 kgf/cm^2
3. Outlet Temperature of steam, T_2 = 460 °C
4. Outlet Pressure, P_2 = 46 kgf/cm^2

Now, Boiler Efficiency

$$\frac{Enthalpy\ of\ Steam\ at\ outlet\ of\ Boiler - Enthalpy\ of\ Water\ at\ inlet\ of\ Boiler}{Mass\ of\ Fuel \times Calorific\ Value\ of\ fuel}$$

$$\eta_b = \frac{m_s \times h_2 - m_w.S.\Delta t}{m_f \times C.V.}$$

$$\eta_b = \frac{522.93\times3360 - 522.93\times4.18\times105}{94.86\times4600\times4.18} = 0.8375$$

η_b = 83.75%

Turbine

1. Inlet Temperature of Steam, $T_{2'}$ = 455 °C
2. Inlet Pressure, P = 46 kgf/cm^2
3. Outlet Temperature of steam, T_3 = 260 °C
4. Outlet Pressure, P_3 = 3.5 kgf/cm^2
5. Speed of Turbine N = 6000 r.p.m.

Turbine Efficiency

$$\eta_T = \frac{Enthalpy\ Drop\ in\ Turbine}{Enthalpy\ of\ Steam\ at\ the\ inlet\ of\ Turbine}$$

$$\eta_T = \frac{3360-2820}{3360} = \frac{540}{3360} = 0.1607$$

$$\eta_T = 16.07\%$$

Alternator

Armature Efficiency,

$$\eta_A = \frac{Power\ Output\ of\ Armature}{Work\ output\ of\ Turbine}$$

$$\eta_A = \frac{53.63\times10^3\times3600}{521.56\times1000\times540} = 0.6855$$

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$$\eta_A = 68.55\%$$

- **JULY 2012**

Average steam consumption per day,

$$m_s = \frac{16063}{31} = 518.16 \text{ Metric Tonne}$$

Average Power Generation per day,

$$P = \frac{1649.84}{31} = 53.22\ MWH$$

Average Fuel (Coal) consumption per day,

$$m_f = \frac{2916.84}{31} = 94.09 \text{ Metric Tonne}$$

Boiler

1. Inlet Temperature of water, T_1 = 105 °C
2. Inlet Pressure, P_1 = 1.5 kgf/cm^2
3. Outlet Temperature of steam, T_2 = 460 °C
4. Outlet Pressure, P_2 = 46 kgf/cm^2

Now, Boiler Efficiency =

$$\frac{Enthalpy\ of\ Steam\ at\ outlet\ of\ Boiler - Enthalpy\ of\ Water\ at\ inlet\ of\ Boiler}{Mass\ of\ Fuel \times Calorific\ Value\ of\ fuel}$$

$$\eta_b = \frac{m_S \times h_2 - m_W.S.\Delta t}{m_f \times C.V.}$$

$$\eta_b = \frac{518.16 \times 3360 - 518.16 \times 4.18 \times 105}{94.09 \times 4600 \times 4.18} = 0.8367$$

$$\eta_b = 83.67\%$$

Turbine

1. Inlet Temperature of Steam, $T_{2'}$ = 455 °C
2. Inlet Pressure, P = 46 kgf/cm^2
3. Outlet Temperature of steam, T_2 = 260 °C
4. Outlet Pressure, P_2 = 3.5 kgf/cm^2
5. Speed of Turbine N = 6000 r.p.m.

Turbine Efficiency

$$\eta_T = \frac{Enthalpy\ Drop\ in\ Turbine}{Enthalpy\ of\ Steam\ at\ the\ inlet\ of\ Turbine}$$

$$\eta_T = \frac{3360 - 2820}{3360} = \frac{540}{3360} = 0.1607$$

$$\eta_T = 16.07\%$$

Armature

Armature Efficiency,

$$\eta_A = \frac{Power\ Output\ of\ Armature}{Work\ output\ of\ Turbine}$$

$$\eta_A = \frac{53.22 \times 10^3 \times 3600}{528.16 \times 1000 \times 540} = 0.6818$$

$$\eta_A = 68.18\%$$

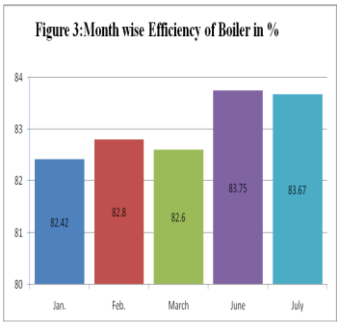

Figure 3:Month wise Efficiency of Boiler in %

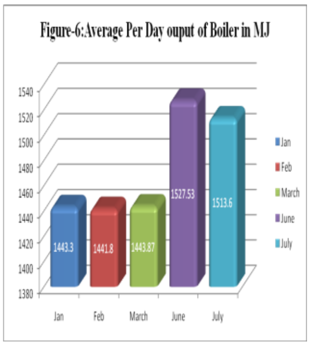

Figure-6:Average Per Day ouput of Boiler in MJ

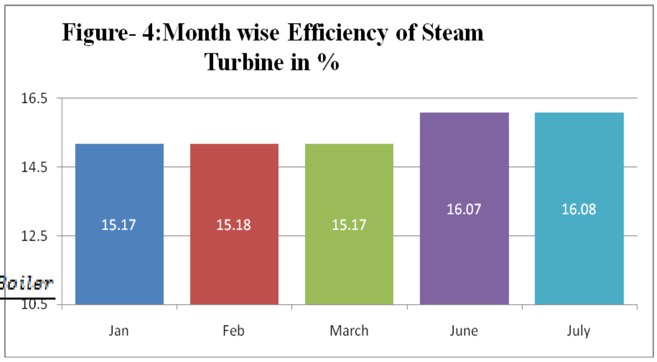

Figure- 4:Month wise Efficiency of Steam Turbine in %

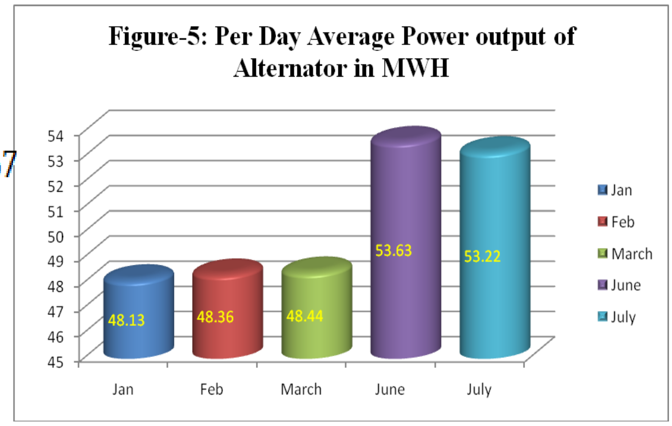

Figure-5: Per Day Average Power output of Alternator in MWH

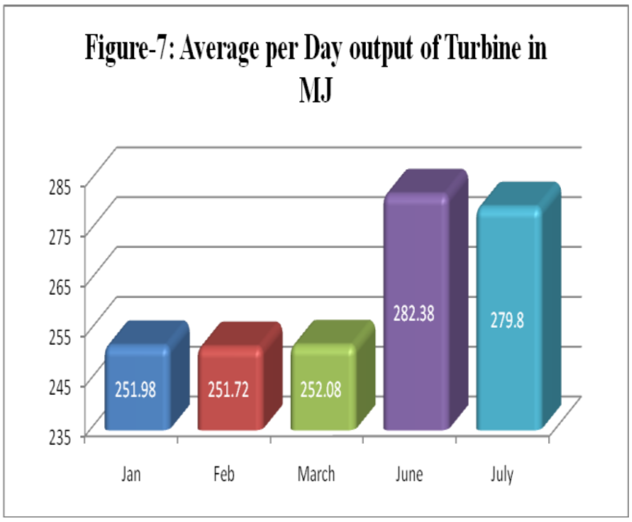

Figure-7: Average per Day output of Turbine in MJ

XI. CONCLUSION

In the present work Steam Power Plant of "Gwalior Alcobrew Private Ltd. Rairu" was selected for the implementation of Total productive Maintenance. Data

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related to performance and efficiency of different parts of Steam Power Plant was collected to find out the changes after the implementation of TPM. On comparison of these data, following conclusions were drawn from this work.

1. TPM initially seems to be expensive activity, but after proper implementation, expenditure is justified by the gain in output and efficiency.
2. Training of workers on regular basis helps them to learn new skills and a positive inclination in their morale is registered.
3. Preventive Maintenance is always better than Breakdown maintenance (Corrective maintenance)
4. Implementation of TPM is not limited to a manufacturing industry but it can be applied to a power plant also.
5. Normally thermal efficiency of steam impulse steam turbine is approximately 35 % but in this work thermal efficiency of steam turbine is about 15 %. This is because of the fact that exhaust seam of turbine in this steam power plant is utilised for processing.
6. In first three months January, February, March the efficiency of Boiler was approximately equal to 82 %. After the implementation of TPM, 1 % rise in efficiency of boiler was registered.
7. Similarly, efficiency of Turbine increased by 0.8 % after the implementation of TPM.
8. Power Output of Alternator increased from 252 MWH per day to 280 MWH per day. This will reduce the dependence of company on power supply of MPEB.
9. Average Fuel Consumption per day has increased but due to higher power output electrical bills will be lowered.
10. Role of operator is not confined to the running of machine, he is also responsible for regular inspection, cleaning, greasing etc, of his machine

XII. SCOPE FOR FUTURE WORK

The present Experimental work was concentrated on Steam Power Plant. The following works are suggested to be carried out in future. Similar type of study need to be extended for another type of Power Plant like hydropower plant etc., I have made an attempt to implement TPM on a very small section of "Gwalior Alcobrew Private Ltd. Rairu". By the permission of management of company, TPM can be implemented on the whole plant as JK Tyre Banmore, Morena has done. Boiler in this power plant is FBC (Fluidised bed Combustion Boiler) so cheaper fuels like residue of crops can be used along with coal. This will help in reducing cost of fuel.

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