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Energy Conservation Opportunities in Thermal Power Plant

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ABSTRACT

The purpose of the project is to assess the major power consumption by auxiliaries and suggesting cost saving alternatives in terms of energy saving. Energy audit of Plant have been conducted for main auxiliaries of thermal power plant like Boiler, Turbine, Condenser vacuum system, performance evaluation of Air pre-heater, MAKE UP water consumption. Various parameters from Control room and Chemical wings has been taken and it was found that the efficiency of boiler is 85.29% which we can improve up to >89% by reducing dry flue gas losses. There is a lot of wastage of MAKE UP water in the plant; we can save this MAKE UP water by making small investment in terms of replacement of valves, gland, seat etc. Heat rate of turbine was calculated, and it was found that it is more than the design heat rate due to low vacuum and process parameters. Vacuum of condenser can be improved by Condenser online Load Tube Cleaning System. We can improve the vacuum and obtain the saving of more than Rs. 200 Lakhs.

There is a huge amount of water passing in Boiler Feed Pump recirculation line, after carrying out the various calculated on Boiler Feed Pump, it is observed that the anticipated saving of approximately Rs. 27 Lakhs per year with an investment of Rs.5.0 Lakhs by replacement of valves. Therefore by adopting some precautions and recommendations we can reduce the power consumption.

The total anticipated saving will be more than >3500 Lakhs. per annum with an investment of approx. Rs.2300 lakhs and payback period is 7.5 months.The study conducted clearly shows that the preventive maintenance, overhauling and re-assessment of operating conditions of aging plant imparts a major role in keeping a power plant an energy efficient utility.

Key words: cost saving alternatives, make up water, preventive maintenance, overhauling and re-assessment, energy efficient utility

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INTRODUCTION

The Boiler Efficiency calculated by indirect method. It gives various losses and paves path for rectification in process to reduce losses & increase efficiency. Turbine efficiency is calculated and cylinder efficiency improved by strictly keeping parameters intact. Make up & Aux power are always have improvement margin. Here analysis done to reduce make up & aux power consumption. Various improvements suggested to do the same. Calculations done to suggest gain in terms of money. Same implemented & Gain obtained.

The main objective of Energy Audit of 500 MW UNIT was to improve the performance of auxiliaries along with reduction in their power consumption. Asses the performance of Boiler, Turbine, Economizer, Super heaters, introduction of new system (COLTCS, TDBFP etc.). The detailed scope of study covered during the energy audit of 500 MW unit of Thermal Power plant is given below:

	Section-1		**Section-2**
01	Boiler efficiency calculation with heat balance	01	Replacement of Motor Driven Boiler Feed Pump (MDBFP) By Turbine Driven Boiler Feed Pump (TDBFP)
02	MAKE UP water consumption analysis	02	Introduction of Condensate on Load Tube Cleaning System (COLTCS) to improve vacuum.
03	Air Pre heater Performance analysis	03	Turbine Heat rate analysis

04	Economizer Performance analysis	04	Condenser Performance Evaluation
05	SH and RH Performance analysis	05	Installation of Cooling Tower
06	Prevention of Primary and Secondary air leakage		

SECTION-1

1.1 Estimating Boiler Efficiency

Boiler runs at Maximum Continues Evaporation as per design. The boiler efficiency of the Unit was evaluated by loss calculated method. During the time of site measurement parameters like O_2, CO_2 and CO in the flue gas were measured. The ultimate and proximate analysis of coal used for the calculated of boiler efficiency is calculated below and obtained from the laboratory of Plant on the same day of testing. During the test period blow down and soot blowing was terminated. The losses considered for calculated of boiler efficiency are given below:

1. Dry flue gas loss
2. Loss due to moisture in fuel
3. Loss due to Hydrogen in fuel
4. Moisture in combustion air loss
5. Loss due to unburnt Carbon
6. Radiation loss
7. Un-accounted loss

The losses are added and finally subtracted from 100% to get the efficiency of the Boiler. Boiler efficiency by method of losses = 85.295%.

SAVING POTENTIAL BY IMPROVING BOILER EFFICIENCY

Boiler Efficiency = 85.295%; Coal flow rate at 500 MW = 250 TPH
Considering 0.25% improvement in efficiency by bringing down dry flue gas loss.
Fuel Saved @ 0.25% = 0.625 TPH; Total fuel Saved/Year = 4500 T (Considering 24 hrs and 300 days of operation)
Amount Saved per Year @ Rs. 2800/T of coal = Rs. 1.26 Cr
Investment Required (Approx.) = Rs. 35 Lakh
(Expenditure incurred during APH overhauls- Rs.15 Lakhs, Basket replacement-11 Lakhs, replacing worn out gasket-Rs.4 Lakhs seals and bellow scaffolding-Rs.5 Lakhs)
Payback Period = 3.6 months

1.2 Make Up Water Consumption Analysis

The full load is achieved at drum pressure 175 Kg/Cm^2, which is very high as compared to the design drum pressure 170.4Kg/Cm^2. This is due to various losses in the boiler and excess consumption of MAKE UP WATER. At present the MAKE UP Water consumption is 285 TPD, which should be 80 TPD (As per BHEL design manual).

A-Shift 53 TPD; B-Shift 88 TPD; C-Shift 64 TPD

The excess 205 TPD MAKE UP Water consumption is due to passing in boiler side drain valves and safety valves. It can be reduced by replacing following valves;

1. LP Dosing line valve
2. BFP Recirculation valve.
3. HFO Heating valve.
4. HP Heaters extraction Valve.
5. SH attemperation Valve
6. Drum vents and drain valves.
7. BLOW DOWN, IBD valve.
8. Inert steam line leak
9. BLOW DOWN vent valve passing on boiler
10. Soot blowing steam leak at various locations on boiler

SAVING POTENTIAL BY IMPROVING MAKE-UP WATER CONSUMPTION

Excess Water consumption per day = 205 TPD; Mostly max quantity of lost water is from Boiler Drum and it is at 174.4 Kg/Cm^2 pressure and 320^0C
Heat Saving potential per kg of lost water = 345.23 kCal; Total Heat Saving potential /hr = = 29.48 X 105 k Cal
Total coal saving Potential @ 4614 kcal/kg = 638.92 kg/hr; Total fuel Saved/Year = 4600.22 MT
(Considering 24 hrs and 300 days of operation)
Amount Saved/ Year @ Rs. 2800/T of coal = Rs. 1.288 Crore; Investment Required (Approx.) = Rs. 22 Lakh
(For valves replacing and lapping) Payback Period = 5.85 Months

1.3 APH Performance Analysis

The performance evaluation of APH (Tri-SECTOR RECUPERATIVE) can be evaluated based on the measurements taken during the energy audit study. Tramp air including air leakage as percentage of total air is

APH-L = 46.01% (76.22)%; APH-R = 40.015% (88.64)%

Possible sources of in-leakage for tramp air include:

1) Pressure type milling plant
2) Ash hopper seals
3) Ash hopper doors
4) Duct opening
5) Boiler roof seals defective
6) Air heater air bypass dampers passing
7) Attemperating air dampers passing

It is recommended to check above points for air leakage and take corrective action.

1.4 Economizer Performance Analysis

$$\text{Effectiveness of Economizer} = \frac{(Th1 - Th2)}{(Th1 - Tc1)} = \frac{\text{actual heat transfer}}{\text{maximum possible heat transfer}} = \frac{503 - 371}{503 - 251} = \mathbf{52.38\%}$$

1.5 Superheater Performance Analysis

$$\text{Overall Effectiveness of SH (PSH + PLATEN+FINAL)} = \frac{(Th1 - Th2)}{(Th1 - Tc1)} = \frac{1265 - 714}{1265 - 528} = \mathbf{74.76\%}$$

1.6 Reheater Performance Analysis

$$\text{Effectiveness of R/H} = \frac{(Th1 - Th2)}{(Th1 - Tc1)} = \frac{1008 - 880}{1008 - 332} = 18.93\ \%$$

1.7 Prevention of Primary and Secondary Air Leakage

In a coal based power plant PA & Forced Draft Fan s supply primary and secondary air required for combustion. This air is heated in air pre heater to a temperature of 280°C. The hot secondary air is supplied to the boiler from wind box. The joints of air pre heater with primary and secondary air ducts and joints of the wind box are exposed to high wear and tear and results in heavy leakage of hot dust laden air. The surroundings become very hot and difficult to work.

- There were severe ash / hot Air leakages in all four corners from wind box & primary, secondary hot air leakages from expansion bellows.
- MS plate of 3 mm thickness welded from inside the wind box to cover the metallic expansion bellow to avoid direct contact of hot secondary air.
- Fabric expansion bellow provided from outside the wind box to cover metallic expansion bellow.
- Fabric expansion bellow provided at APH outlet duct in primary & secondary metallic expansion bellow.
- Total Air flow maintaining 2230 to 2250 TPH whereas it is designed for 2080 TPH (Secondary air + Primary air).

SECTION-2

2.1 Replacement of Motor Driven Boiler Feed Pump by Turbo Driven Boiler Feed Pump

Unit has 3 Boiler Feed Pumps, out of which 2 remain in operation to meet the feed water requirement of the boiler. The BFP consists of a booster pump, and one main pump. The booster pump is coupled to the same shaft of the motor while the main pump is coupled through a hydraulic coupling.

Recirculation flow in MDBFP-A/ B & C is 30.2m^3/hr, 31.3m^3/hr & 39m^3/hr respectively.

-Hence by replacing BFP recirculation valves the same demand can be achieved by less steam consumption.

-During Energy audit study the flow through bypass line was measured. During normal operation, the recirculation flow will be zero.

But due to passing of bypass line valve, the feed water flow obtained for BFP # A, B & C was 30.2m^3/hr, 31.3m^3/hr & 39m^3/hr respectively.

Hence, it is suggested to rectify the problem of valve passing for above two pumps. This will reduce the feed water flow rate and reduce the power consumption by the pumps. The detailed power saving calculated is given below.

Note: The saving potential is calculated based on actual test conducted in Unit, BFP # B @ 1.16 kW/m^3/hr of recirculation flow.)

Saving Potential by stopping Recirculation flow

Re-circulation flow for BFP # A = 20.7 m^3/hr
Power saving potential for BFP #A = 24.0 kW
Re-circulation flow for BFP # B = 29.7 m^3/hr
Power saving potential for BFP # B = 34.5 Kw
Re-circulation flow for BFP # C = 38.7 m^3/hr
Power saving potential for BFP # C = 44.8 kW
Total power saving potential for 2 pumps = 68.9 kW
Units Saved per annum = 5,45,688 kWh
(Considering 24 hrs/day and 330 days/annum operation)
Amount Saved per annum @ Rs. 5.0/kWh = Rs. 27.30 Lakh
Approximate investment required in rectification of passing valves = Rs. 5.0 Lakh
Payback Period = 3.3 months

2.2 Bullet Cleaning System & Coltcs System to Improve Condenser Vacuum

Raw water source used for cooling causes different tube fouling problems that affect heat transfer and life expectancy of Heat Exchanger and Condenser Tubing in Power Stations. Hence employing Bullet Cleaning as an effective and efficient way of cleaning condenser tubes.

Spring loaded tube cleaner (Bullets) are shot through fouled Condenser Tubes using specially designed water guns at 15-25 kg/cm^2 water pressure. The bullets moving through the tube from one end to the other scrape off the deposits and corrosion scales. Water from the gun flushes out scraped deposits resulting in a clean inside surface for the tube, ideal for good heat transfer. Tube cleaners exit at the end of the condensers, hitting a collection screen hung at the other end. These cleaners are collected, cleaned and used again. Normally a bullet can be used 10 to 15 times.

Fouled tubes cause reduction in Heat Transfer, leading to deterioration in Condenser Vacuum then rated.

Other benefits are:-

1. TG Heat rate is reduced.
2. Condensate flow rate is reduced which reduces Condensate extraction pump loading.
3. COOLING differential temp. across I/L & O/L of condenser is increased.

SAVING POTENTIAL

Coal flow rate at 500 MW = 250 TPH; Vacuum can be improved from 0.875 bar to 0.900 bar.
Vacuum loss due to fouled tubes and air ingress = 2.8 %; Considering minimum 2.8% of vacuum that can be improved on a conservative basis; Amount of fuel Saved = 6.8TPH (standard given by BHEL)
Total fuel Saved/Year = 48960 T (Considering 24hrs and 300 days of operation)
Amount Saved per Year @ Rs. 2800/TPH of coal = Rs. 1.38 Cr.
Investment Required (Approx.) = Rs. 85 Lakh (For tube replacement, COLTCS)
Payback Period = 1.62 months.

CONCLUSION

After performing the energy audit of TPP it was found that there is too much potential is available to save energy in various sections like Boiler, Turbine,etc. An anticipated savings of Rs.47.43 Lakhs/year by reducing dry flue gas losses in boiler with an approximate investment of Rs.20 Lakhs. By minimizing MAKE UP water consumption, we can save 23.25 Lakhs/year with an investment of Rs. 10 Lakhs. Stopping recirculation flow in bypass lines of MDBFPs during normal operations about Rs 27.30 Lakhs/year could be save, and by replacement of MDBFP with TDBFP we can save approximately Rs. 2772 Lakhs/year. There is lot of energy saving opportunities in CHP also.

Critical analysis of audit reveals that about Rs.4108 Lakhs/Year could be saved against the investment of Rs.2592 Lakhs and payback period for this expenditure would be 7.5 months.

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