



An Analysis of Different Methods for Major Energy Saving In Thermal Power Plant

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ABSTRACT: A Thermal power plant consist of various cycles and subsystems like air & flue gas cycle, main steam cycle , feed water & condensate water cycle , fuel & ash cycle, Equipment cooling water (ECW), auxiliary cooling water (ACW) system, Compressed air system ,Electrical auxiliary power & lighting system, HVAC system etc . In India , most thermal power plants employing sub critical technology are able to work only at 30 - 40 percent efficiency . The remaining 60 - 70 %is lost during generation, transmission and distribution out of which the predominant loss is in the form of heat . This paper demonstrates the major energy saving potential areas and methods to improve the overall efficiency of a thermal power plant .

KEYWORDS: HVAC, auxiliary power, efficiency, steam cycle

I.INTRODUCTION

A thermal power plant or TPP can be roughly categorized into 3 distinct areas – boiler turbine generation or BTG , balance of plant or BOP and switchyard . The four basic cycles in the BTG include Steam cycle , Fuel and Ash cycle , Air and draught cycle and Feed water and cooling water cycle . The BOP at Indiabulls power Amravati unit 1 consists of DM water plant , IDCT (induced draught cooling tower) , CHP (coal handling plant) , AHP (ash handling plant) hydrogen generation plant and reservoir system . Other miscellaneous areas of the plant include plant township and ash disposal area . The major energy saving and methods to improve efficiency have been categorized cycle wise as well as area wise .

II.RELATED WORK

Some literary survey was done prior to writing this paper and literary citations as well as theoretical support for some of the findings has been supplemented by the works of Mr. Xu Lian (University of Nebraska) ; Mr. M. Jacob and G.D. Andreescu . All the three mentioned author's works on control systems in boilers was looked into . Fly ash data was cited from. The report on fly ash utilization by Central Electricity Authority , Government of India . Technical manuals of corporations ABB and ALSTOM were also referred to and are cited.

III.BACKGROUND

In light of the rapidly increasing power consumption , there is an increasing and earnest demand for maximum energy conservation and increasing the efficiency for thermal power plants . A lot of methods have been earlier propounded but rarely implemented due to lack of insight or unfeasibility in implementation . This paper presents some ingenious and tested methods for saving energy that are fly ash utilization , fuel switching , improved bowl mill design , condenser tube cleaning , replacement of BFP cartridges , using three element mode of operation , using auto converters and VAMs . All the mentioned methods have been theoretically as well as technically explained . The technical analysis and observations are presented and savings have been approximated for each method via applicable formulas . This paper draws inspiration from several references , which have been mentioned in the end .



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IV.SCOPE OF RESEARCH AND PROPOSED METHODOLOGY

IV.1 Fly ash utilization

According to fly ash utilization data mentioned in the report of Central Electric Authority of India, it has been made mandatory that up to 60 percent fly ash should be utilized in the TPP during the first two years of commissioning. Unfortunately the scenario of fly ash optimization is very recalcitrant in the power sector today. However, some of the ingenious methods for fly ash utilization include manufacturing Portland cement (FAPPC), manufacturing clay fly ash bricks, aerated concrete blocks, ready mix concrete, mortar and other building materials. The use of fly ash from agricultural point of view is also beneficial. Fly ash should be used for building and construction purposes inside the plant, for example a whole township could be set up demonstrating the use and durability of fly ash bricks and FAPPC.

IV.II Increasing efficiency in steam circuit by fuel switching

Energy conservation can be achieved at fuel oil handling plant in terms of steam conservation or electrical energy conservation. Fuel oil system is an important part of a coal based thermal power station, in the absence of which the plant cannot take off from starting condition. A solution to the rising costs of oil and increase in efficiency can be provided by fuel switching from HFO to LDO.

HFO is highly viscous oil, which requires heating to reduce the viscosity up to 15 CST to make it suitable for combustion in the Boiler. Since the HFO is under constant circulation between the boiler and the fuel oil handling plant, which always remains at some distance from Boiler, steam tracing lines are used for the heating purpose. The heating medium being steam, the loss in steam energy and condensate through steam traps are high. Looking at the reliability, availability and history of oil consumption during the past few years at the plant, it is advisable to use LDO. The core advantages of using LDO is less consumption of steam due to absence of steam tracing of LDO lines, and no atomizing, unlike HFO. So, the use of LDO should only be restricted for initial firing and subsequently changing over to HFO.

Technical & Financial Analysis Made:-

Ready steam consumption

Steam consumed due to condensation in atomizing header = 9.44 T/day (approx.)

Steam consumed due to condensation in steam tracing line = 6.2 T/day (approx.)

Daily consumption

Extra steam is consumed during oil firing when raising temperature of oil - 107 kg/ kL

The average HFO consumption in the previous year was - 152 kL

Steam consumed for heating of oil - 16.88 T

Total steam consumption per day $9.44+6.2+6.2= 21.84$ T/day

Total steam consumption per year $21.84 * 365+ 16.88 = 7988.48$ t (approx.)

If Boiler efficiency =84%,

Then total heat loss due to steam consumption= $692*7988.48*1000 = 5528028160$ kcal

Now, the Calorific value of coal = 4259 kcal/kg

Annual Coal quantity in Tonnes required to produce above steam = $(5528028160/ (0.84 *4259*1000)) =1545.19$ T.

Coal cost = 1545 T * 2200 Rs/T (Delivered Price) = Rs33.99 Lakh.

Hence, there is direct saving of 1545 Tonnes of coal per Annum or Rs 34 Lakh.

IV.III Improved design of bowl mills

An ingenious improvement in the bowl mills can be to use Hi-Chrome material instead of Ni-Hard IV for grinding rolls and bull ring segment. This will improve the mill availability from 2500 – 3000 hr to 5000hr synchronizing with boiler annual overhauls and also eliminates fuel oil support due to mill outage.

Typical savings for a 275 MW unit can be estimated to be Rs 100000 per year.



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IV.IV Regular condenser tube cleaning

Reservoir water source used for cooling causes different tube fouling problems that affect heat transfer and life expectancy of Condenser Tubing in Power Stations. Hence we can employ Bullet Cleaning as an effective and efficient way of cleaning condenser tubes. Spring loaded bullets are shot through the condenser tubes. The bullets moving through the tube from one end to the other scrape off the deposits and corrosion scales, resulting in a clean inside surface for the tube, ideal for proper running. These cleaners can be used and cleaned over and over again.

Observations :-

During Unit Shutdown condenser tube cleaning was done by above method. The contribution in condenser vacuum due to tube cleaning is 6.8 mm Hg, and gain in Heat rate is 6.8 Kcal/kWh.

Technical and financial analysis :

Annual coal saving in Tonnes =
$$\frac{(\text{Heat Rate gain} * \text{Unit annual generation})}{(\text{Avg. GCC of coal} * 1000)}$$
$$= (6.8 * 2099.44 \text{ Lakh kWh}) / (4050 * 1000) = 360.66 \text{ Tonnes.}$$
Annual saving in Coal cost = 360 T * 2240 Rs/T (Delivered Price) = Rs8 Lakh

Impact of Implementation:- It is summarized in the following table

Improvement	Quantity
Reduction in coal consumption	By 360 Tonnes per annum
Total savings in Rs. Lakh	8.00
Total Investment Rs. Lakh	3.44
Simple Payback Period	0.66 years

Table 1.1 impact of implementation

IV.V Timely replacement of BFP cartridges

The BFP, or boiler feed pump is a very critical part of the boiler system. It regulates the amount of feed water going into the boiler drum and is part of a complex control system which involves controlling of the throttle valves and regulating the water supply based on the pre-existent water and steam levels in the drum. Thus it is often observed that BFP takes a lot of power. However, if BFP takes higher power, chances of interstage leakage in the recirculation process happen. Therefore, it should be observed as well as checked regularly and the BFP cartridge should be inspected thoroughly on a regular basis. If the need arises, it should be changed for better efficiency and less power consumption.

Impact of Implementation

After replacing the cartridge the current drawn by current reduced by 60 Amp.

Power saved per day = $1.66 * 6.6 * 60 * .84 * 24 = 13,252 \text{ KWH}$

Power saved per year = 4837,117.82 KWH

Saving of cost = $4837,117.82 * 3.4 = \text{Rs}16829515$

IV.VI Using three element mode of operation in BFP operation

BFP operation involves controlling the drum level in two modes – DP mode and the Three element mode. Although the DP mode provides more robust control of the throttle valve, throttling losses do occur. Three element mode reduces these throttling losses by measuring the steam level, steam rate flow as well as the water level simultaneously, thereby resulting in a lesser loss of pressure and hence lesser demand. Pressure drop across the throttle valve can be optimized more efficiently using this method of control.



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Technical and financial analysis :

Energy Saving potential in throttled FRS valve is given below which clearly indicates pump power loss can be optimized by minimizing pressure drop across the valve.

Energy Saving Potential =

$$\frac{\text{Pressure drop across the valve} \times \text{Pump Power}}{\text{Total Pressure Rise across the Pump}}$$

DP optimization in DP mode gives no substantial energy saving due to controlling action of FRS valve. Further pressure drop reduction is only possible in three element mode scoop operation where FRS valve is kept fully open.

Pump losses % =

$$\frac{\text{Pump power (100- efficiency)}}{\text{Generated Load}}$$

In 275 MW capacity unit having overall efficiency of 40 % and for pump power= 7 MW, DP =7.5 kg/cm², Total pr. Developed by pump = 180 kg/cm², Energy saving potential & Calculated pump loss is given below which are unusually high figure.

Energy saving potential =29 %

Calculated pump loss = 1.834 % of Boiler Heat I/P

As flow control by throttling in case of high power pump like BFP is inefficient, flow control by speed regulation by means of BFP scoop is adopted

BFP scoop operation was successfully tested in three element mode for each BFP. Pressure drop across FRS valve is observed to be **3.5 kg/cm²** in valve full open condition.

Ampere saving achievement is given below :

S.NO.	BFP UNIT	AMP. Gain/Hr	KW saving/Hr	GHG reduction KG/Hr
1	BFP - 1A	12	95	80
2	BFP - 1B	2.6	26	21
3	BFP - 2A	4.5	39	36
4	BFP - 2B	14.3	136	120

Table 1.2 Savings in three element mode

BFP hydraulic coupling's response time and subsequent change in drum level shows that drum level control directly through BFP scoop operation in three element mode variation is quite feasible especially under steady operating condition

IV.VII Use of VFD and Converters for lesser loads

VFD or variable frequency drives are a very useful and cost saving measure for underloaded motors . VFDs can also be applied to the BFP and ID fan motors . Another practical aspect can be use of auto star / delta converters for underloaded motors . The star delta starter starts the motor in star to reduce the high starting current , and reconnects the motor in delta after the motor reaches about 80 percent of its rated speed .

However , it has been well observed and documented that for loads approximately less than 50 percent of the full load , using star connection is more suitable . This is so because operating in the star mode leads to voltage reduction of root 3 per phase. Motor output falls to 1/3 of the value in the delta mode, but performance characteristics as a function of load remain unchanged. Thus full load in star mode operation gives higher efficiency and power factor than partial load operation in delta mode.

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During the study the motor (rated motor is 18 kW) was measured and monitored for the loading and other electrical parameters. The details were :

PARAMETER	VALUE
voltage	422V
Current	18.8A
Power factor	0.50
frequency	49
demand	12.58 Kva
power	6.7 Kw
Percentage loading	37 %

Table 1.3 Parameters in Star mode

In view of under loading of the motor, it was suggested to operate the motor in star mode. The plant personnel immediately implemented the measure by converting the delta connection to star mode. The motor electrical parameters after star mode conversion are:

PARAMETER	VALUE	IMPROVEMENTS
voltage	422V	-
Current	12.4A	-
Power factor	0.78	0.78
frequency	49	-
demand	8.45 Kva	4.13
power	6.23 Kw	0.42
Percentage loading	40%	

Table 1.4 Parameters in delta mode

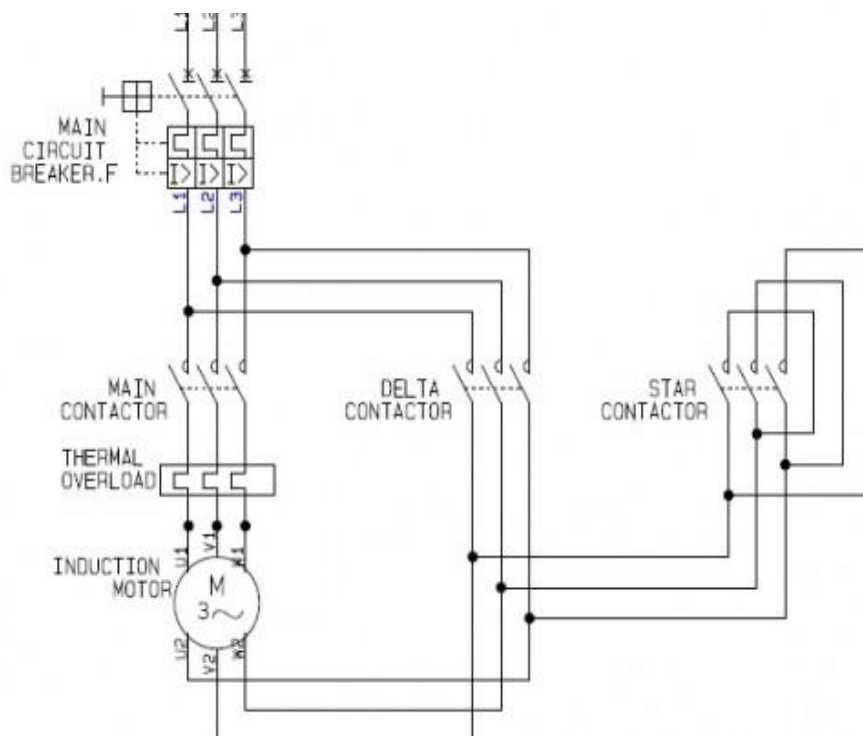


Fig1.1 Connections in delta

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Figure 1.1 shows a relatively simple and yet highly efficient connections of a star delta autoconverter . It consists of two switches in a parallel connected fashion , which are responsible for the mode change between delta and star winding connections

IV.VIII Use of vapor absorption machines (VAMs) for indoor cooling purposes

Presently at most the thermal power projects in India , traditional vapor compression machines are used for cooling purposes The vapor-compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere . However the major disadvantages of this system is that it consumes a lot of electricity and many refrigerants still use HCFC gases as freons and hence contribute to global warming .

A sensible solution to this can be the use of vapor absorption machines . An absorption refrigerator is a refrigerator that uses a heat source (e.g., solar energy, a fossil-fueled flame, waste heat from factories, or district heating systems) which provides the energy needed to drive the cooling process. The main saving principle in this is that this principle can also be used to air-condition buildings using the waste heat from the turbine and steam generation process .

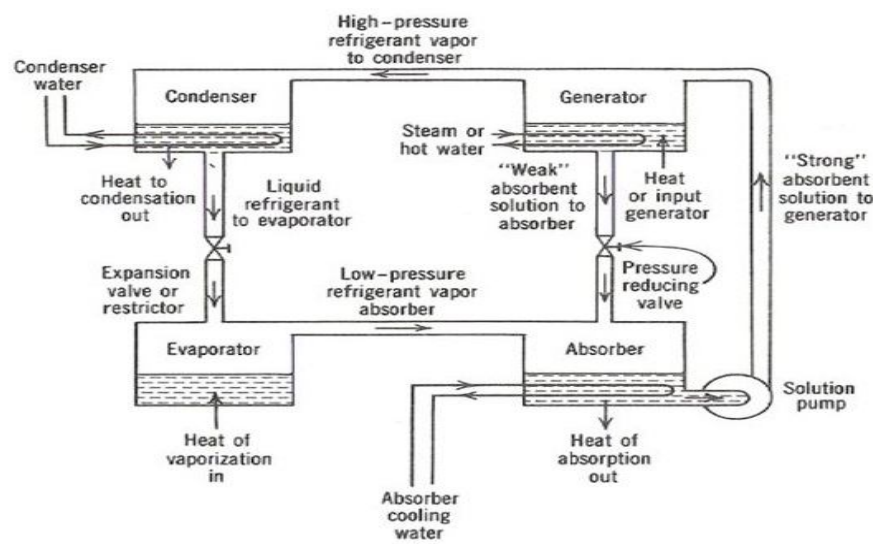


Fig 1.2 Vapor absorption process

Figure 1.2 explains the concept diagram behind vapor absorption process .Its usefulness in thermal power plants evolve from the fact that it can use the waste heat from the steam to run the air conditioning units in the entire plant .

V. SIMULATION

Simulation pertaining to one method - controlling the drum in three element method was done and the digitalized monitoring and control of boiler drum was continuously done from the MCR or main control room . The software used in MCR is a heavily modified version of SCADA . The following simulations were done :

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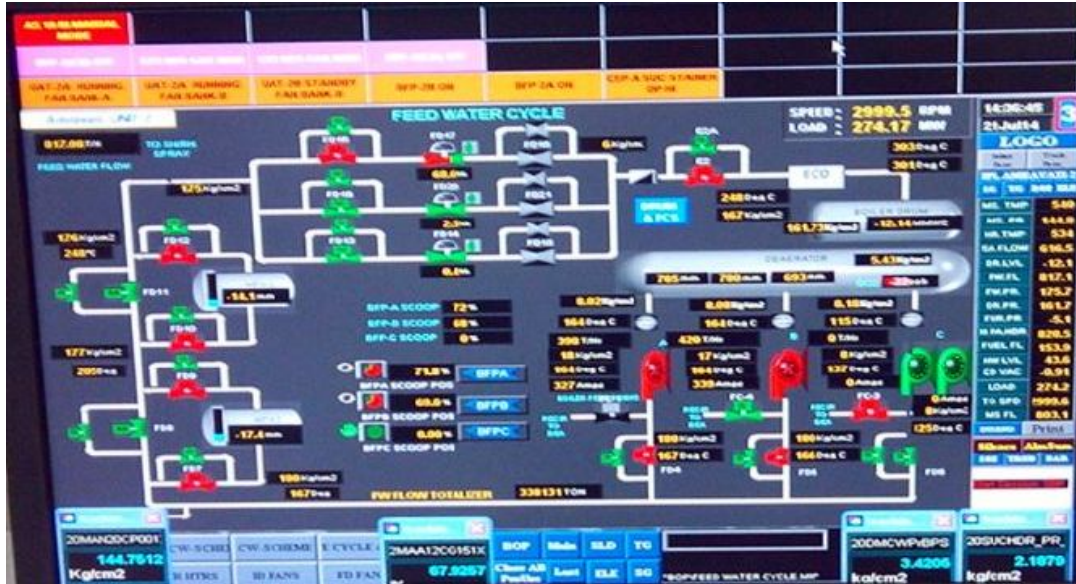


Fig 1.3 Digitalized control and monitoring of boiler drum as seen from main control room

In figure 1.3 , the digitalized control and monitoring of all the boiler drum feed water cycle systems can be seen . The three pumps in the upper left are the symbol of the three element control mode . The 3 element mode can be switched on from here

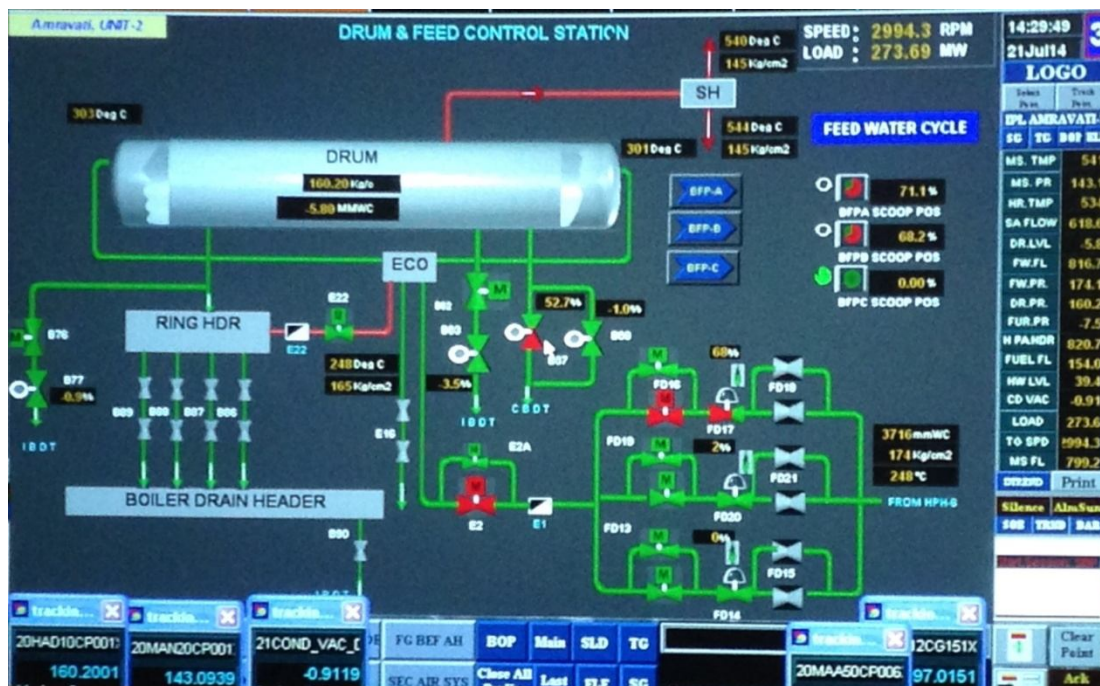


Fig 1.4 Boiler drum control

In figure 1.4 , the digitalized drum and feed control station are shown . Continuous monitoring of the boiler drain header as well as the boiler drum are done and pressure sensors relay the continuous time information on the display screen .



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VI. RESULTS

From the above conducted methods , it was thus documented that a marked improvement in power consumption savings was observed . All the documentable methods and their saving potential observations has been summarized as follows :

- 1.) FLY ASH UTILIZATION - mentioned methods promise upto 60 percent of utilization
- 2.) FUEL SWITCHING – reduction in coal consumption by 1545 tonnes per annum
- 3.) CONDENSER TUBE CLEANING – reduction in coal consumption by 360 tonnes per annum
- 4.) REPLACEMENT OF BFP CARTRIDGES – upto 13,252 KWH of power saved per day
- 5.) THREE ELEMENT MODE OF OPERATION – power savings per hour range from 40 – 130 KW per hour
- 6.) CONVERTERS FOR LESSER LOADS – power demand goes down by 4.13 Kva , improved power factor

VII. CONCLUSION

A marked improvement in energy conservation and increase in overall efficiency of the plant can be observed when the above points are implemented successfully at Indiabulls power Amravati Unit 1 , helping drive the cost of generation significantly lower and improving the overall economics of power generation . The above can also be a role model for the commissioned as well as upcoming new thermal projects throughout India

VIII. ACKNOWLEDGEMENTS

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