Performance Analysis of Economiser, Air Pre-Heater and Electrostatic Precipitator of 210MW Power Plant Boiler

R Boopathi[1] , G.V. Ganapathyraman[2], P. Manimaran[3], A. Prabakaran[4] and S.Prabakaran[5]

[1*]Assistant professor, [2,3,4,5] UG Students,

Department of Mechanical Engineering,

Mahendra Engineering College,

Tiruchengode, 637503

India.

*Corresponding author

ABSTRACT

The main objective of the project is to study and understand the working and power production methods of MTPS-1. The boiler performance including its ability to meet full load, auxiliary power consumption, net plant heat rate, availability of the unit, operation and maintenance cost . An economizer is a device used to heat feed water by utilizing the heat in the exhaust flue gases before leaving through the chimney. Economizer improves the economy of the steam boiler. The following are the advantages of using an economizer. It increases the steam raising capacity of a boiler i.e., it shortens the time required to covert water into steam. It prevents formation of scale in boiler water tubes. There is about an average of 18% of coal saving. Since the feed water entering the boiler is hot, therefore strains due to unequal expansion are minimized Air heater is a heat transfer surface, in which inlet air temperature is raised by transferring heat from the fuel gas. Since the air preheater can be employed successfully to reclaim heat from the fuel gas to low temperature levels, than is possible with economizer, heat rejected to chimney can be reduced to higher extend. For every 20° C drop in flue gas exit temperature the boiler efficiency increases by about 1.0%.In addition to increase boiler efficiency. Electrostatic precipitator contains 24 fields are available in each boiler to separate almost 99% of ash and delivers in dry of wet from according to the requirement of the disposal. First age chimney height is around 130 meters and the second stage is above 220 meters. The field effective analysis is made in order to improve the efficiency of electrostatic precipitator

Key Words: Economiser, Electrostatic precipitator, *Exhaust gas, Preheater, Steam raising, Unequal expansion.*

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1. INTRODUCTION

Coal fired thermal power plant generates major portion of India's electricity. In a typical thermal power plant the raw coal is crushed and pulverized in a mill to a size finer than face powder. The primary air supplies dries and transport the coal into the boiler furnace. The coal burns in the furnace to generate superheated steam which

drives a turbine connected to an alternator to generate electricity. Tuticorin thermal power station, located near new port of Tuticorin, is owned and operated by Tamilnadu electricity board. It has a total capacity of 1050MW comprising 5 units of 210MW each. The station has been erected in III stages; first stage consists of unit I&II of 210MW each. The second stage consists of unit 210MW and the third stage consists of unit IV & V of 210MW each. All the units are coal based; coal is transported by sea through ships from Hadia, Paradeep, vizag ports to TTPS. LP economizer is heat recovery system in which heat is gained from the exit flue gas. It is similar to the economizer in boiler. Economizer can be provided to utilize the flue gas heat for pre-heating the boiler feed water. On the other hand, in an air pre-heater, the waste heat is used to heat combustion air. In both the cases, there is a corresponding reduction in the fuel requirements of the boiler. A simple sketch of an economizer is shown in Fig. 1.

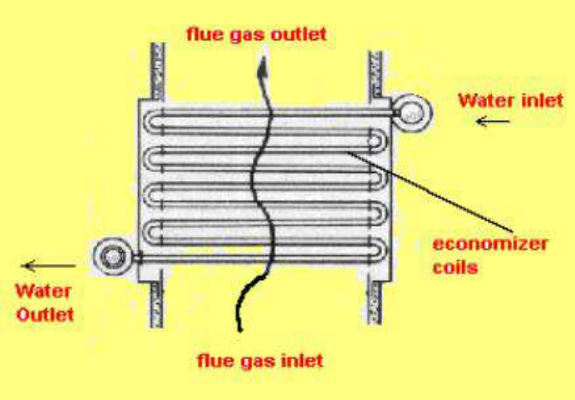

Fig.1. Economizer coil

The location and wind direction for Air cooled Steam condenser in thermal power plant plays a very vital role in their performance as earlier said its efficiency is inversely proportional to the ambient temperatures As the air passes from various heated equipment like Boiler, Air Pre-heater, Economizer, Electrostatic Precipitator (ESP) etc. so the ambient air when comes in-t o the contact of these equipment's receive the heat in the form of convection and gets heated locally and this is a cause of increasing the ambient temperature. We cannot avoid the local heating of air because it is the natural phenomenon and the padding over that equipment is also limited to certain limitations. So it is very necessary that the Air Cooled steam condenser shall be located in the region where the localized heat is minimum or we can say that the location of air Cooled steam condenser shall be optimized to enlarge the performance against the windy condition.

To triumph over those problems of restricted heating and windy condition this account has certain CFD examination on the basis of that we can able to cause the Zone data where the windy condition and localized heating of ambient air is minimized

2. ABBREVIATIONS AND ACRONYMS

The method here used includes, a basic study of entire plant workings and deep study on the accessories on which tapping has to be done, collection and allocation of necessary values and data from operational manuals, obtained

values from divisional engineers, supervisors, service books etc. With the data collected, the amount of Mass flow rate/ Volume flow rate of hot air required to make substitution for the set of heating coils of capacity 6kW for each hopper to make temperature of 120^{o} -130^{o}C around the shell of hopper. The position is preset near the final bend, just in face of the wind box where hot air tapping is to be done. The reserve among the source and sink is around 40 meters. So the fever drop due to heat relocate in the duct, with the specific insulation thickness, is calculated [2]. The hot air in use from the boiler are split up to various twelve different ways in the form of pipelines beside with flow control valves at the necessary locations.

The feed water is pumped from the condenser to series of low pressure heaters after this stage the feed water enters the high pressure heaters for again raising the temperature. After gaining considerable rise in temperature, the feed water enters the economizer. From the economizer the feed water is sent to the boiler drum for generation of steam. The heat for the low pressure and high pressure heaters extracted from the turbine at different locations. The heat for raising the temperature of the feed water in the economizer is derived from the flue gas. The flue gas provides required heat for heating up the feed water in the economizer. It also provides required heat for heating primary and secondary air in the air preheater. After heating the air in the air preheater the flue gas is sucked by the induced draft fan through the flue gas duct. The sucked gas reaches the electrostatic precipitator for the removal of fly ash from the gases.

Dexin Wang developed to extract a portion of the water vapor and its latent heat from flue gases based on a nano porous ceramic membrane capillary condensation separation mechanism. The recovered water and heat can be used directly to replace power plant boiler makeup water to improve its efficiency, and any remaining recovered water can be used for water makeup or other plant uses. The technology will be particularly beneficial for coal-fired power plants that use high-moisture coals and/or Flue Gas De Sulphur cation for flue gas cleanup.

Chaojun Wang emission resulted from the low pressure economizer installation are assessed for three cases in a 600 MW coal-fired power plant with wet stack. Serpentine pipes with quadrate finned extensions are selected for the low pressure economizer heat exchanger which has an overall coefficient of heat transfer of 37 W/m.

3. NEED AND SCOPE

It is used in all modern plants. The use of economizer results in saving fuel consumption, increases steaming rate and boiler efficiency. Some of the common applications of economizer are given below, In steam power plants it captures the waste heat from boiler stack gases (flue gases) and transfers it to the boiler feed water. Air-side economizers HVAC (Heating, Ventilation and Air Condition) can save energy in buildings by using cool outside air as a means of cooling the indoor space.

Refrigeration: This is commonly used in industrial refrigeration where vapour compression refrigeration is essential. Systems with economizers aim to produce part of the refrigeration work on high pressures, condition in which gas compressors are normally more efficient

3.1 Advantages and Benefits of Economizer

It recovers more heat of flue gases which normal air pre-heater cannot do. Due increase in fuel prices, all power plants are facing pressure for increasing boiler efficiency. So by using economizer, this pressure can be minimized. Power plants where it is not used, large quantity of water is required to cool the flue gas before desulphurization which is minimized by using economizers. The efficiency of power plant reduced when steam air pre-heater required steam. Air heater is a heat transfer surface, in which inlet air temperature is raised by transferring heat from the gas. Since the air preheater can be employed successfully to reclaim heat from flue gas to low temperature levels, than possible with economizer, heat rejected to chimney can be reduced to higher extend. For every 20°C drop in flue gas exit temperature the boiler efficiency increases by about 1.0%. In addition to increase boiler efficiency, the other advantages are,

- Stability of combustion by increased temperature of air admitted for combustion.
- The hot primary air is used for drying coal in the mill for better grinding and carrying coal power.
- Better combustion of poor quality of coal, having low volatile content.
- Reduction in incombustibles in flue gas.

The above design deficiencies have the following effect on the APH performance.

a) Increase in Aux. Power consumption due to increase in P.A & I.D fan loading
b) Increase in APHs maintenance due to high erosion of APH internals
c) Less P.A header pressure due to non-availability of margin in fan loading.
d) Increase in O_2 in flue gas after APH due to seal leakage.
e) Difficulty in maintaining mill outlet temperature.
f) Avoidable forced outage of unit due to falling of hot end sector plate because of tie rod erosion.
g) Dust nuisance and environmental hazards in APH area due to leakage, especially in guide bearing area.
h) Reduced boiler efficiency.

4. WORKING PRINCIPLE

The baskets are required to be replaced where the depth of erosion is more than 25mm. It is difficult to remove and replace the hot end elements fully for the erosion since the process shall consume considerably more time, cost and labour. So the hot end layer is subdivided into 2 segments as 200mm+650mm. Instead of replacing the baskets of 850mm height we can now easily replace the baskets 200mm height and 650mm baskets may be reversed and reused. The modified maintenance methodology shall result in reduction of maintenance cost & time and labour, appreciably.

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4.1 Replacing Single Seals by Double Seals

At present the air preheater segments are sealed by single sealing at 30° apart. In this method the sealing surface is minimum and the angle between the adjacent seals is 30°. The leakage in air preheater is more i.e., leakage of primary and secondary air in to flue gas due to lack of perfect sealing. To prevent this leakage, frequent maintenance works are required to be carried out and periodic monitoring is required. The leakages reduce the performance of the equipment and reduction in efficiency. The leakage shall lead to higher gas velocity that affects the performance of ESP. Further this will result in excessive loading of ID fans, FD fans, PA fans and Air preheater itself. Consequently, the boiler efficiency gets reduced and the cost of generation gets increased. To avoid the above mentioned deficiency the single sealing is replaced by double sealing.

The double sealing is method of increasing the area of sealing surface. In double sealing for every 15° rotor angle one seal is provided instead of 30°. This will enhance the sealing in the air preheater. By implementing this double sealing the leakage are minimized in the air preheater when compared to single sealing and the performance air preheater is increased.

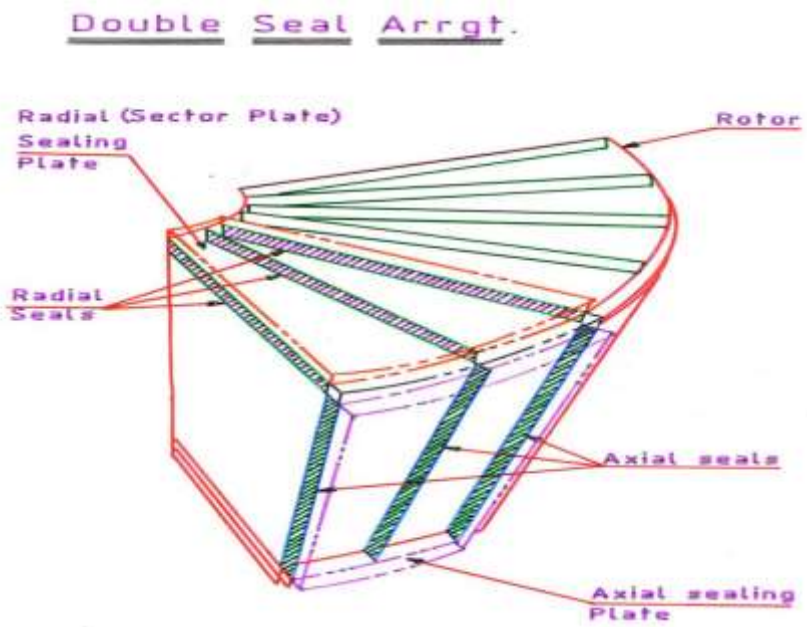

Fig.2. Double seal arrangement

4.2 Analysis of Field Failure

The field failure data were calculated from unit 1 and 2 of MTPS as mentioned in table for reference

4.3 Causes for Under Voltage and Field Short

The following were found as the causes for the under voltage, which leads to field short in ESP, during the observation:

4.4 No Rapping

Even though the rapping motor runs at the set rpm, sometimes there will be inefficient rapping or even no rapping. This may due to:

1. Wear and tear of hammer, hinge, pin etc of rapping mechanism.
2. Erosion of frame joints with collection plates. So that when the rapping hammer hits the frame, the vibration will not be passed on to the collector plates.

3. when there is no rapping, the thickness of ash particle layer sticking onto the collector plates and emitter plate increases.

4.5 Bending of Collector Plates

The bending of collector plate may be due to

1. The striking of flue at high velocity along with some foreign materials such as materials such as metal pieces.
2. The high voltage applied to the collector plates.

4.6 Erosion of Collector Plates at the Joining

The joint of the collector plate with the frame maybe eroded due to its continuous exposure to the high velocity flue gas. when it gets eroded, rapping becomes ineffective and also there is a change of collector.

4.7 Accumulation of Ash in the Hopper

After rapping, the ash is collected in the bottom of the ESP hopper .if the ahs from the hoppers is not removed continuously either by water jet or dry ash removal system.

4.8 Erosion of Gas Distribution Screens

In case of erosion of the primary and secondary gas distribution screens inlet of the ESP, metal pieces or foreign materials enters into ESP along with the flue gas and hit the collector or emitter electrode which causes field short.

4.9 Improper Closing of Doors at the Top

If the doors of the insulator cover at the top of the ESP are not closed properly, there is a change for the rain water to enter into ESP, which suddenly causes field short.

4.10 Erosion of Distribution Plates at the Sides

Due to the continuous exposure of the gas distribution plates at the sides of the collector plates of the flue gas at high velocities these plates can get eroded, then the flue gas may escape through the gap between the collector plates.

5. CONCLUSION

The design arrangement and operation of 210MW Power plant boiler and its associated system were studied in detail. Its observed that the APH outlet flue gas temperature is higher than the design value. Finally the cost wise savings per year is worked out to 216 lakhs and the revamping and also augmentation cost shall be paid back within 3 years. The life of the renovated equipments shall we 12 to 15 years with routine maintenance works. Air preheater recover heat from outgoing the flue gas, the temperature of the flue gas is above the predicted design value there is considerable loss in efficiency.

The performance of APH can be improved there by increasing the efficiency of boiler by 1.13%. By optimizing and modernizing the sealing arrangements leakage in APH minimized there by improving the performance of ID, FD and PA fans and increasing APH efficiency 3.3%.By optimizing the heat transfer elements the performance of the air pre heater is improved there by increasing the efficiency of the boiler. By optimizing the sealing arrangement by minimizing leakage there by improving the performance of ID, FD, & PA FANS.

The stack emission norms fixed by the state pollution control board stipulates that the stack emission level should be within 100 m/Nm^3. Hence, our suggestions for the improvement of the performance of ESP system are given. The efficiency of the ESP system will definitely be improved, incase our recommendations are considered for implementation

This is a method to return heating coils with the presented heat source. This is the manner which can be done without upsetting the routine operation. But the implementation and testing can be done only during the shutdown period of 40 days every year. Thus by this recommended method more amount of energy and cost can be saved which automatically increases the capacity factor of the plant.

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