Performance Analysis of Air Preheater in 210mw Steam Boiler

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Abstract- *The major efficiency loss of a boiler is caused by the hot stack gases discharging to the atmosphere. In the economizer, by adding the extra bank of tubes, the reduction in the flue gas outlet temperature and increase in the feed water outlet temperature are found out and various heat transfer calculations are done. It is found that a rise in temperature of feed water by 6°C improves the boiler efficiency by 1%. In the Air preheater segment, single seals are replaced by double seals. By doing this, reduction influe gas exit temperature and increase in the Boiler inlet air temperature are found out. It is observed that for every 20°C drop in the flue gas exit temperature, the boiler efficiency increases by 1%. The main advantage of this proposed method is that the heat transfer rate in boiler will be increased*

I. INTRODUCTION

The major efficiency loss of a boiler is caused by the hot stack gases discharging to the atmosphere. In order to increase the efficiency of boiler we have to extract maximum amount of heat from the flue gases and increase the heat pick up rate of the feed water outlet into the boiler

The power plants are facing the problem of boiler tube leakage and it is more critical when they are running on full load. It becomes one of the critical reasons among numerous reasons of the energy crisis. Utilities have been fighting boiler tube failure since long. The tube failure cost crores of rupees lost, as it causes loss in generation. Boiler tubes have limited life and can fail due to various failure mechanisms.

Boiler tube failures results in loss of 465 Million Of Units (MU's) in power generation. Moreover the severe service condition in coal fired thermal power plants causes failures such as the effects of high temperature, erosion, stress, vibration and corrosion combined resulting in failure of the boiler tubes thus it is extremely important to determine and correct the root cause to get your boiler back on line and reduce or eliminate future forced outages.

II. ECONOMIZER

Economizer An economizer is a mechanical device which is used as a heat exchanger by preheating a fluid to reduce energy consumption. In a steam boiler, it is a heat ex-changer device that heats up fluids or recovers residual heat from the combustion product i.e. flue gases in thermal power plant before being released through the chimney. Flue gases are the combustion exhaust gases produced at power plants consist of mostly nitrogen, carbon dioxide, water vapour, soot carbon monoxide etc. Hence, the economizer in thermal power plants, is used to economies the process of electrical power generation, as the name of the device is suggestive of. The recovered heat is in turn used to preheat the boiler feed water, that will eventually be converted to super-heated steam. Thus saving on fuel consumption and economizing the process to a large extent, as we are essentially gathering the waste heat and applying it to, where it is required.Nowadays however, in addition to that, the heat available in the exhaust flue gases can be economically recovered using air pre-heater which are essential in all pulverized coal fired boiler.

Working Principle of Economizer

Function of economiser in thermal power plant is to recover some of the heat from the heat carried away in the flue gases up the chimney and utilize for heating the feed water to the boiler. It is simply a heat ex-changer with hot flue gas on shell side and water on tube side with extended heating surface like Fins or gill.

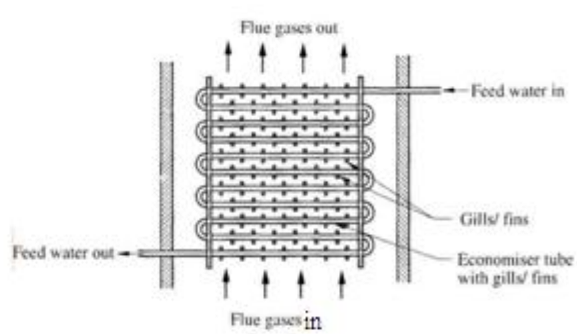

Fig.2.1 Economier

Economizers in thermal power plant must be sized for the volume and temperature of flue gas, the maximum pressure drop passed the stack, what kind of fuel is used in the boiler and how much energy needs to be recovered. When the water is boiled in steam boiler, the steam is produced which is then super-heated after which it is passed to the turbines. Then the exhausted steam from turbine blades, is passed through steam condenser of turbine in which the steam is condensed and this condensed water then is pre warmed first in feed water heater then in it before re-feeding in boiler. It is placed in the passage of flue gases in between the exit from the boiler and the entry to the chimney. In this a large number of small diameter thin walled tubes are placed between two headers. The flue gases flow outside the tubes usually in counter flow.

Process of Heat Transfer

Heat transfer to water in steam generator takes place in 3 different regimes, as shown in the figure below. Water is at first pre-heated sensibly in the economizer in liquid phase at a certain pressure from state 4 to state 5 (refer to the diagram below) till it becomes a saturated liquid. It is then send to the evaporator, where this saturated liquid is boiled associating a change of phase from 5 to 6 by absorbing the latent heat of vaporization, , at that particular pressure. Now this saturated vapour in state 6is further heated in the super-heater, to bring it to state I, i.e, in gaseous or vapour form. For unit mass of fluid, the heat transfer equation in the 3 types of heat ex-changers are given by, Q=h-hQ=h-hQ=h-hOut, of these 3 major heat ex-changer components, only the economizer operates with, zero fuel consumption, and thus it is one of the most vital and economical equipment in a thermal power plant

CI Gilled Tube Economizer

since the air preheater outlet flue gas temperature is brought to 147°C from 163°C (Loss

Sensible Heat loss = WD X Specific heat (To-T)
= (20.23/100) X 30.6 X (147-33)
= 707.10

Heat Loss = (SHX 100) (GCV X 4. 186)
= (707.1XI00)/ (3330X4. 186)
= 5.08

Loss before optimization = 5.773
loss after optimization = 5.077
Reduction in loss = 0.609
Boiler efficiency = 0.7%

As per the study results on energy savings on cost wise for fall fed stations it is
revealed that one degree centigrade reduction of air heater outlet temperature will save
Rs.7,06,406 /yr

Savings by reduction of
16°C (163-147)
= 706406 X 16
= 1.130crores/annum.

Non- condensing Economizer

The most widely used one, in a thermal power plant is the non-condensing economizer. These are basically heat ex-changer coils, that are finned around in the form of a spiral and are located inside the flue gas duct near the exit region of the boiler. They have the ability to reduces the fuel requirements of a boiler by transferring heat from the exit flue gas to the steam boiler feed water. It is used in the case of coal-fired boilers, where the lowest temperature to which flue gas can be cooled is about 250 F (120 C). You can well understand form the discussion above that, cooling the flue gas below 250 F and transferring that additional heat to the boiler feed water would have resulted in greater efficiency, but in a coal fired power plant, this should not be done, since coal as a fuel contains sulphur in a very large extent as impurity. And the flue gas thus formed by burning this coal, results in the formation of sulphurous compounds as by product. Now if this flue gas is allowed to cool below 250 F, condensation of the gaseous compounds result in the formation of sulphuric acid, which is

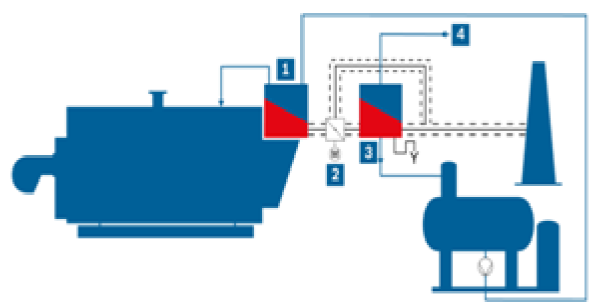

Fig.2.2 Non Condensing Economier

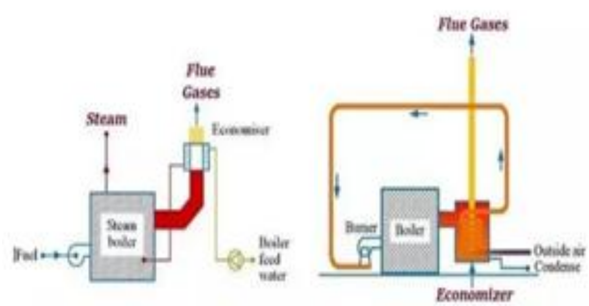

Fig.2.3 Condensing Economier

considered extremely corrosive against the metal surface. Since the installation and maintenance cost of a power plant is huge, it is noteworthy that a non-condensing economizer be installed to limit the cooling capacity of the flue gas to about250 F, ie above the condensation temperature and increase the overall boiler efficiency by about 3 to 6%

Condensing Economizer

The condensing economizers are mainly used in natural gas fired thermal power plants, as they have the ability to improve the waste heat recovery by cooling the flue gas below its condensation temperature, which is about 80°F (25°C). This particular variant of economizers result in greater efficiency of around 10 to 15% and more economical operation as it reclaims both sensible heat from the flue gas and latent heat by condensing water vapour present in the flue gas. This is contradictory to the conventional non-condensing economizers as they increase the efficiency to only about 5%. But the condensing variant with greater value of efficiency can only be used, when the flue gas does not contain any sulphurous, nitrate or other corrosive compounds.

Applications 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.

III. AIR PREHEATER

Air pre-heater is an important boiler auxiliary which primarily Preheats the combustion air for rapid and efficient combustion in the furnace Serving as the last heat trap for the boiler system., a regenerative air preheater typically accounts for Over 10% of a plants thermal efficiency on a typical steam generator. Considering this, when evaluating the performance of an air preheater one should take in into account all of the process variables. A very good method to improve the overall efficiency of a thermal power plant is to preheat the air. If the incoming air for combustion is not preheated, then some energy must be supplied to heat the air to a temperature required to facilitate combustion. As a result, more fuel will be consumed which increases the overall cost and decreases the efficiency

There are many factors, which contribute to the deterioration of air preheater performance like high seal leakage, deterioration of heat absorption characteristics of basket elements due to fouling or plugging. Close monitoring of air pre heater performance and proper instrumentation would enable timely detection of performance degradation. The combustion air preheater for the large fuel-burning furnaces used to generate steam in thermal power plants.

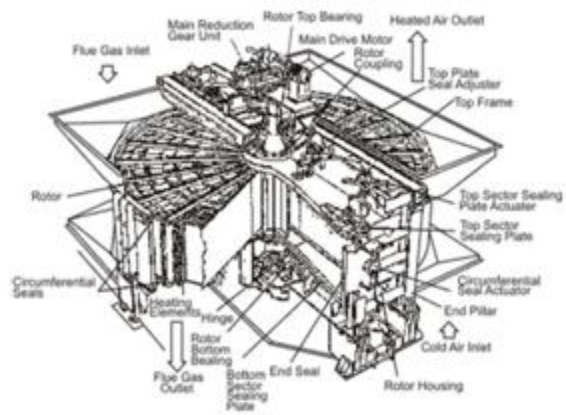

Fig.3.1 Typical tri-sector RAPH view

WORKING PRINCIPLE:

As the name implies the tri-sector pre-heater design has three sections. Use for flue gas .One for primary air (used for drying and transport of coal through mill to the burner) another for secondary air (additional air for combustion around the burners).These helps in avoiding wastage of heat pick up by air due to primary air flow and also help in selecting different temperatures for primary air and secondary air. Whatever is not utilized in primary air can be picked up by secondary air stream. Thousands of these high efficiency elements are spaced compactly arranged with in 12 sectors shaped compartments for heater size from 24.2 to 27 inches, and 24 sector shaped compartments for heater size from 28 to 33 of radial divided cylindrical shell called the rotor. The housing surrounding the rotor is provided with duct connections at both ends and is adequately sealed by radial and axial sealing members forming an air passage through one half of the pre-heater and a gas passage through the other. As the rotor slowly revolves the mass of the elements alternatively through the air and gas passage, heat is absorbed by the element surfaces passing through the hot gas stream. These are the same surfaces are carried through the air stream. They released the stored up heat thus increasing the temperature of the incoming combustion or process air.

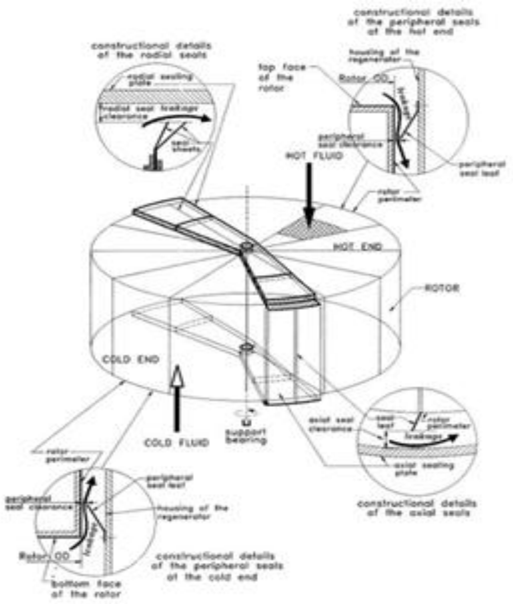

Fig.3.2 Rotary Regenerative air preheater

Rotary air preheater is one of the important energy recovery systems in the steam power plant which was first introduced in 1920 by Ljungstrom. The main function is to primarily preheat the combustion air for rapid and efficient combustion in the furnace serving as the last heat trap for the boiler system, a regenerative air preheater 1ypically accounts for over 10% of a plants thermal efficiency on a typical steam generator. Considering this, when evaluating the performance of an air preheater one should take into account all of the process variables.

A very good method to improve the overall efficiency of a thermal power plant is to preheat the air. If the incoming air for combustion is not preheated, then some energy must be supplied to heat the air to a temperature required to facilitate combustion. As a result, more fuel will be consumed which increases the overall cost and decreases the efficiency. There are many factors, which contribute to the deterioration of air preheater performance like high seal leakage, deterioration of heat absorption characteristics of basket elements due to fouling or plugging. When the rotor rotates, air leakages may exist, eg. Entrained leakage.

Air leakage consumes extra energy from the fan in the boiler system and decreases the heat exchange efficiency of the air preheater. BJ. Drobnic analysed the leakage flow through different leak paths; he showed that the leak path from the cool air to the hot flue gas exerted the most significant effect on the heat transfer efficiency. A method for calculating the mass flows of gas through the seals was also introduced and an adjusting method to reduce the seal clearances in radial seals was further presented. Gromovyk and Ivanik determined the thermal stresses and displacements that occur in an elastic hollow ceramic circular cylinder when convective heat exchange occurs.

DESIGNATION OF AIRPREHEATER-27VIT (M) 80

- 27 Feet Dia.
- Vertical.
- Inverted.
- Trisector.
- Modular.
- 80inch (2000mm) depth.

MODE OF HEATTRANSFER IN APH

The process of heat transfer takes place in APH is Convection, it involves energy exchange between a bulk fluid and a surface or interface. Two kinds of convective Processes exist:

(a) Forced Convection in which motion past a surface is caused by an external agency such as a pump or fan.

(b) Natural or Free convection in which density changes in the fluid resulting from the energy exchange cause a natural fluid motion to occur.

The Air Preheater is a regenerative type Rotary heat exchanger uses forced convection in which flue gases and air passes through a rotating cylinder filled with heat transfer surfaces (heating elements).The flue gas heat the rotating elements, which in turn preheat the air before it is re-circulated to the boiler. In the air heater, there is a heat recovery process as the rotor revolves, the waste heat is absorbed from the flue gas streams and fresh air is heated by the accumulated heat.

WORKING PRINCIPLE OF REGENERATIVE AIR PREHEATER:

The Regenerative Air Preheater absorbs waste heat from flue gas and transfers this heat to the incoming cold air by means of continuously rotating Heat Transfer Elements of specially formed metal plates. Thousands of these high efficiency elements are spacedand compactly arranged w within 24 sector shaped compartments of a radially divided cylindrical shell called the rotor.

The housing surrounding the rotor is provided with duct connections at both the ends, and is adequately sealed by Radial & Axial Sealing members forming an Air Passage through one half of the Preheater and Gas Passage through the other. As the rotor rotates, it slowly rotates the mass of heating Elements alternatively through the air and gas passages.

The heat is absorbed by the element surfaces while passing through the hot gas stream, and then as the same surfaces are carried through the air stream, they release the stored up heat to the air, thus increasing the temperature of the incoming air.

Heating Elements:

Heating elements are made of carbon steel sheets with special corrugations formed by pressing; the hot end heating assemblies are profiled in accordance with shapes and sizes of individual sub-modules. Each assembly is formed by alternately piling up notched undulation sheets with vertical undulations and inclined turbulent corrugations and sheets only with the same inclined corrugations one by one as shown in. All the assemblies of both hot and cold end heating elements are fastened by welding flat bars and angle steels together.

Leakages in rotary heat exchangers:

The basic element of a rotary heat exchanger's operation isa rotating matrix in a compact casing that transfers the heat from the hot flue gas to the cold combustion air. The rotation of the matrix requires an appropriate sealing system to prevent mixing of the flue gas and the air, commonly referred to as leakage. The arrangement of seals around the rotor of a rotary heat exchanger. The seals prevent leakage due to pressure differences between certain locations in the heat exchanger.

IV. RESULT & CONCLUSION

The following are observed after modification of economizer and air pre heater

• The feed water temperature increased by 40^0C.
• The flue gas exit temperature decreased by 60^0C.
• The efficiency of the boiler increased by 1-1.5%.
• Amount of coal supplied can be reduced.

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