IMPROVEMENT IN EFFICIENCY OF AIR PREHEATER IN BOILER TPS- 1 EXPANSION

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Abstract*--** ***An air pre-heater is a general term to describe any device designed to heat air before another process (for example, combustion in a boiler) with the primary objective of increasing the thermal efficiency of the process. They may be used alone or to replace a recuperative heat system or to replace a steam coil. In particular, this project describes the combustion air pre-heaters used in large boilers found in thermal power stations producing electric power from e.g. fossil fuels, biomasses or waste. The purpose of the air pre-heater is to recover the heat from the boiler flue gas which increases the thermal efficiency of the boiler by reducing the useful heat loss of the flue gas in an regenerative pre-heater. This project analysis how operation parameters of an regenerative air preheater can be optimized in order to increase its efficiency and consequently the overall efficiency of a boiler. For this purpose, the RAPH in thermal power station -1 expansion at neyveli is considered and studied for a period and suitable remedies have been suggested.

Keywords—Air preheater, Regenerative air preheater, boiler, and flue gases

I. INTRODUCTION

Modern high capacity boilers are always provided with an 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 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 preheater 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

The organization of this paper is as follows: Section I gives an Introduction and an outlay of the scope of the work. Proposed methodology is elaborated in Section II. Air and flue gas path is given in Section III, and are described in Section V followed by the conclusion in Section VI.

SCOPE THE WORK

After studying the journal papers mentioned above, it is understood that there are some leakages development in the RAPH and maintenances of RAPH is to be considered for the improvement efficiency of the boiler shell and tube air preheater. The project is planned with the following work scope. To identify the problem and to give an suitable remedies for further increases in efficiency of the boiler with the help RAPH.

II. PROPOSED METHODOLOGY

The proposed methodology of the work are detailed discussed and mentioned as below and are shown in Fig.

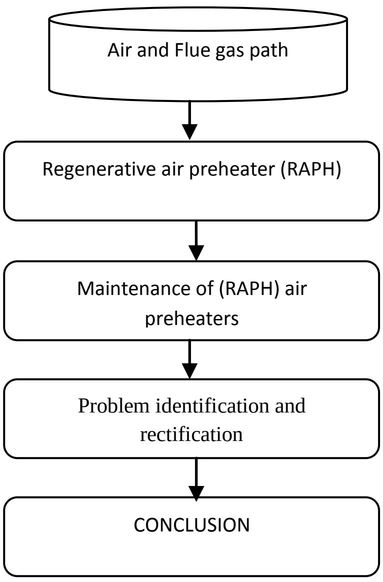

Fig.2. Flow chat of Proposed System

III. AIR AND FLUE GAS PATH

To have uninterrupted and intensified combustion in the furnace, enough air is to be supplied and the products of combustion have to be removed effectively and continuously. The quantity of air to be supplied and the amount of products of combustion to be exhausted from furnace depend on the steaming rate of boiler, which in turn depends on the quantity of fuel consumed in the boiler per hour.

FUNCTION OF AIR AND FLUE GAS SYSTEM

- To supply combustion air to the furnace through oil and coal furnace (secondary air).
- To supply hot tempering air (primary air) to ventilation mills.
- To supply air to after burning grates.
- To suck flue gases produced from combustion process and conveying them to the stack through regenerative air preheaters and to feed recirculation gas system.

AIR PATH

The forced draught fan supplies fresh air to the SCAPH, where it is preheated at an average temperature of 500^{0}C by means of the steam flowing into the heat exchanger, achieving the final temperature of 3000^{0}C.

Downstream regenerative air pre heater, combustion air of both sides is connected to one common combustion air header and then the combustion air flows to:

- Eight oil burners (two for each boiler well), each one equipped with its own related control damper.
- Six secondary (to coal burner) and tertiary (to AAF throats) air ducts, each one equipped with its own related control damper; downstream the damper, each duct is split into two streams in order to supply.
- Secondary air to the two coal burners, each one equipped with its own related control damper. Secondary air is conveyed to furnace through slots between the coal nozzles.
- One primary air ring that, feeds the six re suction ducts at ventilation mill inlet, the primary air is used to control coal/gas/ air mixture, temperature at ventilation mill outlet

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- One cooling air ring, through the shut-off damper, feeds the six Cold Gases Recirculation (CGR) nozzles, the shut-off damper will open, cooling C.G.R nozzle, when cold gas recirculation flow through it drops below 3 to 5% opening valve.
- Two hot air half rings, each one equipped with pressure control valve, feed sealing air duct for three mills.
- The FD fans are equipped with inlet control vane and discharge shut- off damper.
- The air side of regenerative air preheater can be isolated a part of boiler operation by the inlet shut-off damper, located upstream stream coil air preheater, and outlet shut-off damper, in this cases the maximum achievable boiler loads shall be 60% of BMCR.

In between the dampers at the FD fan discharge and at SCAPH inlet, it is provided a cross –over duct, connecting the two FD fans. That supplies cooling air for if that the related regenerative air preheater trips or it is out of services. It allows to operate the boiler equipment’s and it also allow to operate the boiler, at reduced loads, without stripping one FD fan if the related re generative air heater trips or it is out of service and vice versa; this duct also supplies air to auxiliary fans (HHQ01-AN002).

FLUE GAS PATH

The hot gases produced by combustion process, flows across heat exchanger surface (i.e. economizer, super heater and re heater) where they release heat to them, cooling themselves to a temperature of 320^{0}C. Downstream the flue gases flow to the gas side of the re-generative air heaters where they are cooled at the final temperature of 160℃ releasing heat to air systems as above described. The flue gases side of re generative air heater can be isolated apart of boiler operation by the inlet shut-off damper and outlet shut-off damper located downstream ESP, in the case the maximum achievable boiler load shall be 60% of BMCR. Then the flue gases stream passes in the ESP system where the dust is separated from flue gases and collected, hence the clean flue gases sucked by the induced draught fan and sent to the stack. The ID fan is equipped with suction shut-off damper, one suction control vane and shut- off damper on discharge.

In between the damper at ESP outlet and at ID fan suction it is provided a cross –over duct, connecting the two fans, allowing to operate the boiler at reduced load, without stopping one ID fan if the related re generative air heater trips or it is of service and vice versa.

IV. AIR PREHEATER

An air preheater (APH) or air heater is a general term to describe any device designed to heat air before another process combustion boiler with the primary objective of increasing the thermal efficiency of the process. They may be used alone or to replace a recuperative heat system or to replace a steam coil. In particular, this article describes the combustion air preheater used in large boilers found in thermal power stations producing electric power from e.g. fossil fuels, biomasses or waste.

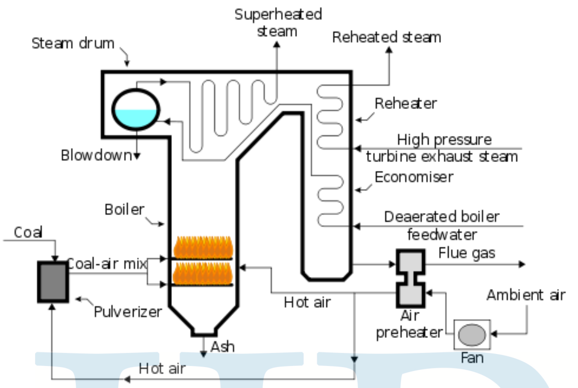

Fig.2 .Coal-fired power plant steam generator highlighting the air pre-heater location

TYPES OF AIR HEATERS

Based on the operating principle air heaters are broadly classified as

- Recuperative air heaters
- Regenerative air heaters

From this two type we are mainly consider the second type for your project.

REGENERATIVE AIR HEATERS

Regenerative air heaters are of rotating type and called as rotary air pre heaters. The heating medium flows through a closely packed matrix to raise its temperature and then air is passed through the matrix to pick-up the heat. Either the matrix or the hoods are rotated to achieve this and hence there is slight leakage through sealing arrangements at the moving surfaces.

Types of Regenerative Air Pre Heaters:

1. Rothemuhle Regenerative Air Pre Heater
2. Ljungstrom Regenerative Air Pre Heater

ROTHEMUHLE REGENERATIVE AIR PRE HEATER

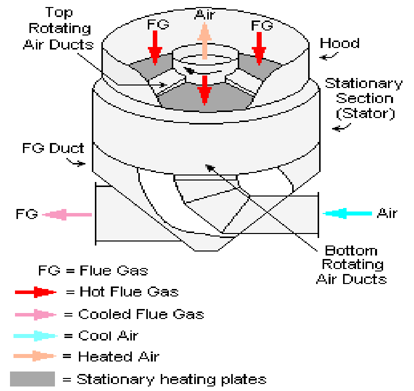

Fig. 3. A typical stationary-plate regenerative air preheater

The heat absorbing element in this type of regenerative air preheater is stationary rather than rotating. Instead, the air ducts in the preheater are rotated so as to alternately expose sections of the heating absorbing element to the up flowing air. The hot flue gas enters at the top of the preheater and flows down through those exposed sections of the stationary heat-absorbing element that are not blocked by the rotating air outlet ducts, thus heating those sections of the stationary element. As the air ducts slowly rotate around, they pass over the heated sections and the incoming air is heated as it flows upward through those heated sections. As indicated in the adjacent drawing, there are rotating inlet air ducts (inside the outer casing) at the bottom of the stationary heat absorbing element as well as the rotating outlet air ducts at the top of the stationary element. The basic heat_transfer principals of the stationary-plate regenerative preheater are the same as for the rotating-plate regenerative preheater. Fig 3. shows the stationary-plate regenerative air preheater

LJUNGSTROM REGENERATIVE AIR PREHEATER

The Ljungstrom Air Preheater is more widely used than any other type of heat exchanger for comparable service. Proven performance and reliability, effective leakage control, and its adaptability to most any fuel-burning process, are the bases for the It is both designed and built to operate over extended periods with durable, uninterrupted service. Simplicity of design also makes it easy and economical to maintain while in operation and at scheduled. Fig 3.5 shows the rotating-plate regenerative air preheater

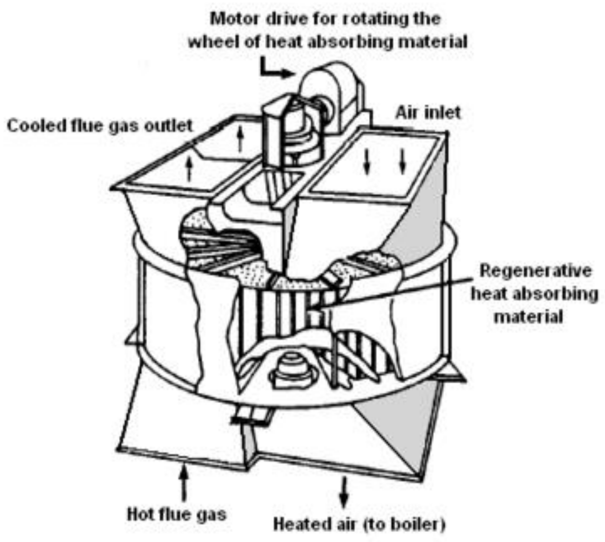

Fig. 4. A typical rotating-plate regenerative air preheater

The rotating-plate air preheater (RAPH) consists of a central rotating-plate element installed within a casing that is divided into sectors. There are three basic designs for the rotating-plate element

- The bi-sector design has two sectors.
- The tri-sector design has three sectors.
- The quad-sector design has four sectors.

In the tri-sector design, the steam generator's hot flue gas flows through the largest sector (usually spanning about half the cross-section of the casing) and transfers some of its heat into the heat-absorbing material within the rotating wheel element. The cooled flue gas is then routed to further treatment in dust removal and other equipment before being vented from the flue gas stack. Ambient air is blown through the second, smaller sector by a centrifugal_fan and absorbs heat from the heated material as it rotates through that smaller sector. The heated air then flows into the steam generating furnace as combustion air. The third sector is the smallest one and it heats a portion of the ambient air which is then routed into the coal pulverizations and is used to transport the coal-air mixture to coal burners . Thus, the total air heated in the RAPH provides: heated primary combustion air, heated air to remove moisture from the pulverized coal and carrier air for transporting the pulverized coal to the coal burners. Since the flue gas pressure is lower than the pressure of the air being heated, there is some small leakage (between the sectors) of flue gas into the air.

The bi-sector design is used in thermal power plants burning fuels (such as oil or gas) that do not require pulverizing or removal of moisture and therefore have need for heated air other than for combustion air. The quad-sector design has a large sector heated by flue gas and three air-heating sectors: one is for the combustion air and that sector is flanked by two smaller air sectors. In applications such as circulating_fluid_bed (CFB) combustion systems where the differential between the air pressure and the flue gas pressure is even higher than in a conventional coal-fired steam generator, flue gas pressure, such a design is ideal since it acts to reduce the leakage of air into the flue gas. The rotating wheel element rotates quite slowly (around 3-5 revolutions per minute) to allow optimum heat transfer first from the hot exhaust gases to the element and then, as it rotates, from the element to the air in the other sectors.

Available in a broad range of sizes arrangements, and materials Ljungström Air Preheaters are custom-engineered to meet specific requirements and operating conditions of a variety of applications.

- Electric power generating plants
- Fluidized bed and marine boilers
- Pack age & large industrial boilers
- Hydrocarbon & chemical processes
- Waste incinerators & drying systems
- Flue gas & other reheating systems

The table 3.1 below provides a comparison of some design parameters between the rotating-plate and stationary-plate preheater

TABLE .1 : SOME COMPARISONS BETWEEN ROTATING PLATE AND STATIONARY PLATE REGENERATION ACTIVE AIR PRE HEATERS

Comparison factors	Rotating-plate	Stationary-plate
Revolutions per minute	1.5 – 4.0 [(a)]	0.7 – 1.4 [(b)]
Gas flow area, % of total	40 – 50	50 – 60
Air flow area, % of total	35 – 45	35 – 45
Seal section area, % of total	8 – 17	5 – 10

From this type of Air preheater we mainly consider rotary type regenerative air preheater (RAPH). An complete case study of this type taken into account for the proposed work of your projects. We have mainly concentrated for the leakages in the RAPH.

RAPH SPECIFICATION

Number	2 per boiler
Type	27.5 VI 2005
Casing diameter	10000mm
Thickness of casing	8mm
No of sector	12
Material of hot basket	Carbon steel
Material of intermediate basket	Carbon steel
Material of cold end basket	Corten steel
Type of heating plates	DL-hot & intermediate
Thickness of hot element	0.6mm
Thickness of intermediate element	0.6mm
Thickness of cold element	1.2mm
Height of the cold end	305mm
Height of the intermediate layer	700mm
Height of the hot layer	1000mm
Total heat transfer area	41900m²
Gas velocity in air heaters	4.8m/sec
Gas flow resistance across air heaters	135mm of WCL
No of sectors exposed to gas	06
Net free area of our gas flow in air heaters	28.64m²
CO_2% before /after RAPH	14.94/13.94
Excess air factor before/after RAPH	1.3/1.392
Air pressure before/after RAPH	286/214mm of WCL
Air velocity in air heater	3.37m/sec
No of sectors exposed to air	6
Net free area for air flow in the air heater	28.54m²
Minimum metal temperature on cold end	77^0C
Average metal temperature on cold end	110^0C
At inlet gas flow	1273T/hr
Air temperature	942.9T/hr
Gas temperature	320^0C

DESCRIPTION OF LJUNGSTROM AIR PREHEATERS

The main components of rotary air heaters are

- Casing
- Rotor
- Rotating gear
- Drive unit
- Sealing

Sealing part are taken into case study of your project

SEALINGS

An often neglected part of air heater performance is gas leakage that occurs through the sealing system dividing the hot and cold sides as the air heater rotates at 1 to 3 rpm. The rotating wheels on air heaters are subject to huge differential temperatures from hot side to cold side, in the range of 204^0C with each rotation. This end-to-end differential temperature causes the wheel to actually bend during rotation. Considering that air heaters in modern boilers exceed 15m in diameter, these large differential temperatures can cause the wheel to deflect as much as an inch, up or down, with each rotation. Optimal air preheater performance requires that the hot and cold sides of the air heater be properly sealed to prevent cross-air leakage that negatively affects performance. The existence of the cyclical thermal deflection that occurs in rotary air heaters, however, makes sealing especially difficult. For the most part, plant operators tend to focus on the deterioration and plugging of the heat exchange element in air preheaters, which leads to increased pressure drop and increased demand on forced draft and ID fans. In many cases, the pressure drop can become so great that the fans cannot move enough air through the preheater to sustain full load. This is especially common during summer months when warm ambient temperatures thin the incoming air, placing a greater demand on boiler fans. Improved seals are the best way to control and minimize leakage .High Efficiency Flexible Air Preheater Seals.

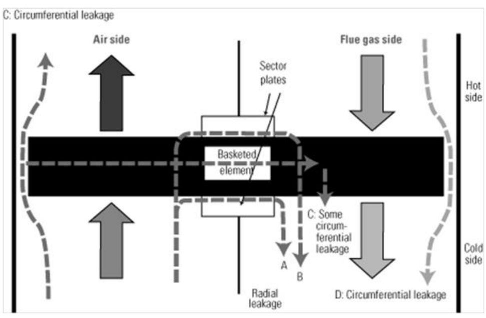

Fig. 5 Air Leakages in RAPH

Advantages of Seals:

Reducing and maintaining low air preheater leakage is vital to minimize the fan horsepower required to move the air and gas flows through the air preheater. It also serves to reduce the dilution effect and corrosion potential of the leaving gas stream due to mixing with colder air at the air inlet temperature. Seals can wear due to soot blowing, corrosion, erosion, and contact with the static sealing surfaces on start up and/or shutdown. Seal wear and seal settings should be checked at least once per year so that seals can be reset to proper clearances or replaced should they exhibit excessive wear. Sealing plate surfaces may also wear due to contact with the seals and erosion, and they may also become out of level and out of plane. Seal plate wear should also be repaired as soon as detected, and plate alignments should be verified every 3-5 years and reset as soon as the need is detected.

V. MAINTENANCE OF AIR PREHEATERS

REPLACEMENT OF HEATING PLATES

If systematic operation of soot blowers and water washing of air heater plates is carried out, replacement of plates may become necessary only after several years of operation. Normally the cold end plates may have to be changed at first instance and the hot end plates only much later. The replacement of the baskets can be done only after putting air heaters out of service or during general repairs or major overhaul of boiler.

COLD END BASKETS REPLACEMENT

For replacing the cold and basket, the baskets extracting doors are installed on the casing and the rotor. Mantle must be dismounted. The baskets are to be pulled out individually and then lowered down to '0' ML. The loading has to be done in the reverse order. To ensure uniform loading of rotor shaft and bearings, it is expedient to pull to pull the baskets out of the opposite sectors in alternate sequence.

REPLACEMENT OF HOT SIDE BASKET

For replacing the baskets of the hot side, the door installed at the side of the upper gas duct must be removed first. A lifting hoist having a minimum load carrying capacity of 1 ton is fixed on the located inside the gas duct. The particular sector, the basket of which is to be replaced is to be turned to the gas side, then its basket is lifted up and lowered to '0' ML. Basket in opposite sectors are thus individually removed in alternate sequence. The mounting is to be done in reverse order. On completion of replacement of all the damaged baskets, the dismantled doors are put back in position.

MAINTENANCE OF AIR HEATER SEALINGS

The three types of sealing i.e. circumferential, radial and axial sealing need periodical checks for wearing. In case intensity of wear is more anywhere and if the adjustment of gap there is not possible, then the seals may have to be placed. The air heaters have to be stopped for adjustment or replacement of sealing.

CIRCUMFERENTIAL SEALS

After checking the seal gaps, the adjustment of the gap to the prescribed values can be done by bending the rotor flange.

RADIAL SEALS

Generally radial sealing, if adjusted correctly serve for long periods and replacements are done only along with the renewal of other parts of air preheaters. The gap adjustment of radial air sealing have to be performed partly at cold state and partly while the equipment is in service. The air seal strips interposed between radial plates and sector have to be adjusted, keeping in mind the contact between circumferential air seals strips to the radial plates.

AXIAL AIR SEALINGS

The axial air sealing interposed between rotating and stationary part need a minimum maintenance. Besides the cold and operational adjustment of sealing, maintenance includes the occasional replacement of the seal strips.

VI. PROBLEM IDENTIFICATION AND RECTIFICATION

- Steam generators uses rotary air preheaters to absorb the heat from the flue gas and release that heat to the incoming combustion air.
- Thus absorbing the waste heat from the flue gas the efficiency of the boiler in increased. It is estimated that for every 20^{0}C decrease in gas temperature, the efficiency of boiler goes up by 1%.
- With increase in operation cost demand for power and pollution constraint today, every savings in boiler efficiency results in the big money. Recollect the slogan 'every MW saved is the MW generated'.
- Air preheaters are one of the major areas of concern for efficiency improvement. It is necessary that we should go for renovation and modernization only for performance improvement.
- Even maintaining the "Regenerative Air Preheater" in the correct way will result in the efficiency improvement.

VII. CONCLUSION

The "IMPROVEMENT IN EFFICIENCY OF AIR PREHEATER IN BOILER" was carried out with enthusiasm as a part of our project work.

By implementing the case study of RAPH the reduction in air leakage by 30\% can be expected, by which it can improve the efficiency of RAPH-II in Unit-I, TPS-I (Expansion). For the boiler (Unit-I, TPS-I Expansion) and with these knowledge we are going to implement as experimental in phase-2 of the project and expecting the benefit

The benefit in terms of (A) power savings per year =23,36,400 units/year (B) Cost Savings per year = Rs. 50,93,352/year

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