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Analysis of Rotary Air-Preheater for Different Operating Conditions - (A Review)

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***Abstract*- This review paper is on the basis of the numerically and complexity related to different rotary air-preheater & the heat transfer structure surfaces used for the different operating conditions. Voluminous papers and ample amount of literature were gone through channel to understand how an air-preheater is modifications & fabrication, numerically design and the effective performance parameters associated with the different conditions/ same conditions/ operating conditions. It has widely application in many a sector i.e., thermal power sector, nuclear power sector and gas-based power sector. It helps in saving of energy and fuel, to enhance overall efficiency of boiler, heat exchanger and others equipment. Many a researcher studied, different profile modifications of geometry (matrix duct profile & different inlet angles) for rotary air-preheater to enhance the operating thermal performance, X- factor, effectiveness and rate of heating/cooling.**

Keywords— Roatary Air-Preheater, thermal performance , Duct profile, Heat exchanger and X-factor.

I. INTRODUCTION

In modern world energy shortage is one of the most important problem we are facing on. Hence the enhancement of energy conversion efficiency during the process of consumption of energy is of great significance and hence it attracted the global attention. In 1920, One of the methods which is used to recover essential energy in steam-based power plant called rotary air preheater is taken into use by Ljungstrom. energy is transferred from hot steam fluid to cold fluid by a rotating matrix made up of regular packed space plates. There have been many studies carried out about preheater efficiency, which consider the importance of effect of the air preheater on the efficiency of cycle. There is one publication, published by warren on Ljungstorm which says that Ljungstorm is a particular type of exchanger which exchange air to air and on the basis of experimental results, he confirmed that there is a reduction of at least 10% in fuel consumption in power plants. Rajan et al [1,2], the optimization of the pressure drops and increasing the inlet opening angle of RAPH helps in improving the X-factor of air pre-heater, also reduces the temperature of flue gas. There is another publication, carried out by Skiepko, [3] who investigated the effects of heat conduction in the matrix, matrix length and number of peclet on the preheater performance. There is one statement given by Worsoe-Schmidt [4] which states that it is observed efficiency of the exchanger is decreased by using separator, but we can't remove the separator because it is used to reduce the leakage in fluid. On the basis of various numerical analysis and several experiments, Sadrameli and Ghodsipour [5] carried out studies on the effects of matrix's rotational speed and mass flow rate on the performance of preheater and it was showed that effect of flow rate is more significant than the rotational speed. The basic application of RAPH is to recover waste energy from flue gas. The combustion air, heated by RAPH just not only enhance the combustion but also mandatory for drying and transportation, of pulverized coal. There are basically two types of air- preheater, regenerative and recuperative. The process in which heat is transferred between hot and cold fluid in a continuous process is called recuperative. In this there are tubular type air pre-heater and plate type air preheater. In regenerative type preheater, there is also exchange of heat is between the hot and cold fluid but it is not continuous. The various modification of design of Rotary air-preheater are widely used in modern power plant and enhance for fast heat transfer for boiler and condenser. RAPH perform better operation after modification in matrix shell for high rate of heat transfer. However, the pressure drop in rotary air-preheater in the matrix shell is higher for a higher loss consideration. So an optimally design is needed to achieve the maximum heat transfer performance with heat loss and leakage air/pressure.

II. TYPES OF MODEREN RAPHS.

Recuperative [6]- This unit may start operation with no leakage but leakage is observed as thermal and time cycles unites. Leakage can be controlled below 3percent with regular maintenance. You can determine approximate air heater leakage based on gas inlet and outlet analysis. Plugging and Erosion, When the high-speed dust particles move over materials, it removes its layers called it Erosion whereas closing down and fouling of heat transfer flow passage by gas is dominated with corrosion products and ash particles. Dangerous result of erosion is observed such as loss of heat transfer area, structural weakening and perforation of components. Erosion could be controlled by decreasing the velocities, clearing the affected material galvanization. The cold end flue gas temperature is drawn for acid due point in APH, as completed burnt of coal is done.

Regenerative [7] In that study, mainly 2heating elements are used, either stationary or rotary. Wear and tear of the plates is reported as a primary problem and, high ash and silicon content is seen in dust laden incoming flue gases. Leakage of gases from gaps in the mid of stationary and rotary structures is reported as the secondary problem, it also affects the performance of APH to a larger extent. Seal is used in the APH for the stoppage of leakage. One more problem is seen as the deposition of unburnt particles on the surface of APH. Cold air and flue gases flow over unburnt deposits, ignition

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temperature is achieved along with sufficient amount of oxygen causes particles starts burning. Explosion may be possible inside of APH because of this. You can see Dew Point Corrosion in all types of pre heaters. Dust laden flue gases contains sulphates and chlorides is coming out of the furnace. As soon as the flue gases reach to acid saturation temperature, condensation of sulphates and chlorides takes place in the form of sulphuric acid, hydro chloric acid etc. Condensation is seen on steel tubes and plates, the part of the tubes or plates which is encircled by acids is less oxygenated, behaves a anode while the parts which is not by acids behaves as a canoed.

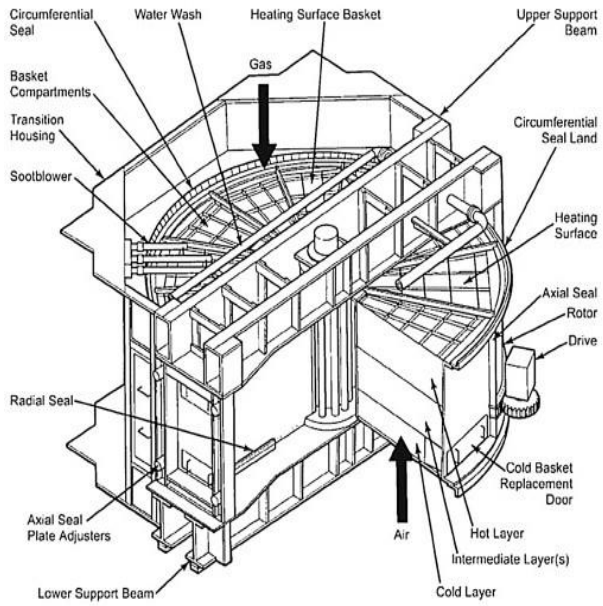


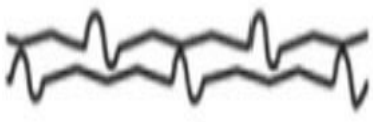
Fig.

Typical Regenerative RAPH [8]

Special class of heating element used in RAPH

DU CLASS (Double undulated): These class contains wavy nature. The main feature of this class is alternate stacking of undulated element sheets with sheets having both undulations and notches. the profile of Du class is shown below.

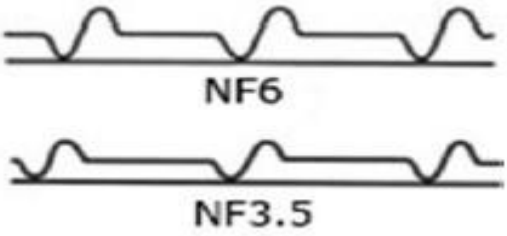
DN CLASS (Double notched): Fouling factor is highly reduced by using this type of plates. pressure drop and heat transfer characteristics is same to DU class.



DL CLASS (Double notched loose packed): The profile is same as that of DN class. however, the element is hold loosely within the basket hence the element gets disturb back and forth at most 1 inch during soot blowing.

FNC CLASS (flat notched cross): Compared to DU type element these elements offer better thermal performance and lower pressure drop.

NF CLASS (notched flat): This type of plate consists of notched flat plate further followed by complete flat plate. most common type of NF class is NF6 and NF3.5 shown as below.



CLASS (Notched undulated): These are identical to NF series. The only difference between them is that NU class consists of undulated sheets while NF class consists of flat sheets diagram of NU class is shown below:

CU CLASS (Corrugated undulated): The element of cu is more open than DU. This profile is used in natural gas fired unit. The figure of cu profile is shown below.

III. CORRELATION FOR ROTARY AIR-PREHEATER.

Many a Researcher have developed empirical correlation for classical or modified RAPHs. This correlation has been taken from [9].

$$\eta_r = \frac{1-\exp[-NTU(1-C_b)]}{1-C_b\exp[-NTU(1-C_b)]}\left[1-\frac{1}{9C_r^{1.93}}\right]$$

NTU is called number of transfer unit and for hot & cold side it is given as follows-

$$NTU = C_a\left[\frac{4a_1 D_{dl} G}{\overline{\mu}_c(1-x)\varepsilon}\right]^a \frac{L}{D_{dl}}\overline{Pr}^{-2/3}$$

$$NTU = C_a\left(\frac{4a_1 D_{dl} G}{\overline{\mu}_h x\varepsilon}\right)^a \frac{L}{D_{dl}}\overline{Pr}^{-2/3}$$

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$$\eta_0 = \left[1 - \frac{(T_7 - T_1)(1+X)B}{T_1 - BT_3}\right]\eta_v - \frac{B(1+X)T_1 kR}{(T_1 - BT_3)(k-1)c_p}\left[\frac{a_2^{(k-1)/k}}{\eta_{ff}} + \frac{T_6(a_3^{(1-k)/k} - 1)}{T_1\eta_{fd}}\right]$$

IV. CONCLUSION

According to many researchers have summarize the conclusion as follow-

- In power plant the use of Air pre-heater leads to improve the plant efficiency, if increasing the height and width of RAPH with in operating conditions.
- While using the advance cooling system together with RAPH, enhance the efficiency.
- Modification in geometry i.e., tri sector, quad-section RAPH to enhance boiler, condenser and overall efficiency.
- By increasing primary air opening thermal performance of air pre heater is improved, as flue gas temperature drop across air pre heater is increases with increased primary air opening angle.
- Gas side efficiency which is ratio of flue gas temperature and temperature head justify the improved performance, as gas side efficiency increases with increase in Primary air opening.
- In our case the value of X-ratio is good & it increases with increase in primary air inlet opening.
- Increase in primary air opening angle lowers the pressure drop across primary section of air pre heater but it lowers PRIMARY AIR temperature also.
- Increasing the spacing between the adjacent sealing sheets leads to increase the heat loss which results in reducing the direct air leakage.
- RAPH helps in recovery of waste energy which helps in improving the boiler efficiency up to 10 %.

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