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PERFORMANCE ANALYSIS AND OPTIMIZATION OF AIR PREHEATER IN THERMAL POWER PLANT

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Abstract - *This paper presents working of air preheter with performance analysis and optimization. The regenerative air preheater absorbs waste heat from flue gas. Absorb this heat transfers to cold air by means of continuously rotating heat transfer element of specially formed metal sheets. Bi-sector Air preheater preheats the combustion air and primary air that is required to preheat & carry pulverized fuel to the burners. Tri-sector air preheater preheats secondary air for use combustion. A performance evaluation and optimization of an air preheater based on routine operation data measured onsite at Chhabra Thermal Power Project, Chhabra. The performance was evaluated before and after radial sector plate and Axial Seal Plate clearance adjustment and improvement seen along with air preheater optimization.*

Key Words: Air preheater, air leakage, gas side efficiency, seals and x-ratio.

1. INTRODUCTION

Modern high capacity boilers are essential air pre heater. Air preheater is an important auxiliary of boiler which used improve the efficiency. Air preheater primarily preheat combustion air for smooth operation the furnace as last system of boiler heat recovers. If the incoming air for combustion is not preheat then more fuel consume which increase overall cost increase and decrease plant efficiency. There are many factors depend on air preheater performance like as high seal leakage, basket element fouling and plugging. [1]

These high efficiency elements are spaced and compactly arranged with in twelve shaped compartments for heater size from 24.5 to 36 inches of a radically divided cylindrical shell called the rotor. The housing surrounding the rotor provided with duct connections at both ends. Seals are both end radial, axial and circumference for restriction air leakage. The air pre heater size 27.5 VIMT 2000, total weight 295000 kg, weight of one module assembly 17200 kg, Hot end basket weight 700 kg and cold end basket weight 320 kg.[7]

2. WORKING PRINCIPLE

As the name implies the tri-sector air pre heater design three sections one used of flue gas, second as primary air used for drying and transport of coal mill to furnace and third as secondary air used for combustion. Air preheater wastage of heat recovers and used increase thermal efficiency of boiler.

The rotor slowly revolve element alternatively through the air and gas passage, heat absorbed by element surfaces passing through the flue gas side. These same surfaces carried through the air side. They released the stored up heat increase the temperature of the incoming combustion air. The ljungstrom air pre-heater is more widely used than other type heat exchanger. The regions for performance and reliability, effective leakage control and any fuel burning process. Simplicity of design makes it easy and economical to maintain operation and schedule outage. [2]

3. HEATING ELEMENTS

The heating element is a compact arrangement of formed metal sheets contained in the rotor in two and more layer. The basket element at the cold end air admitted and flue

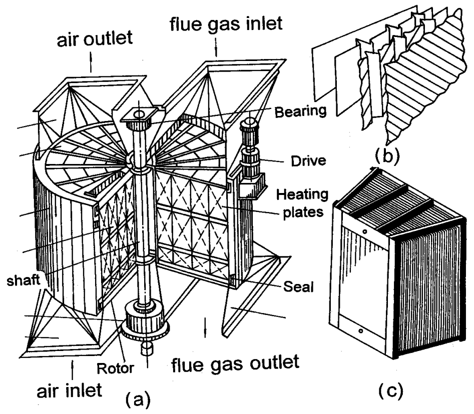

Fig-1: (a) Air Preheater (b) Heating Element(c) Basket [5]

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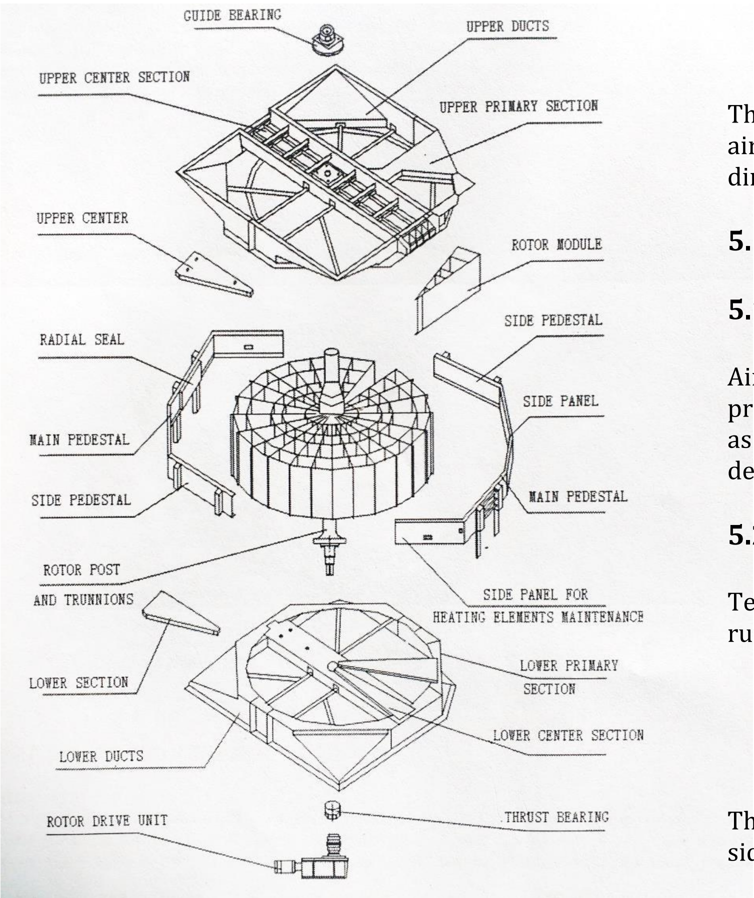

Fig-2: Tri Sector Air Preheater [7]

gases are discharged can be remove by access door in the air pre heater housing without disturbing sealing of the pre heater components.

Table-1: Basket material, Type, Thickness and Height [7]

Layer	Thickness (mm)	Height (mm)	Material	Type
Hot End	0.8	850	Corbon steel	Double undulated
Hot Intermediate	0.8	850	Corbon steel	Double undulated
Cold End	1.214	300	Corten Steel	Notched Flat

4. SEALING SYSTEM

Air preheater air leaks into gas due to pressure differences. At This leakage air decreases the flue gas temperature without heat absorb. In this leakage reduces seals are provided. The rotating part some working clearance between static parts to avoid any interference them. In air preheater rotor is construction to have higher clearance due to thermal expansion. This gap between flexible seal attached. Mostly used seals in air preheater as [4]

1. Radial seals
2. Axial seals
3. Bypass seals

The main purpose of these seals is to reduce the leakage of air into gas stream in radial axial circumferential directions respectively.

5. EXPERIMENTAL SET UP AND PROCEDURE

5.1 Principle of operation

Air preheater test is conducted of regenerative type air preheater to improve efficiency. Various performance like as air preheater leakage, gas side efficiency, X-ratio are determine using test. [7]

5.2 Test set up

Test procedure is during full load condition and same mills running. The operation of test run is as follows.

a. Air heater soot blowing is done during the test.
b. Unit operation is kept steady at least 60 minutes prior to the test.
c. Steam coil Air heater is kept isolated.
d. No mill changeover.

The test period control room data completely analysis gas side and air side on Air heater inlet outlet duct.

Table-2: Parameter before adjusting sector, axial plate and seals clearance [8]

S. No	Parameters	Values
1	Average Flue Gas Temperature APH inlet	312 °C
2	Average Flue Gas Temperature APH out	153.5 °C
3	Average Flue gas O2 APH inlet	3.2%
4	Average Flue gas o2 APH outlet	5.3%
5	Average Primary air to APH Temperature	38.4 °C
6	Average Primary air to APH Temperature outlet	277.5 °C
7	Average Secondary air to APH Temperature inlet	31.5 °C
8	Average secondary air to APH Temperature outlet	273 °C
9	Total secondary air flow	624 T/Hr
10	Total Primary air Flow	265 T/Hr

6. CALCULATION

(A) Before adjusting clearance between Sectors, Axial plate and seals-

Total Air = Primary Air + Secondary Air
= 624 + 265
= 889 T/ Hr

Air leakage (AL)

$$AL = \frac{(O2gl - O2ge)}{(21 - O2gl)} * 0.9 * 100 \quad (1)$$

$$AL = \frac{5.3 - 3.2}{21 - 5.3} * 0.9 * 100$$

$$= 12.03\ \%$$

Weighted Air Inlet Temperature

$$= \frac{(\text{Secondary Air Flow} * \text{Secondary Air inlet temperature}) + (\text{Primary air Flow} * \text{Primary air Temperature})}{\text{Total Air}} \quad (2)$$

$$= \frac{(624 * 31.5) + (265 * 38.4)}{889}$$

$T_{Air\ In}$ =33.55 °C

Weight air outlet temperature

$$= \frac{(\text{Secondry air flow} * \text{Secondary air outlet temperature}) + (\text{Primary air flow} * \text{Primary air outlet temperature})}{\text{Total air}} \quad (3)$$

$T_{Air\ Out}$ = 274 °C

Gas outlet temp corrected for no leakage (T_{gnl})

$$Tgnl = \frac{AL*(Tgl - Tae)}{100} + Tgl \quad (4)$$

$$Tgnl = \frac{12.03 * (153.5 - 33.5)}{100} + 153.5$$

$$Tgnl = 167.93\ °C$$

Gas side efficiency (GSE)

$$= \frac{\text{Tempertaure Drop}}{\text{Temperature Head}} * 100 \quad (5)$$

$$\eta = \frac{(Tge - Tgnl)}{Tge - Tae)} * 100$$

$$\eta = \frac{(312 - 167.93)}{312 - 33.55} * 100$$

$\eta_{gas\ side}$ = 51.73 %

Air Side Efficiency (η)

$$= \frac{(Tal - Tae)}{(Tge - Tae)} * 100 \quad (6)$$

$$= \frac{274.32 - 33.55}{312 - 33.55} * 100$$

$\eta_{Air\ side}$ = 86.47 %

$$X - Ratio = \frac{\text{Efficiency Gas side}(\eta)}{\text{Efficiency Air side}(\eta)} \quad (7)$$

$$X - Ratio = \frac{51.73}{86.47}$$

$$X - Ratio = 0.598$$

Table-3: Seal Clearance between Sector, Axial Plate and Seals [7]

S. No.	Seals	State	APH A Clearance	APH B Clearance
1	Radial Seal	Hot End Inboard	0.2 mm	0.4 mm
		Hot End Outboard	0.4 mm	0.3 mm
		Cold End Inboard	0.5 mm	0.4 mm
		Cold End Outboard	13 mm	13 mm
2	Axial Seal	Hot End	7.7 mm	7.8 mm
		Cold End	4.4 mm	4.6 mm
3	Bypass seal	Hot end	4.1 mm	4.1 mm
		Cold End	1.1 mm	1.1 mm

Table-4: Parameter after adjusting sector, axial plate clearance [8]

S. No.	Parameters	Values
1	Average flue gas Temperature APH inlet	323 °C
2	Average Flue gas Temperature APH out	137 °C
3	Average flue gas O2 APH inlet	3.1 %
4	Average Flue Gas O2 Temperature outlet	4.9 %
5	Average Primary Air to APH temperature inlet	39 °C
6	Average Primary air to APH Temperature Outlet	290 °C
7	Average secondary air to APH Temperature Inlet	35 °C
8	Average secondary air to APH Temperature outlet	294 °C
9	Total secondary air flow	516 T/Hr
10	Total Primary air flow	233 T/Hr

(B) After clearance adjustment between sector, axial plate and seals-

$$\text{Total Air Flow} = 516 + 233$$

$$\text{Total Air Flow} = 749\ T/Hr$$

$$\text{Air Leakage (AL)} = \frac{(4.9 - 3.1)}{(21 - 4.9)} * 0.9 * 100$$

$$\text{AL} = 10.06\ \%$$

Weighted air inlet temperature ($T_{air\ in}$)

$$= \frac{(516 * 35) + (233 * 39)}{749}$$

$T_{air\ in}$ =36.24 °C

Weighted Air outlet Temperature ($T_{air\ out}$)

$$= \frac{(516 * 294) + (233 * 290)}{749}$$

$$= 292.75\ °C$$

$$\text{Tgnl} = \frac{10.06 * (137 - 36.24)}{100} + 137$$

$$\text{Tgnl} = 147.13\ °C$$

Gas Side Efficiency (η)

$$= \frac{(323 - 147.13)}{(323 - 36.24)} * 100$$

$\eta_{\text{Gas side}}$ = 61.33 %

Air side Efficiency (η)

$$= \frac{(292.75 - 36.24)}{(323 - 36.24)} * 100$$

$\eta_{\text{Gas Side}}$ = 89.46 %

$$\text{X} - \text{Ratio} = \frac{61.33}{89.46} \quad = 0.685$$

Table-5: Comparison before and after clearance adjustment sector, Axial and seals

S. No.	Parameters	Before clearance adjust	After clearance adjust
1	Air leakage	12.03%	10.06%
2	Efficiency gas side	51.73%	61.33%
3	Efficiency air side	86.47%	89.46%
4	X-Ratio	0.598	0.685

7. CONCLUSION

By adjusting the sector,axial plates through mechanical jaculators to closely follow the shape of the deformed diaphragm plate leakage reductions are achieved and maximum efficiency can be obtained. Results are found decrease air leakage area, increase air and gas side efficiency and X-ratio indicates maximum heat recovery in the Air preheater.

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