Effect of Air preheater size on boiler efficiecy in coal based power plant.

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Abstract— **Waste heat of flue gases from chimney outlet can be considered as a source of heat which can be utilized to improve boiler efficiency. In this current work, experiments were conducted to recover this waste heat up to significant level according to the allowances by modifying the dimensions of air pre-heater (APH) at Wanakbori Thermal Power Station, so that the usage of coal as a fuel can be minimized and the efficiency of boiler performance will be improved. VIMT (Vertical Inverted Modular Trisector) is used instead of VIT (Vertical Inverted Trisector) with modified dimensions in size 2000 mm in place of 72 inch, alleviated overall height from 1829 mm to 2000 mm and increased heating surface area 21629 square meter per APH instead of 18497 square meter per APH to plummet the temperature of flue gases at chimney outlet. Moreover, VIMT is divided into 12 parts. If any failure occurs in between then one only need to change that portion, no need to change whole air pre-heater. So, rate of cost decreases and time will also get reduced for changing APH part.**

*Keywords— **Air preheater, Air moisture, Boiler efficeincy .***

I. Introduction

Wanakbori is coal based power station. It uses coal as its fuel. Here boiler is vertical pendant, Radial proof, tangentially coal fired, dry bottom ash design. Boiler is a steam creating device, which deliver steam with consuming fuel. Essentially coal is utilized as a fuel in boiler. On the off chance that the fuel has higher gross calorific esteem, than it can deliver more warmth per kg of fuel. It is specifically corresponding to the proficiency. Productivity of the boiler ought to be figured by two strategy, coordinate technique and roundabout technique.

When investigating steam systems the boiler is the primary targets for improvement of efficiency. Many tools used for evaluating of boiler performance. Boiler efficiency is useful tool for boiler performance. Basically boiler efficiency defined as fuel energy is converted into steam energy which is useful for generating power. But 100% fuel input energy is not converted into useful energy. Investigation of boiler evaluates the losses for finding the reasons of losses and find out solution for reduction of losses[1].

Present day high limit boilers are constantly given an air pre-heater. Air pre-heater is an imperative boiler assistant which basically preheats the burning air for quick and effective ignition in the heater serving as the last warmth trap for the boiler framework, a regenerative air pre-heater commonly represents more than 10% of a plants warm proficiency on a run of the mill steam generator. Thinking about this, while assessing the execution of an air pre-heater one should consider the greater part of the procedure factors. A decent strategy to enhance the general proficiency of thermal power plant is to preheat the air. On the off chance that the approaching air for burning isn't preheated, at that point some vitality must be provided to warm the air to a temperature required to encourage ignition. Accordingly, more fuel will be expended which builds the general cost and reductions the effectiveness.

There are numerous variables, which add to the weakening of air pre-heater execution like high seal spillage, crumbling of warmth ingestion attributes of crate components because of fouling or stopping. Close checking of air pre heater execution and legitimate instrumentation would empower opportune discovery of execution debasement. The ignition air pre-heater for the substantial fuel-consuming heaters used to produce steam in thermal power plants.

II. Air preheater model

The 2Ljungstrom air pre-radiator is more generally utilized than some other sort of burning air pre-warmer in the power business, due to its minimized plan demonstrated execution and dependability, and its fuel adaptability. The model LAP 13494/2200 means a Ljungstrom air pre-warmer with rotor measurement of 13494mm is utilized as a part of Wanakbori control plant. The statures of warming components of 3 segments are individually 762mm, 762mm and 304.8mm start to finish of the rotor. The icy end warming components of 304.8mm tallness are made of carbon plate while the hot end warming components are made of regular carbon steel. The metal weight of one air pre-radiator is roughly 620 tons, including 465 tons for the rotor gathering (around 75 percent of the aggregate weight).

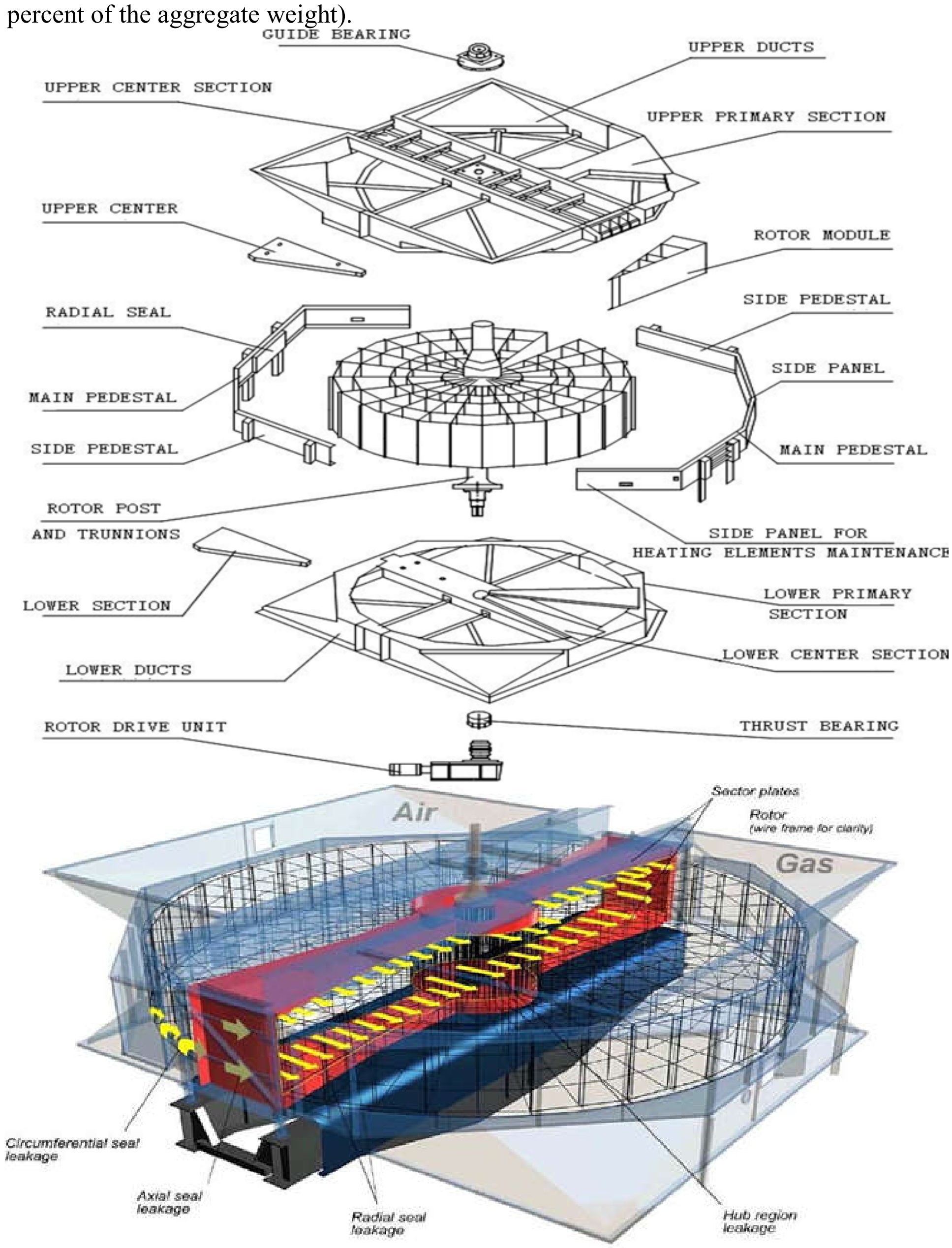

Fig. 1 Experimental Model Ljungstrom (Regenerative) Air Preheater (Lap 13494/2200)[2]

2 The air pre-warmer is tri-part write. The model LAP 13494/2200 tri-area revolving air pre-radiator as appeared in Fig. 1 is a counter stream regenerative warmth exchanger. Uncommonly folded warming components are firmly set in the part compartment of the rotor. The rotor turns at a speed of 0.99 rpm and is partitioned into gas channels and air channels. The air side is made of essential air channels and optional air channels. At the point when gas moves through the rotor, it discharges warmth and conveys it to the warming components and after that the gas temperature drops; when the warmed components swing to the air side, the air going through them is warmed and its temperature is expanded. By keeping up such dissemination, the warmth trade is accomplished amongst gas and air.

Modified APH details which are utilized in G.S.E.C.L. Wanakbori UNIT 3:-

Table 1 APH Details

Sr. No.	Details	APH (Old Design)	APH (New Design)
1	APH Size	**VIT 72" (inch)**	**VIMT 2000 (mm)**
1	Hot End	0.6 mm, 762 mm, Carbon Steel	0.8 mm, 300 mm, Carbon Steel
2	Hot Intermediate	0.6 mm, 762 mm, Carbon Steel	0.63 mm, 700 mm, Carbon Steel
3	Cold Intermediate	-	0.63 mm, 700 mm, Carbon Steel
4	Cold End	1.2 mm, 305 mm, Corten Steel	0.8 mm, 300 mm, Corten Steel
5	Overall Height	**1829 mm**	**2000 mm**
5	Sealing System	Single Seal	Double Seal
6	Heating Surface Area Provided	**18497 sq. m per APH**	**21629 sq. m per APH**
7	Rotor Design	Conventional	Modular

III. Result & Discussion

A. Calculations of Boiler efficiency with and without modification of air pre-heater:

BOILER EFFICENCY = 100 - TOTAL LOSSES

- [3]Different Losses need to be considered

(1) DRY GAS LOSS =

100 * Dry Gas * Specific heat of Dry Gas *(Temp. of Gas leaving - Ambient Temp.) (4.186 * Gross Calorific Value)

A) Ash collected / kg of fuel:
- Fly Ash = (% of ash) * (% of ash appearing as ash in chimney) 100 - % combustible
  = 33.614088 * (0.90)100 - 0.9
  = 0.3053 kg / kg of fuel

- Bottom Ash = % of ash *(% of ash appearing as ash in Bottom ash) 100 - % combustible

= 33.614088 *(0.10) 100 - 2.92
= 0.0346 kg / kg of fuel

A) Combustible matter in Ash:

- Fly Ash = Ash collected per kg of fuel * (% of combustible) 100
  = 0.3052743 * (0.9)100
  = 0.0027475 kg / kg of fuel... (1)

- Bottom Ash = Ash collected per kg of fuel * (% of combustible) 100
  = 0.0346*(2.9) 100
  = 0.0010 kg / kg of fuel... (2)

- Total Comb. (U) = (1) + (2) = 0.00274747 + 0.0010 = 0.00376

- Dry Gas = 1/12 CO2 [%C + (%S / 2.67) - U]
  = [43.79 + (0.47/2.67) - 0.0038*100] 12*12.77
  = 0.28446 mole / kg fuel

- Sensible Heat = Dry gas * Specific Heat of Dry gas * (Temp. of gas Leaving APH - Ambient Temp.)
  = 0.28446 * 30.6 * (156.77 - 34)
  = 1068.633777 KJ/kg.. (1)

After modification of Air Pre-heater (APH) I will get the temp. of flue gas leaving chimney around 130°C instead of 156.77°C. So, our new Sensible Heat can be given as;

- New Sensible Heat = Dry gas * Specific Heat of Dry gas * (New Temp. of gas leaving APH - Ambient Temp.)
  = 0.28446 * 30.6 * (130 - 34)
  = 835.6296 KJ/kg... (2)

(1) Dry Gas Loss =Sensible Heat * (100) Gross Calorific Value * 4.186
=1068.63 * (100)3985.61823 * 4.186
=6.4052%... (A)

- New Dry Gas Loss =Sensible Heat * 100 Gross Calorific Value * 4.186
  =835.63 * 100 3985.61823 * 4.186
  =5.0086%... (B)

Loss Due to Combustible

=Total Combustible in Ash * C.V. of Carbon * 100 Gross Calorific Value
=0.0038 * 8049.11 * 100 3985.61823
= 0.7670%

(3)Loss Due to Sensible Heat in Ash [3]

Fly Ash
= (0.9*% of Ash)*Specific Heat of Ash *(Corrected temp of flue gas APH outlet - Ambient Temp.) 100 * Gross Calorific Value

= 0.90 * 33.61 * 0.2 * (184.95 - 34) 100 * 3985.61823

= 0.2292%

(B)Bottom Ash

= (0.1 * % of Ash) * Specific Heat of Ash * (Temp. of bottom ash - Ambient Temp.) 100*Gross Calorific Value

= 0.10 * 33.61 * 0.25 * (1100 - 34) 100 * 3985.61823

= 0.225%

Total = 0.229 + 0.225 = 0.4539%

(4) Loss Due to Radiation = 0.5%

(5) Loss Due to % of moisture & Hydrogen in Fuel

Total Moisture = % of moisture + (9 * % of H2) 100

= 11.45 + (9 * 3.03)100

= 0.3873 kg / kg

Heat per kg of Moisture = 1.88 (corrected Tg - 25) + 2442 + 4.2 (25 -Ta)

= 1.88 (184.95 - 25) + 2442 + 4.2 (25 - 34)

= 2704.906 KJ/kg

- Moisture Loss = Total Moisture * (Heat / kg of Moisture) * 100 * 4.186 * Gross Calorific Value

= 0.3873 * 2704.9 * 100* 4.186 * 3985.61823

= 6.2796%

(6)Loss due to coal mill rejects

= Weight of reject coal in kg/hr * C.V. of Reject coal * 100*1000 * coal flow rate in Ton/hr * Gross Calorific Value

=1750 * 1302 * 100 *1000 * 140.88 * 3985.61823

= 0.4058%

(7)Loss due to carbon monoxide (CO)

= 7 * % age of CO in flue gas * % age total carbon in fuel *(C.V. of C - C.V. of CO)3 * (CO2 + CO) * Gross Calorific Value

=7 * 0.012 * 43.79 (8049.11 - 2415) 3 * (16.16 + 0.012) * 3985.61823

=0.1072%

(8) Loss Due to Moisture in air

- Total Moisture in air = Stoichiometric air * Excess Air * Weight of moisture in air

Where

Stoichiometric Air = (2.664 * % age Carbon + 7.937 * % age Sulphur - % age O2 in coal) 23.2

= (2.664 * 43.79 + 7.937 * 3.03 + 0.996 * 0.47 - 5.81) 23.2

= 5.8349 kg / kg of coal

Where, Excess Air = 21 / (21 - O2 at APH outlet)

= 21 / (21 - 6.23)

= 1.422 kg / kg of air

- Total Moisture in Air = Stoichiometric air * Excess Air * Weight of moisture in air
  = 5.83 * 1.42 * 0.016
  = 0.1327 kg / kg of air

- Loss Due to Moisture in Air = Total Moisture in Air * 1.88 * (Temp. Of Gas Leaving - Ambient Temp.) * 1004.186 * Gross Calorific Value
  = 0.13 * 1.88 * (156.77 - 34) * 100 4.186 * 3985.61823
  = 0.1836%.. (I)

- Loss Due to Moisture in Air = Total Moisture in Air * 1.88 * (New Temp. Of Gas Leaving - Ambient Temp.) * 100 4.186 * Gross Calorific Value
  = 0.13 * 1.88 * (130 - 34) * 100 4.186 * 3985.61823
  = 0.1406%.. (II)

Table 2 Performance of boiler along with old pre-heater

BOILER PERFORMANCE (Before)				
Sr. No	Results	Actual Losses	Unit	Theoretical Losses
1	DRY GAS LOSS	6.405	%	5.239
2	COMBUSTIBLE LOSS	0.759	%	0.875
3	SENSIBLE HEAT LOSS	0.454	%	0.509
4	RADIATION LOSS	0.500	%	0.214
5	MOISTURE LOSS	6.280	%	6.033
6	LOSS DUE TO MILL REJECT	0.406	%	0.019
7	LOSS DUE TO CARBON	0.107	%	0.335
8	LOSS DUE TO MOISTURE IN AIR	0.184	%	0.202
9	UNCOUNTED LOSSES	1.000	%	1.000
10	**TOTAL BOILER LOSSES**	**16.094**	%	**14.426**
11	**BOILER EFFICIENCY**	**83.906**	%	**85.574**

Table 3 Performance of boiler along with modified pre-heater

BOILER PERFORMANCE (after)				
Sr. No	Results	Actual Losses	Unit	Theoretical Losses
1	DRY GAS LOSS	5.009	%	3.915
2	COMBUSTIBLE LOSS	0.759	%	0.236
3	SENSIBLE HEAT LOSS	0.454	%	0.174
4	RADIATION LOSS	0.500	%	0.214
5	MOISTURE LOSS	6.280	%	6.531
6	LOSS DUE TO MILL REJECT	0.406	%	0.009

7	LOSS DUE TO CARBON MONOXIDE(CO)	0.107	%	0.458
8	LOSS DUE TO MOISTURE IN AIR	0.140	%	0.065
9	UNCOUNTED LOSSES	1.000	%	1.000
10	**TOTAL BOILER LOSSES**	**14.655**	**%**	**12.603**
11	**BOILER EFFICIENCY**	**85.345**	**%**	**87.397**

IV. CONCLUSIONS

As per the calculations I have shown earlier the modification done in Air Pre-heater is as follows:

(1) Increased height of Air Pre-heater from 1829mm to 2000mm as per allowance.
(2) Increased Air Pre-heater size from VIT 72" to VIMT 2000.
(3) Increased heating surface area from 18497 sq. m per APH to 21629 sq. m per APH
(4) Changed rotor design from Conventional to Modular.
(5) Modified double sealing system instead of single sealing system.

Because of all these modifications the boiler efficiency increases from design efficiency of 83.906% to 85.345%.

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