Evolution of performance of Primary and Secondary Air preheaters

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***Abstract*— The primary objective of the air heater is to increase the thermal efficiency of the process. The purpose of the air pre heater is to recover heat from the boiler flue gas, which increases the thermal efficiency of the boiler by reducing the useful heat lost in the flue gas. For every 20^0 C drop in the flue gas exit temperature, the boiler efficiency increases by 1%.**

Air heater performance procedure provides a systematic approach for conducting routine air heater performance tests on tubular and rotary regenerative air heater. Various performances indices like air heater leakage, gas-side efficiency, x-ratio etc can be determined using this procedure.

***Keywords*— Air Pre-heaters, Flue Gas Exit Temperature, Air heaters Leakage.**

I. INTRODUCTION

An air pre heater or air heater is a general term to describe designated to heat air before another process with the primary objectives of increasing the thermal efficiency of the process. Air heater is a heat transfer surface in which air temperature is raised by transferring heat from other media such as flue gas. Since air heater can be successfully employed to reclaim heat from flue gas at low temperatures than is possible with Economizer, the heat rejected to chimney can be reduced to higher extent thus increasing the efficiency of the boiler. For every 20^0C drop in the flue gas exist temperature, the Boiler efficiency increases by about 1%.

The purpose of air pre heater is to recover the heat from the flue gas which increases the thermal efficiency of the boiler by reducing the useful heat lost in the flue gas. As a consequence, the gases are also sent to the flue gas stack at a lower temperature, allowing simplified design of the ducting and the flue gas stack. It also allows control over the temperature of gases leaving the stack.

The most common way to preheat the air is with a heat exchanger on the flue
exhaust. The heat exchanger can be either air-air or air-liquid-air. The design of air pre heaters today requires weighing often, conflicting demands for high heat transfer, small pressure drop, reduced fouling, and ease of cleaning.

II. AIR PRE-HEATER PERFORMANCE TEST

This procedure provides a systematic approach for conducting routine air heater performance tests on tubular and rotary regenerative air heater. Various performance indices like .

a. Air heater leakage
b. Gas side efficiency
c. X-ratio etc.

Objectives:

a. To determine air pre-heater performances indices-leakage, gas-side efficiency and X-ratio.
b. To provide information for performance analysis and identify the causes of performance degradation, if any
c. To cross-check the readings of online instruments around air heaters.

The operating conditions of each test run are as follows.

a. No furnace or air heater soot blowing is done during the test.
b. Unit operation is kept steady for at least 60 minutes prior to the test.
c. Steam coil air heaters (SCAPH) steam supply is kept isolated and gas re-circulation dampers if any, are tightly shut.
d. No mill change over is done during the test.
e. All air and gas side dampers positions should be checked and recorded.
f. The test is abandoned in case of any oil support during the test period.
g. Eco hopper de-ashing or bottom hopper de-ashing is not done during the test.
h. Regenerative heaters should be in service with normal drip cascading.

Test duration:

The test run duration will be the time required to complete two transverse for temperature and flue gas analysis. Two separate test crews should sample the gas inlet and outlet ducts simultaneously.

Measurement locations:

The number and type of instruments required for conducting this test depend on the unit being tested. The following table lists the measurement locations.

Table I
Measurement locations

MEASUREMENT	TEMPERATURE GAS ANALYSIS	PRESSURE
AH Gas Inlet	Yes	Yes
AH Gas outlet	Yes	Yes
AH Air Inlet	Yes	Yes
AH Air Outlet	Yes	Yes

A. *Air heater Performance Indices:*

AIR HEATER LEAKAGE:

Air heater leakage is expressed as a percentage of gas flow entering the air heater.

It's determined by following equation.

AIR HEATER LEAKAGE (AH) =

$\{(CO_{2\,ge}-CO_{2\,gl})/CO_{2\,gl}\}*100$

$CO_{2\,ge}$ = % CO_2 in gas entering air heater

$CO_{2\,gl}$ = % CO_2 in gas leaving air heater

Alternatively, the air heater leakage may also be determined from the following equation.

AIR HEATER LEAKAGE (AH) =

$\{(CO_{2\,gl}-O_{2\,ge})/(21-O_{2\,gl}\}*100O_{2\,gl}\}*100$

$O_{2\,gl}$ = % O_2 in gas entering air heater

$O_{2\,ge}$ = % O_2 in gas leaving air heater

Air heater leakage dilutes the flue gases and lowers the measured exit gas temperature. Gas outlet temperature corrected to no leakage condition is calculated using the formula.

$T_{gnl} = \{AL*C_{pa}*(T_{gl}-T_{ae})/(100*C_{pg})\}+T_{gl}$

Where,

T_{gnl} = Gas outlet temperature corrected to no leakage.

C_{pa} = The mean specific heat between T_{ae} and T_{gl}

T_{ae} = Temperature of the air entering air heater

T_{gl} = Temperature of the air leaving air heater

C_{pg} = Mean specific heat between T_{gl} and T_{gnl}

B. *Air heater Gas-side Efficiency:*

Air heater gas-side efficiency is defined as the ratio of the temperature drop, corrected for leakage, to the temperature head, expressed as a percentage. Temperature Drop is obtained by subtracting the corrected gas outlet temperature from the gas inlet temperature. Temperature head is obtained by subtracting air inlet temperature from the gas inlet temperature. The corrected gas outlet temperature is defined as the outlet gas temperature calculated for 'No Air Heater Leakage'.

C. *Gas-side Efficiency (gse):*

GSE = (temperature drop/ temperature head)*100

GSE = $\{(T_{gl}-T_{gnl})/(T_{ge}-T_{ae})\}*100$

Where

T_{ae} = Temperature of the air entering air heater

T_{gnl} = Gas outlet temperature corrected to no leakage.

D. *Air Heater X-Ratio:*

Air heater X-ratio is the ratio of heat capacity of passing through the air heater to the heat capacity of the flue gas passing through the air heater and is calculated using the following formula.

AIR HEATER X-RATIO =(WAIR OUT *C_{pa})/(W gas in*C_{pg})

AIR HEATER X-RATIO =

(Tgas in-T_{gas} out (no leakage))/(T_{air} out T_{air} in)

E. OBSERVATIONS:

Table : II

FOR PRIMARY AIR PRE-HEATER-A:

PARAMETER	UNIT	DESIGN VALUES	ACTUAL VALUES
Air inlet temperature	^{0}C	36	39.36
Ai outlet temperature	^{0}C	318	320.13
Flue gas inlet temperature	^{0}C	343	368.38
Flue gas outlet temperature	^{0}C	125	139.91
Air differential pressure	mmwc	47	49.61
Flue gas differential pressure	mmwc	90	100.6
Oxygen at flue gas inlet	%	3.50	3.58
Oxygen at flue gas outlet	%	5.35	5.71

Table : III

FOR PRIMARY AIR PRE-HEATER-B

PARAMETER	UNIT	DESIGN VALUES	ACTUAL VALUES
Air inlet temperature	^{0}C	31	37.08
Ai outlet temperature	^{0}C	318	317.93
Flue gas inlet temperature	^{0}C	343	369.28
Flue gas outlet temperature	^{0}C	125	134.15

Air differential pressure	mmwc	47	56.44
Flue gas differential pressure	mmwc	90	110.25
Oxygen at flue gas inlet	%	3.50	3.60
Oxygen at flue gas outlet	%	5.35	5.63

Table : IV
FOR SECONDARY AIR PRE-HEATER-A

PARAMETER	UNIT	DESIGN VALUES	ACTUAL VALUES
Air inlet temperature	^{0}C	31	30.48
Ai outlet temperature	^{0}C	317	355.7
Flue gas inlet temperature	^{0}C	343	390.73
Flue gas outlet temperature	^{0}C	125	142.18
Air differential pressure	mmwc	41	55.73
Flue gas differential pressure	mmwc	90	103.82
Oxygen at flue gas inlet	%	3.50	3.52
Oxygen at flue gas outlet	%	4.85	5.13

Table : V
FOR SECONDARY AIR PRE-HEATER-B

PARAMETER	UNIT	DESIGN VALUES	ACTUAL VALUES
Air inlet temperature	^{0}C	28	30.44
Ai outlet temperature	^{0}C	317	351.68
Flue gas inlet temperature	^{0}C	343	376.02
Flue gas outlet temperature	^{0}C	125	141.08
Air differential pressure	mmwc	41	55.66
Flue gas differential pressure	mmwc	90	105.73
Oxygen at flue gas inlet	%	3.50	3.42
Oxygen at flue gas outlet	%	4.85	5.02

F. RESULTS AND Discussions

The following results are obtained from the above observations

Table : VI
FOR PRIMARY AIR PRE-HEATER-A:

DESCRIPTION	UNITS	DESIGN VALUES	ACTUAL VALUES
Air heater leakage	%	11.82	13.93
Air heater gas side efficiency	%	67.75	65.39
Air heater X-ratio		0.7376	0.7663
Flue gas temperature drop across Air heater	^{0}C	218	235.13
Air side temperature rise	^{0}C	282	280.85

Table : VII
FOR PRIMARY AIR PRE-HEATER-B

DESCRIPTION	UNITS	DESIGN VALUES	ACTUAL VALUES
Air heater leakage	%	11.82	13.207
Air heater gas side efficiency	%	67.75	67.11
Air heater X-ratio		0.7376	0.7938
Flue gas temperature drop across Air heater	^{0}C	218	235.13
Air side temperature rise	^{0}C	282	280.85

Table : VII
FOR SECONDARY AIR PRE-HEATER-A

DESCRIPTION	UNITS	DESIGN VALUES	ACTUAL VALUES
Air heater leakage	%	8.359	10.144
Air heater gas side efficiency	%	67.479	66
Air heater X-ratio		0.736	0.7311
Flue gas temperature drop across Air heater	^{0}C	218	248.55
Air side temperature rise	^{0}C	286.77	321.24

Table : VIII
FOR SECONDARY AIR PRE-HEATER-B

DESCRIPTION	UNITS	DESIGN VALUES	ACTUAL VALUES
Air heater leakage	%	8.359	10.01
Air heater gas side efficiency	%	66.76	64.93
Air heater X-ratio		0.727	0.698
Flue gas temperature drop across Air heater	^{0}C	218	234.94
Air side temperature rise	^{0}C	289	321.24

III. Conclusions

From the above tabulated values it indicates that the actual air heater leakage is more when compared with the designated values. The air heater leakage is an indication of the condition of the air heater seals. From the analysis the performance of air preheaters has been evaluated and efficiency can be increased by proper maintenance.

References

[1]. P.N.Sapkal, P.R.Baviskar, M.J.Sable, S.B.Barve — " To optimise air preheater design for better performance". NEW ASPECTS of FLUID MECHANICS, HEAT TRANSFER and ENVIRONMENT. ISSN: 1792-4596, ISBN: 978-960-474-215-8, PP.61-69.

[2]. Pipat Juangjandee — "Performance Analysis of Primary Air Heater Under Particulate Condition in Lignite-Fired Power Plant" Engineering, Computing and Architecture, " ISSN 1934-7197,vol 1,issue 2,2007

[3]. Bostjan Drobnic, Janez Oman. — "A numerical model for the analyses of heat transfer and leakages in a rotary air preheater" , International Journal of Heat and Mass Transfer 49, PP.5001–5009, 2006.

[4]. Stephen K.Storm,john Guffre, Andrea Zucchelli "Advancements with Regenerative Airheater Design, Performance and Reliability" POWERGEN Europe 7-9 June 2011.

[5] P.N.Sapkal, P.R.Baviskar, M.J.Sable, S.B.Barve, "Optimization of Air Preheater Design for the Enhancement of Heat Transfer Coefficient", International Journal of Applied Research in Mechanical Engineering (IJARME), ISSN: 2231 –5950, Volume-1, Issue-2, 2011.