EFFECTS OF AIR INGRESS ON PERFORMANCE OF BOILER AND AIR PREHEATER OF THERMAL POWER STATION

[1]Mr. Shastri Viranchi H., [2]Prof. B.A.Shah, [3]Mr. D.M.Jethva
Mechanical Department, Institute of Technology, Nirma University, Ahmedabad
Mechanical Department, Institute of Technology, Nirma University, Ahmedabad
Executive Engineer, Wanakbori Thermal Power Station, GSECL
Email:[1]13mmet18@nirmauni.ac.in, [2]balkrushna.shah@nirmauni.ac.in, [3]dinkar.jet@gmail.com

Abstract— It is inevitable for developing countries like India to focus on increasing the generation capacity and energy conservation measures. As far as thermal power plants are concerned, there are huge potentials for energy savings and increasing energy efficiency. Air ingress in to boiler and air preheater results into the high auxiliary power consumption ultimately leading to lower power generation capacity and increase in the heat rate. Air ingress is the cause of negative pressure, aging, leakages and corrosion of various system components. Air ingress also leads to increased velocities resulting in erosion of internal components, which affects the energy efficiency through sub-standard performance. Air preheater leakage must be checked periodically and minimized to prevent the under performance of the unit resulting from overloading. The objective of this work is to quantify air ingress by O_2 mapping, calculate its effects on the energy efficiency of boiler and air preheater and find ways to enhance their performances.

Index Terms— Air Ingress, O_2 Mapping, Ljungstrom Rotary Air Preheater.

I. INTRODUCTION

The Perform Achieve Trade (PAT) Scheme originated in 2001 under Energy Conservation Act, which empowers Indian Government to identify energy incentives industries as Designated Consumers (DCs) and set mandatory energy conservation standards for them. Out of 478 facilities covering 8 sectors identified by the Ministry of Power's Bureau of Energy Efficiency (BEE), 144 thermal power plants are given target to reduce energy consumption under PAT scheme. In the year 2006, under the Indo-German Energy Programme (IGEN) power plant component is being implemented by Central Electricity Authority (CEA) in association with Bureau of Energy Efficiency (BEE) for performance optimization and efficiency improvements of thermal power plants. The identified mapping studies of 49 units of 210 MW were completed during the period 2007-2009 in 14 Indian states [1]. The findings of the studies on 210 MW plants is as shown in Table I:

I: Average GHR and Boiler Efficiencies

Parameters	Average Design (kcal/kWh)	Average Operating (kcal/kWh)	Average Deviation (%)	Range of operating (kcal/kWh)
Gross Heat Rate	2408.3	2765.8	14.8	2384 - 3064
Boiler Efficiency	85.8	81.7	4.8	71.0 – 86.0

Wanakbori Thermal Power Station consist of subcritical boilers of two pass natural circulation radiant reheat, dry bottom with direct tangentially coal fired. In balanced draft furnace, the FD fan / PA fan / SA fan pump the air in to the furnace. The flue gas produced is drawn through the boiler by the ID fan. Hence the furnace and downstream the furnace the boiler is

under negative pressure. Thus if some leakage spots are there, the ambient air is drawn through such openings [2][3].

II. METHODOLOGY

A. O_2 Mapping Procedure

There's a lot of stratification in flue gas at air heater outlet ducts and sometimes at air heater inlet ducts due to bends in gas duct & skin air ingress. So a representative value of flue gas composition (O_2/CO_2/CO) and temperature is to be obtained by grid sampling of the flue gas at multiple points in a plane perpendicular to the flow at APH inlet and outlet, using a portable flue gas analyzer & digital thermometer. [4]

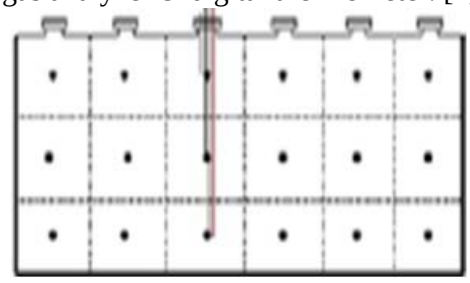

Fig.1 Grid Sampling Traverse for correct assessment

Typical cross section of the flue gas duct with an 18-point grid is shown here in fig. 1. Each dot indicates a sampling point for the measurement of gas composition and temperature. As shown above, fixed multiple point sampling probes are installed with thermocouples forming a grid covering the complete cross-section of the duct. Alternatively, single tube probes can be used to perform a traverse across the section of the duct. Gas duct is divided into equal cross-sectional areas and gas samples drawn from center by point by point traverse.

B. Instruments Used

1. *Flue Gas Analyzer*
2. *Digital Thermometer*
3. *Digital Manometer*

C. Test Procedure

Test runs are conducted at an easily repeatable level at defined baseline condition at full load. The operating conditions for each test run are as follows. [5]

- No furnace or air heater soot blowing is done during the test.
- Unit operation is kept steady for at least 60 minutes prior to the test.
- Steam coil air heater (SCAPH) steam supply is kept isolated.
- No mill changeover is done during the test.
- All air and side damper position should be checked during the test period.
- The test is abandoned in case of any oil support during the test period.
- Regenerative heater should be in service with normal drip cascading.

D. Performance Indices

1. Air in leakage

   Air heater leakage is the weight of air passing from the air side to the gas side of the air heater. This index is an indicator of the condition of the air heater's seals and increases with wear of seals.

$$AL = \frac{(O_{2gl} - O_{2ge})}{(21 - O_{2gl})} * 0.9 * 100$$

   Flue gas gets diluted because of air in leakage to flue gas side. Flue gas corrected temperature for no leakage is calculated as below:

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

2. 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.

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

3. X-ratio

   Air heater X-ratio is the ratio of heat capacity of air passing through the air heater to the heat capacity of flue gas passing through the air heater.

$$X - ratio = \frac{W_{al} * C_{pa}}{W_{ge} * C_{pg}} = \frac{T_{ge} - T_{gnl}}{T_{al} - T_{ae}}$$

III. RESULTS AND DISCUSSIONS

Measurement is done on a flue gas duct by Grid Method (Shallow, Middle and Deep of the duct). Measurement points (tapping position) as per standard code are made before actual test being conducted. In each flue gas duct four points have been made from where sample has been taken. To calculate leakage percentage, path wise (Left

and Right, Pass A to D) and segment wise calculation has been done for various locations and also overall air leakage calculation is also done by taking the average of all the values of different path.

A. *Readings*

II. APH parameters before overhauling

Parameters	Unit	Inlet A	Inlet B	Outlet A	Outlet B
O_2	%	2.85	3.24	6.2	6.68
CO	PPM	1357	274	1325	392
NO	PPM	134	156	117	130
CO_2	%	16	16	14	13
SO_2	PPM	564	557	123	136
NO_x	PPM	141	164	485	504
Draft	mmWC	-59	-62	-140	-136
T_a	°C	33	33	270	283
T_g	°C	325	310	128	142

III. APH parameters after overhauling

Parameters	Unit	Inlet A	Inlet B	Outlet A	Outlet B
O_2	%	3.01	3.05	5.39	5.06
CO	PPM	1244	357	1205	381
NO	PPM	226	225	246	239
CO_2	%	15	15	13	14
SO_2	PPM	577	484	118	156
NO_x	PPM	237	163	147	256
Draft	mmWC	-60	-62	-144	-135
T_a	°C	30	30	280	295
T_g	°C	311	322	124	136

B. *Results*

I. There is a significant reduction in air ingress into APH from 21% to 12.5%

II. Gas side efficiency improved from 56% to 61% after overhauling.

III. There is also improvement in air temperature rise at APH inlet and gas temperature drop at APH outlet.

C. *Air Ingress Comparison*

- O_2 percentage at economizer inlet is 1.98% and jumped to 11.37% at ESP outlet
- Air ingress is very predominant between APH outlet and ESP inlet.
- APH is suffering from huge ingress and oxygen percentage jumps from 3.24% to 6.86%.
- There is marginal ingress between economizer inlet and outlet.

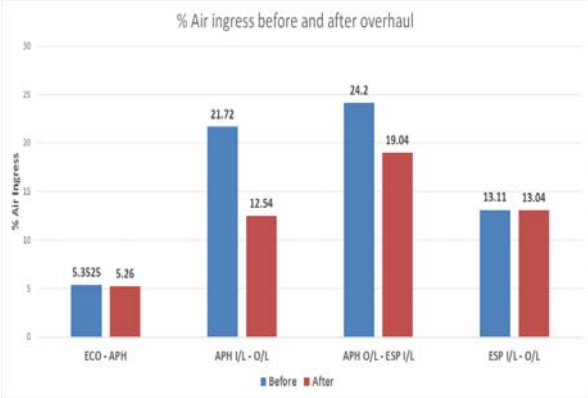

Fig.2 Air ingress comparison

IV. CONCLUSION

a. Air preheater performance is improved after replacement of seals and cleaning of basket elements.

b. Load on fans are reduced by arresting air ingress downstream the boiler and hence operating cost is reduced.

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