EFFECT OF AIR INGRESS IN BOILERS

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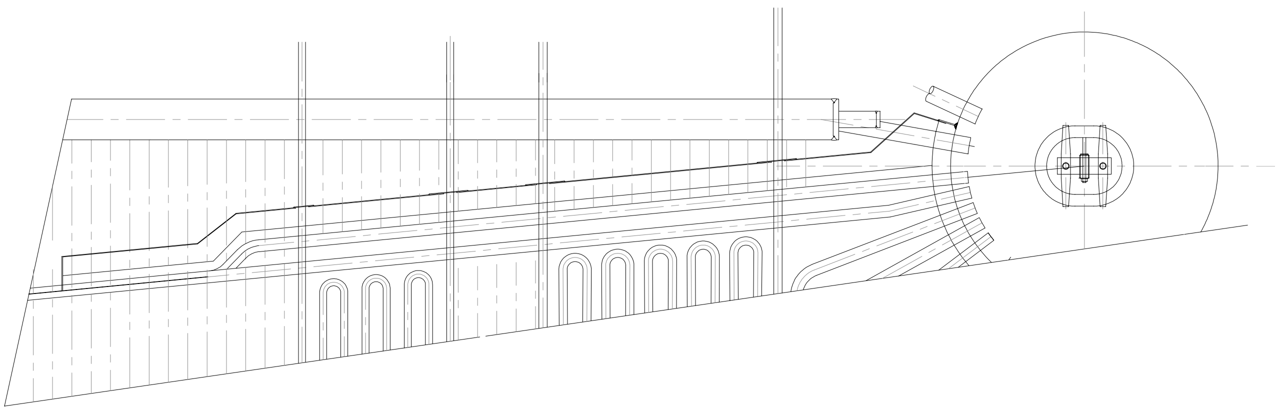

Figure 1

Many boiler users are ignorant about the air ingress in their boilers. In this article, the detrimental effects of air ingress are brought out. Some of the readers may feel that I have exaggerated some points. Reality is that some of our fellow boiler users are carrying losses with air ingress.

WHAT IS AIR INGRESS?

In balanced draft furnace, the FD fan / SA fan / PA 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.

WHY IS THIS AIR INGRESS?

By virtue of boiler configuration, openings are to be made in the boiler enclosures / Waterwall enclosure. If a seal is improperly designed or improperly erected the seal may fail and develop leakages. The seals may not have been erected properly. It is possible some of the seals are not taking care of thermal expansion or the service conditions and thus leakage may develop. One step further the repairer has not put back the seals as per design. A user can be pardoned for not doing the seal work during a maintenance since he may not have the blue print of the original design. Let us begin on what is this air ingress.

WHERE IS THE AIR INGRESS?

In the balance draft furnace there are several areas for ingress. The possible locations include

1. Roof top where SH coils penetrate in
2. Membrane walls where the convection banks penetrate
3. Roof tubes termination in steam drum
4. Boiler bank tubes termination in side, front, rear of steam drum
5. Boiler bank tubes termination in side, front, rear of water drum

6. Between boiler bank hopper and water drum
7. Hopper manholes
8. Hopper isolation gates & flanges
9. Worn out rotary ash feeders
10. Failed fabric expansion joints
11. Corroded metallic expansion joints
12. Incomplete fastened flange joints
13. Improper roped flanged joints
14. Refractory wall cracks
15. Eroded / corroded APH tubes
16. Economiser casing joints
17. Access doors
18. Roof panel to side walls side joints
19. Water drum to bank casing plates
20. Nose panel to Water drum termination
21. Soot blower openings
22. Gas pressure tappings
23. Leaky view holes
24. Boiler bank casing plate joints

HOW TO LOCATE THE AIR INGRESS?

There can be many more possible locations where the air leaks in. An easy way in solid fuel fired boiler is of course the ash would leak out in locations where the air goes in. You can always see the fresh ash spillages around leakage points.

To locate the leakage points the smoke test is done. Another way is to carryout a flame test with ID fan running. Having identified the leak points measures are to be taken to arrest the leakage. Some leakages are simply rectified. But at some locations, the design may be faulty, for which one has to call up the designer / consultant for help. The seals may call for better contemporary design. The design may need for a review from the boiler thermal expansion point of view.

FINE, SO WHAT IF THE AIR GOES INSIDE?

The list is quite long. Some of the points cost heavy for some boiler users.

1. High unburnt carbon in fly ash

It is a general practice to trim the air flow based on O2 indication from flue gas. When the air leakage is present the O2 indicated by the on-line O2 meter would mislead the operator. The furnace runs in to substochiometeric condition. This ultimately leads to increased to unburnt.

2. Increased fuel consumption.

The air ingress downstream the flue path leads to increased heat loss in the chimney. To compensate for the heat loss one has to feed more fuel.

3. Overloaded ID fan

When we experience that the ID fan is falling short of capacity, we tend to invest in new ID fan / we start with fan vendors for increasing the fan capacity. In many cases the second ID fan is opted with higher capacity with the assumption that the existing ID fan is short of capacity. In some cases even the second ID fan may also prove useless as the leakage persists and the furnace still goes with positive pressure. The boiler operating expenses increase due to additional power consumption.

4. Back fire in furnace

The back fire is continuously experienced. The ID damper is at full open position. The operator has no option except to continue with the problem. The unsafe situation persists. The Insulation of the boiler is spoilt on this account. Soot is seen around the furnace access doors.

5. Secondary combustion in superheater zones

The furnace begins to starve when the air ingress is more from roof seal box / Convection SH seal box. The leakage air allows secondary combustion of volatiles. The SH temperature becomes uncontrollable. Particularly at the time of load variation, the fuel feeder rpm is regulated by the operator and he finds the SH steam temperature rises faster than the pressure. This is seen in boilers fired with biomass fuels.

6. Secondary combustion in Boiler bank hoppers

The Unburnt fuels burn at the boiler bank ash hoppers, since the furnace is at substochiometeric conditions when there is air ingress is present downstream. The unburnt fuel travels downstream instead of completely burning in the furnace. The ash hoppers get distorted due to secondary combustion.

7. Ash blockages in boiler bank Baffles

When the ash is not fully burnt in the furnace, the flow ability of ash comes down. The ash particles now contain fuel particles which may be fibrous / irregular in nature. Thus the fuel and ash settle at every possible location, where the surfaces are less inclined or flat. The ash does not flow freely and thus ash accumulates at baffles. Whatever the draft is set the ash does not flow due to nature of the accumulations.

8. Ash blockages in Hoppers

Carryover of fuel particles to ash hoppers would lead to combustion in ash hoppers. Lumps form due to static combustion. We try to poke the ash drain pipes but situations repeat often. The combustion is not complete at the furnace and hence the troubles.

9. Excess Desuperheater spray

In most of the designs the furnace is designed to be hotter as the combustion is to take place here. The furnace dimensions are so chosen, to achieve the necessary residence time for the fuel particle to burn fully. Starvation occurs when the air can bypass the furnace and enter the flue gas downstream. No one can assess the amount of air ingress at leaky zones. Under such conditions the combustion zone shifts to SH section. Simultaneous combustion and heat transfer at SH section leads to excess Steam temperature. To our luck if excess capacity is available in the spray control valve, we tend to spray more. More spray will lead to solids added to SH section. The solids leave behind in SH leading to deposit related failures. More the spray the turbine blade deposition is experienced.

10. Clinkers formation in furnace

The furnace temperatures are controlled by incorporating necessary heat transfer surface and by admitting required excess air to cool down the gas below the ash melting temperatures. The excess air can not be given in the furnace when the ID draws the leakage air downstream. Refractory furnaces get coated ash deposits. Honey combing of ash accumulations is seen in some agro waste fired boilers. Refractory roof tops eventually collapse due to increased weight.

11. High furnace temperatures and refractory walls cave in

The excess air when not given in the furnace, the furnace temperature exceeds the design gas temperatures. When the fuel does not have much of ash, the furnace temperatures go up. The refractory walls expand unusually leading to furnace walls caving in.

12. Furnace doors failures

Furnace doors in balanced draft furnaces are refractory lined to thickness of not more than 250 mm. The doors get cooled by the outside ambient air present around the door. When the furnace is under +ve pressure the ambient air is not present near the vicinity of the doors. Then the doors bulge. The manhole frame and manhole distort due to heat. We think the doors fail due to material defect.

13. Furnace refractory failures

The refractory totally collapse often since they loose strength at higher temperatures. The High temperatures are experienced when the excess air is less and the furnace temperatures go up. The refractory design would be unstable at higher service temperatures unless the design is modified for the new service conditions.

14. Furnace seal plates run hot

Many furnaces, particularly in small boilers, are provided with casing plates to prevent air ingress. When the furnace temperatures are controllable due to insufficient excess air, the casings run hot. When the furnace goes positive, the gas reaches the air gap between the casing plate and the refractory. The flame / smoke is seen. Particularly in gas fired boilers the gas burns inside the casing.

15. Fly ash nuisance around the boiler

The fly ash poses a great nuisance not only harming the eyes but also lungs. The boiler house becomes shabby. The industrial standards go down in front of your customers. The costs for cleaning the boilers go up. During maintenance, hours are to be allocated only for cleaning. The boiler downtime increases due to this.

16. Metal wastage due to corrosion beneath ash accumulations

Some fuel ash / coal ash has alkali content. Coupled with flue gas condensation, it would lead to corrosion of metals.

17. Injuries to personnel

Some of the boilers are provided with penthouses where, the ash accumulates to high level. It poses safety hazard for any one who enters the penthouse. The hot ash lying underneath could cause hot burns as well.

It is true not all the points apply to all boilers. Persons who have had experience of operating several types / makes of boiler would appreciate. Let us attack the leakages henceforth.

Photo 1: Furnace ash deposits in bio mass due to high furnace temperature

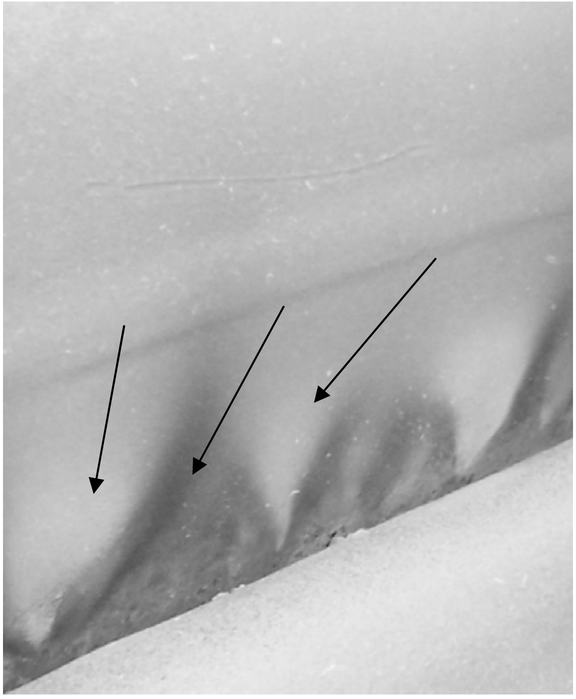

Photo 2: Marks of outside air ingress below water drum in a boiler

Photo 3: Fresh ash spills around leakage points in roof seal box

Photo 4: Ash waterwall roof panel inside penthouse. Wherever the cracks are there, the air gets inside.

Photo 5: The failed metallic expansion joint is seen after removal of insulation cladding at Economiser inlet duct. Such leakage locations lead to wrong to O2 indications.

Photo 6: Indications of smoke at penthouse confirm air ingress. When the furnace pressure goes positive at times, the flue gas comes out.

Photo 7: Indications of dust below waterwall nose panel. The seal was not done as per drawing.

Photo 8: Ash inside airpreheater confirms failure of preheater tubes. FD air directly mixing with flue gas can lead to starvation inside furnace.