SHUT DOWN INSPECTION OF A CHINESE MAKE CFBC BOILER

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Every shut down inspection of a boiler is an experience for us. It gives an insight to behavior & health of boiler. We share herewith our findings on shut down inspection of a 130 TPH CFBC boiler. Many times we are given an agenda by the boiler owners. The O&M problems faced by the boiler owner are given to us for review. Other than the problems referred, we identify several other problems and give corrective solutions.

1. Final Superheater distortion

The final SH coils had undergone distortion since commissioning. See photo 1. The Primary SH and Final SH are arranged in the second pass. The secondary SH is arranged in the furnace itself. The supporting system for Final SH and primary SH was little unconventional.

See figure 1 below. The final SH has two start coils. Each coil has two supports from steam cooled wall. Incidentally each coil supports come on either one wall only. The load of the coils is taken through the strap & the pins. The superheater coil is made of T22 and T91 material. Both materials are ferritic steels. Hence the thermal expansion coefficient does not differ much. Only stainless steel has higher thermal expansion coefficient due to its face centered crystal structure. The straps are made of SS309S material. The straps are uncooled.

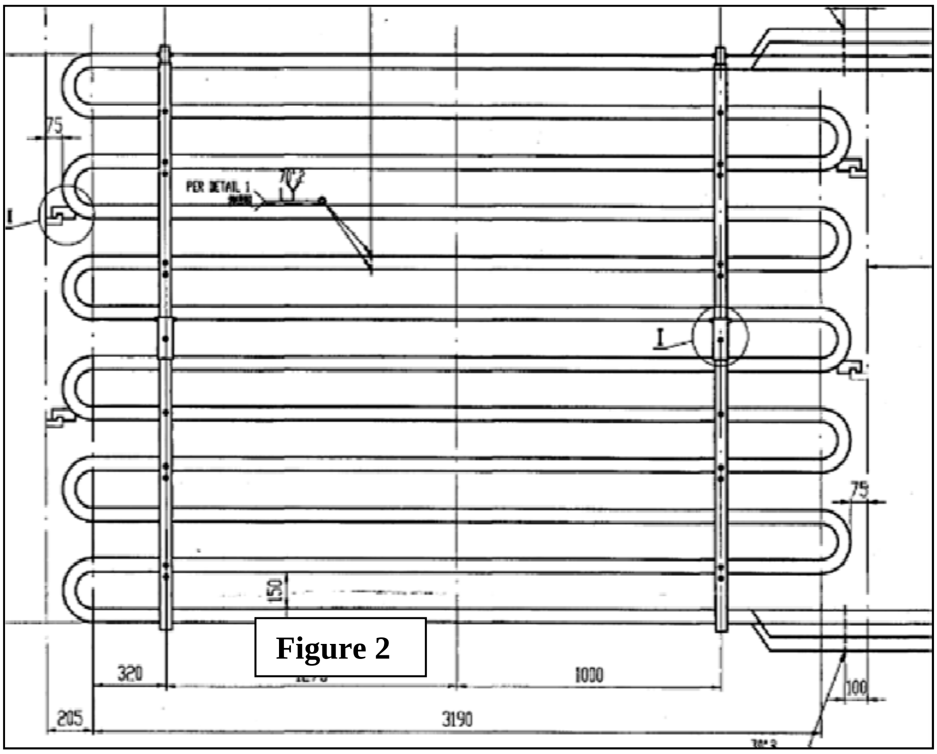


Figure 2

Straps are held in position by stoppers welded to the tube. The stoppers are available at three levels. The stoppers have 2 mm clearance. See photo 2. The stoppers are welded in one coil only. While handling the second coil would have moved freely.

<u>*Observations*</u>

The furnace side straps are found to be distorted see photo. The rear side straps are not found distorted. There is no oxidation seen in strap material. The distortion pattern is same across all coils. The inner tubes have shifted out of alignment at several places.

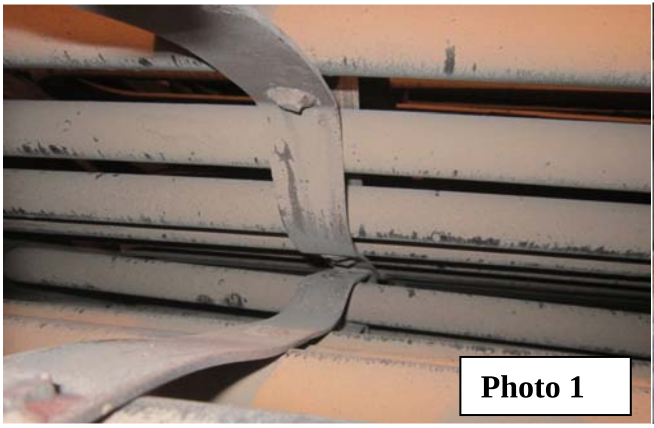


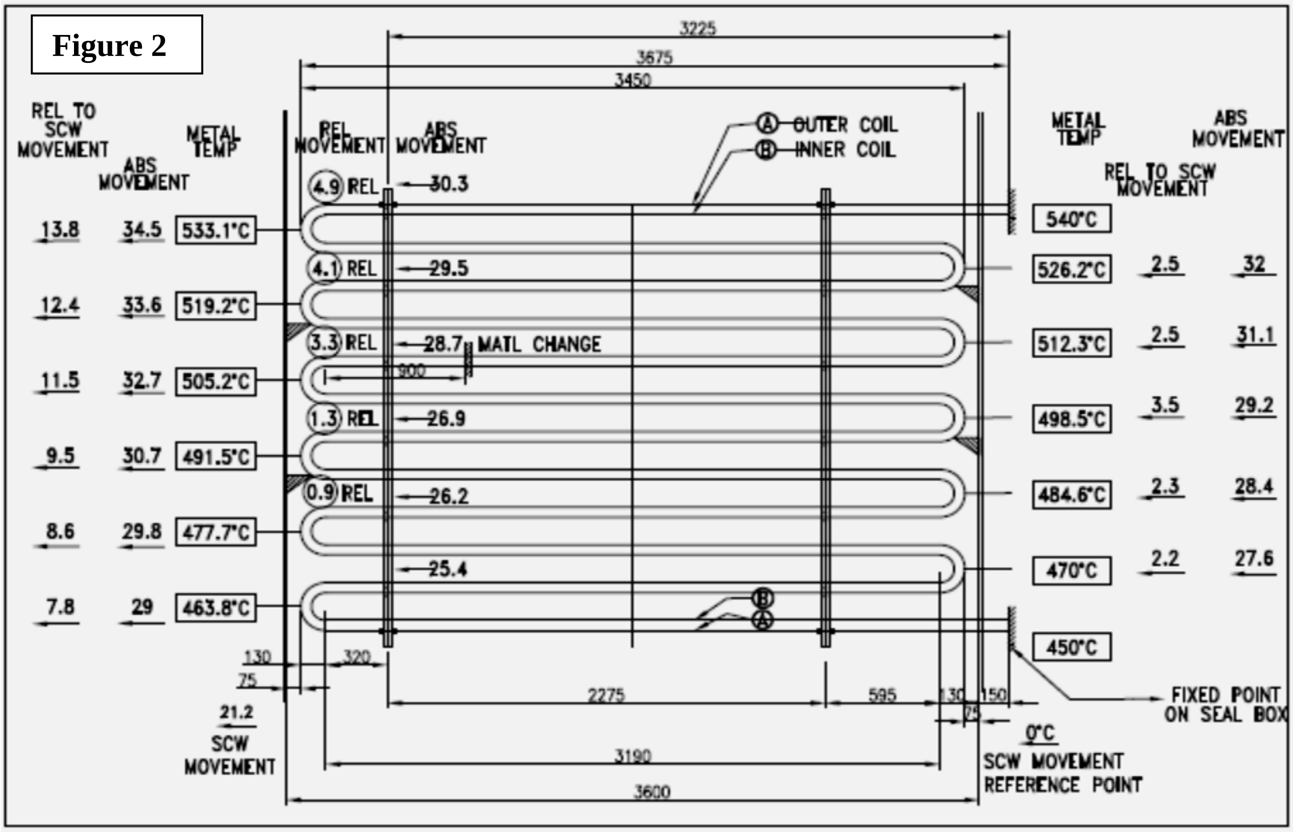
Photo 1

Photo 2

A picture on thermal expansion behavior

- The superheater coils are fixed in the sealbox end. The seal box for the finishing SH is at rear. Hence the coils move towards furnace. The furnace side coil ends move forward by 29 mm to 34.5 mm from bottom to top. The rear side bends move relatively forward by 2.2 to 3.5 mm as they expand relatively towards rear side.
- The steam cooled walls expand by 21.2 mm relative to seal box. Net effect the SH coils would move forward by 7.8 mm to 13.8 mm. At the supports (at steam cooled wall brackets), they move by 9.5 mm at bottom support and by 12.4 mm at top support.
- Straps are held in place by stoppers welded at three levels. The coils expand differentially from bottom to top. At the top the expansion can be up to 4.9 mm at the front support. The coils expand differentially by 2.2 mm from top to bottom at the front strap support. The stoppers are pulling the straps on thermal expansion.

Figure 2



- Strap can expand up to 38 mm vertically due to its length of 2.3 m for an average gas temperature of 700 deg C. This is due to the fact that the supports are uncooled. When coils prevent their expansion they can buckle inwards or outwards.

Recommendations

Stoppers were removed at top and bottom, so that straps are not pulled along.

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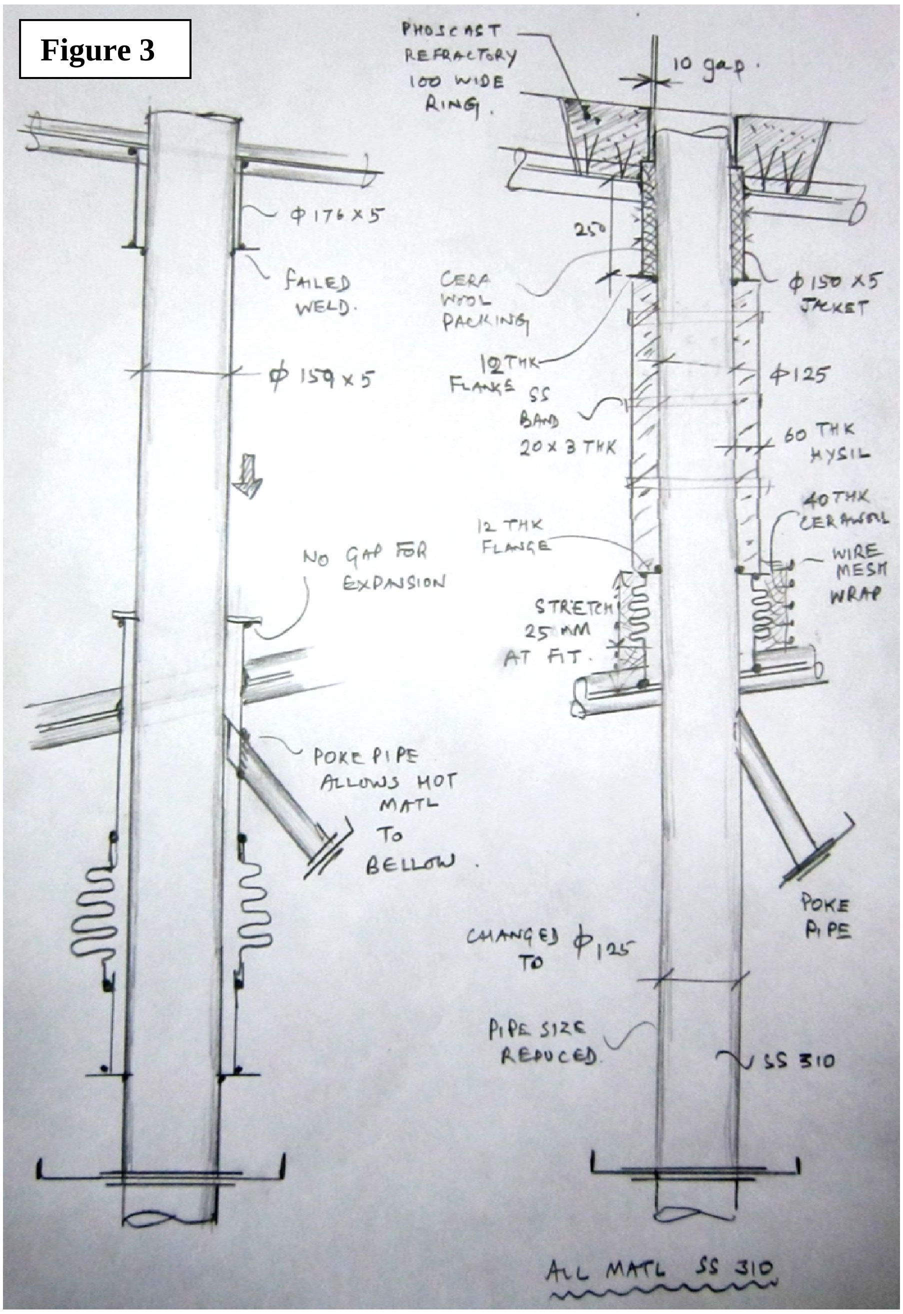
2. Bed material seepage in to windbox

Figure 3



Flooding of bed material in the windbox was being experienced in this plant.

Design review

In the original design, the 150 nb ash drain pipe is provided with sleeve pipe at the floor panel & at the bottom panel of windbox. See figure 3 here. The bottom sleeve does not permit movement of inner pipe. Also the poke hole added is found passing through the outer jacket pipe & inserted in a manner that the expansion is restricted.

Recommendation

It was suggested to change the ash drain pipe with the expansion bellow inside the airbox. This is similar to AFBC boiler design. Only heat protection is required for ash drain pipe since the boiler is with duct burner. Calcium silicate blocks can be wrapped over the ash drain pipe if the refractory breaks down.

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3. Distortion of vortex finder

Photo 3

Vortex finder is supported in many ways depending on the water cooled / steam cooled / hot cyclone constructions. In all the cases, the vortex finder remains uncooled. It needs space around the periphery for thermal expansion. If it is not provided, the vortex finder comes down from position.

Photo 3 shows the distortion of vortex finder due to restrictions in thermal expansion. See figure 4 below showing the present arrangement of supporting system. The mistakes are pointed out in the drawing itself.

There are eight supports. Each support is as shown in the figure 4.

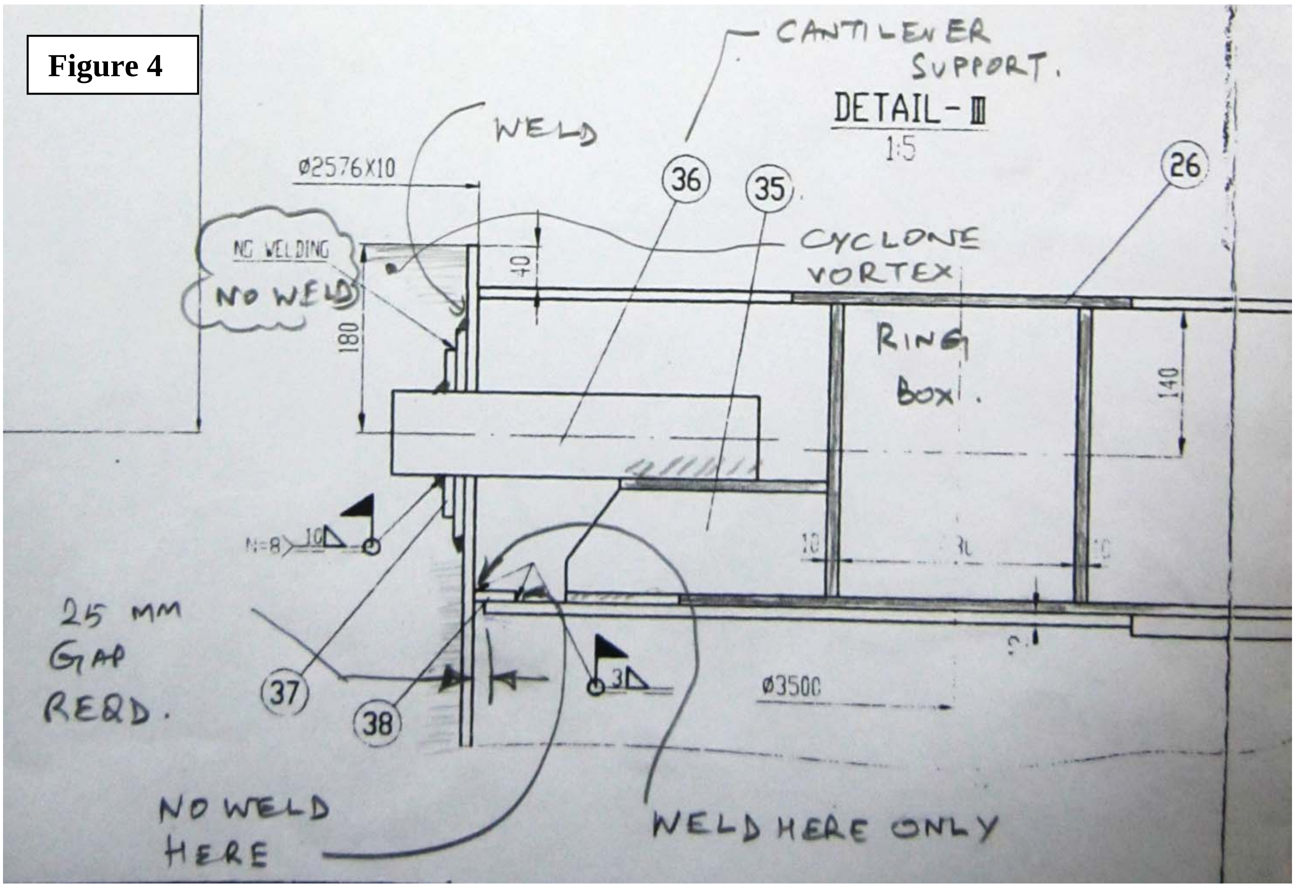

Figure 4

The 25 mm gap required should be ensured. Once such a gap is provided, there can be short circuiting of bed material / flue gas. A sealing is required. The sealing arrangement recommended is shown in figure 5. Further the space shall be provided with sealing system as shown in figure 5. The warping that occurred in the vortex finder cannot be corrected insitu.

It is necessary to check the fly ash particle distribution on daily basis. The sieve sizes can be 25, 50, 75 and 90 microns. In case there is a problem in loop seal / due vortex finder damage, the size distribution pattern changes immediately.

Figure 5

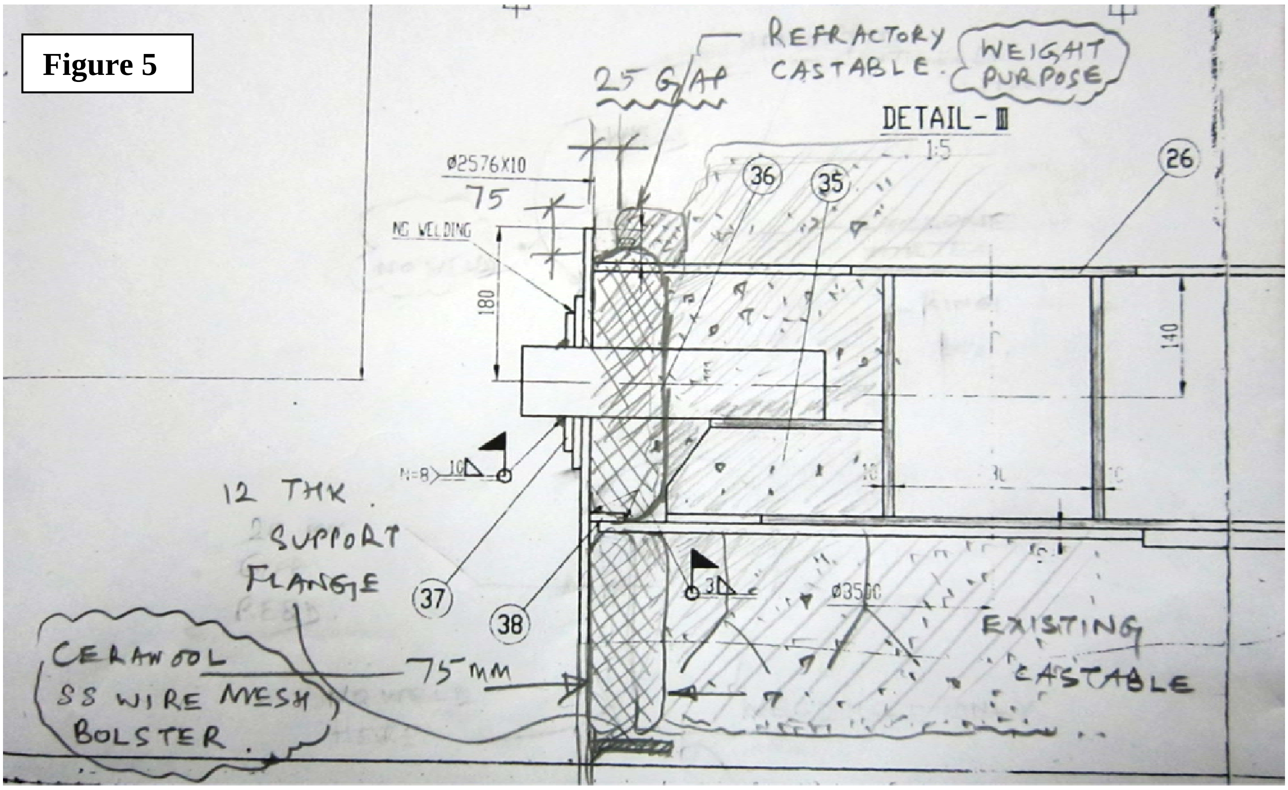

Photo 4

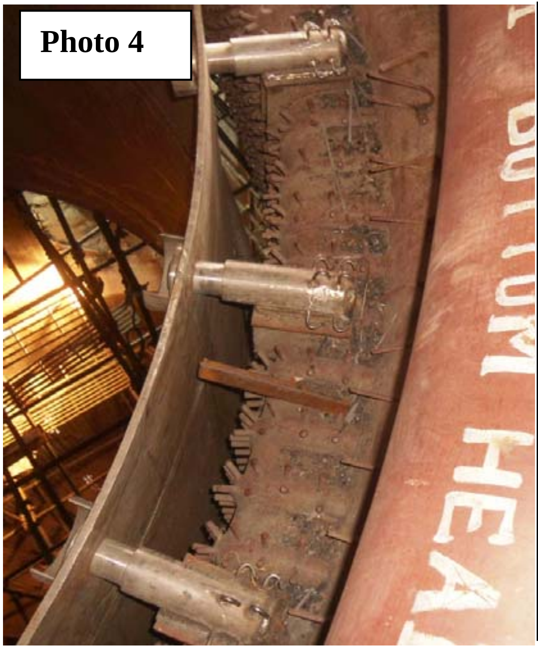

Figure 6

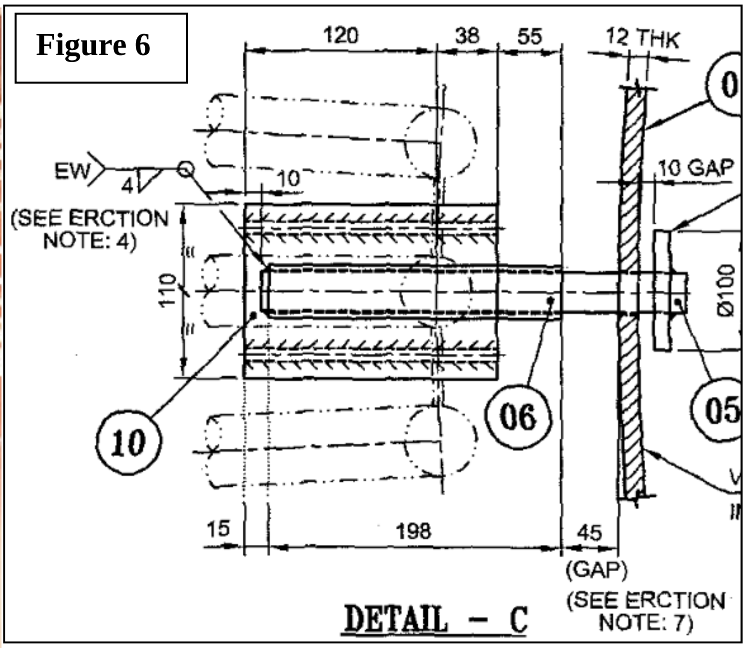

Photo 4 and figure 6 show the vortex finder fixing arrangement with expansion gap and the condition of the vortex finder at another plant. No distortion was seen even after several runs.

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4. Random erosion of CFBC furnace waterwall

Waterwall erosion is seen at seal box area, excess fin weld area and at corners. See photos 5 & 6 below. Any protrusions inside CFBC combustor wall causes erosion nearby. Photos 5 & 6 show that the erosion was caused due to improper fin to fin field weld.


Photo 5


Photo 6

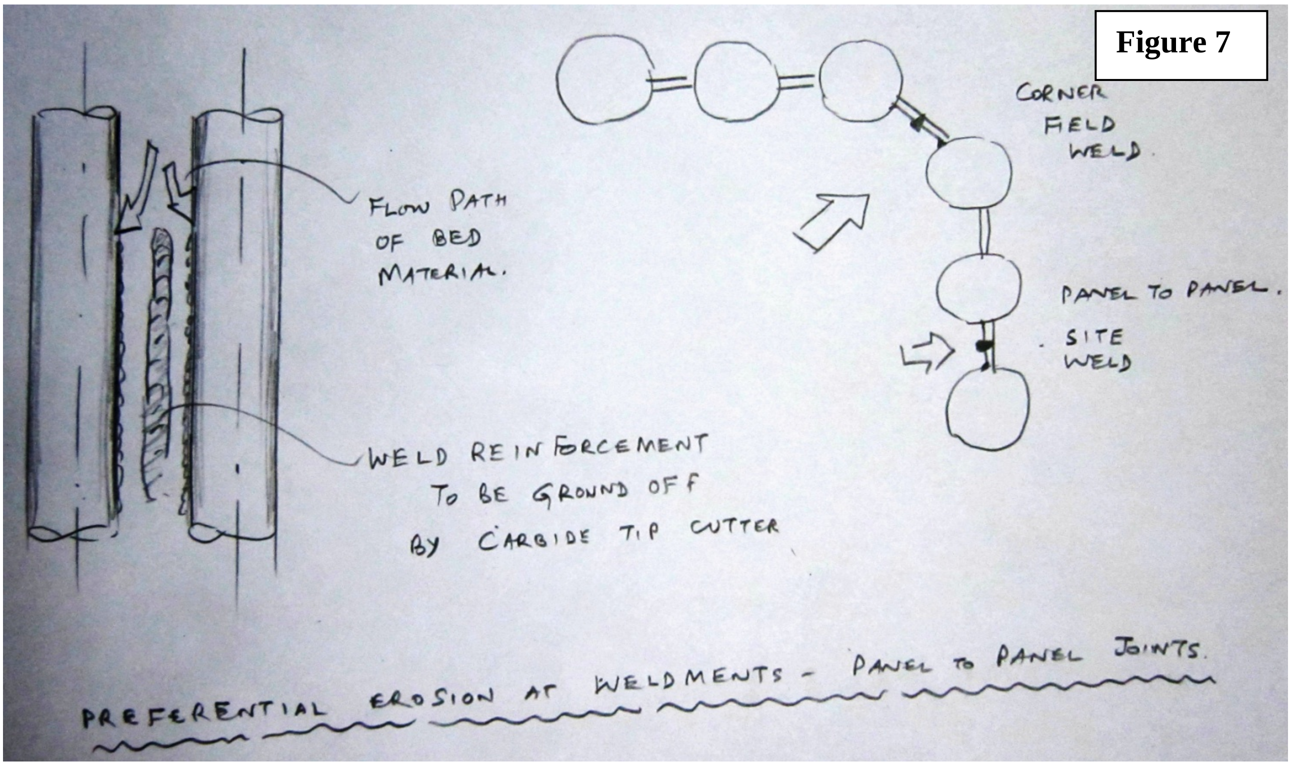

Figure 7

Erosion at improper field weld joint / shop weld joint is a general phenomenon. It happens at all CFBC installations. Once the weld reinforcement is eroded, the erosion ceases. In the case of excess reinforcement in fin welds, the bed material is directed to adjacent tubes. This can be avoided by removing the excess weld reinforcement. It was advised to deploy portable carbide tip cutters to remove the excess weld reinforcements.

Photo 7

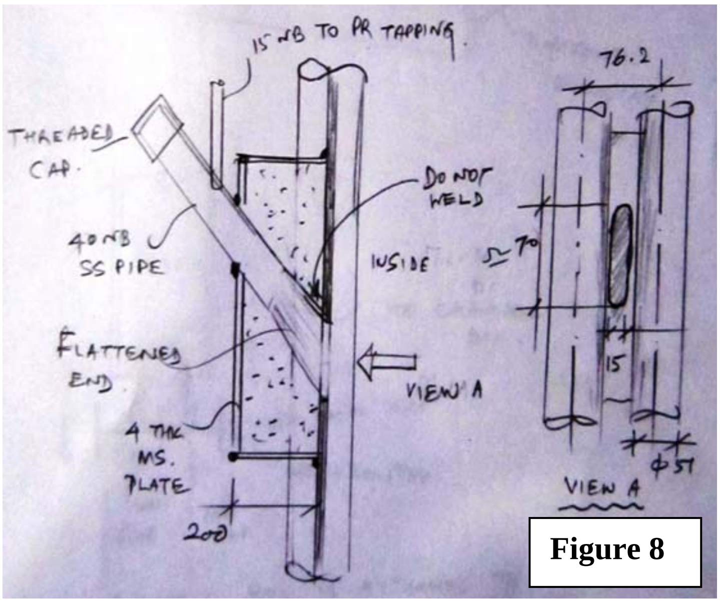

Figure 8

Even a draft tapping made in the furnace wall causes erosion, when the draft pipe is extended inside. It needed correction as shown. Lifting lugs, overlapping fins cause erosion in CFBC furnace walls.

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5. Haphazard erosion of the air nozzles

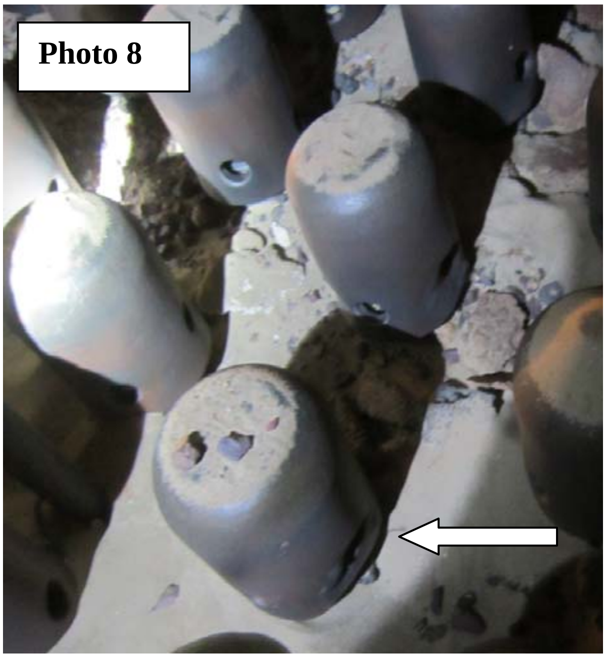
Photo 8

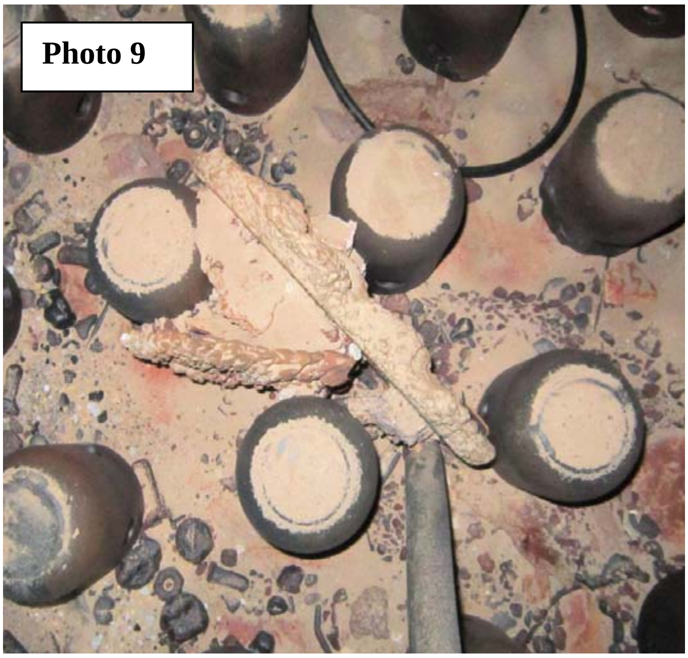
Photo 9

Air nozzles were found to have eroded in haphazard manner as seen in the photo on the left. This can be due blocking the air jet passage by broken refractory / foreign material trapped between the air nozzles. Improper furnace refractory patch up work could spall off in service.

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6. Bull nose brick work

Photo 10

Bull nose refractory is seen to crack from position. This happens due to many reasons.

a. Refractory work at bull nose is thicker as compared to nearby wall. There will be differential expansion during the boiler start up.

b. Proper refractory dry out is necessary once the casting is done. It is necessary to have steam vent holes by drilling from the hot side of the refractory. Dry out for local repair work may not be practical always. It is better to avoid castable work. It was advised for substitution of precast anchor bricks followed by special bricks.

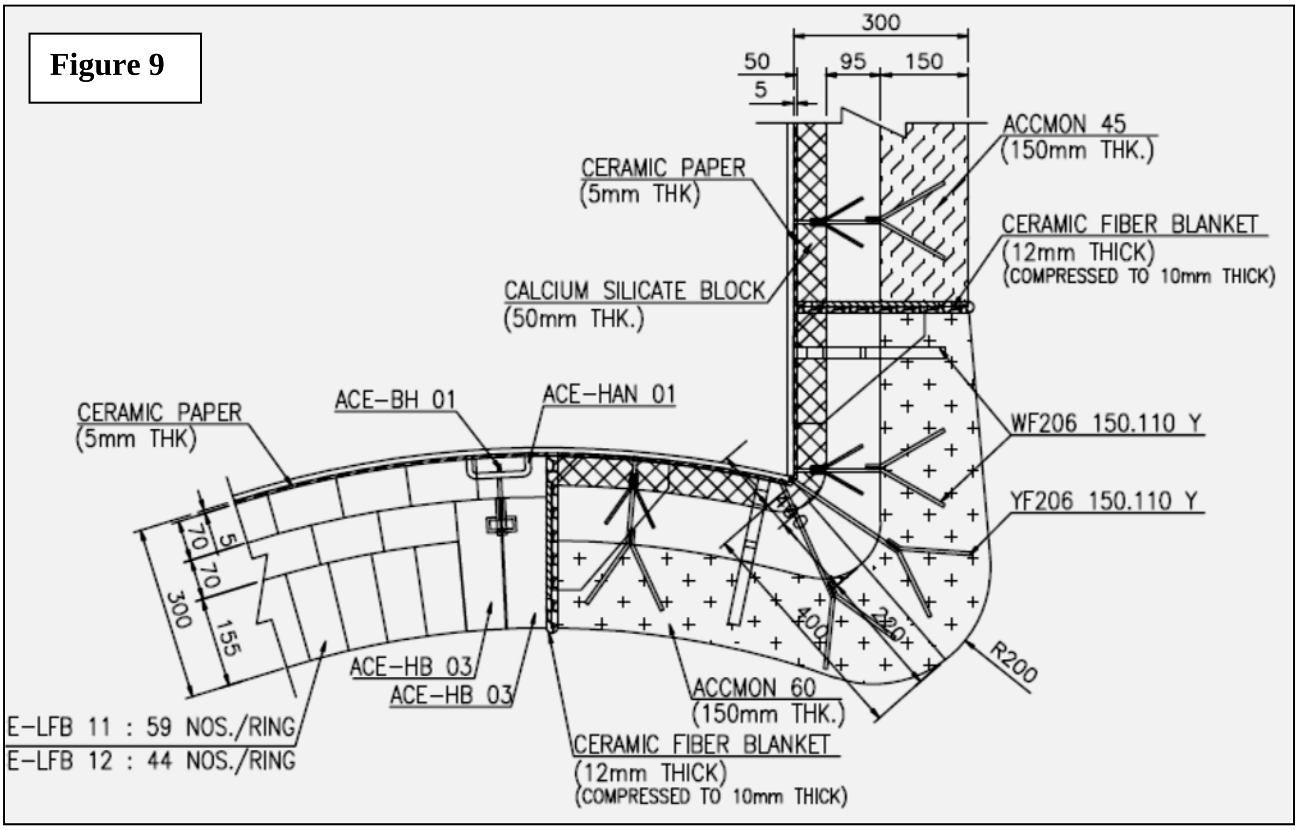

Figure 9

c. In case the bull nose cracks away from near refractory brick, the crack should not be filled again. Because by design there should be expansion allowance and the bull nose should be casted separately.

*7. **Wrong Buckstay fitment***

It is seen that some of the buckstays in furnace waterwall are not erected as per drawing. It leads to straining the waterwall. The zero axis is at the centre of the waterwall. Hence the pin connections have to be with an offset of 10 mm as per drawing detail.


Photo 11

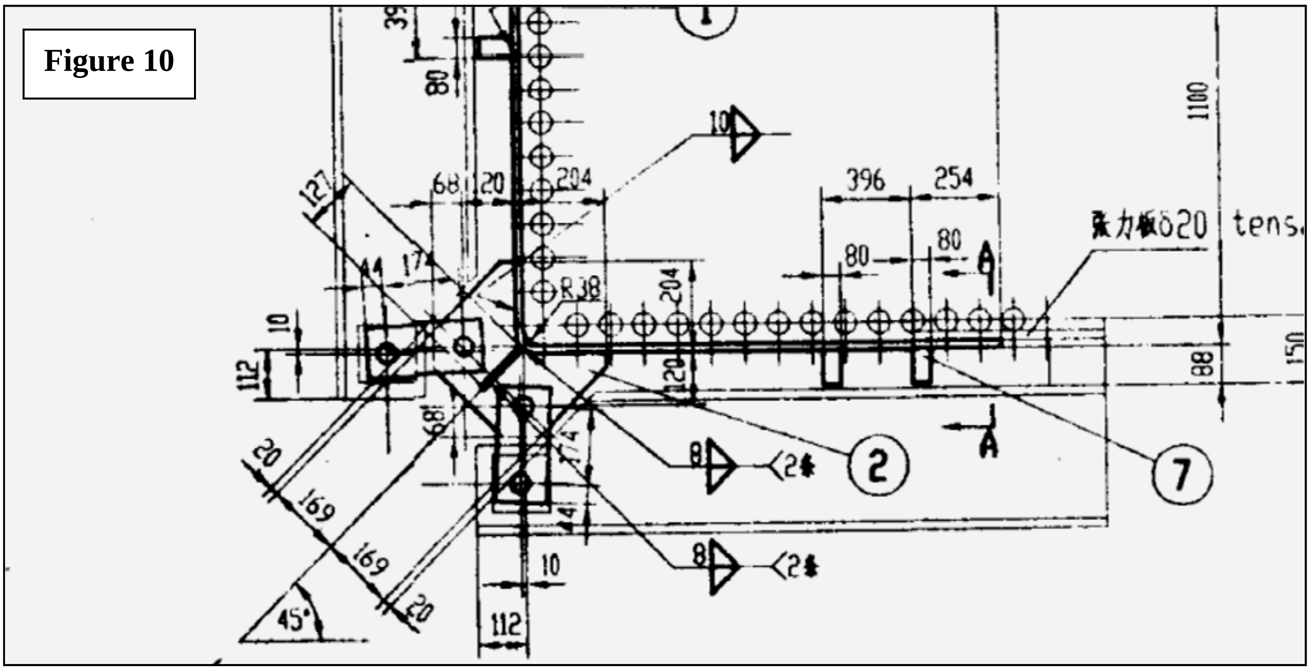

Figure 10

It is seen that second pass is guided along the centre of the panels. However at the top it is offset due to some reason. See photo 12 & photo 13 below. The buckstay needs correction.

Photo 12

Photo 13

There may not be any failure immediately. After cycling operation, the panel may develop cracks along the corner tube- fin weld. Waterwall caves out or in between the buckstays when the buckstays restrict thermal expansion.

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8. Failure of tube at corner welds of steam cooled wall duct connection

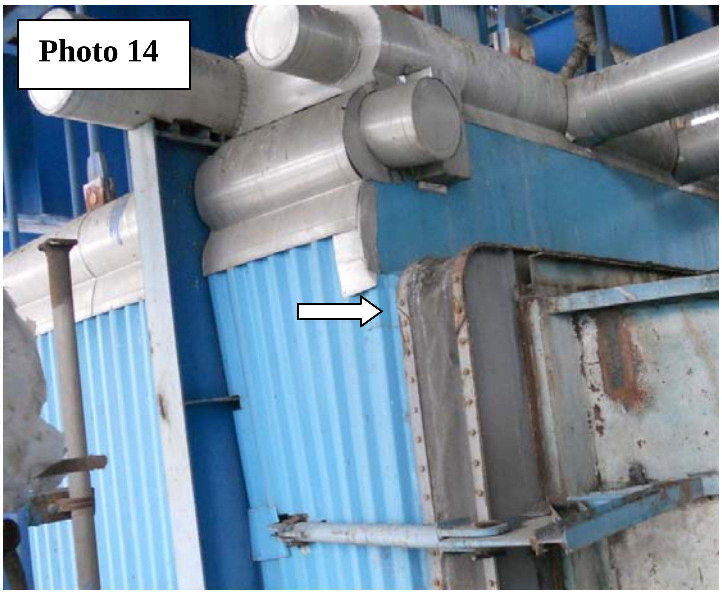

Photo 14

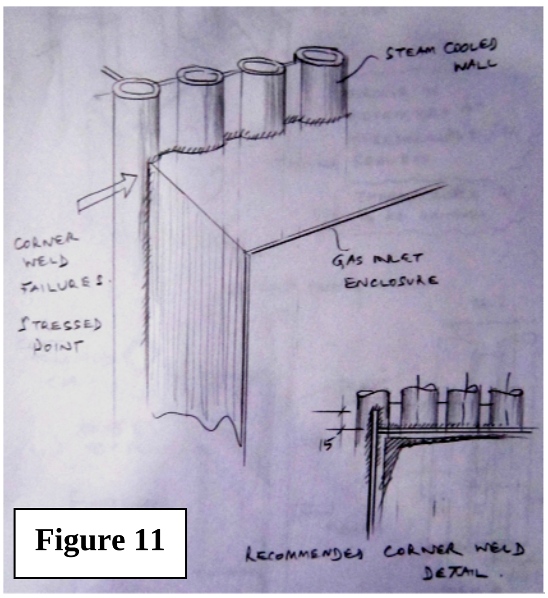

Figure 11

Any corner joint terminated at tube fails due to cyclic thermal strain. This kind of failure is seen at many plants. The location is shown in photo 14 & figure 11. The corner joint should be as shown in the sketch by the side. It is advised to minimize the weld size.

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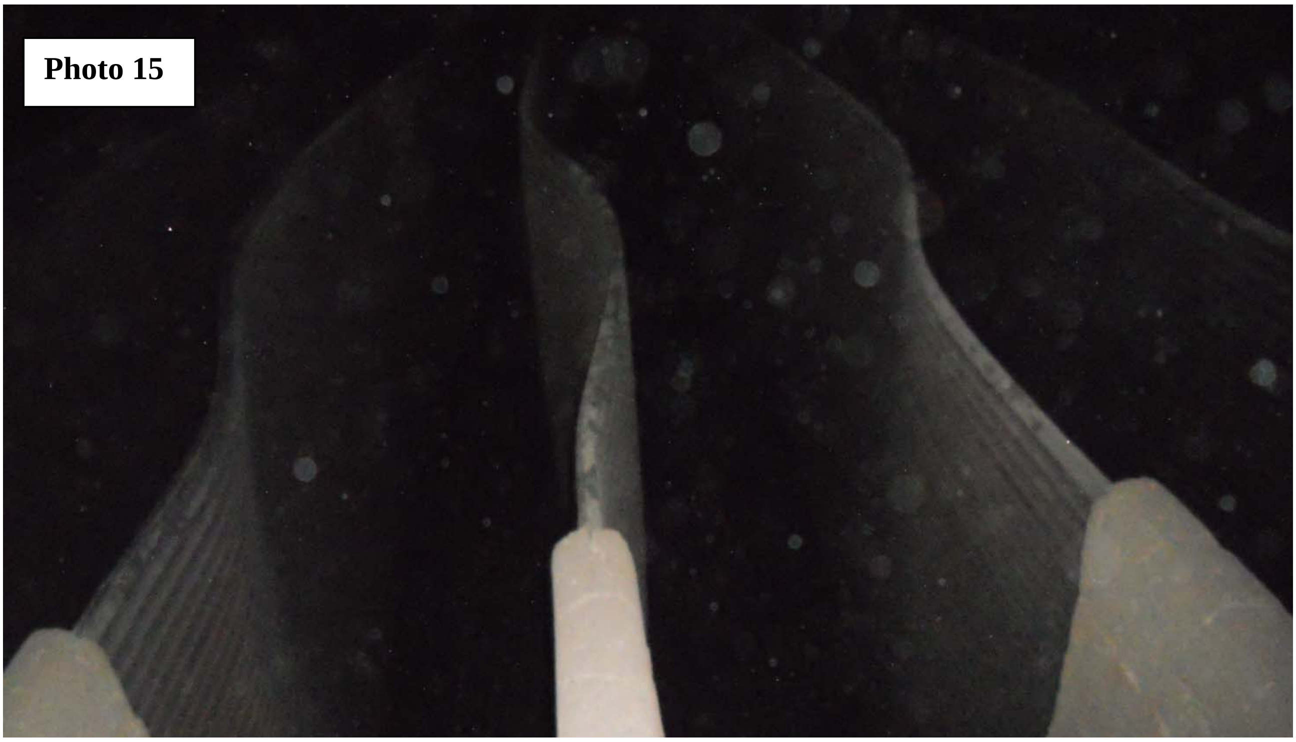
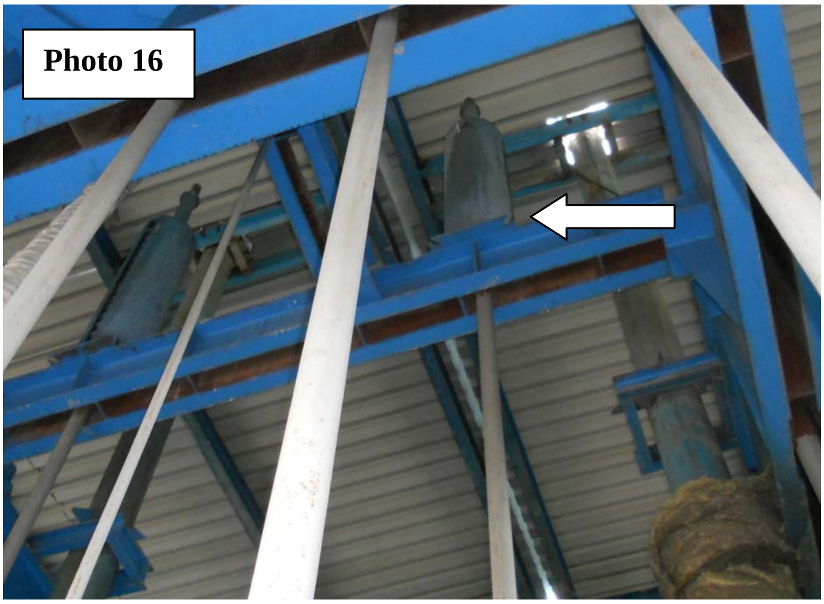
9. Buckling of the platen SH panel



Platen superheater at furnace is seen distorted. Platen SH assembly is supported at top by variable spring hangers. This should be constant load hanger so that the thermal expansion load comes on to the hanger. In variable load hanger this does not happen properly.



Another reason for buckling is that the quick start with excess fuel feed without sufficient steam flow. Many operators try to pressurize the boiler by throttling the start up vent. This is not a correct method. Start up vent should be full open so that the pressurization can occur due to sufficient steam flow.

It was advised to add retractable thermocouple below the platen SH so that one can control gas temperature at entry to platen SH during start up.

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10. Char formation at fuel feed openings

Charring of coal is seen at the fuel feed openings. Earlier a fuel spreader fan was used for fuel spreading. Its pressure was about 1400 mmWC. Now the PA air is used for fuel spreading. The air flow has come down from previous flow. This is because the nozzles provided kill the pressure.

It is possible during start up and during hot restart there may not be sufficient spreader air flow / air pressure to spread the fuel. It may be possible that after the start up & load raising the PA pressure raises and it could be enough.

It is advised to check the spreading of fuel by running the PA fan only at 800 mmWC and check the spreading at MCR feeder rpm. Otherwise it is necessary to modify the spreader with higher diameter nozzles to have enough air flow.

The refractory work at fuel nozzle should be sloped downwards so that the fuel flow is not obstructed.

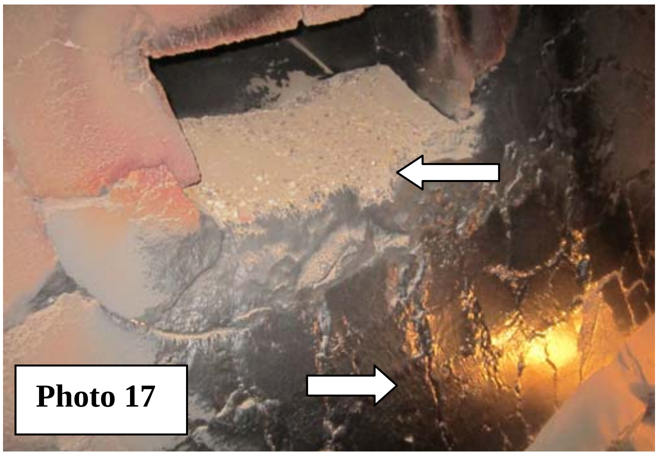

Photo 17

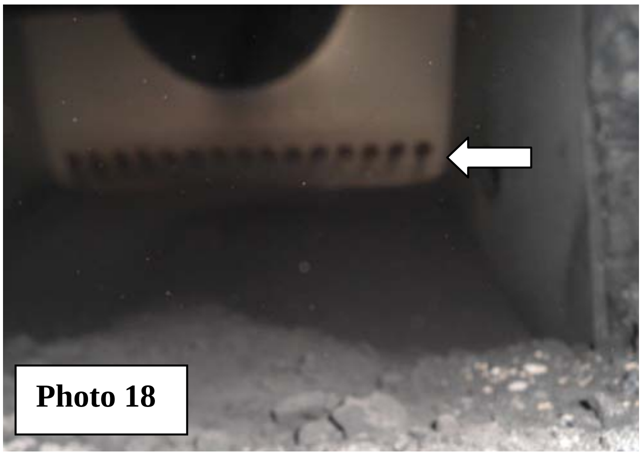

Photo 18

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11. Observations in bag filter

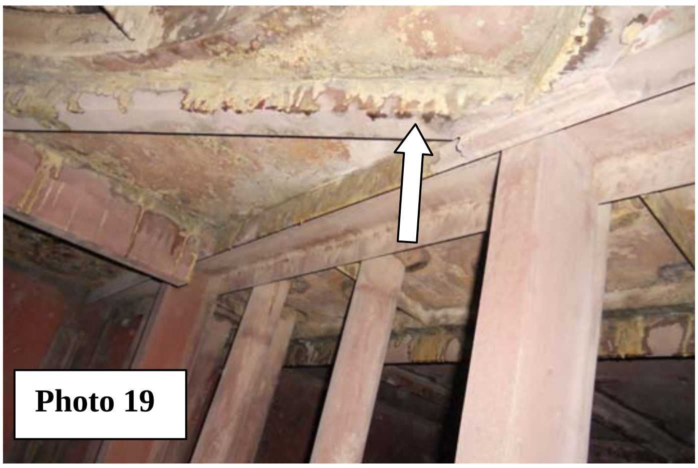

Photo 19

- Poppet valve housing is to be insulated to avoid condensation of flue gas inside the bag filter.
- Poppet valve housing flange has to be corrected. The rope was not fitted during installation.
- Bag filter hoppers are provided with double door system. But the inspection door at clean chamber at top is single door. This has to be of double door system. In between the two doors insulation mattress shall be filled. See photo 20.
- One clean chamber was seen with condensation of sulfur dioxide. There must have been high air

ingress. This can be due to improper closure of inspection door. It is advised to change the rubber seal every time the inspection doors are opened. This is because the resilience is lost once the rubber seal is put in service.

- The bag filter needs a rain cover at top to prevent rain water in to the bag house. This can happen when the door seal is not proper. The rain cover can be with removable roof cover.


Photo 20


Photo 21

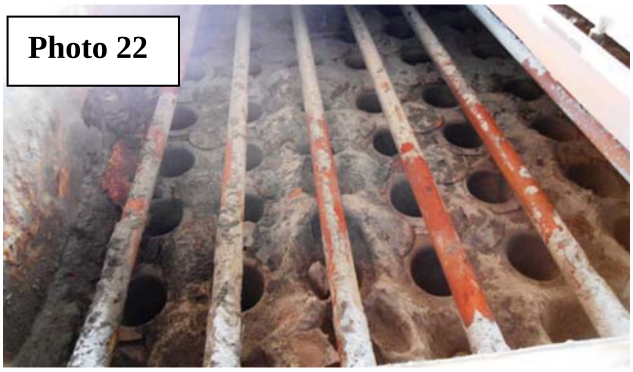
Photo 22

- The dampers in the bag filter should be insulated. Uninsulated dampers would condense the flue gas and it may drip through the flange joints. See photo 21.
- The bag filter top floor should be covered with removable insulation mattress bags to avoid cooling the flue gas and the condensation of moisture. See photo 22 showing the damage at another plant.

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12. Air cooled condenser


Photo 23

Feed water pH and condensate pH are controlled by Morpholine & Ammonia. Hydrazine dosed in the deaerator breaks down to ammonia and contributes to pH rise in condensate. Ammonia is more volatile and hence the pH does not rise in the first condensate. Only when the condensation is complete, we can find the pH rises fully.

Due to this phenomenon there is small amount of corrosion takes place continuously at the inlet end of each ACC tube. This has been found out when there were serious outages in units with ACC. EPRI recommends to raise the pH of condensate to a level that that there is no corrosion in the ACC. Corrosion can be identified by Iron test and SDI test.

ACC of unit was internally inspected. There was corrosion of ACC duct and the tubes. Hence it was advised to measure SDI and dissolved iron in the condensate and raise the pH by dosing additional morpholine at turbine exhaust duct or at Main steam line.

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13. Observations in steam drum / boiler water chemistry

- ***Steam drum inspection***

The condition of the steam drum is good. See photo 24. The magnetite layer is good. The surface is free from corrosion and the magnetite layer is intact. This is due to boiler water pH being maintained properly. The boiler water chemistry is maintained by the phosphate to a level of 4 to 5 ppm.


Photo 24

The yellow ochre marks are due to Dosing pump being in operation even after the fire is put off / circulation is put off. The HP dosing pump should be tripped when the fuel feeders are tripped.

- ***Deaerator storage tank***

The corrosion product could be seen floating inside the deaerator tank. Look at the marks above the NWL in photo below. The source is Air cooled condenser. Air cooled condenser needs pH in the range of 9.6 to 9.8. This is because the inlet end of ACC tubes experience low pH due as the amine / ammonia have different distribution ratio in water & steam.

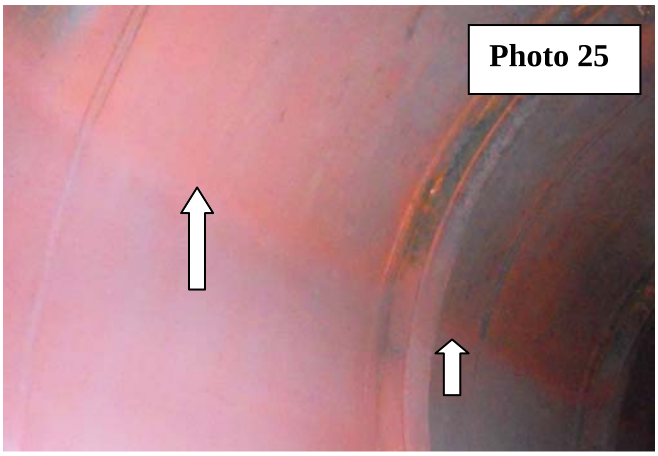
Photo 25

Rejection of ACC condensate during start up is a must as the first run off contains iron contamination. Till the SDI / turbidity is cleared the condensate must be sent back to raw water tank. A separate line is to be added from CEP discharge to raw water tank.

Contaminated condensate leads to under deposit corrosion in boiler tubes and can lead to caustic attack or hydrogen attack depending on boiler water chemistry. Such problems occur in high heat flux regions.

Conclusion

As we audit many power plants in shut down and during tube failures, we have learnt a lot about the boiler problems. We had been able to offer design solutions to improve the availability and reliability of the power plants. In the above is the condensed version of our inspection report of a Chinese make CFBC boiler.

M/S Venus energy audit system – Trouble shooting of boiler failures and operational issues. Company carries out design audit, construction audit, shut down audit and operational audit.

M/S Sri Devi engineering consultancy and agency – engaged in non pressure parts spares supply for FBC boilers.

M/S Sri Devi boiler equipment and spares – engaged in supply of pressure part spares for all type of boilers

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