ROLE OF INSULATION TO PREVENT THERMAL CYCLE STRESS (FATIGUE) RELATED FAILURES IN HIGH PRESSURE BOILERS

Boiler working pressures had gone from low pressure to supercritical over the last 50 years. Boiler designs have become complex based on the fuels fired. Boiler configurations have been tailored to burn fuels as per fuel availability & as per economics. One important factor that takes away the boiler availability is thermal cycling stresses due to incomplete / improper insulation. While boiler makers specify normal start up rate and shut down rate, unscheduled shut downs occur due to several reasons. It could be mostly due to tube failures. Abrupt cooling cycles can cause thermal cycle stress related cracks in areas such as buckstay attachment welds, sealbox fins, end plates of headers, thermowell stubs, etc. This article is on creating awareness on the role of insulation in preventing thermal cycle stress related failures.

Insulation of seal boxes

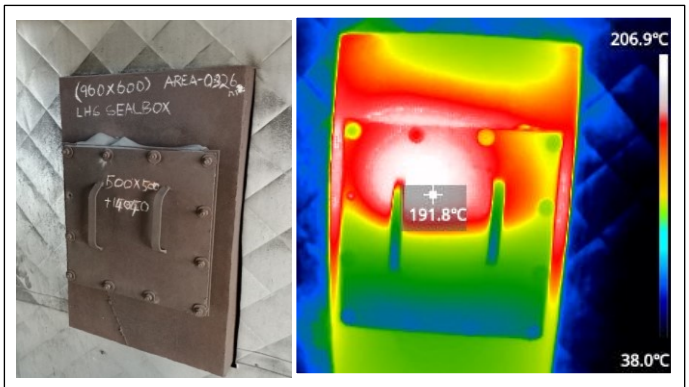

Photo 1 & 2 : uninsulated sealbox and its skin temperature.

Seal boxes are required in a boiler waterwall panels / steam cooled wall panels for accommodating soot blowers, inspection doors, secondary air injection ports, view ports in general. Some boilers need seal boxes for accommodating burners, coal injection pipes. The seal boxes are filled with refractory castable or insulating castable depending on the temperatures prevailing in the respective zones. There is always differential expansion between the pressure containing parts and the seal boxes. Seal boxes are mostly full welded to tubes / fins / tubes & fins depending on flue gas side pressures. Seal boxes are made out of 4 / 5 mm thick structural quality plates. There is always differential thermal expansion between the seal box and the pressure parts. By choosing thinner seal plates and by providing a bellowed plates system, the differential expansion between the attached part and the rest is taken care. When the seal box is left exposed to ambient, without proper insulation, there will be issue of stress due to difference in rate of cooling at the attachment weld. Thick seal welds usually crack at the tubes. Many boiler users ignore the requirement to insulate the sealbox.

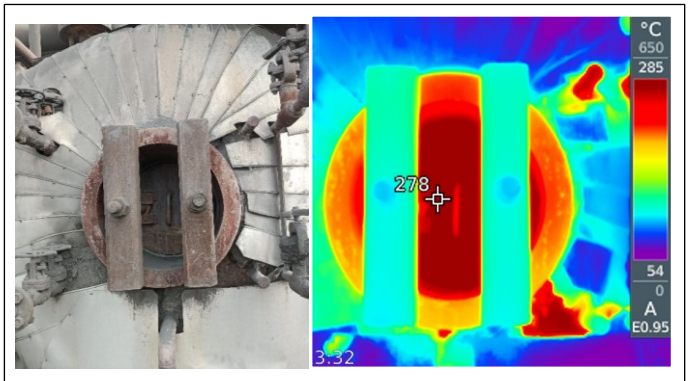

Photo 3 & 4 : uninsulated manhole frame & door.

Insulation of manholes at drums

Subcritical boilers have a single drum or twin drum depending on the operating pressure and the process steam demand surges. The manholes fitted in the thick drum shells / dished ends need to be insulated. This is a serious matter. The thickest part in the boiler is the drum dished ends. Some drums are designed with compensating pads too. When the main

dished end is not insulated or when the manhole cover is not insulated, there is a risk of crack development in thick manhole frame / shell welds due to differential cooling rate between inner & outer surfaces.

Insulation of header hand hole pipes

Header hand hole pipes are provided for cleaning after an operational chemical cleaning process. Often, they are left uninsulated as the insulation is not removable type. Plan to make header end caps insulation as removable type.


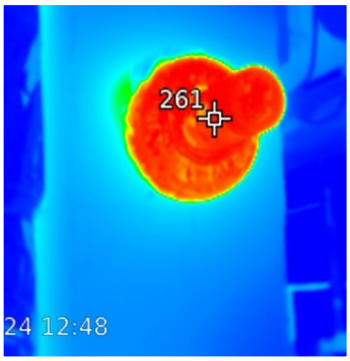

Photo 5 & 6 : uninsulated header handhole pipe.

Insulation of thick stubs & their attachment welds to drum and headers

Downcomer insulation slips down over a period, exposing the thick shell nozzle weldment. Many insulation companies do not provide the support system required for long downcomers. During abrupt cooling cycles, this thick weldment area is subject to differential cooling. Safety valve stubs, air vent valve and instrument stubs, thermowells are to be properly insulated.



Photo 9 & 10 : Uninsulated & insulated safety valve stubs.

Insulation of valves and main steam line and high-pressure distribution headers

Wherever valves are arranged very closely arranged as in distribution header or in Main steam line, rigid insulation with Calcium Silicate blocks / Thick Ceramic Fibre Blankets should be used to prevent deterioration of insulation as days go by. Low density insulation mattress sags over a period causing a differential cooling between top and bottom of the pipes. Wherever distribution headers are laid outside the boiler / turbine house consider sheds to prevent rain water impingement to the high-pressure valves / piping. Many boiler users arrange PRDS system in open conditions. Valves and piping insulation gets trenched in rain water causing deterioration of metallurgy. Leaving high-temperature components exposed to rain is unsafe.



Photo 11 & 12 : Uninsulated valves. Rigid insulation

Insulation of hot buckstays

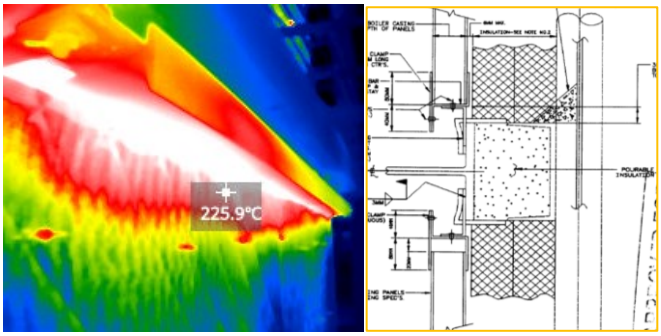

Photo 13 & 14 : Poor insulation at buckstay / pourable insulation behind hot buckstay

In some designs a combination of hot buckstay and cold buckstay structural sections are provided to prevent waterwall / steam cooled wall panels from distortions due to furnace puffs. The hot buckstay should remain close the tube wall temperature. This is made possible by pourable insulation as the space is congested and a regular mattress insulation is not feasible. When this is not done, there are possibilities that the tube / fin attachments fail after some heating and cooling cycles.

Insulation of pipe attachments in high temperature piping

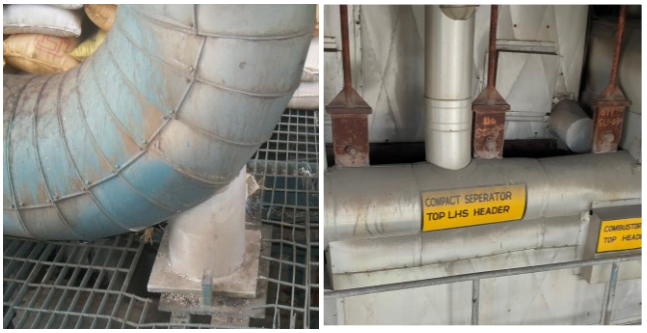

Photo 15 & 16 : Insulation to cover the attachments made to the thick walled pipes / headers

High temperature pipes / headers are provided with support pads / hanger supports / pipe guides. The pads / hanger plates are also to be provided with proper insulation to prevent differential cooling.

Insulation of control valves

Photo 17 & 18: Uninsulated vent valve & well insulated thermowell.

Control valves are provided with E/P convertors and position transmitters which need to be protected from heat radiation from below. Removable insulation jackets must be used to prevent malfunctioning of the control valves. Please be aware that the RTD head or Thermocouple heads are to be prevented from heat radiation from the pipe.

Insulation of boiler roof with headers and piping - Air ingress / ash leaks

The most difficult location where the insulation cannot be applied satisfactorily is the boiler roof. Penthouses are possible for larger size boilers where working space becomes available. In medium sized industrial boilers, there is inadequate working space. When the sealing is not properly done, the insulation is flooded with fly ash. In case of air ingress, the pressure parts get differential cooling. Most industrial boilers used for captive and cogeneration often have this issue. The better option here is to provide a combination of rigid insulation to prevent insulation damage during the process of application itself. For

finishing the insulation, instead of using aluminium cladding, refractory cement or POP application is found to be useful. The air ingress causes wrong flue gas oxygen indications, which leads to improper combustion. Some boiler house sheds are not properly done against rain water ingress. In that case, the pressure parts get damaged due to direct water poured over the high-pressure components.


Photo 19 & 20: Uninsulated vent valve & well insulated thermowell.

Photo 21: Insulation covered by refractory cement / POP to make the boiler roof leak proof.

The boiler guardians / engineers / operators should stand up to rectify the insulation defects as the safety is in question. Safety auditors need to extend their vigilance to boiler house too.

K.K.Parthiban, Boiler Consultant, Venus Energy Audit System, India.