

Boiler tube failure investigation





The process environment of fossil-fired boilers and HRSGs, along with operation errors during engineering, fabrication, erection, operation, and maintenance will always result in occasional boiler tube failures . The goal is for to reduce the forced outage with zero chemistry related failures. The frequency of these failures depends on the corrective actions taken to prevent or reduce boiler tube damage. Reoccurrence of failures results in to forced outages and do poses huge cost implication for tube replacement with direct and indirect economic losses.

Metallurgical root cause investigation helps to narrow down the reason of failure and provides inputs to make proper corrective action.

Damage mechanism's causes premature failures in boiler tubes

Caustic gauging



Localized corrosion due to the concentration of caustic or alkaline salts that usually occurs under evaporative or high heat transfer conditions. It can be mitigated by water chemistry control and design.

Flow accelerated corrosion (FAC)



FAC involves the formation and removal of the protective oxide layer. It can occur in carbon or low alloy steel piping systems under flowing, water at elevated temperature. Flow rate, pH, oxygen content, temperature and geometry can affect the mechanism.

Erosion, erosion & corrosion

Erosion is the accelerated mechanical removal due to relative movement from liquid, vapour or solid particles or mixture.

When corrosion contributes to erosion by removing protective films or scales, the combined action is erosion & corrosion.

Stress assisted corrosion (SAC)

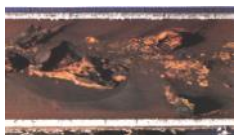


Both mechanical stress and corrosive environment are necessary to initiate SAC, dissolved oxygen, pH excursion can be the major water chemistry variable that contribute. SCC cracks are frequently found where attachments exist. Stress on the tube surface can break the magnetite film formed.

Water corrosion

Dissolved oxygen, low pH and the scale depositions are the main reason of water side corrosion. Maintaining the water chemistry with respect to operating pressure and boiler type is a key to avoid the water corrosion.

Oxygen pitting



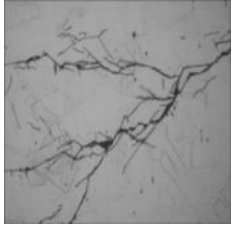
Localized corrosion occurs in form of severe pitting especially at the location where the water is not easily drain during shut down which comes contact with air.

Fire side corrosion



Sodium and Vanadium in fuel, Boiler operation under oxidizing atmosphere, formation of low melting (995F) Point Oxides of Sodium (Na_2O) and Vanadium (V_2O_5), Formation Pyrosulfates of Sodium and Vanadium. Release of Sulphur and Chloride compound by unburnt coal particles due to incomplete combustion, Can eat away the tube surface leading to thinning or puncture under hot condition.

Stress corrosion cracking



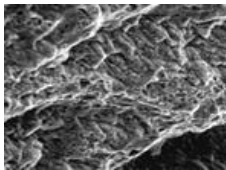
Highly stressed (Austenitic SS), Sodium salts concentration and deposition on surface hide out in dense steam and sudden release while superheated under constant pressure is susceptible to SCC. Solution annealing of SS and sodium level maintaining can prevent SCC. During shutdown precautions are necessary to avoid Polythionic Acid stress corrosion cracking(PASCC) of sensitized Austenitic SS.

Thermal fatigue



Thermal fatigue can occur due to cyclic stresses caused by temperature fluctuations. Damage is in the form of cracking that may occur due to relative movement expansion and this is constrained, under repeated thermal cycling. The cracks are observed with blunted tips and filled with scales.

Fatigue



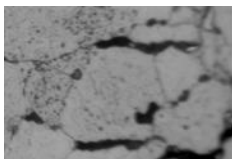
Mechanical fatigue can occur when the repetitive stresses are due to vibration, pressure fluctuation that can arise especially during start ups. The failure has typical signature of having fatigue striations on the fractured/crack surface.

Stress rupture



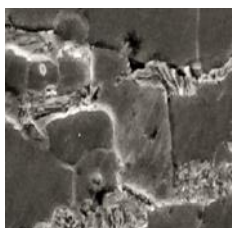
Short term over heating appears with bulging, it occurs at operating stress due to localized overheating. It can be due to design, secondary combustion in the boiler, shifting of combustion zone, starvations or obstacles to stem flow.

Long term creep failures



Creep failures occurs due to high temperature exposure of the boiler tube that slowly and continuously deformed under load below yield stress. Several factors like basic metallurgical condition, internal scale deposition and operating factors can contribute to creep failure.

High temperature hydrogen attack (HTHA)



Hydrogen damage of boiler evaporator tube, also called hydrogen attack, results in serious and irreparable damage to the tube steel and should not be confused with "hydrogen embrittlement" which is sometimes reversible adsorption of hydrogen into steel. It occurs due to acidic condition and deposition on the heat transfer surfaces due to poor water chemistry.

Team of experts investigate the boiler tube failures with a unique approach of correlation of operational parameters along with deep down understanding of damage mechanism.

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