Revolutionary Superheaters for Recovery Boilers

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Introduction

• When recovery boilers are designed one of the most difficult questions that arise is; what kind of materials should one use for different parts of the boiler.
• There is no single good solution for superheaters
What we do know of superheater corrosion

• Superheater tube side surfaces thin.
• Ash is sticking to the windward side of the tube.
• Molten layer exists at tube sides.
• Fuels contain minor amounts of impurities.
• These impurities can cause high temperature corrosion in the superheaters.
• Especially vanadium, sulfur and alkali metals cause high temperature corrosion
• Higher surface temperature = higher corrosion rate
Superheater corrosion

- Even the most modern recovery boilers suffer from superheater corrosion
- Corrosion is the main problem that limits the ability of kraft recovery boiler to produce electricity
- In comparison to coal fired boilers kraft recovery boilers have higher rates of alkali metals, chloride in gaseous form and often highly reducing conditions caused by carryover particles
- On the other hand levels of some high temperature corrosion causing substances like antimony, vanadium and zinc are typically low
Corrosion of lower bends is not uniform!
Chromium decreases corrosion

[Graph showing relationship between weight loss and chromium content]
Even best materials corrode in RB SH

(Salmenoja and Tuiremo, 2001)
Chloride corrosion

- Chloride in fuel forms NaCl, Cl₂ and HCl in gaseous form
- In active oxidation these gases react with iron to FeCl₂
- When in contact with oxygen it reacts back to Fe₂O₃ releasing chloride in gas form
- Reformed iron oxide layer is porous and does not offer protection from corrosion
- Released chloride can react with fresh iron oxide and the cycle repeats
- Active oxidation leads to rapid waste of superheater tubes
Hot chlorine corrosion, inner tubes forming the hair pin are the most corroded ones.
Superheater design and materials

Operation problems that cause superheater failure can be

1. Condensate blocked tubes during start up
2. Water from hydrotest not being evacuated during start up
3. Water carryover from the drum
4. Desuperheater spray water quality control issues
5. Sootblower action
6. High temperature cycling caused by poor superheating control
Increasing temperature -> corrosion

(Fujisaki et al., 1994)
Superheater corrosion – steam temperature

- Main steam temperature is the main parameter that affects the choice of superheater materials.
- The rule of thumb is to keep the superheater surface temperature below the first melting temperature of deposits.
- Corrosion rates in final superheaters are increased because superheater material temperatures are highest.
- Typically there is some temperature range where the corrosion rate is acceptable.
- Increasing tube temperature by some tens of degrees can significantly increase corrosion rate.
What we need to know

• Effect of potassium and chlorine content on superheater deposit = effect on superheater corrosion
• Effect on 85 % dry solids to superheater corrosion
• Is the choice of ~25 % Cr materials the only sensible choice for high pressure and high temperature boilers
• How to estimate superheater tube surface operating temperatures more accurately