ADVANCED CERAMIC COATINGS REDUCE FIRESIDE DEPOSITS, CORROSION AND EROSION IN COAL FIRED UTILITY BOILERS

Speaker: EDWARD LLOYD
Plants burning pulverized coal are typically only 35% efficient due to the effects of coal ash deposits

- Reduced operational efficiency and boiler performance
- Increased operational problems - de-ratings
- Increased maintenance cost - Tube failures and shut downs
Coal ash deposits are complex

• Can contain many different organic and mineral matter properties
• Combustion kinetics - molten ash particles in hot gas path
• Mineral decomposition - Tube corrosion
• Heat transfer to and from the deposit - insulating slag - poor emissivity
Slagging = deposits that form in the combustion or furnace zone and consists of molten ash

- Insulates the water wall tubes impeding heat transfer
- Increases furnace gas exit temperatures (FEGT) allowing for molten particles to solidify on the screen tubes and in convection passes.
- Slag deposits around burners can block coal flow into the furnace causing burner damage.
- Under deposit corrosion can occur on tube surfaces causing metal wastage.
Superheater/screen tube slagging a rise in (FEGT) can contribute to superheater slagging due to molten ash particle solidification on tubes.

- Slag can bridge reducing the sectional areas and impeding flue gas flow.
- Gas velocity can increase and decreased heat transfer can cause build up in the convection pass.
- Large deposits can dislodge and drop onto the slopes in the lower furnace causing damage.
Ash deposits on convection tube sections are typically referred to as fouling. Associated problems are:

- Increased fly ash erosion in localized areas due to higher gas velocities
- Increased fan requirements
- Increased tube corrosion due to fly ash erosion removing protective oxides thus allowing deposits in liquid phase.
- Decreased heat transfer
- Increase in soot blowing required
- Impedance in gas flows
Coal ash corrosion caused from burning coal with high sulfur, alkali, or high chlorine coals

- Tube wastage causes tube failures, unplanned outages and increased boiler down time
- Increased corrosion on tube surfaces can accelerate ash bonding and compound corrosion and slagging.
Typical options used to reduce ash deposits

• Soot blowers
• Chemical treatments (targeted in furnace injections)
• Coal treatments
• Pulse detonation wave technology
• Anti-fouling coatings
• Ceramic coatings
Advanced Ceramic Coatings development criteria for the power utility industry

• Must mitigate corrosion
• Must provide erosion protection at high temperatures
• Must have high emissivity and high thermal conductivity
• Must form a chemical and mechanical bond and have a non-porous structure
• Must be applied thick enough to overcome surface irregularities and prevent mechanical damage

Pendant reheats ceramic coated
Additional ceramic coating development requirements:

• Must mitigate bonding of slag deposits on tube surfaces and prevent chemical reactions (oxidation and carbonization) that produce surface scale
• Must be non-reactive, (non stick) and as chemically neutral as possible
• Must be dense enough to prevent diffusion of carbon, oxygen, sulfur and other gaseous contaminants into the metal tubing thus allowing the boiler tubing to maintain its designed metallurgical properties and mechanical strength.
Requirements for application

• Must be water-based ceramic slurry that can be applied at ambient temperatures.
• Must be a spray-applied, multiple pass coating system which will enable a quick, easy and pinhole free protective surface layer application.
• Must achieve application rates that will reduce or eliminate any extra boiler down time.
• Must provide an end product that will be forgiving to applications in (on-site) boiler environments during outages.
Bond/cure and firing considerations

• Must bond to a properly prepared substrate using generic abrasive blasting materials that are available to most job sites. A NACE1 white blast specification with .002 to .003 anchor tooth profile must be achieved.
• Firing requirements for cure must be achieved during initial boiler start up.
• Thermal shock resistance and bond strength must be such that the tubing can be heated to its maximum temperature and cooled to room temperature without any cracking, spalling or bond losses.
Environmental and safety concerns

- Personal safety is of great concern since the application takes place in an enclosed space where breathing toxic solvents or materials and the potential for a solvent vapor explosion are of great concern and are unacceptable.
- The ceramic coating is non-solvent, environmentally sound, non-toxic and non-flammable.
- The ceramic materials must comply with existing environmental laws.
Review of a coal fired boiler field application and results

- Equipment – 480 megawatt CE tangential fired boiler
- Fuel - High sulfur eastern US bituminous coal
- Reason for application - severe fouling, fly ash erosion and water wall corrosion
Areas ceramic coated

• Pendent platens, nose arch and reheater inlets to prevent severe fouling build up.
• Total area 820 square meters
• Furnace water walls from lower slope upwards to tops of burner corners on all four walls. Ceramic coating was applied to mitigate tube loss due to reducing atmosphere corrosion.
• Total furnace area coated 1,209 square meters
Ceramic coating specifics

- Ceramic coating system was applied consisting of two compatible but different formulations. The coating was applied as a two-coat system.
- First (bottom coat) was applied .006 thick. Coating had high bonding characteristics and high resistance to corrosion and erosion. The base coat was both chemically and mechanically bonded to the tube substrate.
- Second (top coat) was applied .006 thick. Coating was formulated to reduce slagging and prevent fouling of the upper sections of the boiler while providing added sulfide corrosion protection. The top coat of ceramic was chemically bonded to the base coat.
- Both ceramic coatings applied had high emissivity values greater than 0.88

Lower furnace water walls ceramic coated to prevent corrosion
Post application results

- After 4 months the boiler was shut down due to unrelated refractory issues.
- Upon inspection the pendent platens, nose arch and re heater inlets were clean and free from fouling.
- Lower furnace inspection showed no signs of slag building or corrosion.
- The boiler has been on line for over a year and the inspection results continue to show no fouling, and only minimal slagging and no water wall corrosion was observed in the coated areas.

Coated reheaters on line after three months run.
RESULTS

Photo of reheater taken one hour after shut down during 4 month run
Customers expected return on investment

- Higher heat absorption in the coated areas
- Reduced erosion and tube stress associated with soot blowing
- Significantly less time required to clean the elements in order to gain boiler entry especially during forced outages.
- No forced outages due to fouling
- Reduced cleaning cost during outages
- Can maintain higher boiler rating
Inspection of ceramic coating thickness in lower furnace
Ceramic coating formulated to reduce erosion of CFB tubes
Erosion resistant ceramic coating applied over welds to reduce weld profile erosion
Ceramic condition after two years applied at refractory interface in CFB boiler