Solving Corrosion Issues in Power Plants with Thermal Spray Coatings

Longboat Key, Florida
May 9th, 2013
Jorge Costa, P.E.
Outline

- Corrosion
- Corrosion of Plant Infrastructure & Equipment
- Thermal Spray Coatings
- Applications
- Examples
Corrosion of Steel
Nature of Corrosion

Man-Made Materials and Nature
Why Metals Corrode

- Steel is an high energy state
- Steel has a tendency to return to its most stable energy state
- The process that allows this to happen is corrosion
- The corrosion process involves a series of steps (reactions) resulting in the release of energy and production of oxides
- Energy is released in the form of an electric current discharged from the surface of the steel
Corrosion of Steel in Concrete

CHLORIDES

REBAR
Corrosion of Steel in Concrete
REBAR CORROSION
REBAR CORROSION
Corrosion Risks in Power Generation

- Systems
  - Filters / screens
  - Pumps
  - Heat exchangers
  - Condenser water boxes
  - Firewater, service piping
  - Insulated steam lines
  - Grounding
  - Flue Gas Path
  - Boilers
  - Scrubbers

- Infrastructure
  - Canals
  - Intakes
  - PCCP Pipe
  - Outfalls / Discharge
  - Tunnels
  - Pedestals
  - Pits
  - Slabs
  - Containment
  - Structural steel
Thermal Spray Development

- First patented early 1900’s
- Development supported by:
  - American Welding Society,
  - International Thermal Spray Association,
  - American Society of Materials /TSS & ITSC,
  - NACE,
  - SSPC,
  - Academia (Stony Brook, Missouri)
  - Suppliers & Applicators
Thermal Sprayed Coatings

- Metalized Coatings
- Process of spraying molten metal on to a surface to form a coating
- Feedstock material is brought to molten or near-molten state by a heat source.
- Atomized particles are propelled to a prepared surface with a gas.
- TS Coating is built up by proper application technique.
- Process is “line-of-sight”.
- Resulting coating has unique characteristics.
Thermal Sprayed Coatings

- Feedstock
  - Powder
  - Rod
  - Wire

- Substrates
  - Steel
  - Concrete
  - Metals
  - Plastics

- Heat Source
  - Combustion
    - Flame
    - HVOF
  - Electric Energy
    - Plasma
    - Wire Arc
Metalized Coating

- droplets
- oxide skin
- splatter droplets
- embedded oxide skin
- voids
- splats
- substrate
Multiple Impact of Nickel Particles on 0.5×0.5 mm Stainless Steel
Diameter = 40-80 μm, Velocity = 40-80 m/s, Impact time interval = 2 μs

\[ T_{di} = 1600-2000°C, \quad T_{wd} = 20°C, \quad R_e = 10^{-7} \text{ m}^2\text{K/W} \]
TS Coating Characteristics

- Lamellar Structure
- Heterogeneous Composition
- Platelets
- Oxides
- Voids
- Un-melted Particles
TSCs for Structural Steel

- Barrier is primary function
- Galvanic Protection at coating break
- Superior to galvanizing
- CUI
- High Temperature Applications
- Alloys: Al, Zn, Al-Zn alloys

Galvanic protection at coating break
Hot Dip Galvanizing
TSC Selection

- Aluminum
  - Marine
  - Industrial
  - High Temperature
- Zinc
  - Atmospheric
  - Alkaline
  - Cathodic Protection
- Alloys
  - 15% AlZn
  - 28% AlZn
  - Bond coats (Ni containing Al)
  - Wear resistant alloys (90% Al, Aluminum oxide)
  - High temperature (reducing or oxidizing environment)
Powders allow for virtually any composite alloy material.

Use powder in a different way; where the feed stock shares the benefits of powder.

Using Tubing as Feed Stock provides for a Controlled Environment.

Feed Stock & Powders structured in such a way that when melted, will produce a composite.

Applied using Twin Wire Arc Spray (TWAS) methods provide a complete melt and consistency.
Thermal Spray Equipment
Flame Spray Schematic

- Powder
- Burning gases
- Sprayed material
- Fuel gases
- Aspirating gas
- Nozzle
- Spray stream
- Prepared substrate
- Deposit
- Air cap
- Wire nozzle
- Wire
- Air
- Oxyacetylene
**Arc**

- More coverage (shot gun approach)
- More productive (>100lb/hr)
- Higher quality, less porous coating

**Flame**

- Targeted (rifle approach)
- Less spark and flame
- Easier to handle
- More portable
- Less productive (20lb/hr)
Thermal Spray Application Areas

**Corrosion**
- Boiler Tubes
- Scrubbers
- Bag Houses
- Structural & Access Steel
- Hoppers & Chutes
- External Corrosion
- Corrosion Under Insulation
- Concrete

**Erosion/Abrasion**
- Material Handling Equipment
- Fan Rotors

**Safety/Other**
- Skid Plates, Walk Ways

**High Temperature**
- Gasifier Baffles
- Superheaters
- Economizers
Cathodic Protection

- Delivers a small direct current through the concrete to the steel.
- Current is discharged into the concrete from an anode.
- Previously corroding anodic areas receive current.
- Anodic areas are converted to cathodic areas.
- Corrosion is arrested.
Sacrificial Cathodic Protection System

- Anode is coated on concrete surface
- Anode is connected directly to steel
- Voltage difference generates protective current
- Metalized anode corrodes and steel does not
Examples
Galvanic CP for Power Plant Intake Structures
Galvanic CP for Power Plant Intake Structures
TSA for CUI

Thermally Sprayed Aluminum (TSA)

Insulation

Surface Prepared

Corroded Pipe Section
High Temperature Applications – Corrosion Under Thermal Insulation
High Temperature Boiler Applications

- Application by Wire Arc
- Successful Long Term Results
Boiler Tube Applications
A composite approach is needed to insure that the entire coating will function as protection - not just the surface of the coating.

Sulfur induced corrosion on alloy 625 weld overlay and a Ni/Cr thermal sprayed composite coating.

Compromises in the alloy’s surface film require a constant source of oxygen to repair.

Approximately one third of the overall composite becomes the method of protection by forming a sulfide corrosion product.
COATING STRUCTURE

- Dispersed oxides are the foundation of which all benefits of the coating are derived.

Laminar oxide structure and high metal content = internal stress

Dispersed oxides and less metal content = less internal stress
Example of the Benefits of Dispersed Oxides

As applied Ni/Cr .040” thick onto carbon steel.

Localized heating to greater than 1800 degrees Fahrenheit and water quenched.

Ni/Cr composite coating still well attached and showing no signs of disbondment.
Thank you

Questions?