Application of Corrosion Resistant / Antifoulant Coating on Latter – Stage Steam Turbine Blades

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Twelve 2nd stage turbine blades fractured on a two-stage rotor after approximately 4 years of service.

Failure analysis shows these were fatigue cracks which initiated from a corrosion pit.

Pitting was caused by deposit buildup on blades.

Blade material was AISI 403 stainless steel.
Fractured 2\textsuperscript{nd} Stage Blades
Fractured 2\textsuperscript{nd} Stage Blades
Fatigue Fracture Surface
On Blade #93
Airfoil

Initiation Site at Corrosion Pit
On Blade #83
Fatigue Cracking
Initiating from
Corrosion Pit
On Blade #86

Exposed Fracture Surface
On Blade #86

Fatigue Cracking
Initiating from
Corrosion Pit
On Blade #86

Exposed Fracture Surface
On Blade #86
Deposit Buildup on Blade Airfoils
Pitting Corrosion Beneath Deposit
EDS Scan on Corrosion Pit
Both condensing and non-condensing industrial turbines can encounter problems with deposit building up on the turbine blade airfoils.

Hydroscopic salts, such as sodium hydroxide, can absorb moisture when superheated steam becomes saturated and condenses in the latter stages of the turbine/Wilson line.
Fouling

- Wet hydroscopic salts have a tendency to adhere to turbine metal surfaces
  - Can entrap other impurities such as silica, metal oxides, and phosphates
  - Very difficult to remove
  - Can cause a decrease in efficiency and an increase in vibration
Fouling

- Smooth, clean steam paths will not collect deposits as easily as dirty, previously contaminated surfaces
  - Desirable to prevent further deposit buildup and remove the problems associated with the presence of the deposits by cleaning the turbine
  - Effectiveness of water removal procedures mainly depend on the adherence of the deposit to the substrate
Another option is to coat the surface with a material that has a superior antifouling or antistick / corrosion characteristics

- Reduce the tendency for contaminants to stick
- Increases the effectiveness of water washings
Solution

- Applied coating to second stage blades
  - Hard, 3-part coating which is chemically bonded to the blade
    - Top coat is an amorphous nickel
  - Provides significant improvement in foulant release ability, minimizing the amount of buildup
  - Provides excellent corrosion protection
  - No reduction in fatigue properties of base metal
  - Durable coating, only removed by extensive liquid impingement
Picture of Coated Blade
Foulant Release Testing Device

**Formula**

- 50 ml CORN OIL
- 2 g CARBON BLACK
- 0.4 g CABOSIL
- 10 g IRON OXIDE
Foulant Release Testing of Anti-Fouling Coatings

Comparison of Foulant Release Performance of Bare Steel Against Proprietary Coating and Cr-TiN Coated Samples
Cavitation Testing of Anti-Fouling Coatings

Comparison of Bare AISI 403 Stainless Steel Against Proprietary and Cr-TiN Coated Samples after 10 Hours of Modified ASTM G32 Testing
Reasons for Selecting Coating

- Foulant buildup on blades led to corrosion pits which helped initiate a fatigue crack

- Amorphous nickel top coat provides significant improvement in foulant release ability in comparison to AISI 403 stainless steel

- It is also a corrosion resistant coating which helps prevent pitting corrosion

- Durable coating which is able to withstand operating conditions and washing cycles
Coatings can be used to help prevent foulant buildup on latter-stage turbine blades to maintain efficiency and extend the life of a steam turbine

- Foulant buildup can lead to corrosion pits, a common cause of turbine blade failures because they create initiation sites for fatigue cracks
- Foulant buildup can reduce efficiency

Unfortunately, field data is not yet available on coating performance
Questions