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

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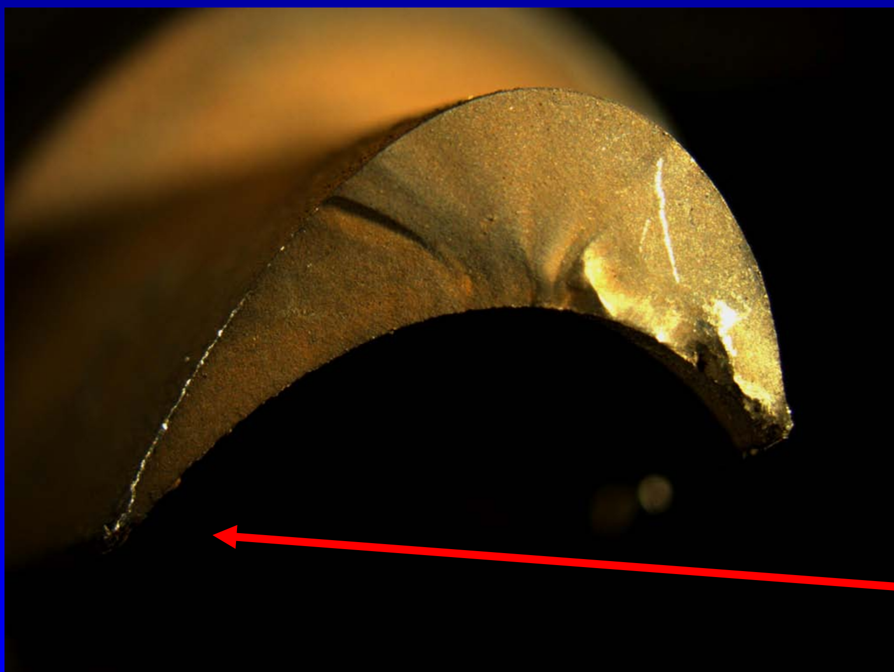
Background

- 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

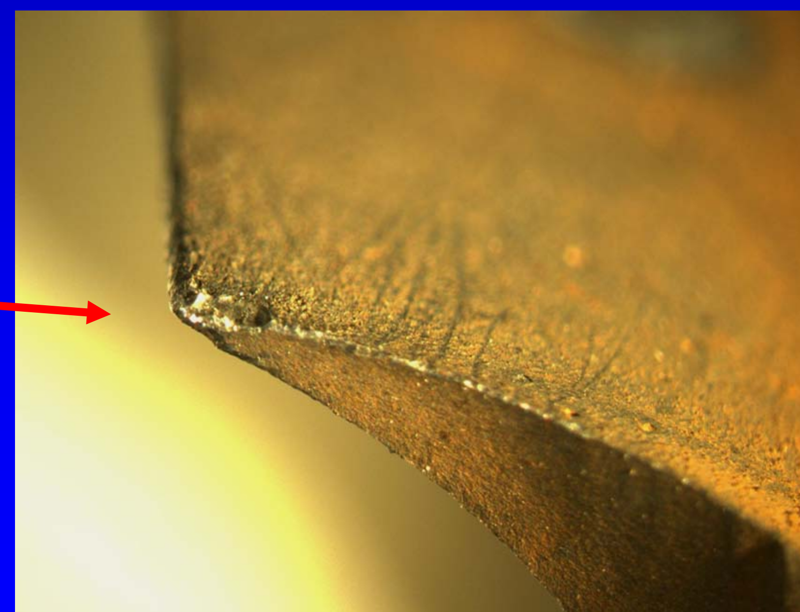
Fractured 2nd Stage Blades

Fractured 2nd Stage Blades

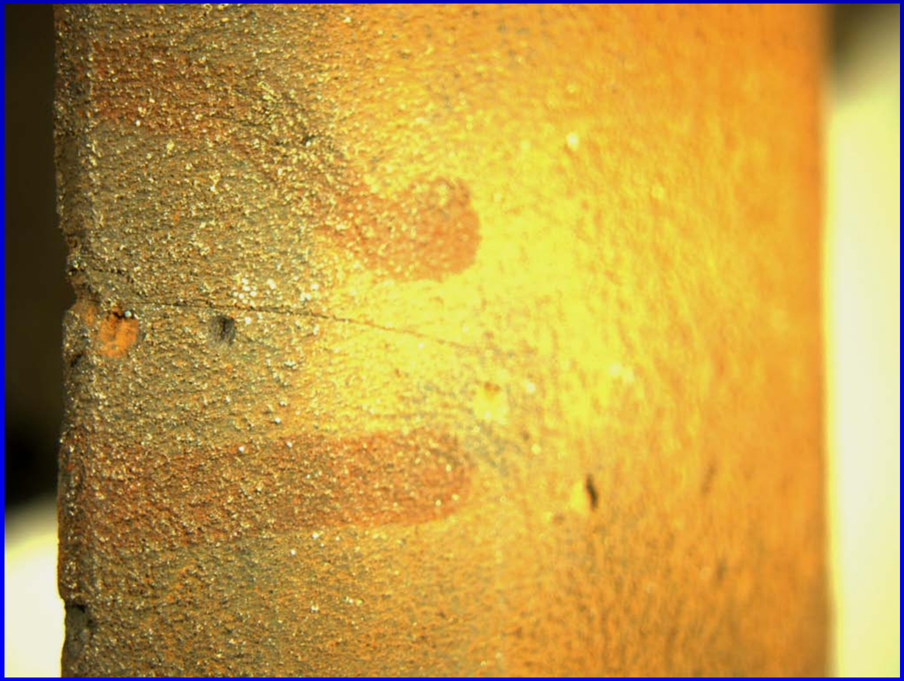
Fatigue Fracture Surface On Blade #93 Airfoil



Initiation Site at Corrosion Pit On Blade #83



Fatigue Cracking Initiating from Corrosion Pit On Blade #86

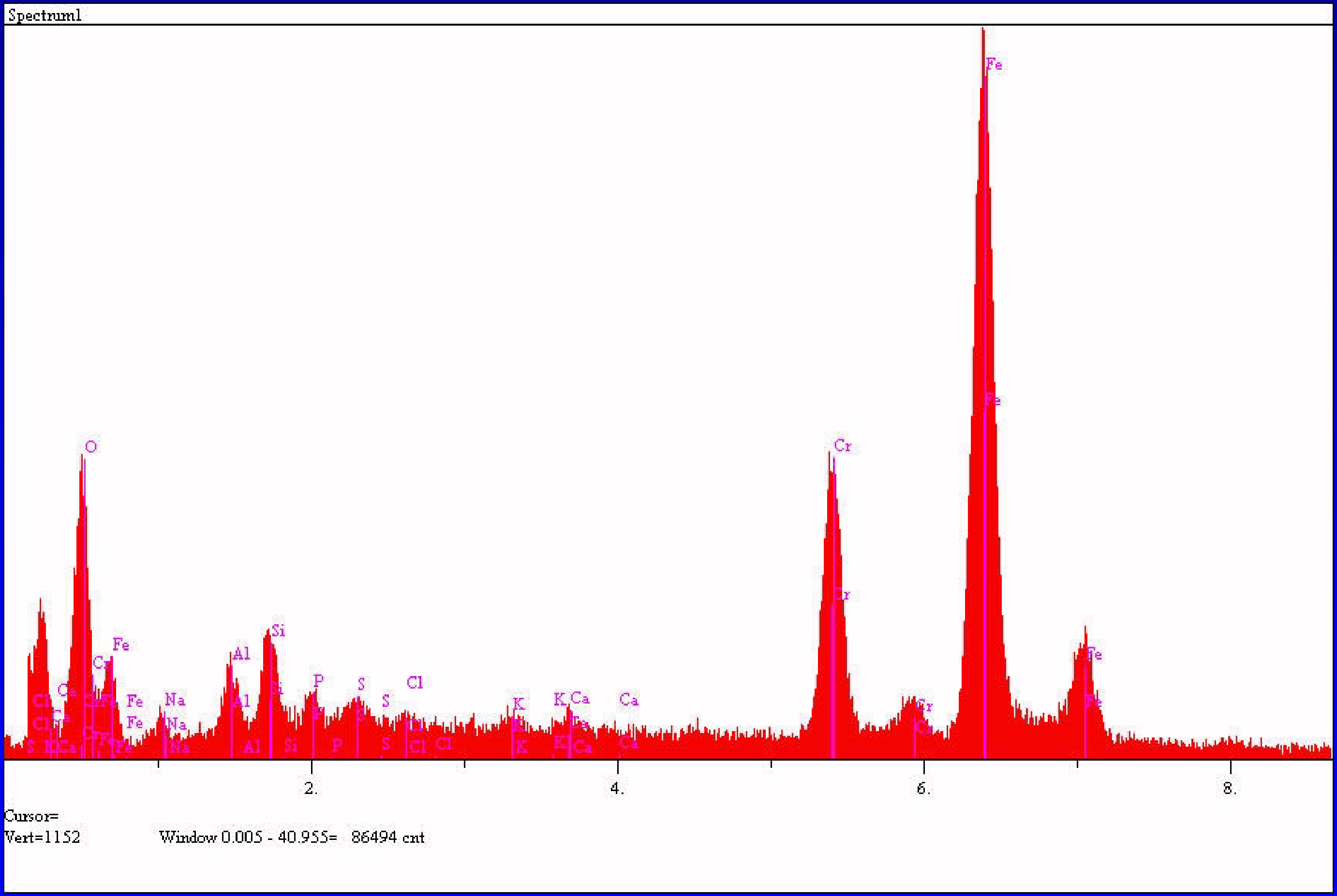


Exposed Fracture Surface On Blade #86

Deposit Buildup on Blade Airfoils

Pitting Corrosion Beneath Deposit

EDS Scan on Corrosion Pit



Fouling

- 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

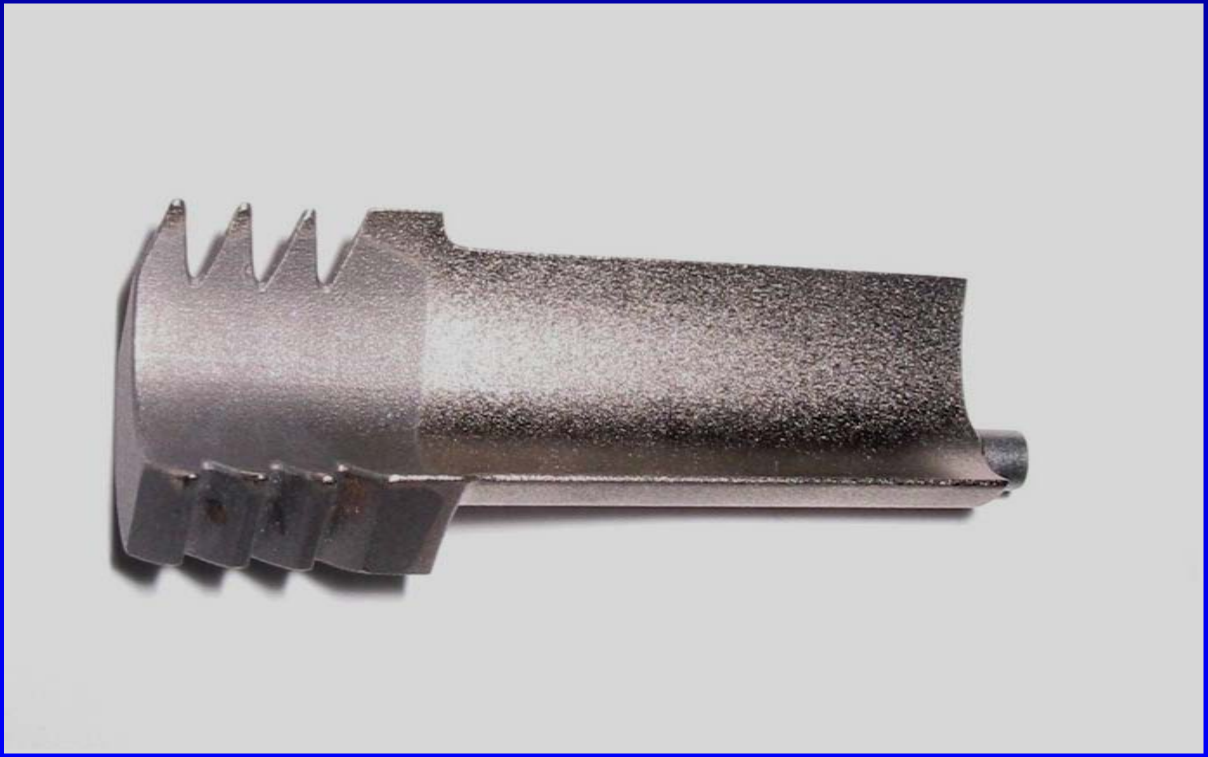
Fouling

- 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

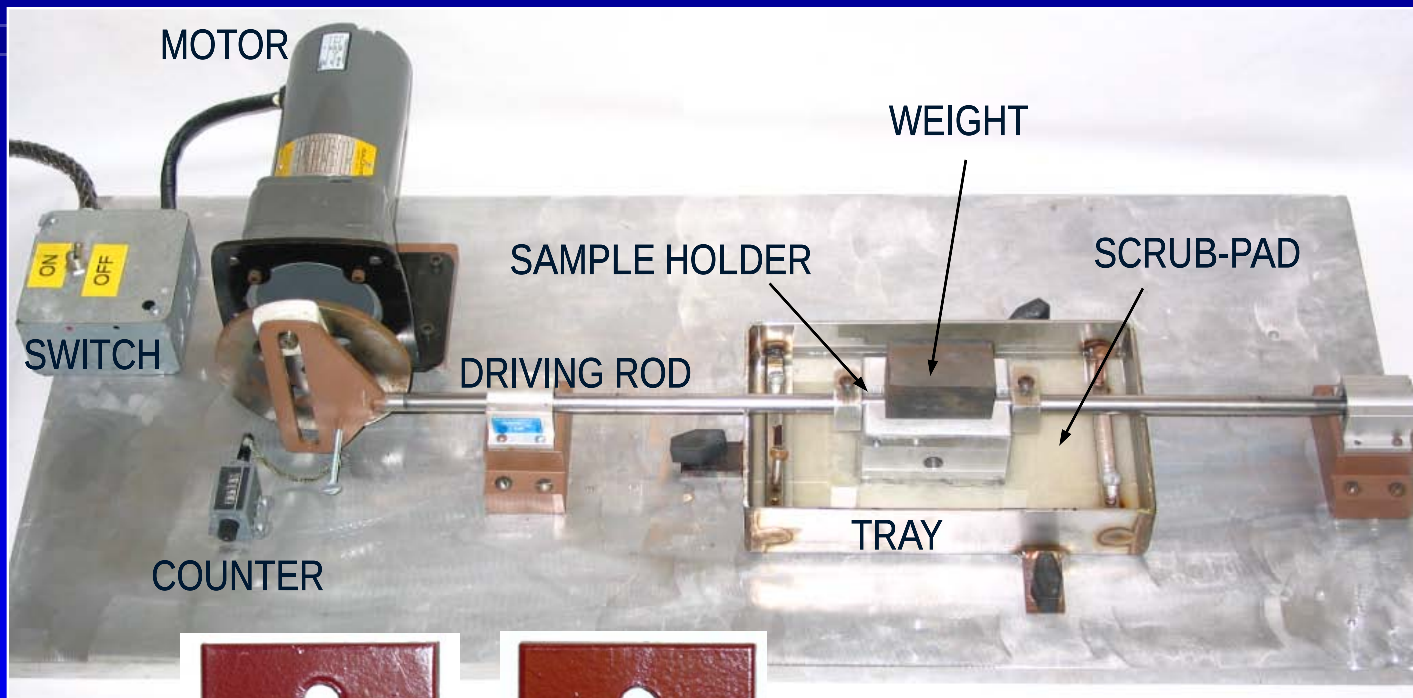
Solution

- 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



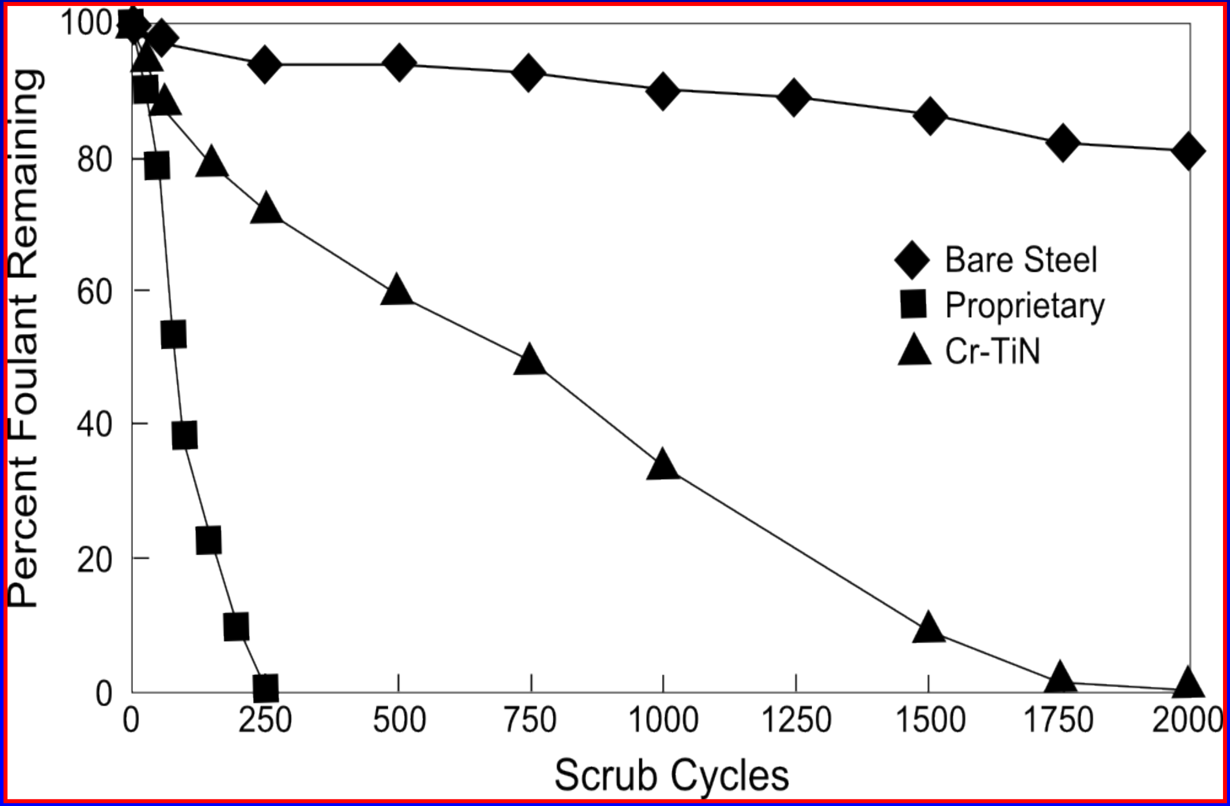
Foulant Release Testing Device



FORMULA

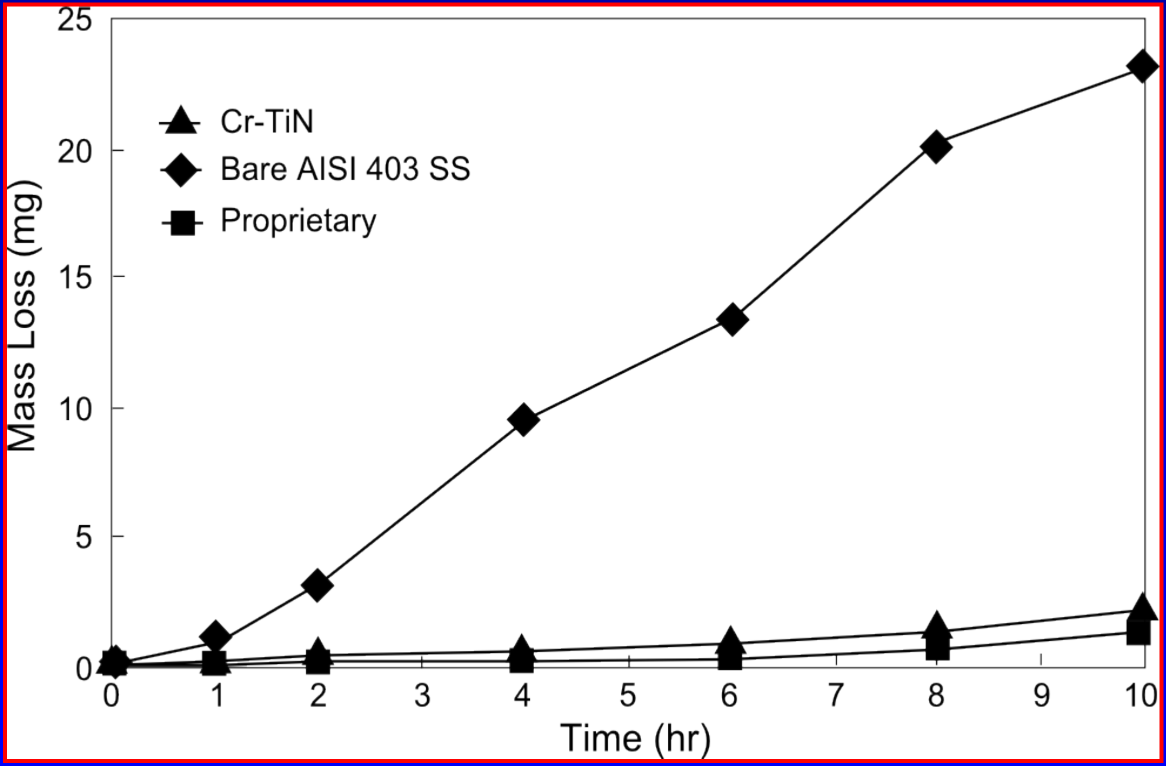
50 ml	CORN OIL
2 g	CARBON BLACK
0.4 g	CABOSIL
10 g	IRON OXIDE

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**

Conclusions

- 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