Remote Visual Inspection of Steam Turbines

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Outline

- Remote Visual Inspection Tooling
- Case Studies
  - Worthington turbines at Sabine River Works (SRW)
  - Elliott turbine at SRW
Remote Visual Inspection Technology

- Used extensively and regularly for a variety of equipment
- Mostly off-the-shelf ‘one size fits all’ tools
- Not commonly made to go to particular places in particular equipment

Typical Video Probe
Custom Tooling for Steam Turbines and Other Large Rotating Equipment

- A family of tools designed to go where off-the-shelf tools cannot
  - To reach 1st stage nozzles in large steam turbines
  - To go further down rows of turbomachinery
  - To cross long unsupported distances
Worthington Steam Turbines at SRW

Turbine cross section: Inspection paths marked in red
Worthington
Inspection Description

- Two identical Worthington units inspected
  - GB201 and GB501

- Inspection took place in the first three days of a five week turnaround
  - Afforded maximum time possible for any maintenance action

- Both critical units fully instrumented:
  - Vibration monitoring
  - Efficiency, steam rate, and torque monitoring
  - Monthly oil analysis
Worthington
Diagnostic Triggers

- Loss of performance on one unit (GB201) due to fouling
  - GB201 typically ran at full capacity
  - Required monthly online water wash to maintain capability
  - Concern about resulting erosion/corrosion

- No mechanical issues (vibration, torque, etc) detected

- Primary goal of inspection was to evaluate status of nozzles, buckets, and coatings
Worthington
Low Pressure Stage

- Access through pressure tap port
- Stiff tooling ‘parked’ at the leading edge of the first stage nozzles
- Flexible video scope extended through the nozzles and the radial guide nozzles to the second stage rotating buckets
Worthington: Low Pressure Stage
Key Find: Eroded Radial Nozzles
Worthington
Low Pressure Stage Eroded Radial Nozzle Stills
Worthington: Low Pressure Stage

Maintenance Action: Immediate Maintenance Required

- Erosion was severe enough to warrant opening casing and replacing exhaust end radial vanes on both turbines
- One spare was in stock
- The other set of vanes was rebuilt and reinstalled
- There was foreign object damage (FOD) on the buckets which required repairs to one of the removed rotors prior to reinstallation
Worthington: **Low Pressure Stage**

**Maintenance Action:** Remove Casing to Replace Nozzles

Pictures above were taken after casing was removed
Worthington: Low Pressure Stage
Maintenance Action: Radial Nozzle Replacement

Radial guide nozzles replaced with in-stock spares
Worthington: High Pressure Stage
Key Find: Coating Evaluation

- An antifoulant coating had been added to the entire steam path
- Inspection revealed it had eroded away on the first stage buckets
- No further damage was seen
Worthington: High Pressure Stage

Maintenance Action: No Immediate Maintenance Action Required

- Blade coating status obtained from inspection
  - Top antifoulant coating was gone
  - Intermediate and base coats meant to prevent erosion/corrosion of base materials was still present
  - Antifoulant coating was gone due to poor steam quality
    - Poor steam quality due to surface condenser leaks and treatment chemicals
Case

Elliott Steam Turbine at SRW

11 stage turbine
Elliott

Inspection Description

- Each stage accessed through stage-specific pressure ports
- Below: Unit with Casing Off in 1999
Elliott

Exhaust End Stages

- Coating has eroded away
- Otherwise buckets are in adequate condition

- Fouling deposits visible
Elliott

*Inlet End Stages*

- Nozzles and Buckets in better condition than on the exhaust stages
- Less evidence of corrosion or deposits
Elliott
Maintenance Action

- **Condition not unexpected given**
  - The unit’s time in service
  - The online water washing that had been done
- **No immediate maintenance action is required**
Turnarounds are a rare opportunity to assess the condition of large rotating machinery.

Tooling specially designed to maximize coverage inside the machinery makes the best use of the turnaround opportunity.

If the inspections are done early in the turnaround, maintenance can be performed if problems are found.

Spare parts and maintenance planning are enhanced even if no problems are found requiring immediate maintenance action.