Best Practices for Fluorescent Penetrant Inspection of Drum Rotors and Deep Well Spools

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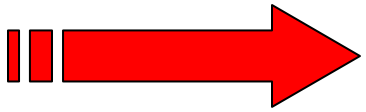
Pratt & Whitney

Best Practices for Fluorescent Penetrant Inspection of Drum Rotors and Deep Well Spools

- Work in Progress
- Many contributors to date



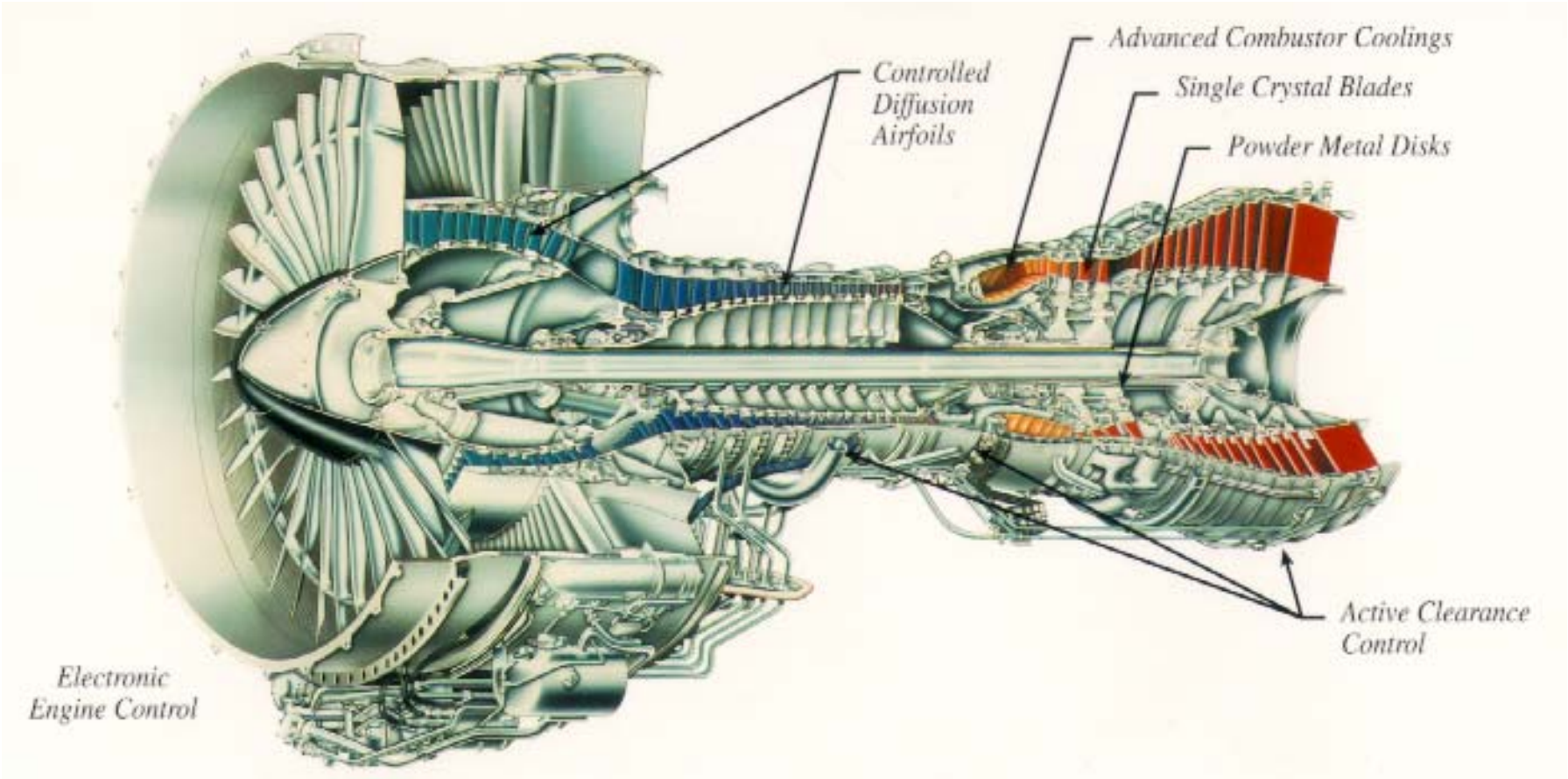
- A. Broz, P. Swindell - FAA
- L. Brasche - ISU
- K. Griffiths RR - UK
- B. Griffiths RR - UK
- T. Dreher RR - US
- T. Kessler - Consult. (GE)
- J. Lively - PW
- W. Rummel - Consult.
- L. Clements – Delta
- B. Stevens - United

Drum Rotor FPI Best Practice

Motivation

- Drum Rotors are:
  - **Critical** Pieces of Rotating Hardware
  - **Typical** in modern compressor design
  - **Challenging** to inspect – especially with FPI- compared to bolted rotors
  - **Unique practices** at engine shops

Drum Rotor FPI Best Practice



Drum Rotor FPI Best Practice

Benefits of Industry Best Practice

- Compliance Straight-forward (compromise solutions not necessary)
- Less variability across the industry
- Improved inspection sensitivity and reliability

Drum Rotor FPI Best Practice

Observations

O/H Shop	Cleaning	FPI Process	FPI Fixturing	Viewing	Viewing Fixture
A	aqueous alkaline cleaner	Ultrahigh Sensitivity; Hydrophilic Emulsifier	Sling	Video System	Yes
B	aqueous alkaline cleaner	Ultrahigh Sensitivity; Hydrophilic Emulsifier	Sling	UV Scope	No - Sling
C	aqueous alkaline cleaner	Ultrahigh Sensitivity; Hydrophilic Emulsifier	Modified Sling	Video System	Yes
D	aqueous alkaline cleaner	Ultrahigh Sensitivity; Hydrophilic Emulsifier	Sling	Mirror and UV source	No -Sling
E	aqueous alkaline cleaner	Ultrahigh Sensitivity; Hydrophilic Emulsifier	Sling during emulsification. Fixture during penetrant application.	Mirror and flex UV light guide	Yes

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Approach

- Augments existing shop processes
  - Consistency across stages
  - Addresses blind areas
- Performance-based vs. Equipment-based
- Assurance of complete viewing

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2 Primary Sections to Best Practice

- FPI Processing

- Viewing System Requirements

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FPI Processing Key Elements

- Ultrahigh Sensitivity Penetrant System
- Processing Chemistry / Times Consistent with Individual Facilities

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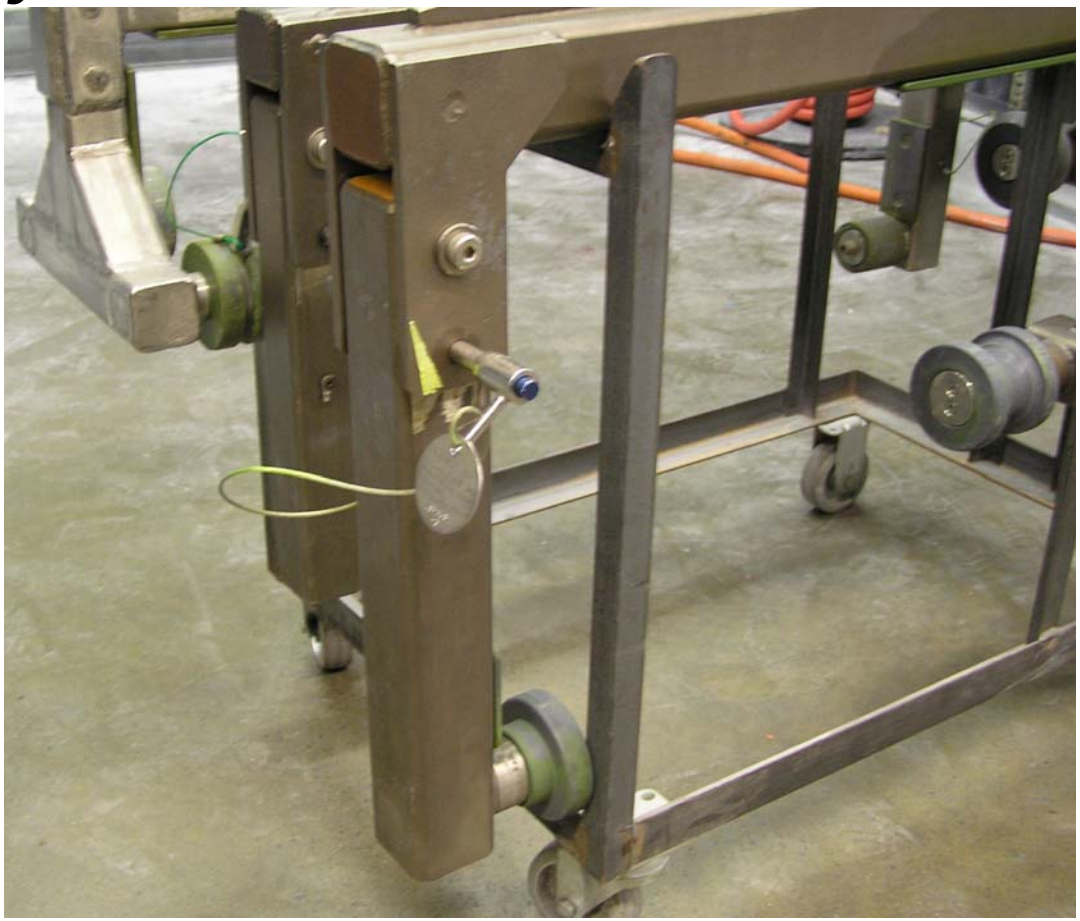
FPI Processing Key Elements

- Fixturing
  - Safe, Smooth Manipulation
  - Addresses areas obscured by fixturing



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FPI Processing Key Elements

- Tighter control on emulsification time
  - 10% on shop specific emulsifier contact time
  - Stop bath recommended
  - Pumping or siphoning

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FPI Processing Key Elements

- Drying
- Developer
  - Manual Wand Required

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FPI Processing Key Elements

- Viewing System Requirements for
  - Resolution – Fluorescing gage
  - UV intensity (max and min) – To be amended in AMS 2647
  - White light contamination limits (AMS 2647)

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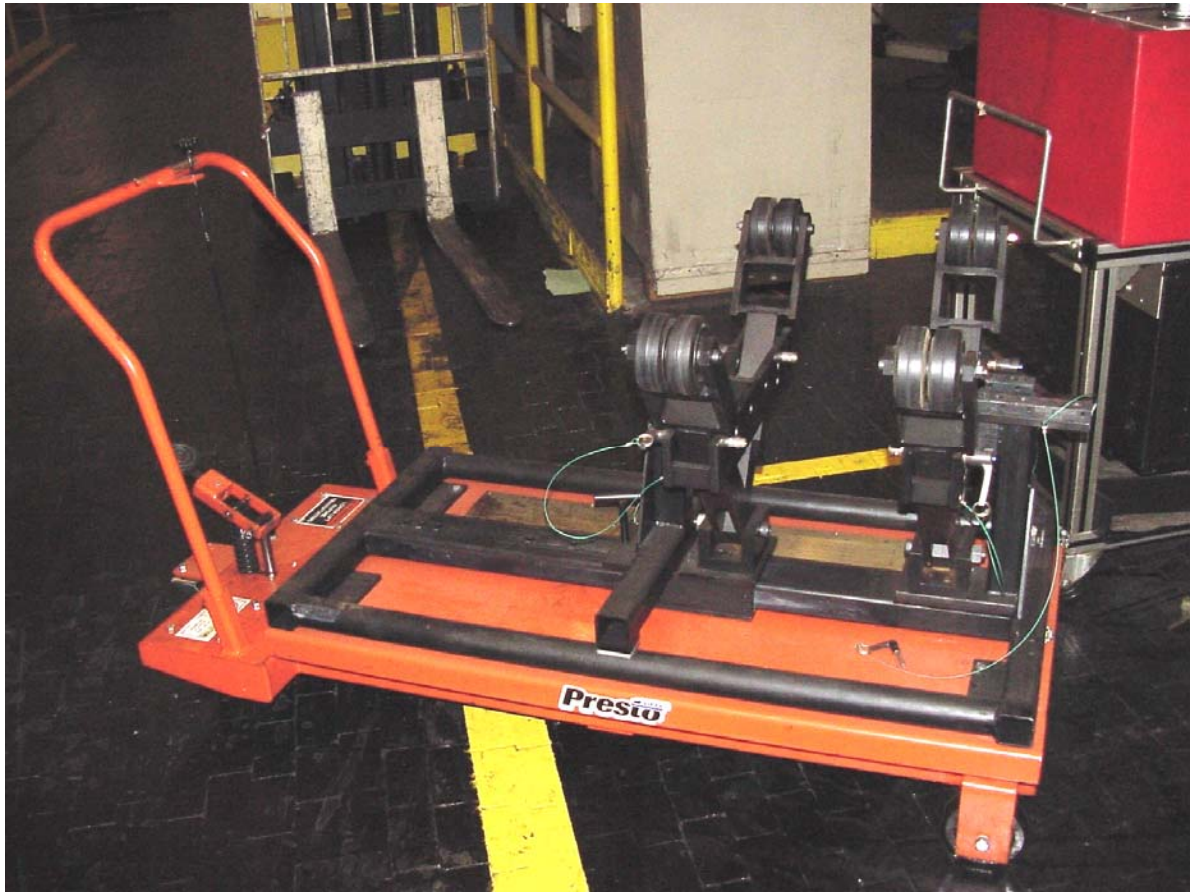
Part Holding Fixture for Viewing



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FPI Processing Key Elements

- User Establishes Key Usage Parameters
  - Stand off distance
  - Field of View
  - Index Size
  - Process to assure full viewing

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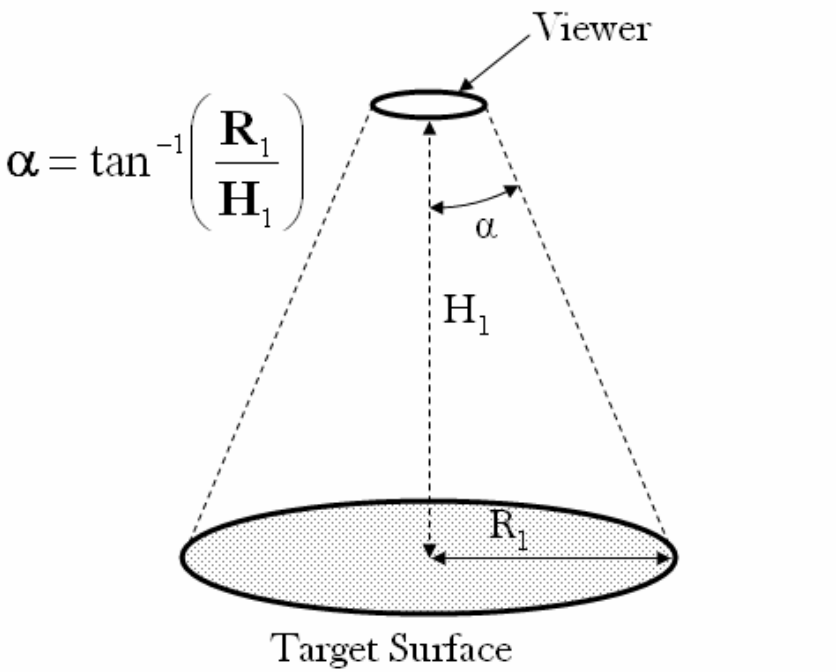
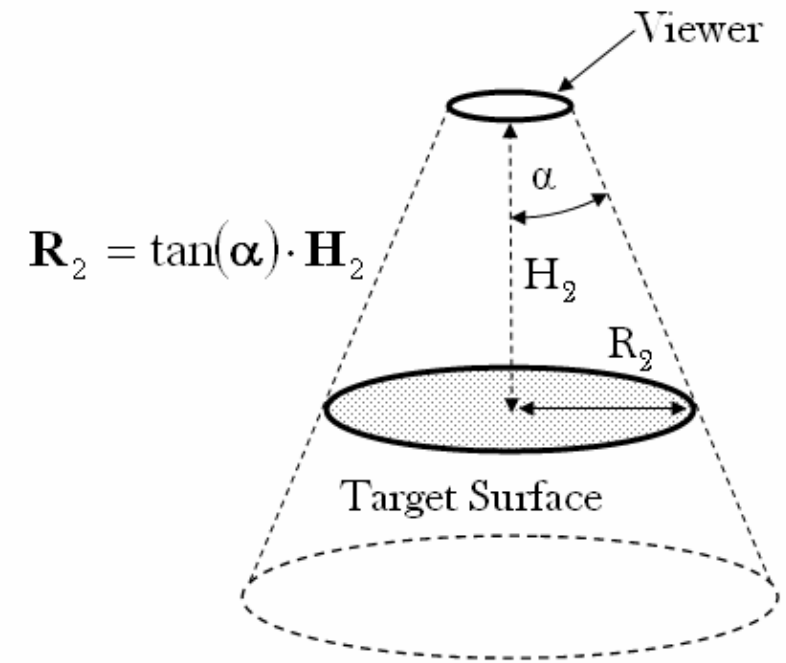
- Field of View Determination





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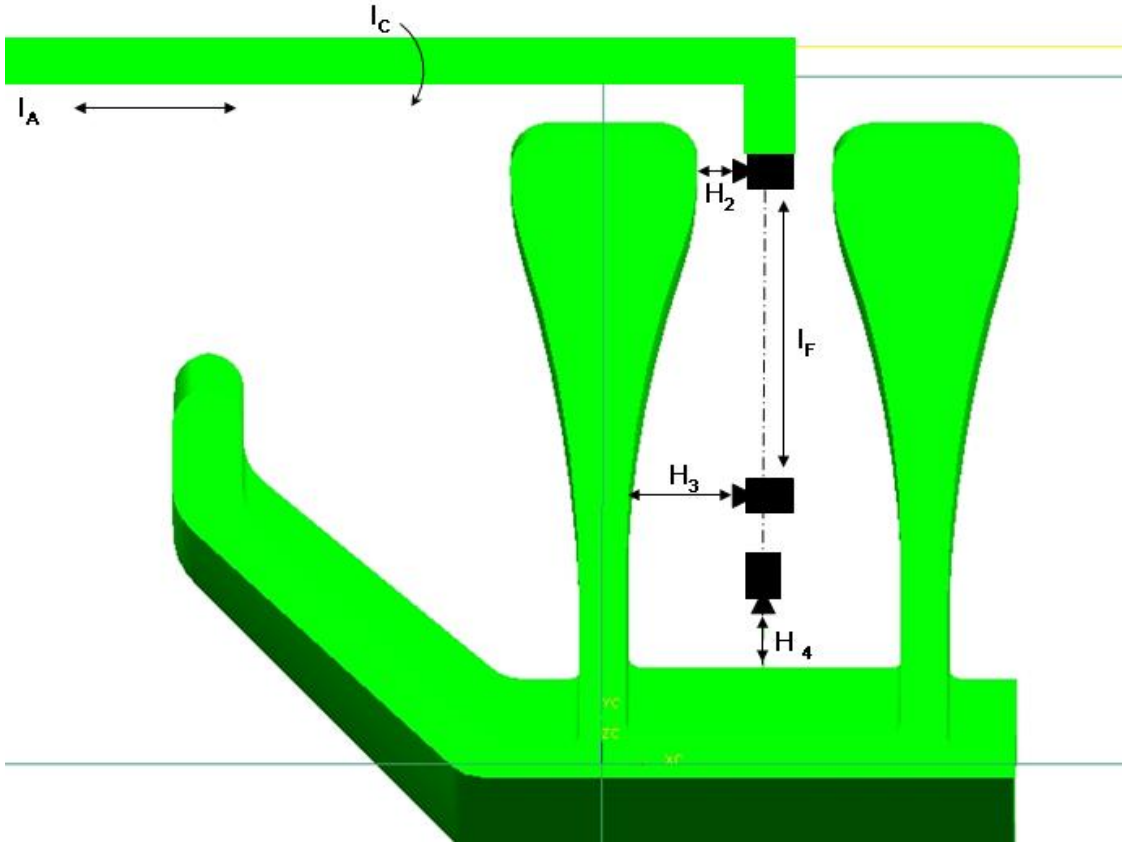
- Standoff Distance



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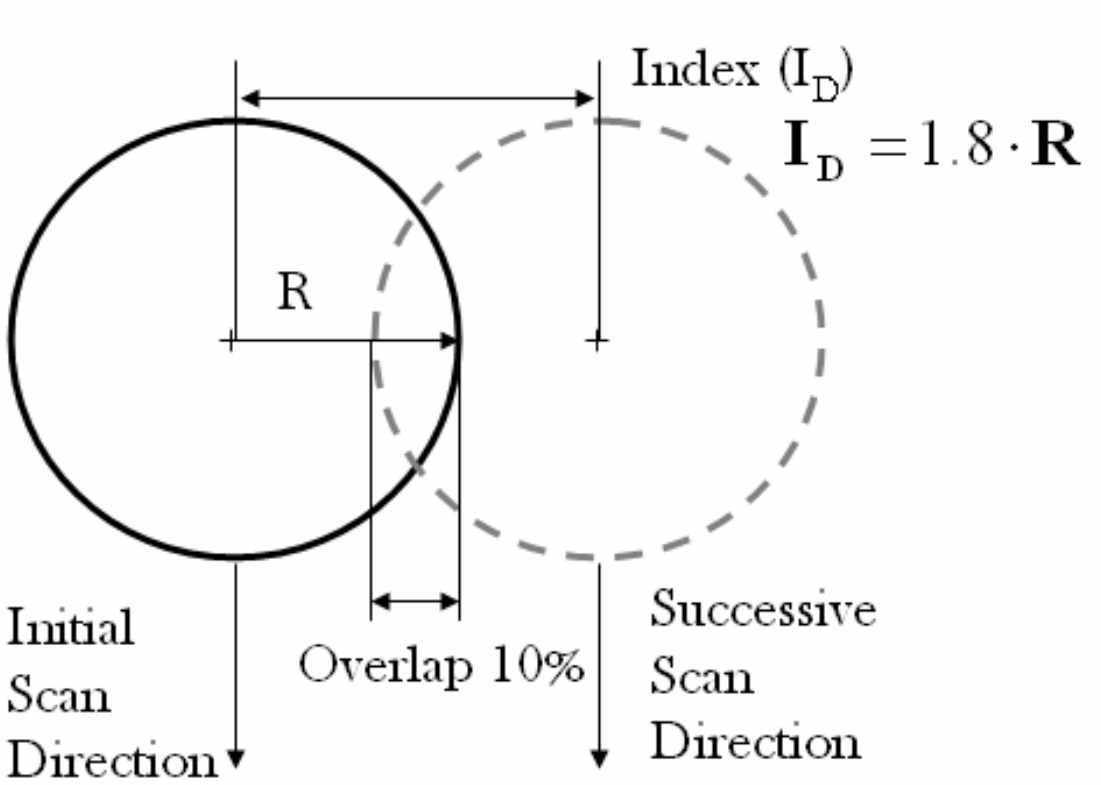
- Index / Overlap



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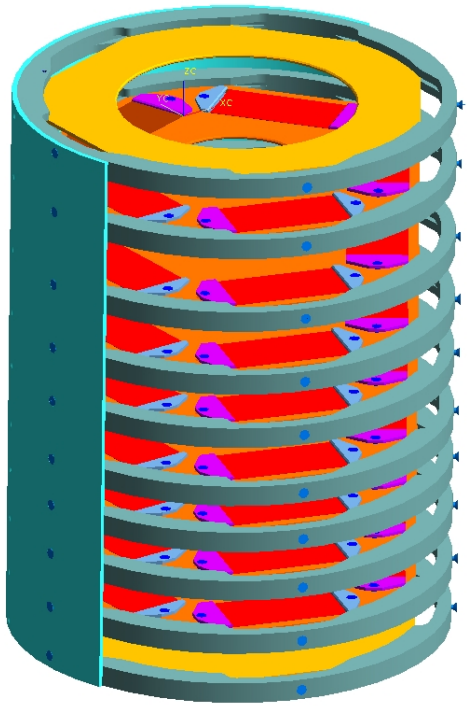
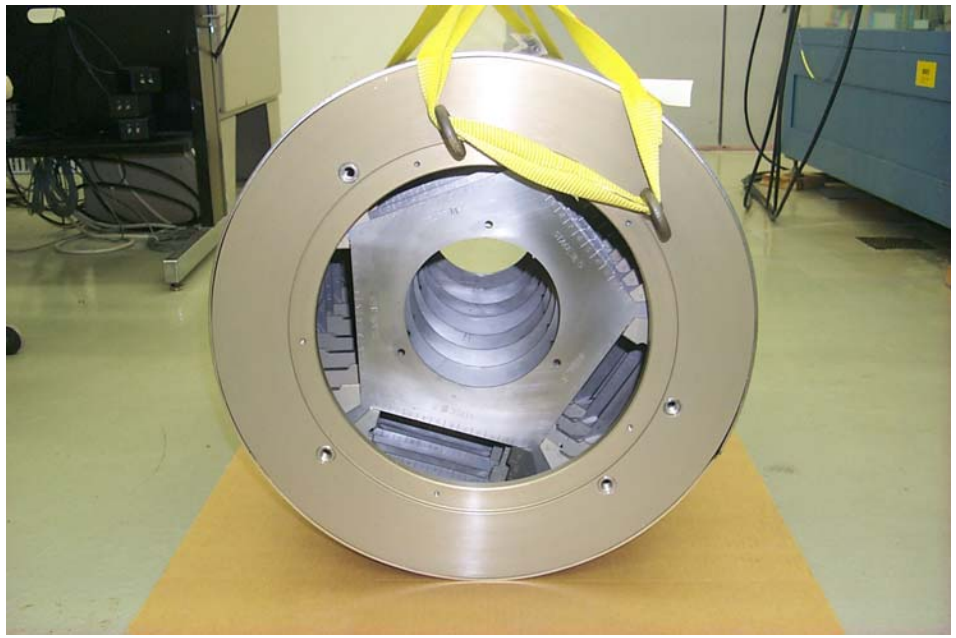
- Drum Rotor FPI Probability of Detection Fixture Design and Fabricated





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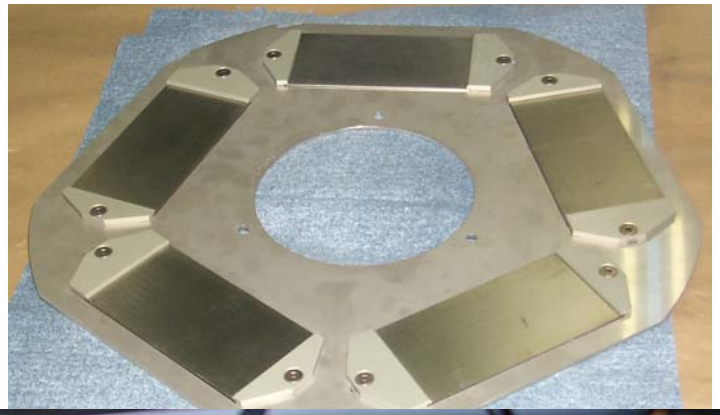

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Data Collection

- Processing performed on production FPI line
- Data collected in lab environment
  - Technicians accustomed to looking for small cracks typically produce 0.04” – 0.05” 90/95 on this set
  - Production facilities typically produce ~0.060” 90/95 on this set
  - Data included in this presentation were generated in lab with technicians
  - Approximately 8 hours required to complete inspection in drum rotor inspection with borescope. Development time controlled to within limits of specification (developer applied with bulb as inspection progressed.)
- Variables Tested With POD Fixture
  - Emulsification Time (1 min when processed as web vs. 5 min when processed as drum)
  - Mirror vs. Viewing System

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Data Collection

- Definitions
  - Drum – panels installed in “webs” and “webs” installed in drum rotor fixture
  - Borescope – UV borescope used inside drum rotor fixture
  - Mirror – UV light guide attached to shop mirror used in drum rotor fixture

Drum Rotor FPI Best Practice

- Results - All values 90% POD / 95% CL
- Results are from laboratory environment in a controlled setting

Processing / Viewing*	***Processing – Webs[1]***	***Processing – Drum[2]***
Viewing as Webs with no visual aids	X	0.050”
Viewing as Drum with Borescope	0.078”	0.091”
Viewing as Drum with Mirror	X	>0.150”

Drum Rotor FPI Best Practice

- Next Steps
  - Address within SAE Committee K
  - Finalize Best Practice
  - Potential for separate document or attachment to AMS 2647

Conclusions

- Fixtures for FPI processing and viewing are a necessity for inspection of drum rotors
  - Control the process parameters and to assure coverage and overlap
- POD estimates were generated in a laboratory environment under controlled conditions and may not be representative of production POD values
  - Inspection of drum rotor took 8 hours using fixtured borescope
- Repeat of the POD study in overhaul environment would be beneficial in supporting fleet management objectives