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FAA Center for Aviation Systems Reliability

CASR FPI – Engineering Studies: Introduction Motivation and Approach

Lisa Brasche, Rick Lopez, David Eisenmann, and Bill Meeker

Center for Nondestructive Evaluation

Iowa State University

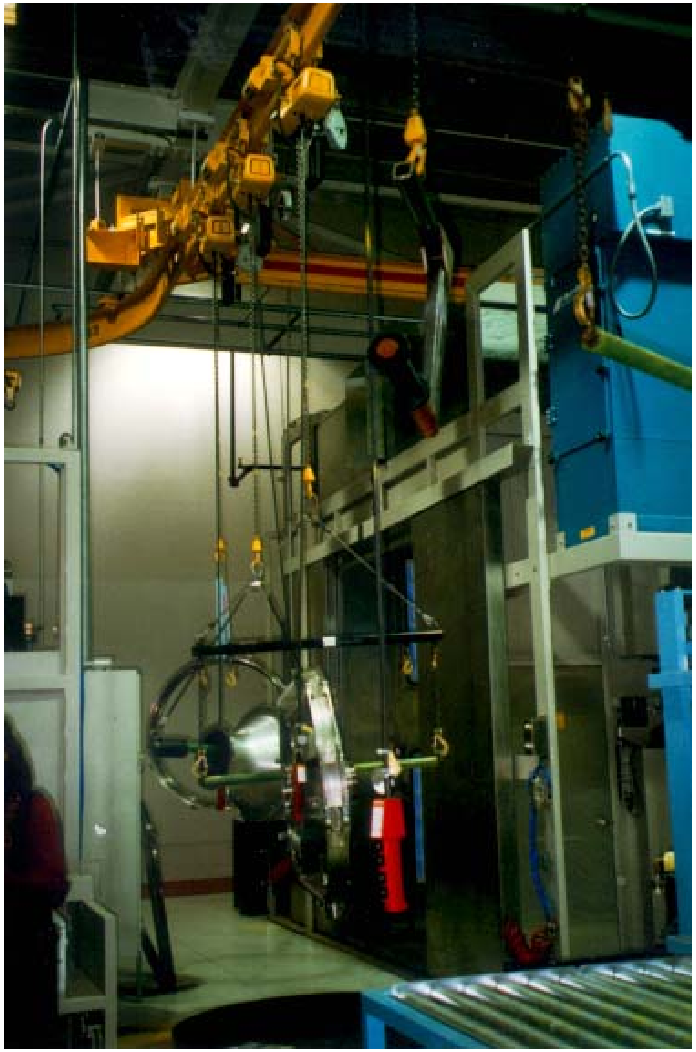
lbrasche@iastate.edu

(515) 294-5227

Funded by the Federal Aviation Administration

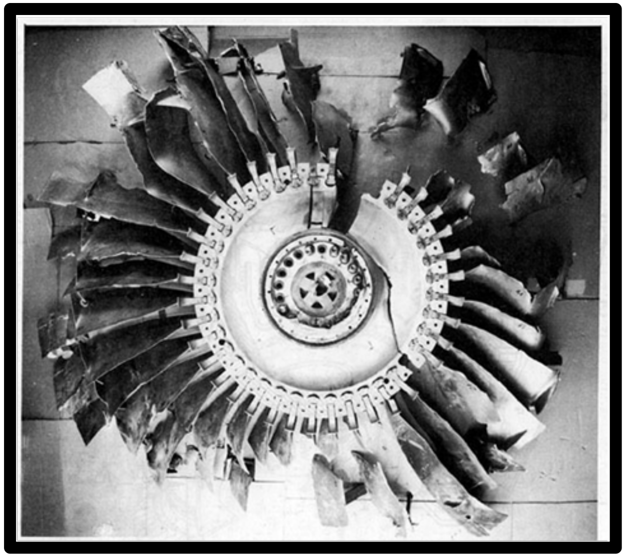
Motivation: Improve Public Safety

- A typical US commercial aircarrier will have over 30,000 parts in their inventory that will require FPI at some time in its life
- Over 90% of metal components will be inspected using FPI at least once during it's lifetime
- Given the importance, FAA supported this research program to improve the reliability of this important tool in the inspection toolbox



Motivation: Failure Prevention

- Failures of the FPI process have contributed to catastrophic events
  - Sioux City
  - Pensacola
- NTSB recommendations have included reference to improved FPI
  - A98 11 through 15 – Recommendations related to improvements to FPI and identification of research needs
- Simplification of the specification process will lead to improved reliability and safety



Motivation: Support the Inspector

Engineering Assessment of FPI

- Provide engineering data to support decisions regarding the safe application and relevant use of FPI
- Includes data to support changes in specifications
- Generate tools for use by airlines and OEMS that improve FPI processes
- Strong industry team with extensive experience

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Program Partners

Cooperative university/industry program which brings together aircraft and engine OEMs, airlines, vendors, as well as technical expertise from the NDE community.

FAA: Al Broz, Paul Swindell, Dave Galella

ISU: Lisa Brasche, Rick Lopez, Dave Eisenmann, Bill Meeker

ISU Students: Dustin Skogerboe, James Wade, Allison Wright, Trevor Laughlin, Jason McReynolds, Austin Brasche, Kimberly Ferguson, Brady Engle

Industrial Advisory Panel

- Boeing - Long Beach: Dwight Wilson, John Petty
- Boeing – Seattle: Steve Younker, Mike Davis
- Delta Airlines – Atlanta: Lee Clements, Scott VanDiver, John Lee
- United Airlines – Indianapolis: Dave Arms, Bob Stevens
- Pratt & Whitney - EH and WPB: Kevin Smith, John Lively, Pete Ozga
- Rolls Royce - Indianapolis and Derby (UK): Pramod Khandelwal, Keith Griffiths, Bill Griffiths, Tom Dreher
- GE Aircraft Engines: Terry Kessler, Thadd Patton, Wayne Kitchen, Phil Keown, Bill Brooks
- Honeywell - Pheonix: Andy Kinney, Waled Hassan
- Sherwin – Cincinnati: Sam Robinson
- Met'lChek: Bill Mooz
- Magnaflux – Chicago: Tammie Simmons, Paul Dunwall, Kevin Walker
- D&W Enterprises – Denver: Ward Rummel

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Technical Approach

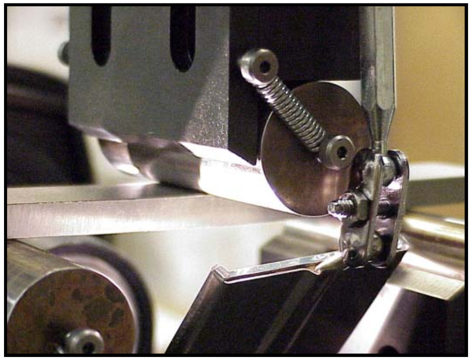
- Define factors for which engineering data is deficient
  - Change in process, e.g., environmental changes
  - Change in applications
  - Data not available in the public domain
- Design engineering study that provides quantitative assessment of performance
  - Brightness measurements
  - Digital recording of UVA indication
  - Probability of Detection
- Complete study using either lab or shop facilities as appropriate
- Distribute results through use of web
- Support changes to industry specifications as warranted
- Utilize results to update/create guidance materials
- Transition process to airlines for internal, self-assessment

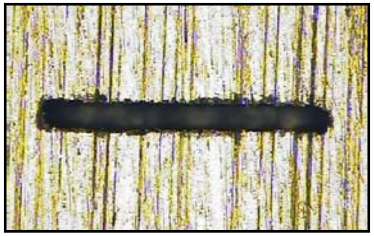
Brightness Measurement

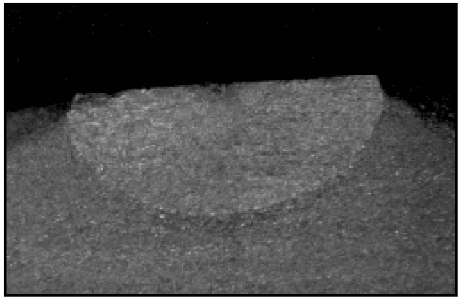
- Used rigid fixturing to assure repeatability with transportability for brightness measurements
- Photo Research PR-880 Photometer used to record indication brightness in ft-Lamberts

Sample Fabrication

- Materials:
  - Titanium 6Al-4V
  - Inconel 718
  - Aluminum 6061-T6511
- EDM notches used as starter defects
- Three point bending at 0.1 R-ratio gave 2.5:1 aspect ratio
- Lengths from 20 to 180 mils, centered at 80 mils

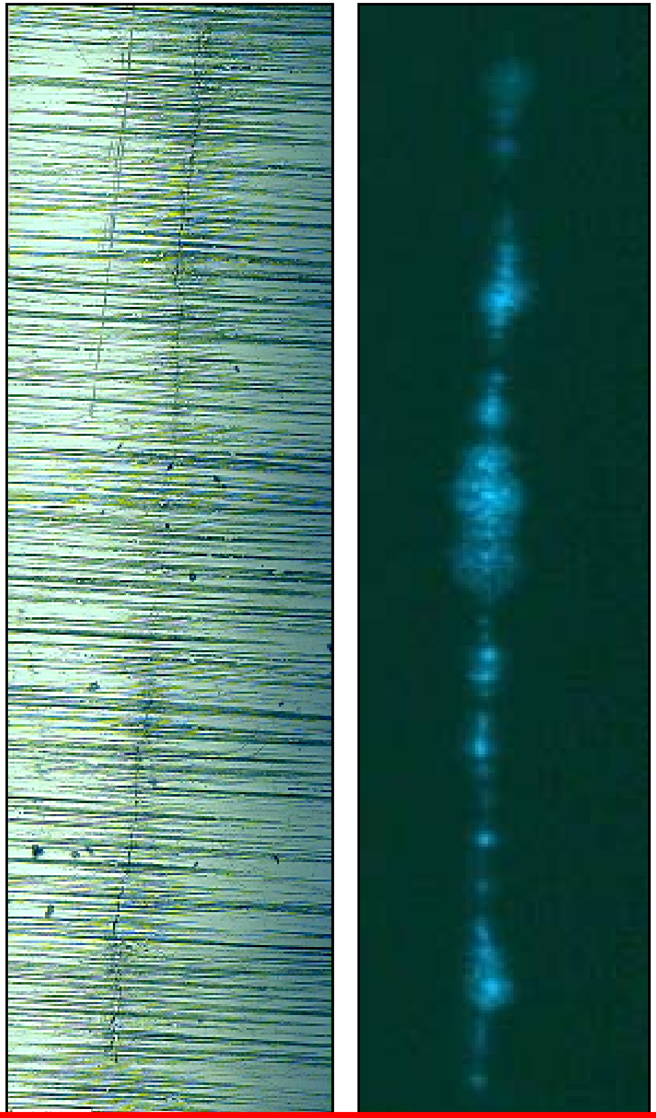






Sample Characterization

- White light micrographs captured for each defect
- Indication luminance measurements
- UV-A micrographs captured to establish baseline response
- Removed those that showed high variability



http://www.cnde.iastate.edu/faa-casr/fpi/index.html

Field Studies

- Requires access to typical drying, cleaning and FPI methods used in commercial aviation
- Several partners have provided access to their facilities
  - Access to cleaning lines for Ti and Ni as well as mechanical blasting facilities
  - FPI line for sample processing
  - Inspection booth for characterization and brightness measurements

Field Studies

- 15 - 20 samples per basket
- 20 minute penetrant dwell
- 90 second pre-wash
- 120 seconds emulsifier contact with vertical motion
- Two 30 second cycles of air agitated water rinse, then a 90 second post-wash
- Samples dried for 8 minutes at 150ºF
- Drag-through application of developer
- 10 minute development time
- Brightness reading using Spotmeter
- Length reading using UVA and image analysis software

Laboratory Studies

1. Apply Penetrant
2. Dwell Time: 20 minutes
   - Level 4
     - Water rinse 90 sec
     - Place in Emulsifier for 2 min, agitate every 15 sec
     - Water rinse 90 sec
   - Level 3
     - Water rinse 90 sec
3. Dry samples at 160F for 8 minutes, cool to touch
4. Dip/drag application of Form A developer
5. Dwell 10 minutes
6. Measure brightness and capture UVA images
7. Rinse and ultrasonically clean for 30 minutes in acetone
8. Oven dry at 160F for 30 minutes





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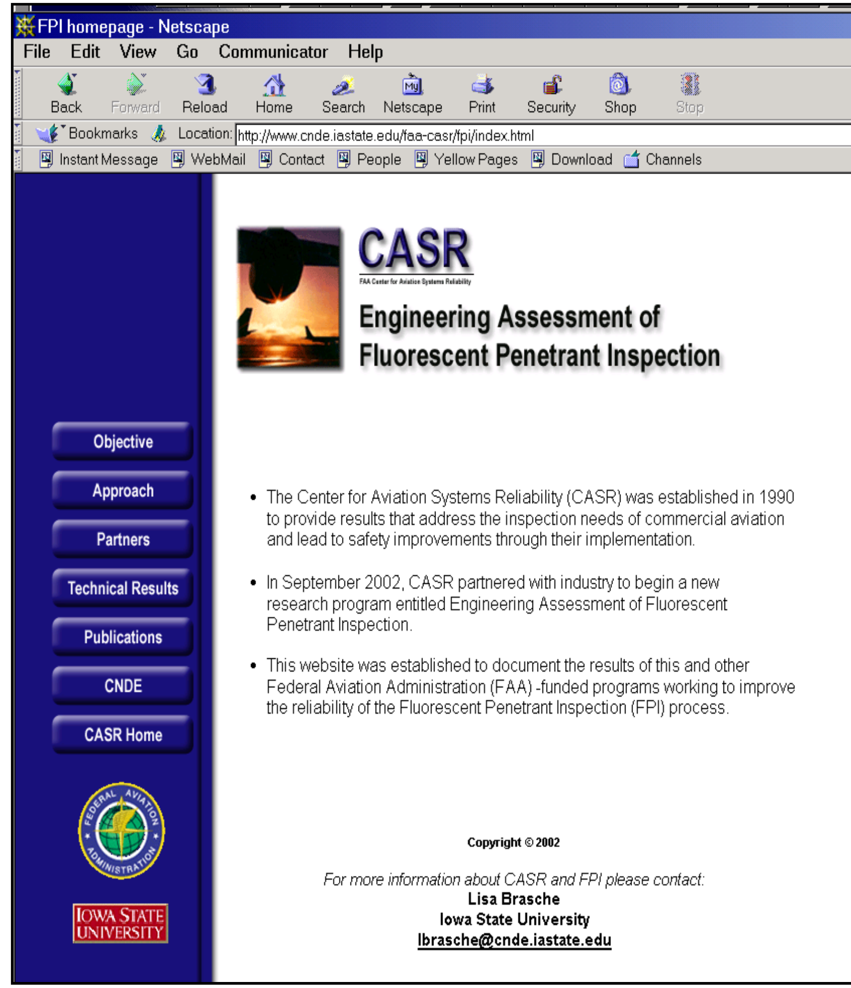
Questions?

- Website provides background info and published technical results
- Links to FAA Reports available



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