Commercial High Bypass Engine Instrumentation

New Product Development

Date: 17/11/2016
Lecture Topics

1. New product development in IAI
2. Turbofan Cross Section
3. Instrumentation process examples
4. Instrumented Load Cell (Thrust Plate)
5. Calibration Process
6. Conclusions
New Products Development at IAI

• IAI Engines Division main focus is in the area of Maintenance Repair and Overhaul (MRO) for commercial and military aero jet engines

• New products development formed to expand the division scope of future business

• A feasibility study to convert a commercial aero jet engine into a gas turbine was one of the key activities in the past years
Turbofan Test Challenges

2. Data Acquisition System (DAQ)
   - Plane
   - Transducers
   - Calibration
   - Interface
Basic Engine Measurements (MRO)

Exhaust gas Temperature measurement
New Additional Instrumentation (~200 lines total)
Cold Section- Fan & LPC (Install and Rout)

Static Pressure

Total Pressure
Cold Section- Fan & LPC (Install and Rout)

Total Pressure

Hypo: AMS 5580 In600 / Kielhead: 7570 (Up to 500F\100 psi)
Hot Section- HPT, LPT & Exhaust (Install and Rout)
Metal Temperature

TC wire Type: N / Termination: Type K male connector (up to 1200°F / 400 psi)

Max wire separation in region of desired junction ~ 0.10”

Bare T/C Wire Elements

Apply 4 to 5 tack welds

Max wire separation in region of desired junction ~ 0.10”

Apply 4 to 5 tack welds
Wall Temperature

TC wire Type: N / Termination: Type K male connector (up to 600°F \ 400 psi)
Thrust Plate

- A very important measurement is the axial load on the main engine bearing (No. 1)
Original No. 1 bearing Assembly
Thrust Plate Addition To The Assembly

- 305-003-304-0 – No.1 brg Support
- E5IA920101 – Plate, Thrust
- 301-537-905-0 – No. 1 Brg Outer Retainer

Not shown:
- 301-537-803-0 – Keywasher
- J205P1100 – Keywasher

FWD
AFT

IAI Engines Division

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Thrust Plate - Design & Fabrication

Design Concept
- Material: 17-4 PH H1025
- 12 pads on each face offset
- 2 Anti rotation tabs at OD
- Pads chamfer at OD to allow wire routing
- Designed for a preload of 8,000 lbf
Thrust Plate - FEA Analysis

Results
- Analysis up to 14,000 lbf load
- Axial deflection of 0.064"
- Peak stress: 65.1 ksi (safety factor 2.22)
- Max stress occurs when bearing is loaded in both directions:
  - Mean stress: 37.2 ksi
  - Alternating stress: 27.9 ksi

Goodman Diagram for Thrust Plate

- Endurance Limit = 67.7 ksi
- Loaded aft and fwd
- Loaded only fwd
- Loaded only aft

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Thrust Plate Calibration

- 2 Calibration Steps with 2 different configurations:
  
  I. Setup using only the spanner nut installed
  
  II. Setup using the T/P, housing, spanner nut and dummy bearing

System Setup Overview
Thrust Plate Calibration Configurations

1. **Thrust sensor only** - removing the spacer ring from housing assy. Records load-strain relationship without influence of bearing stiffness

2. **AFT loading** - Full assy preload to the T/P. Records load-strain relationship due to AFT load

3. **FWD loading** - Full assy preload to the T/P. Records load-strain relationship due to AFT load
Thrust Plate Calibration Results

Bridge 2 Calibration

Bridge Reading (mV/V) vs. Axial Load (lbf)

Bridge 1 Calibration

Bridge Reading (mV/V) vs. Axial Load (lbf) (+ is aft, - is fwd)

Symbols:
- X: Fwd Load, 70 deg F
- A: Aft Load, 70 deg F
- ○: Fwd Load, 160 deg F
- □: Aft Load, 160 deg F
- ▲: Fwd Load, 250 deg F
- ▼: Aft Load, 250 deg F
Conclusion

• First time that a commercial certified turbofan engine is being instrumented in Israel

• Modifying engine parts and engine final assembly with new instrumentation present a challenge

• In addition to the engine instrumentation, a compatible DAQ system was fabricated at IAI

• The Turbofan final test is designed to begin early 2017

• The test will cover all engine’s basic run modes and also explore some off design operating points
Thank you!