Resolution of Premature 777 APU Bearing Failures using VLM Simulation

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**Issue**

- American Airlines was experiencing high replacement on 777 APU bearings and needed to find resolution
- In March ‘07, the FAA mandated AA to “cold-start” the APU quarterly, each aircraft, during flight
- AA was averaging 3-4 APU removals per year
  - High replacement cost
  - Aircraft out-of-service cost
  - Typical Odor In Cabin event
- AA engineering internal study – possible causes were bearing material, bearing design, lubricant, or operating protocol
- This presentation addresses state-of-art simulation analysis conducted by VEXTEC on the APU issue
Virtual Life Management Technology: Computational Product Life Sensitivity Forecasting

- VEXTEC is an information processing company
- VLM predicts part life probabilistically, taking into account varying conditions of material processing, design, and in-service load conditions
- Virtual TwinTM Simulator software is used to determine cause of in-service performance issues and evaluating corrective action alternatives
- AA is an early pioneer in using VLM for airline needs
AA had no OEM part engineering/design analysis

AA could provide:

- Broken parts
- A good part (as comparison)
- Operating history
- General operating conditions (temperature, pressure)
VT Simulator Set-up: 60 day Reverse Engineering Design & Material Processing

- CADD from Broken Parts
- Acquired Material Statistics
- Stress Estimate from ANSYS
- Evaluated Failure Mechanism
VT Simulator Checkout

- VT Simulated AA fleet of 47 aircraft w/ 2 bearings each
- Initial simulation setup found to be in the general “ball-park”
- AA provided VEXTEC with 3 years field data to refine Simulator output
VT Simulation of 777 APU Fleet
**Normal vs. Cold Start Sensitivity Study**

*47 APU's, 94 bearings, Type II lubrication, failure is crack size of 0.032”*

Cold-start simulated as micro-seconds without lubrication. Cold Starts found to be root cause of pre-mature APU bearing failures.
VT Load and Design Sensitivity Study

47 APU's, 94 bearings, Type II lubrication, failure is crack size of 0.032”

VT simulations did not identify any issues relative to the overall bearing design and/or manufacturing.
Simulated Lubrication Sensitivity Study

47 APU’s, 94 bearings, Type II lubrication, failure is crack size of 0.032”

VT Simulation results provided AA with a quantified business case for changing type of lubrication being used.
AA consolidated VEXTEC VT Simulation metrics with own internal work

FAA reviewed AA documentation and approved requested changes to Cold Start protocol

AA Engineering converted 777 fleet to Type 1 lubricant Aug ‘11

Since lubricant change – no APU bearing failures have occurred ($3-4 million annual savings)

Vextec analysis also showed bearing redesign changes would not “FIX” problem and could increase failures

VEXTEC VT Simulations helped identify and quantify sensitivity impacts in a matter of a few months

AA planning more extensive use of VLM technology for other evaluations