Development and Certification of Composite Rotor Blades

Presentation for FAA Composite Modifications Workshop
July 19-20, 2016

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Company Description

• Located in Tempe, Arizona
• Founded in 2001, now more than 25 employees
• Business Model
  • Design, test, certificate, and manufacture composite main and tail rotor blades
  • Focus on legacy helicopters (developed 1960s-1970s) that still use metal rotor blades
  • VHA composite blades offer improved performance and increased service life versus metal OEM blades
Models Supported (Current/Future)

Bell 206B/L  
Bell 505  
Bell UH-1  
MD 500 Series  
Bell 412/212
Rotor Blade Design Approach

• Use 2X Estimated Ultimate Load

• Avoid secondary bonds
  • Root end metallic components are fastened
  • Exception: bushings are pressed

• Co-cure Composite Assembly
  • Uses structural foam as layup mandrel (Fly away tooling)
  • Upper surface layup mold
  • Shell concept with no internal structure (NDI not required!)
  • Tolerate lower surface imperfections
Rotor Blade Design Approach

- Root Doublers Stacked Internally
  - Avoids any highly loaded ply drop-offs
- Sacrifice Design Elegance for Manufacturability
  - Simple airfoil/twist contours
  - Surface preparations to reduce sanding/paint prep
- Not Focused on Weight Savings
  - Direct replacement blades need to be approximately same weight as OEM
  - More plies of carbon than needed for minimum strength
UH-1 Tail Rotor Blade

Legend
Dark Blue = Carbon/Epoxy Prepreg
Light Blue = Structural Foam Core
Green = Fiberglass/Epoxy Machined From Pre-cured Sheet
Other = Metallic
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Dark Blue = Carbon/Epoxy Prepreg
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206 Tail Rotor Blade Manufacturing
Bell 412/212 Tail Rotor Blade

Legend
Dark Blue = Carbon/Epoxy Prepreg
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Green = Fiberglass/Epoxy Machined From Pre-cured Sheet
Other = Metallic
Bell 206B Main Rotor Blade

Legend
Dark Blue = Carbon/Epoxy Prepreg
Light Blue = Structural Foam Core
Green = Fiberglass/Epoxy Machined From Pre-cured Sheet
Other = Metallic
206B Main Rotor Blade Tooling
206B Main Blade Sub-Assembly
206B Main Blade Root Bonding
Test Methodologies

• DOT/FAA/AR-10/6 Report Used as Basis for Structuring Lab Test Program

• Coupon Testing
  • Actual layups used
  • Establish Weibull shape factors

• Flight Testing
  • Flight strain survey to measure flight loads to be used in structural tests and analyses
206B Main Blade Flight Strain Survey
Test Methodologies

• Service Life/Fatigue Testing
  • Spectrum loading used
  • Analyses used to determine failure modes for three environmental factors:
    • RTD – Room Temperature Dry (ambient)
    • CTD – Cold Temperature Dry
    • ETW – Elevated Temperature Wet
  • Loads obtained from flight strain survey
  • Maintain fidelity between flight test loads and fatigue test loads
  • Include affected components
206B/L Tail Rotor Blade Fatigue Test
206B Main Rotor Blade Fatigue Test
206B Affected Component Fatigue Tests

Main Rotor Grip

Main Rotor Yoke
206B Affected Component Fatigue Tests

Main Rotor Pitch Horn

Main Rotor Control System
Future Development Work

• What is the actual rate and level of long term moisture absorption for composite rotor blades utilizing several layers of protection (primers and topcoats)?

• What is the rate of cooling through the cross section of main and tail rotor blades from stopped to operating rpm?

• Fretting protection for composite and metallic mechanically fastened components
Future Development Work

• Embedded real time rotor blade load measurements

• Thermoplastic vs thermoset rotor blade construction
Thank you for your attention!

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