Helicopter Dynamic Components Project

Presented at:
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January 2006
Report Documentation Page

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Technical Objectives

- Conduct demonstration/validation program that will result in qualification of HVOF-thermal spray coatings as replacements for hard chrome plating for manufacturing and repair of helicopter dynamic components on military aircraft, including rotor head, transmission and gearbox components;

- Through materials testing and component evaluations, demonstrate improved performance and reduced life-cycle costs for HVOF coatings as compared to hard chrome
Project Plan

- Demonstration site: Naval Air Depot Cherry Point
  - HCAT acquired and installed HVOF system in Cherry Point in 1998
  - Contracts awarded to Sikorsky (H60); Boeing (H46/H47) and Bell (UH-1/AH-1) in 2003
    - Conducted analysis of helicopter dynamic components onto which hard chrome is applied by OEM or in repair
    - Identified materials and rig tests that would be required to qualify HVOF coatings as replacement for chrome on their components
    - Submitted reports on results of analysis and designation of required tests
    - Participated in stakeholders meeting to complete Joint Test Protocol and discuss potential component rig tests
**Project Activities**

- **Component tests for qualification of HVOF**
  - Flight test on H-46 generator gears
  - Rig test to be performed on UH-1 transmission rotor brake disc adapter
  - Rig test to be performed on UH-1 tail rotor control rod
  - NADEP Cherry Point discussing possible rig testing at Pax River on sun gear and pinion gear from H-46

- **Execution of Cost/Benefit ECAM analysis by CTC at NADEP Cherry Point for implementation of HVOF**

- **Development of standards and specifications for depositing HVOF coatings on dynamic components**
Materials Joint Test Protocol

- At stakeholders meeting and through subsequent discussions, developed Materials Joint Test Protocol

- Base materials to be evaluated:
  - 4340 steel (200-220 ksi)
  - PH13-8Mo stainless steel
  - 9310 carburized steel
  - Aluminum 7075-T73 alloy

- Coatings to be evaluated:
  - WC/17Co and WC/10Co4Cr
  - Tribaloy 400
  - WC/17Co plus T-400 bond layer for Al alloy only

- Materials testing to be performed includes axial fatigue, G85 SO₂ salt fog corrosion and crevice corrosion, F519 environmental embrittlement, and fluid compatibility testing
**Fretting Fatigue Test**

- Working with Sikorsky, identified fretting fatigue test developed at United Technologies as critical for qualification of HVOF coatings on dynamic components; this type of test has not been performed in any of the other HVOF projects.

- Coated fretting fatigue specimen is tested in axial loading while the fret pins bear against the center of the gage surface with a constant load and slip against the fretting specimen surface at an amplitude controlled by the fret actuator.
Fretting Fatigue Test

- Fretting fatigue specimen fabricated from round bar with rectangular cross section; shot peened and grit blasted prior to coating
- Hard chrome or HVOF coatings applied along entire gage length
- Hard chrome coatings to be ground to specified surface finish; HVOF to be ground or superfinished
Fretting Fatigue Test

Fretting fatigue test matrix established as follows:

<table>
<thead>
<tr>
<th>Coating</th>
<th>Thickness (mil)</th>
<th>Surface finish (µ”)</th>
<th># of specimens PH13-8Mo</th>
<th># of specimens 9310 carb</th>
<th># of specimens 7075 Al</th>
<th># of specimens 4340</th>
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<td>EHC</td>
<td>10-12</td>
<td>4-6 ground</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>WC-Co</td>
<td>10-12</td>
<td>4-6 ground</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>WC-CoCr</td>
<td>10-12</td>
<td>4-6 ground</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>T400</td>
<td>10-12</td>
<td>4-6 ground</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>T-400 + WC-Co</td>
<td>7-9/3-4</td>
<td>4-6 ground</td>
<td></td>
<td></td>
<td>3*</td>
<td></td>
</tr>
<tr>
<td>EHC</td>
<td>10-12</td>
<td>1-2 super</td>
<td>3</td>
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</tr>
<tr>
<td>WC-Co</td>
<td>10-12</td>
<td>1-2 super</td>
<td>3</td>
<td>3</td>
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<td>WC-CoCr</td>
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<td>1-2 super</td>
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<td><strong>24</strong></td>
<td><strong>30</strong></td>
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<tr>
<td><strong>Grand total</strong></td>
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<td></td>
<td><strong>102</strong></td>
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Component Testing

- Contract issued for Bell Helicopter to perform UH-1 tail rotor control rod component test
  - Test setup to duplicate current aircraft installation, i.e., seal and guide bearing identical as on UH-1
  - Test to be conducted for 50,000 cycles at full stroke (10 full pedal strokes per hour for 5000 flight hours), followed by component inspection
  - Then test parts to be reassembled and run additional 5000 cycles with a light coat of gearbox lubricant and Arizona road dust applied to test surfaces; component inspected at end of test
  - Two tests to be performed: one with standard hard chrome plate on component and one with HVOF WC/Co on component; performance comparison will be made
Component Testing

- Contract issued to Bell Helicopter to perform 100-hour bench test on UH-1 transmission rotor brake disc adapter flange
- HVOF WC/Co-coated flange will be installed in a transmission during testing so that mating seal will be run in the same lubrication environment as during normal operation
Component Testing

- Two H-46 generator gears coated with WC/Co for 900-hour lead-the-fleet flight test
- Flight clearance was obtained from NAVAIR
- Gears have been in production shop at Cherry Point awaiting installation for over two years
- Once installed, gears will be inspected every 100 flight hours
Technology Transfer

- Dynamic component change approved for damper assembly on CH-53 (NAVAIR executing change in cooperation with Sikorsky)
- HVOF WC/Co to be applied to piston and lands on cylinder housing
  - Miniature plasma spray gun to be used to apply Triballoy 400 to ID of cylinder and positioner housing (approximately 3-inch ID)
- Drawings have been changed to reflect application of new HVOF coatings; repair work to be performed in-house at Cherry Point using production HVOF systems
- Cherry Point discussing acquisition of miniature plasma spray gun with vendors