Helicopter Dynamic Components
Project

Presented at:
HCAT Meeting
January 2006
**Report Documentation Page**

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*Standard Form 298 (Rev. 8-98)*
*Prescribed by ANSI Std Z39-18*
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

Figure 9. Test Specimen for Fret Tests
## Fretting Fatigue Test

Fretting fatigue test matrix established as follows:

### Fretting fatigue test matrix.

<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>4-6 ground</td>
<td>3</td>
<td>3</td>
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<tr>
<td>WC-Co</td>
<td>10-12</td>
<td>4-6 ground</td>
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<td>3</td>
<td>3</td>
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<tr>
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<td>4-6 ground</td>
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<td>3</td>
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<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>3*</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>EHC</td>
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<td>1-2 super</td>
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<tr>
<td>WC-Co</td>
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**Total** 24 24 30 24  
**Grand total** 102
### 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.
• 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