Electrodeposition of Nanocrystalline Cobalt-Alloy Coatings as a Hard Chrome Alternative

Technical Objectives

- Demonstrate/Validate nCo-P electroplating as an alternative to both LOS and NLOS applications for depot level maintenance.
- Fully define deposition condition envelope.
- Acquire remaining performance data (e.g., fatigue, HE).
- Resolve production issues (e.g., masking, process control).
- Validate performance.
- Develop industrial plating procedures and specifications.
- Perform field testing (initially on non critical components/GSE).
- Initiate DoD and GMS approval process.

Benefits of nCo-P vs. Hard Chrome

- Reduced power consumption (50% reduction).
- Increased throughput (8x increase in plating rate).
- No constituents on EPA or AFMC list of hazardous materials.

Environmental Benefits of nCo-P as a Hard Chrome Alternative

- Eliminates hexavalent chrome plating and all its hazardous waste.
- Eliminates worker exposure to Cr+6.
- Primary cost savings from reduced engineering controls and all required maintenance monitoring.
- Some savings from reduced power use (more efficient process).

Table: Performance Benefits of nCo-P vs. Hard Chrome

<table>
<thead>
<tr>
<th></th>
<th>nCo-P</th>
<th>Hard Chrome</th>
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</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>85-86%</td>
<td>15-35%</td>
</tr>
<tr>
<td>Deposition Rate</td>
<td>0.005-0.009 in/h</td>
<td>0.0005-0.001 in/h</td>
</tr>
<tr>
<td>Emission Analysis</td>
<td>Below OSHA limits</td>
<td>Cr+6</td>
</tr>
<tr>
<td>Hardness</td>
<td>530-600 VHN</td>
<td>Mn 100-150 VHN</td>
</tr>
<tr>
<td>Ductility</td>
<td>2.7%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Adhesive Wear (Pin-on-disk)</td>
<td>6.7 x 10^-6 mm3/Nm</td>
<td>9.11 x 10^-6 mm3/Nm</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Salt Spray ASTM B117</td>
<td>Protection Rating 8  (1000 h)</td>
</tr>
</tbody>
</table>

Technology Demonstration site at NAVAIR JAX

Process Validation

- Coupons trials (flat plates and IDs).
- Component plating trials.

Proposed Classes of Demo Components

- P-3 MLG Actuating Cylinder.
- Crash Crane Hydraulic Cylinder.

Supplemental Work

- Task 1: Process Window
  - Variables: current density, pulse frequency and polarity, duty cycle.
  - Determine whether effects were due to current density, pulsing or combination.
  - Output: HE, stress, hardness, microstructure.
  - Screening with 1a1 (short bars), confirmation with 1a2 (long bars).

- Task 2: Data Acquisition
  - Microstructure, stress, adhesion, porosity.
  - F19 HE and re-embrittlement.
  - B117 and C58 corrosion.
  - Fatigue – Rotating beam (rapid results), axial.

- Task 3: Productivity
  - Cost tube IDs and flat test specimens - Evaluate appearance, deposition rate, masking, adhesion, etc.

- Task 4: Cost Benefit Analysis
- Task 5: Reporting