HVAF Flash Carbide  
As Economical Alternative  
To Electroplated Hard Chrome

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Problem description:

• During 30 years of development, thermal spray coatings (mainly HVOF) replaced only 5% of Electroplated Hard Chrome (EHC)

• Main reason of EHC still remains in the market is its COST, which is dramatically lower than developed alternatives.

• The cost of direct materials used in HVOF coatings is 7 times higher than the cost of chromium in EHC.

• Main developments of EHC alternative were focused on using lower-cost materials and increase of deposition efficiency DE
The most economical coating is not the one sprayed with the low-cost material and the highest DE.

It’s the thinnest coating.
Problem description (cont.)

EHC market is dominated by a very thin coating, known as “Flash Chrome” (15…20 micron)
Flash Carbide Principles

The WC-10C04Cr HVAF Flash Carbide coating technology is based on the similar to Flash Chrome principles:

- The part is ground to the lowest tolerance dimension
- The coating thickness is comparable to tolerances, set for the final coated part (i.e., 20-25 micron or less)
- The coating roughness is low – “ground-like” Ra 1.5-1.7 micron
- Such coating does not require dimensional grinding
- Polishing to Ra 0.2-0.3 micron removes only 5 micron of “as-sprayed” thickness

The final cost of Flash Carbide is 1/10 of conventional WC-coating
Requirements for Flash Carbide:

• Thin WC-10C-4Cr coating (20-25 micron after polishing) must be dense to provide adequate corrosion resistance

• As-sprayed coating roughness must be low enough to avoid the need for grinding (Ra less than 2.0 micron)

• The coating material must not degrade during application (= should not become brittle)

• The technology should be reproducible
Flash Carbide: ASTM B117 Salt Spray Corrosion Test
AK06 HVAF WC-10Co4Cr: 15 µm (0.0006“) thickness as-sprayed

0 h  168 h  336 h  504 h  672 h  1008 h
Flash Carbide: ASTM B117 Salt Spray Corrosion Test
AK06 HVAF WC-10Co4Cr: 25 µm (0.0010“) thickness as-sprayed

0 h  168 h  336 h  504 h  672 h  1008 h
Flash Carbide: ASTM B117 Salt Spray Corrosion Test
AK06 HVAF WC-10Co4Cr: 15-μm Coating micrograph after 1008 hours of test
# Mechanical Properties of (Thick) HVAF and HVOF WC-10Co-4Cr Coatings

<table>
<thead>
<tr>
<th></th>
<th>HVAF (AK06)</th>
<th>HVOF (JP)</th>
<th>HVOF (JP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder Size (µm)</td>
<td>- 15</td>
<td>25/5</td>
<td>45/15</td>
</tr>
<tr>
<td>Spray System</td>
<td>AK06</td>
<td>JP-5000®</td>
<td>JP-5000®</td>
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<tr>
<td>Porosity (%)</td>
<td>&lt;0.5</td>
<td>0.9</td>
<td>0.8</td>
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<tr>
<td>$HV_{300}$</td>
<td>1444</td>
<td>1250</td>
<td>1180</td>
</tr>
<tr>
<td>ASTM G65 m.B (mg)</td>
<td>14</td>
<td>21</td>
<td>18</td>
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<tr>
<td>E-Modulus (GPa)</td>
<td>325</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Cavitation Wear (mg)</td>
<td>1.4</td>
<td>2.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Metallic Co (%)</td>
<td>ca. 5.5</td>
<td>(zero)</td>
<td>ca. 4</td>
</tr>
<tr>
<td>Ra (µm)</td>
<td>1.5 – 1.8</td>
<td>2.9</td>
<td>5</td>
</tr>
</tbody>
</table>
Structure of HVAF and HVOF WC-10Co-4Cr coatings

HVOF, 25/5µm. Bright: eta phase

HVOF, 45/15µm. Less eta phase, cermet structure still visible

HVAF. Cermet structure with few eta phase
Flash Carbide: Factor affecting surface roughness

Influence of WC-10Co-4Cr coating thickness on surface Roughness Ra, micron: One-pass and Multi-pass

Coating thickness, micron

Ra (1-pass)  ▲ Ra (multi-passes)  □ Ra (multi-pass, large DIA)
Flash Carbide Process

- Dimension-grind the part to lowest tolerance, Ra 0.5 micron
- One pre-heating/cleaning pass with the gun flame
- Pass(es) of coating, HVAF fine/dense WC-10Co-4Cr powder (30 micron)

- Polish surface to needed roughness (remaining 22-25 micron of coating)
- Total cost of coating to 38 mm OD x 300 mm L rod, Ra 0.2 μm finish: <15 USD
Summary

The concept of “Flash Carbide” coating is developed, targeting deposition of high-quality WC-10Co-4Cr coatings at extremely low cost due to reduction of coating thickness and elimination of the need for dimensional grinding in the process.