KINETIC METALLIZATION™
WC-CO WEAR RESISTANT COATINGS

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INTRODUCTION
KINETIC METALLIZATION™
(KM)
Deposition Processes

- Gas: Vapor Deposition
- Liquid: Thermal Spray
- Solution: Electrochemical
- Solid: Impact Consolidation
- IVD
- HVOF
- Plating
- KM
- CVD
- A/VPS
- Anodize
- CS
- PVD
- D-Gun
- Chemical
KINETIC METALLIZATION™ PROCESS

- Gas Storage System
- Powder Fluidizing Unit
  - Powder
  - US Patent 7,273,075
- Heat
  - Thermal Conditioning Unit
- Powder Preheater Mixing Chamber
  - Friction Compensated Sonic Deposition Nozzle

INOVATI
- Impact Consolidation Process
- Feed-stock: fine powder,
- Accelerant: inert light gas
- Solid-state Consolidation
- No Melting
- No Liquid Chemicals

- Environmentally Innocuous
- No Particle release
- No Chromate formation
- No Hazardous Gas Emission
- Enhanced worker safety
POWDER FLUIDIZING UNITS

- Patented Brush-Sieve Design
- Light-weight pressure vessel
- Powder/ Gas flow rate independent
- Powder Size: 500nm - 50μm
- Feed Rate: 0-100g/min
- Large Capacity - 4 hour run time
QUALITY ASSURANCE

- Automatic report generation
- Eliminates manual parameter logging
- Parameter statistics
- Detailed process history for QA purposes

- Quickly view run overview
- Plotted parameters for quick evaluation
- Configurable
## Run Details

**Operator**
- Name: [Redacted]
- Customer: INOVATI

**Date**
- 1/46/05

**Project**
- WC-Co Dummy

**Time**
- 12:38:03

**Task**
- Sample Coating

### Substrate

<table>
<thead>
<tr>
<th>Material Group</th>
<th>Bond Coat</th>
<th>Surface Prep</th>
<th>Thickness (in)</th>
<th>Surface Roughness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>Bond Coat</td>
<td>A200 Grid Blast</td>
<td>0.04</td>
<td>124</td>
</tr>
</tbody>
</table>

**Substrate Comment**
- 3Wx4"x1/4" V-groove

### Powder 1

<table>
<thead>
<tr>
<th>Material Group</th>
<th>Drying Method</th>
<th>Alloy</th>
<th>Set Point (%)</th>
<th>Feed Rate (g/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tungsten</td>
<td>Preblend</td>
<td>KM 1F-10-10</td>
<td>55</td>
<td>70</td>
</tr>
</tbody>
</table>

**Powder 1 Comment**
- [Redacted]

### Powder 2

<table>
<thead>
<tr>
<th>Material Group</th>
<th>Drying Method</th>
<th>Alloy</th>
<th>Set Point (%)</th>
<th>Feed Rate (g/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>—</td>
<td>Preblend</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**Powder 2 Comment**
- [Redacted]

### Nozzle

<table>
<thead>
<tr>
<th>Type</th>
<th>Serial Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight</td>
<td>1201</td>
</tr>
<tr>
<td>Throat Diameter (in)</td>
<td>0.039</td>
</tr>
</tbody>
</table>

**Nozzle Comment**
- [Redacted]

### Spray Parameters

**Gas**
- PFU Gas: 10 in
- TCU Gas: 10 in

**TPU Parameters**
- Units: in
- Set Point: 4.2

### Robot Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Set Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>in</td>
<td>4.2</td>
</tr>
<tr>
<td>Width</td>
<td>in</td>
<td>1</td>
</tr>
<tr>
<td>Substrate Thickness</td>
<td>in</td>
<td>0.02</td>
</tr>
<tr>
<td>Standoff</td>
<td>in</td>
<td>0.45</td>
</tr>
<tr>
<td>Speed</td>
<td>in/sec</td>
<td>5</td>
</tr>
<tr>
<td>Step Size</td>
<td>in</td>
<td>0.08</td>
</tr>
<tr>
<td>Strokes</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Layers</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Turn Table Rotation Speed</td>
<td>rpm</td>
<td>0</td>
</tr>
</tbody>
</table>
KINETIC METALLIZATION™
WC-CO
KM WC-CO

- Fine grain structure
- 99.9% Dense
- Tunable hardness
TUNABLE HARDNESS

HV (300g) = 1495 kg/mm²
WC-CO ON BLADE ALLOYS

Inconel 718

Ti-6-4

In718

Ti 6-4

HV(300g)

1,600

1,200

800

400

0

100 µm

100 µm

INOVAI
WC-CO ON BLADE ALLOYS

ASTM C633 ADHESION TESTING

KM1000 WC-Co

In718

Ti 6-4

Sample 1
Sample 2
Sample 3
Sample 4
KM APPLICATIONS
WC-CO
WEAR RESISTANT COATINGS
KM WC-CO

- ID & OD
- LARGE & SMALL
- SMOOTH & SHARP
TI6-4 KNIFE EDGE WC-CO

Longitudinal X-section

X-section
F/A-18 (AMAD) HYDRAULIC GEAR SHAFT REPAIR

AMAD - Aircraft Mounted Accessory Drive
REPAIR OVERVIEW

Hydraulic Pump Spur Gear
- Wear at sealing surface (AMS 6265)
- High Cost
- Low Part Availability

Current Repair
- Hard Chrome Plating
- Human Health & Environmental Issues

KM Repair
- No Toxic Chemicals
- Better Performance Than Original Part
DAMAGED HYDRAULIC GEAR

- 0.005” deep wear groove
- Detail
KM Repair F/A-18E/F
Hydraulic Pump Gear Shaft

AMS 6265
Hv = 384

WC-Co
Hv = 1000

Wear damage removed and replaced with Tungsten Carbide-Cobalt using Kinetic Metallization™
## Accelerated Wear Testing

<table>
<thead>
<tr>
<th></th>
<th>Hours of Accelerated Wear</th>
<th>Surface Roughness (Ra) (μ-in) Before</th>
<th>Surface Roughness (Ra) (μ-in) After</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEM Gear AMS 6265</td>
<td>22</td>
<td>18-20</td>
<td>&gt;200</td>
</tr>
<tr>
<td>Chrome Plate</td>
<td>21</td>
<td>4-5</td>
<td>&gt;200</td>
</tr>
<tr>
<td>KM WC-Co</td>
<td>61</td>
<td>2-3</td>
<td>16-17</td>
</tr>
</tbody>
</table>
KM – HVOF COATING PERFORMANCE COMPARISON
LCF TESTING

Key Finding for High Loads

- 220ksi, R = -0.33
- 0.005” KM coating integrity equaled 0.003” HVOF
- More ductile coating & uniform thickness provided improved grind performance over HVOF

0.003” KM coating at 160ksi, R = -1
KM – HVOF SUPERFINISHING COMPARISON
WC-CO SUPERFINISHING

- Surface finishes
- WC-17Co – Kinetic Metallization™
- WC-86Co-4Cr – High Velocity Oxygen Fuel (HVOF)
Conclusions

• KM WC-Co Applications
  • Restoring wear damage to F/A-18 components
  • Extended life of hydraulic spur gears (AMAD)
  • Applicable to journal bearing surfaces
  • Permits sustainable seal/bearing wear surfaces
  • Tunable hardness range Hv = 800 to 1500
  • Ultra-fine microstructure eliminates seal degradation
  • Adhesion strengths of >10-ksi
VISIT BOOTH 1064

KM-SAM Process & Equipment