EternAloy® TCHP
Tough-Coated Hard Powders

Nanotechnology Solutions for Extreme Combined Hardness and Toughness

**Ceramic Core**
- Strong Outer Binder Coating
- Tough Inner Coating
- Superhard Core Particle

**Superhard Core**
- Tough Inner Coating
- Strong Outer Binder Coating

**EternAloy® Grade**

<table>
<thead>
<tr>
<th>Core Particle</th>
<th>NL-3-2</th>
<th>TL-3</th>
<th>SiC-WC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (HV)</td>
<td>1700-1750</td>
<td>1776-1790</td>
<td>1500-1530</td>
</tr>
<tr>
<td>Toughness (MPa/m)</td>
<td>12.5-13.5</td>
<td>11.8-11.5</td>
<td>N/A</td>
</tr>
</tbody>
</table>

(Note: Particles intentionally fractured for SEM examination)

**TCHP Mechanical Properties**

- **Toughness vs. Hardness**
- **Superhard**
- **Ceramics**
- **Carbides**
- **Metallics**
- **Ti and Fe Alloys**

**TCHP Technology**
- Establishes a entirely new class of powdered metals with extreme combinations of strength and wear-resistance
- Customizable hardness, toughness, strength, wear, thermal conductivity, and other desired performance characteristics

**EternAloy® TCHP Coating on Stainless Steel Substrate**

**Toughness vs. Hardness**

**Toughness (Kt, MPa/m)**

**TCHP Blended with Metal Matrix A**

**Toughness (Kt, MPa/m)**

**TCHP Blended with Metal Matrix B**

**Toughness (Kt, MPa/m)**

**Future Work**
- Allomet is collaborating with leading industrial and academic partners to optimize coating quality using a variety of HVOF equipment and to characterize wear performance, including sliding and fretting wear at elevated temperatures.

**HVOF (High Velocity Oxygen Fuel)**

- SEM photos of TCHP consolidated microstructure collected in backscattered electron mode. The dark circular areas in the microstructure are the hard core particles and the bright regions illustrate the WC and Co matrix.

**Industrial Component in Operation with TCHP Coating**
- Industrial components with coating thicknesses as thin as 0.002” on a contoured surface currently outperforming the best tool in a manufacturing operation.
- TCHP coatings have significantly increased the operational life of these critical components.

**TCHP Microstructure**
- Uniform distribution of core particles in the matrix with porosity values less than 1% for a wide range of HVOF spray parameters.
- “Hotter” spray conditions produce oxides, increased microhardness and slightly reduced bond strengths.

**TCHP Microhardness**
- Averages range from 1100 to over 1300 HV0.1 depending on HVOF equipment and processing parameters.
- TCHP has been qualified for use on:
  - Sulzer Metco DL™ Hybrid
  - Praxair JP-8000™
  - Stellite Jet Kote®

**TCHP Sprayed Thickness**
- Thicknesses as thin as 0.002” (0.050mm) and as thick as 0.062” (1.6mm) can be achieved with no cracking or delamination.
- TCHP has been applied successfully on:
  - 316 & 410 Stainless steel
  - Carbon Steel
  - Inconel 718
  - AA6061

**LMD (Laser Metal Deposition)**

- TCHP surface coatings have been deposited with LMD utilizing two different techniques. One uses TCHP only and a second technique allows for TCHP to be blended with a metal matrix alloy.

- **TCHP – 100% - LMD Coating Cross-Section**
  - Initial LMD trials included deposition of a TCHP-only layer. Although extremely high hardness values were achieved, the incidence for cracking was high, which may be undesirable for certain applications.
  - In addition, TCHP particles were melted and re-solidified, creating a complex, multiphase structure. Current development includes blending TCHP with metal matrix alloys to provide additional strength and ductility to a TCHP-based LMD coating.

**TCHP & WC-12Co LMD Coatings - Microhardness**
- The average TCHP microhardness is 20% greater than the average WC-12Co microhardness value.
- Measurements were taken left-to-right across the cross-section.

**LMD of a TCHP Alumina Core Material Blended with Various Metal Matrix Alloys**

- **TCHP Blended with Metal Matrix A**
  - TCHP alumina core material, seen as dark circular areas in SEM backscattered electron mode, are distributed throughout the matrix with more uniform distribution in Metal Matrix A.
  - TCHP blended with Metal Matrix B results in a multiphase microstructure.

- **Metal Matrix Alloys**
  - TCHP has been blended in various ratios with the following metal matrix alloys:
    - Ni-Cr-Mo
    - Co-Cr-Ni-Al-Y
    - Ni-Si-B
    - Stainless Steels (316, 410 and 431)

**Future Work**
- Allomet is collaborating with leading industrial partners to minimize cracking in TCHP-only deposits, to minimize TCHP dissolution in TCHP – Metal Matrix blends, and to determine the performance benefits of all TCHP-based LMD deposits as wear resistant coatings.

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