Romania - Republic of Serbia
IPA Cross-border Cooperation Programme

Characterization of surface layer-deposited structures
Thermal spray coating - coating produced by a process in which molten or semi-molten particles are applied by impact onto a substrate
Thermal spraying methods:
- plasma spraying:
  - atmospheric plasma spraying (APS)
  - vacuum plasma spraying (VPS)
  - high velocity oxygen-fuel (HVOF)

Drawbacks:
- internal oxide formation
- low passivity
- open pores and crevices between lamellae
- degradation of material during spraying
Investigation on high-velocity-oxygen-fuel-sprayed specimens of CoNiCrAlY powder with 8 wt.% Al and WC-Co powder with different WC grain sizes

**MCrAlY coatings**

- Structural modifications in the MCrAlY coatings before and after EB remelting
- Structure and thickness of the grown oxide scale

**WC Co 83 17/Al8Si20BN coatings**

- Variation of the coatings morphology
- Corrosion and wear resistance behaviour

**Experimental results**
MCrAlY’s are a family of materials which have a base metal(M) of cobalt, nickel, and or iron, plus chromium, aluminium, yttrium and sometimes other alloying elements.

Excellent performance at elevated temperatures and corrosive type environments

**MCrAlY coatings**
Thermal barrier coating system and temperature gradient during service
Substrate - Ni superalloy - INCONEL 617

<table>
<thead>
<tr>
<th>CoNiCrAlY</th>
<th>Co</th>
<th>Ni</th>
<th>Cr</th>
<th>Al</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 %Al</td>
<td>37.5</td>
<td>32</td>
<td>22</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>12 %Al</td>
<td>30.75</td>
<td>26.25</td>
<td>30.2</td>
<td>12</td>
<td>0.8</td>
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<tr>
<td>15 %Al</td>
<td>25.5</td>
<td>21.8</td>
<td>36.8</td>
<td>15</td>
<td>0.9</td>
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</tbody>
</table>

SEM micrographs of the CoNiCrAlY powder
SEM micrographs of the CoNiCrAlY coating: (a) as-sprayed, (b) after the heat treatment, (c) after electron beam remelting
SEM images of MCrAlY coatings after oxidation at 950°C in air: as-sprayed (a) and EB beam treated (b) coatings.
X-ray diffraction patterns of the as-sprayed coating before (a) and after oxidation at 950 °C for 100 h (b).
X-ray diffraction patterns of the remelted coating before (a) and after oxidation at 950 °C for 100h (b)
CERMET is a CERamic-METallic material and it is a composite coating that has ceramic particles in a metal matrix.

CerMet

- Ceramic phase
  - WC, Cr$_3$C$_2$, TiC
  - Good wear behavior

- Metallic phase
  - Co, Ni, Cr
  - Good corrosion resistance

Cermet materials
<table>
<thead>
<tr>
<th>Cermet coatings</th>
<th>Properties</th>
<th>Application field</th>
</tr>
</thead>
<tbody>
<tr>
<td>WC/Co; TiC&lt;sub&gt;x&lt;/sub&gt;N&lt;sub&gt;1&lt;/sub&gt;/Mo</td>
<td>Wear resistance, high temperature resistance</td>
<td>Cutting tools and processing devices</td>
</tr>
<tr>
<td>Al&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;/Al; Al/SiC</td>
<td>Wear and breaking resistance; stiffness</td>
<td>Pistons, disc brake, bearings, crankshafts</td>
</tr>
<tr>
<td>Al&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;3&lt;/sub&gt;/Ni-Co</td>
<td>High temperature resistance</td>
<td>Parts of shuttle engines, planes and helicopters</td>
</tr>
</tbody>
</table>
Information about the feedstock powders

<table>
<thead>
<tr>
<th>No</th>
<th>Chemical composition</th>
<th>Powder particle size range [$\mu$m]</th>
<th>WC grain size range [$\mu$m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>WC Co 83 17</td>
<td>15-45</td>
<td>1-5</td>
</tr>
<tr>
<td>2.</td>
<td>WC Co 83 17</td>
<td>15-45</td>
<td>0,1-0,5</td>
</tr>
</tbody>
</table>

SEM micrographs of the WC-Co 83 17 powders
(a)-microscale WC-particles, (b)-nanoscale WC-particles
SEM micrographs of the WC-Co coating obtained from microscale WC-particles (sample 1)

SEM micrographs of the WC-Co coatings obtained from nanoscale WC-particles (sample 2)
X-ray diffraction patterns of sprayed coatings

(a)-sample 1, (b)-sample 2
Wear behavior of the WC-Co coatings

Pin-on-disk method

WC ball – $\Phi=6$ mm

$F = 15$ N, $v_r = 20$ cm/s, $d= 1000$ m, $R=5.4$ mm
Wear rates of the tested samples

<table>
<thead>
<tr>
<th>Material</th>
<th>Wear rate [mm³/N/m]</th>
<th>Wear rate $10^{-7}$ [mm³/N/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>0.0000032</td>
<td>32</td>
</tr>
<tr>
<td>Sample 2</td>
<td>0.0000048</td>
<td>48</td>
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</tbody>
</table>

Sliding wear rates of the tested samples
Values of the measured corrosion potential and current density

<table>
<thead>
<tr>
<th>Sample</th>
<th>Electrochemical data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$i_{\text{corr}}$ (mA/cm$^2$)</td>
<td>$E_{\text{corr}}$ (mV)</td>
</tr>
<tr>
<td>1</td>
<td>0.0245</td>
<td>-154.6</td>
</tr>
<tr>
<td>2</td>
<td>0.0058</td>
<td>-140.5</td>
</tr>
</tbody>
</table>

Polarization curves of the tested materials in $10^{-3}$ M $\text{H}_2\text{SO}_4$ at room temperature
Improvement of the wear resistance of the titanium

SEM micrographs of the Al8Si20BN powder and of the as-sprayed coating

SEM micrographs of the as-sprayed and EB remelted coating
Optical micrographs of the deposited and remelted coating (surface and interface...

<table>
<thead>
<tr>
<th>Material</th>
<th>Titanium</th>
<th>Titanium alloyed 1</th>
<th>Titanium alloyed 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV50</td>
<td>130</td>
<td>531</td>
<td>447</td>
</tr>
</tbody>
</table>
Thank you for your attention!