WEAR CHARACTERISTICS OF THE SPRAYED COATINGS WITH AMORPHOUS MATERIAL

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ABSTRACT
Characteristics of the sprayed amorphous material’s coating have been investigated in order to improve the life of liners used in a blasting system. The amorphous materials of interest were commercial Fe-Cr-B alloys and the processes employed were arc spray and HVOF spray. Erosion wear property of the coatings were evaluated using a steel grit blasting machine and actual blasting system. The coating produced by HVOF spraying method showed a very dense structure so that porosity content of the coating was less than 1% and split was not formed. Due to these features with its high hardness, the wear resistance of the HVOF sprayed coating was superior to that of the arc sprayed coating. Microstructural characteristic of the amorphous material’s coating were analyzed using SEM, EDX and XRD.

INTRODUCTION
Prematured wear of the liner in the blasting system is a frequently encountered problem which makes increase in production cost due to unexpected operational stop for the overhaul of the system. Surface modification such as wear resistant coating was proposed as a cost effective alternative to the current bulk hard alloy casting or machined parts. Amorphous alloys have been studied for the wear resistant coating material due to their prominent performance [1, 2]. Application of wear resistant amorphous coatings using thermal spray process has been studied in order to find a possibility of an application of the alloys to the blasting liner component. Investigation on both the effect of coating process on wear performance and determining factors of wear performance has been conducted.

EXPERIMENTAL PROCEDURES
Coating specimens of commercial Fe-Cr-B alloys have been prepared using arc spray and HVOF (High Velocity Oxy-Fuel) spray process. Characteristics of the coating material and spray coating parameters are shown in Table 1 and 2, respectively.

Erosion wear performance of the coatings was evaluated by a measurement of wear loss using the blasting machine. Metallurgical characterization of the coating such as hardness and porosity content evaluation have been performed in order to understand correlation between erosion wear performance and metallurgical characteristics of the coating. Porosity content measurement has been performed using image analyzer along with optical microscope and scanning electron microscope. Crystalline phase analysis using EDX along with SEM was also conducted to find the extent of formation of hard phase which determines hardness of the amorphous coating.

Table 1. Coating materials and their typical properties

<table>
<thead>
<tr>
<th>Description</th>
<th>Material Type</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVOF coating</td>
<td>LMC-M Powder (ARMACOR M)</td>
<td>1200~1400 HV</td>
</tr>
<tr>
<td>ARC coating</td>
<td>LMC-M Wire (ARMACOR M)</td>
<td>69~73 HRC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Process Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVOF coating</td>
<td>Spray System : JP-5000</td>
</tr>
<tr>
<td></td>
<td>Gun Nozzle ; 4inch barrel</td>
</tr>
<tr>
<td></td>
<td>Fuel &amp; Gas</td>
</tr>
<tr>
<td></td>
<td>Oxygen ; 210psi/1900scfh</td>
</tr>
<tr>
<td></td>
<td>Fuel ; 170psi/6gfh</td>
</tr>
<tr>
<td></td>
<td>Nitrogen ; 50psi/26scfh</td>
</tr>
<tr>
<td></td>
<td>Spray Rate ; 74g/min</td>
</tr>
<tr>
<td></td>
<td>Standoff ; 280~330mm</td>
</tr>
<tr>
<td>ARC coating</td>
<td>Spray System : TWAS</td>
</tr>
<tr>
<td></td>
<td>Air Pressure ; 80psi</td>
</tr>
<tr>
<td></td>
<td>Arc Voltage ; 25V</td>
</tr>
<tr>
<td></td>
<td>Arc Current ; 250~300A</td>
</tr>
<tr>
<td></td>
<td>Standoff ; 150~200mm</td>
</tr>
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</table>

RESULTS AND DISCUSSION
It was found that wear performance of the HVOF sprayed coating was much better than that of the arc sprayed one as shown in Figure 1.
It was found that higher hardness and lower porosity level of the HVOF coating as shown in Table 3 were responsible for better erosion wear resistance. Hardness of the Fe-Cr-B amorphous alloy coatings were attributed to dense microstructure along with higher hard phase content as shown in EDX phase analysis (Figure 2 and 3).

Table 3. Hardness of the sprayed coatings

<table>
<thead>
<tr>
<th>Description</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVOF coating</td>
<td>1050</td>
<td>1250</td>
<td>1171</td>
<td>974</td>
<td>1160</td>
<td>1121</td>
</tr>
<tr>
<td>ARC coating</td>
<td>671</td>
<td>648</td>
<td>741</td>
<td>673</td>
<td>652</td>
<td>677</td>
</tr>
</tbody>
</table>

In conclusion, selection of proper process and coating material with microstructure control are very important in order to ensure erosion wear resistance performance of the coating. In addition, better adhesion was also considered as an important factor for better wear life of the coatings.

Erosion wear performance of the HVOF sprayed coatings would be verified through field test, an application of the coated liners to actual blasting system.

CONCLUSIONS

Following conclusions can be drawn from a study on wear characteristics of the sprayed coatings with amorphous material.

1) Erosion wear resistance of the liner can be substantially improved by an application of the HVOF sprayed amorphous alloy coatings.
2) Better erosion wear performance of the HVOF coating is attributed to the higher hardness, more dense microstructure and better adhesion with the substrate.
3) Proper selection of coating process and material are therefore critical to ensure erosion wear resistance of the amorphous alloy coating.

REFERENCES


Figure 1. Erosion wear performance of the sprayed coatings.
Figure 2. Microstructure of the sprayed coatings indicating difference in adhesion; (a) HVOF sprayed coating and (b) Arc sprayed coating
Figure 3. Morphology and EDS profile of Cr rich hard phase found in HVOF coating