Microabrasion Resistance of Laser Clad Cobalt-based Alloy Coatings

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1. Introduction

Cobalt superalloys are materials applied in severe conditions which may involve high temperatures and different types of wear \[1\].

These conditions are found, for example, during the production of second generation ethanol, in which sugarcane biomass is processed at high temperatures in the presence of solid particles \[2\]. This work investigates the tribological behavior of cobalt superalloys in microabrasion.

2. Experimental method and materials

Randomized microabrasion wear tests were performed with commercial microabrasion tester Plint TE66, with a fixed spherical configuration. Abrasives of SiO\textsubscript{2}, Al\textsubscript{2}O\textsubscript{3}, and SiC with slurry concentration of 0.1 g/cm\textsuperscript{2} were used. The test load was 0.3 N.

Samples of cobalt superalloys were produced by the laser cladding technology with powders from Stellite alloys 1, 6 and 12. These alloys were deposited on a cast substrate of Co30Cr19Fe alloy. Table 1 shows the chemical compositions of the powders used and the substrate material.

Optical microscopy (OM) and scanning electron microscopy (SEM) were used for microstructural characterization and investigation of micromechanisms.

3. Results and discussion

3.1. Microstructure

The sample Co30Cr19Fe, fig. 1a, is composed of a cobalt matrix with Cr and Fe atoms in solid substitutional solution, with coarse grains and dendritic structure. The sample coated with Stellite 1, fig. 1b, is formed by chromium-rich primary carbides, probably of the M\textsubscript{2}C\textsubscript{3} type, dispersed in a eutectic matrix containing secondary carbides. The samples coated with Stellites 6 and 12, Figs. 1c and 1d, respectively, present similar microstructures, formed by primary cobalt dendrites surrounded by eutectic carbides precipitated in the interdendritic regions.

The cast sample Co30Cr19Fe had the lowest average hardness, 248 ± 12 HV\textsubscript{10}, among the materials. The sample coated with Stellite 1 showed the highest average hardness, 678 ± 33 HV\textsubscript{10}, followed by Stellite 12 with 522 ± 12 HV\textsubscript{10} and Stellite 6 with 458 ± 6 HV\textsubscript{10}.

3.2. Microabrasion tests

Table 2 shows the values of the dimensional wear coefficients (k) obtained in the tests.

![Fig. 1: Microstructure of the samples. a) Co30Cr19Fe (OM), b) Stellite 1 (SEM), c) Stellite 6 (OM), d) Stellite 12 (OM).]

<table>
<thead>
<tr>
<th>Materials</th>
<th>Co</th>
<th>Cr</th>
<th>W</th>
<th>Mo</th>
<th>C</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co30Cr19Fe</td>
<td>Bal</td>
<td>30</td>
<td>13</td>
<td>&lt;1</td>
<td>2.5</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Stellite 1</td>
<td>Bal</td>
<td>30</td>
<td>13</td>
<td>&lt;1</td>
<td>2.5</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Stellite 6</td>
<td>Bal</td>
<td>28</td>
<td>4.6</td>
<td>&lt;1</td>
<td>1.2</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Stellite 12</td>
<td>Bal</td>
<td>30</td>
<td>8.5</td>
<td>&lt;2</td>
<td>1.4</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Co30Cr19Fe</td>
<td>Bal</td>
<td>30</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
<td>19</td>
</tr>
</tbody>
</table>

The results of the tests were statistically evaluated through analysis of variance. In general, higher wear coefficients were achieved when using the Al\textsubscript{2}O\textsubscript{3} abrasive, followed by SiC and SiO\textsubscript{2}. The material used as substrate showed higher wear coefficient regardless of the abrasive. This alloy presents the lowest amount of carbides and, therefore, less hardness. Among the coated, an increase in the wear resistance with increased carbon content is observed for the tests carried out with SiO\textsubscript{2} and SiC. The predominant wear micromechanism was grooving, except for samples coated with Stellite 6 and 12 and tested with SiC, which presented mixed and rolling mechanism, respectively.

4. Conclusions

The coating with Stellites alloys, by the laser cladding process, promoted an increase in microabrasive wear resistance of the samples evaluated. The sample coated with Stellite 1 presented higher resistance to wear between materials.

5. References