Laser cladding of NiCrBSi-WC coatings with non-homogenous distribution of carbides

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Synopsis

This paper studies the non-homogenous distribution of non-melted tungsten carbides in NiCrBSi-WC coatings obtained by laser cladding.

Introduction

This paper studies the non-homogenous distribution of non-melted tungsten carbides in NiCrBSi-WC coatings obtained by laser cladding. Ni base metal matrix coatings reinforced by spherical shape WC particles, show a good wear performance in dry sliding contacts, as the authors have studied [1, 2]. However, during the laser cladding process, it was observed that WC particles tend to fall down to the bottom of the melted coating, and as a consequence, the percentage of carbides increases in areas near the interface with the C45E steel substrate, and decrease on the top of the coating. This non-homogenous distribution has been observed by other researchers [3].

The distribution of non-melted tungsten carbides was studied in laser cladding coatings made with different weight percentages of WC adjusted in the powder feeder (10%, 20%, 30%, 40% and 50%). A 1700 W CO2 laser and Sulzer Twin 10C powder feeder was used in the cladding process. The process parameters for different wt% of carbides was adjusted in order to obtain coatings with similar height (due to the different densities of base Ni alloy and WC, the powder feed rate had to be adjusted in the cladding process). The actual concentration of carbides along the depth of the coating was determined by optical micrographs of the cross section. An image processing software was used to measure the actual volume percentage of WC in 100 µm height areas along the entire depth of the coating.

Results and Discussion

Figure 1 shows a cross-section of a laser cladded NiCrBSi+WC coating with 30 wt% WC feeder concentration (the value was adjusted in the feeder during the manufacture process). It can be seen the non-homogeneous distribution of the WC particles in the coating. Due to higher melting points and the density of these particles when compared with those of the matrix phase, the WC spheres tend to precipitate, causing a greater concentration of carbides in the areas of overlapping between tracks [4] and at the bottom of the coating.

![Figure 1 – Cross section of a coating (theoretical 30 wt% WC concentration introduced in the powder feeder)](image)

The measure of the actual percentage of WC along the entire depth of the coatings with different wt% WC in the feeder tested, shows that the average actual concentration of WC particles in the coating is approximately 80% of wt% WC in the feeder in all cases.
The graph in figure 2 shows the evolution of the actual distribution of WC versus the distance to the substrate in the cross-section of laser cladded NiCrBSi + WC coatings, for different wt% WC in the feeder.

![Graph showing the evolution of the actual distribution of WC versus the distance to the substrate](image)

**Figure 2 – A) Average wt% WCactual concentration versus the distance to the substrate in the cross-section of the coating for each wt%WCfeeder concentration[1] and B) ratio between the actual distribution of WC particles and the theoretical concentration used in the feeder, according to the distance from the substrate, for different wt% WC in the feeder.**

In all the cases, the actual percentage of wt% WC in the areas close to the substrate is significantly superior to the wt% WC in the feeder, and it diminishes as the distance from the substrate increases, down to values below the wt% WC in the feeder. The speed of change is different for each wt%WC in the feeder.

In the graphs related to the 10 to 40% WC feeder there is a stabilization in the curve. It should be noted that above coatings approximately 450 microns high, the actual concentration of WC particles is stable in all cases, except for 50% in the feeder, probably due to the thickness of the coating not being large enough. Moreover, the graph in figure 2 offers some relevant information: the actual percentage of WC particles is stabilized around 40% of the wt% WC in the feeder, in all the cases in which it stabilizes.

**Conclusions**

An accurate actual percentage of WC particles on the surface of the coating can be obtained by simultaneous control of feeder concentration and grinding depth of the coating. The knowledge of the distribution of carbides in such coatings, allows to obtain an optimized manufacture process in coatings made for wear performance.

**References**


