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MICRO-SCALE SLIDING WEAR BEHAVIOR OF HVOF SPRAYED WC-Co(Cr)

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ABSTRACT: The paper presents the investigations of the sliding wear behavior of two different thermal sprayed cermet coatings. WC-Co and WC-CoCr powders were HVOF sprayed on a C45 steel substrate using an ID Cool Flow gun. Scanning electron microscopy (SEM) and X-Ray Diffraction (XRD) were performed in order to investigate the coatings morphology as well as the phase modification achieved through the HVOF spraying process. Tribological tests concerning the sliding wear behavior of the tested materials were performed using the pin-on-disk method.
KEYWORDS: sliding wear behavior, thermal sprayed cermet coatings

❖ INTRODUCTION

In industries, mechanical components have to operate under severe conditions such as high load, speed or temperature and hostile chemical environments. Usually, various surface treatments have been used in order to improve the surface characteristics. Such treatments are: ion implantation, laser nitriding alloying, physical vapor and thermal spraying deposition etc [1].

Thermal spray coatings are becoming increasingly used as surface engineering option to resist corrosive and sliding wear and as thermal barriers in many industries [2]. Thermal spraying involves projection of powders particles into a high temperature flame, produced by igniting hydrogen, oxygen and kerosene, where they are melted and accelerated on the substrate surface. The resulted coatings are formed by the immediate solidification of the molten droplets on the substrate surface of lower temperature where they form splats.

High velocity oxygen fuel (HVOF) is a thermal spraying method which allows spraying of coatings with advanced and often unique properties. Therefore the process has been used in numerous advanced applications and has become very popular over the last two decades [3].

One of the great advantages of the HVOF process is the higher velocity reached by the particles and the low temperatures involved which minimizes any potentially damaging effect to the coating and substrate [4].

Wear protection is an important application field of HVOF sprayed coatings. HVOF technology has improved over the years and now provides coatings with better compaction and low chemical decomposition, especially for WC- based cermet coatings [5].

It is known that high velocity oxy-fuel (HVOF) spraying provides superior results than any other thermal spraying technology by manufacturing cermet coatings, because of the gas velocity and lower flame temperature [6]. A cermet is a composite material composed of ceramic and metallic materials which have the optimal properties as high temperature resistance, high hardness and the ability to undergo plastic deformation.

WC- based coatings are deposited not only on originally manufactured components but also on worn areas of used components for repair purpose. The use of WC based thermal spray coatings has been increasing in several areas due to their potentially high erosion and sliding wear resistance.
The present work investigates the sliding wear behavior of the obtained coatings deposited on C45 specimens using an HVOF gun and as feedstock WC-Co 86 14 and WC-CoCr 86 10 4 micro powders.

❖ EXPERIMENTAL PROCEDURE

The substrate used in this study was rectangular C45 still plates with dimensions of 50x50mm which were thoroughly sand-blasted with electrocorindon in order to enhance the binding force between the substrate and the deposited coating. After the grinding process the samples were cleaned with acetone.

The feedstock material used in the study were WC based cermet powders, respectively WC-Co 86 14 and WC-CoCr 86 10 4 micro powders.

The morphology of the powder and of the sprayed samples has been characterized by scanning electron microscopy (SEM) and X-Ray diffraction (XRD) using a Cu-K_{α} radiation.

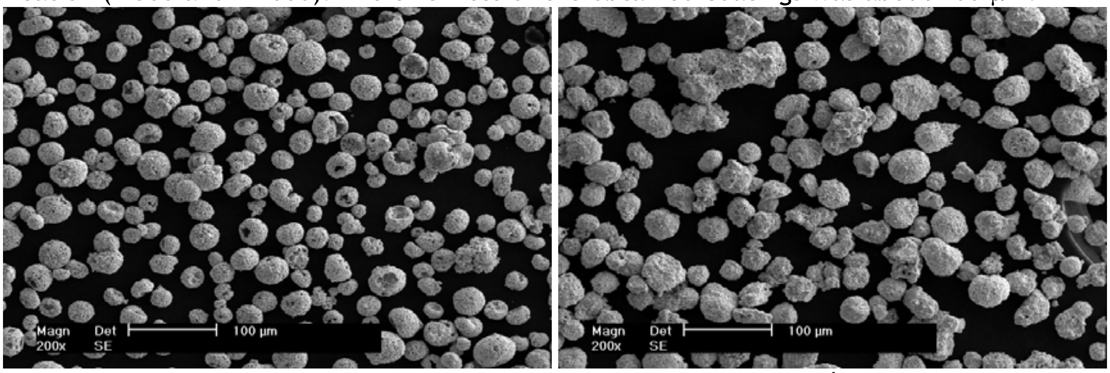
The sliding wear resistance was determined using the pin-on-disk method by calculating the variation of the wear track depth with the applied load.

The normal load applied of the ball (WC-Co with a 6 mm diameter) was 10 N, relative velocity between the ball and surface was v = 20 cm/s, and the testing distance 1000 m (the trajectory was a circle with a radius of 5.4 mm). The relative humidity was 65 %.

❖ RESULTS AND DISCUSSIONS. COATING MORPHOLOGY

The morphology of the used powder is shown in the SEM micrographs from figure 1. The powder particles are spherical having the size between -45+15 μm.

Figure 2 and 3 presents the SEM micrographs of the HVOF sprayed coatings at different magnification (x 500 and x 2000). The thickness of the obtained coatings was about 200 μm.



a b

Fig. 1: SEM micrographs of the WC Co (a) and WC CoCr (b) powder

In both cases one may observe a good adhesion between the coating and substrate (Fig.2a and 3a). Comparing the SEM images at higher magnitudes (Fig.2b and 3b) both HVOF sprayed coatings present a certain degree of porosity respectively of internal oxidation.

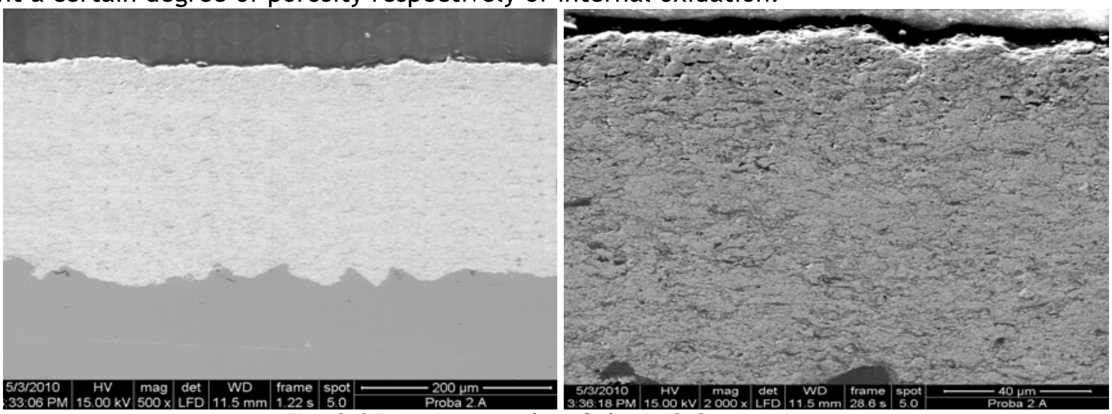


Fig. 2 SEM micrographs of the WC Co coatings

The XRD patterns of the WC-Co(Cr) sprayed coatings are similar, no transformation of the WC-phase into W_2C-phase occurred during the deposition process (figure 4). However one may see a broad signal corresponding to the WC_{1-x}-phase, which indicates a light decarburization of the WC-phase.

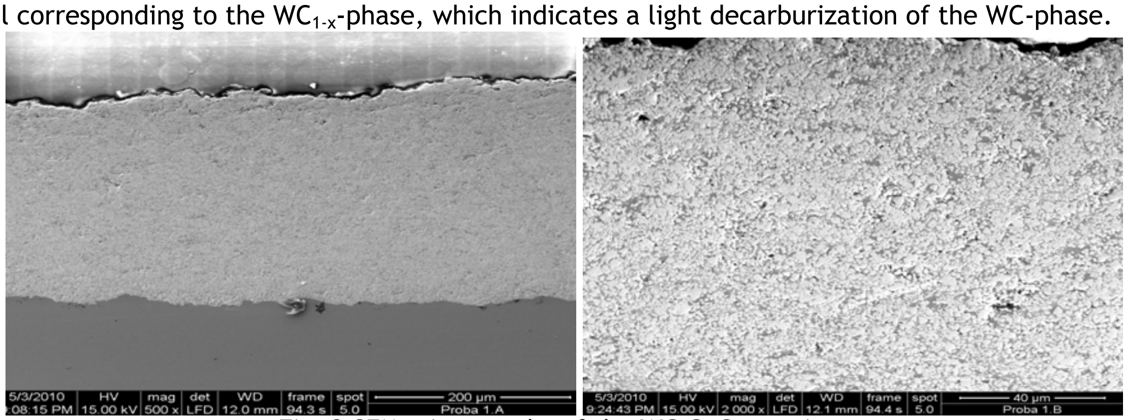


Fig. 3 SEM micrographs of the WC CoCr coatings

The Co-and CoCr-phases corresponding to the metallic matrix were not identified by XRD-measurements due to its low content in the chemical composition.

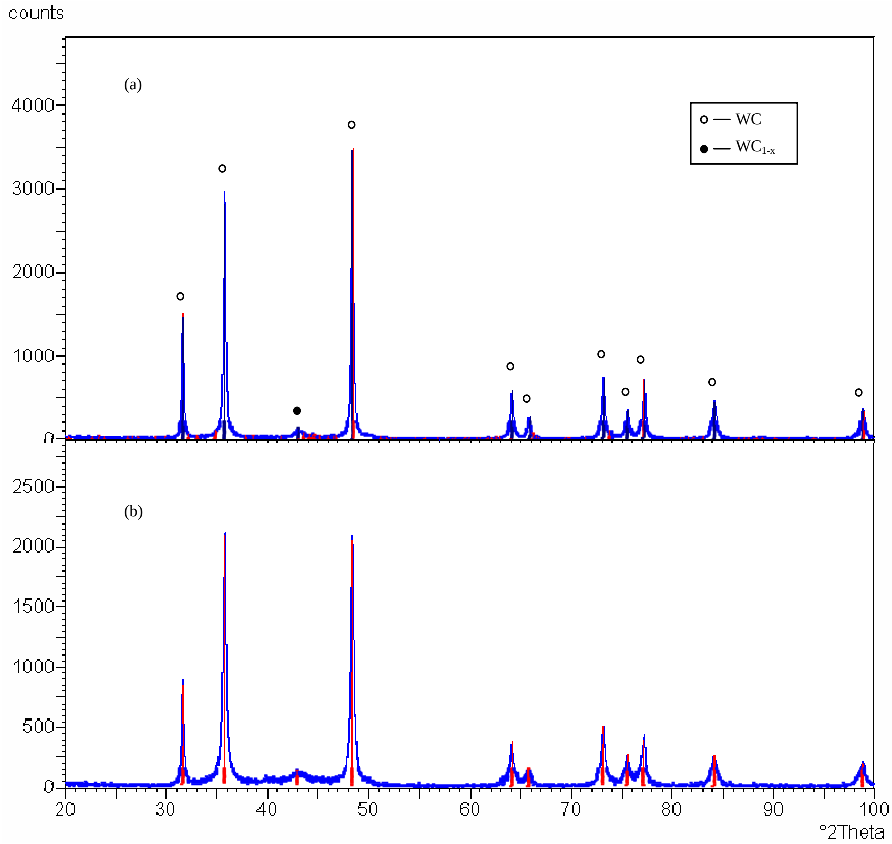


Fig. 4 X-ray diffraction patterns of sprayed coatings WC-Co coating, (b) WC-CoCr coatings

❖ RESULTS AND DISCUSSIONS. WEAR RESISTANCE TESTS

The pin on disk tests indicated that sliding wear resistance of the deposited coatings was different. The results are summarized in table 1 and the sliding wear rates histograms are shown in figure 5.

Comparing the obtaining result it can be seen that the material loss in case of WC Co was higher in comparison with the WC CoCr coatings. The phenomenon can be explained by the fact that addition of Cr to WC-Co improves binding of the metallic matrix with the WC grains and provides better wear resistant coating.

Table 1. Wear rate of the coatings.

Coating	Wear rate*10^{-7} [mm^3/N/m]
WC-Co	51.71
WC-CoCr	39.21

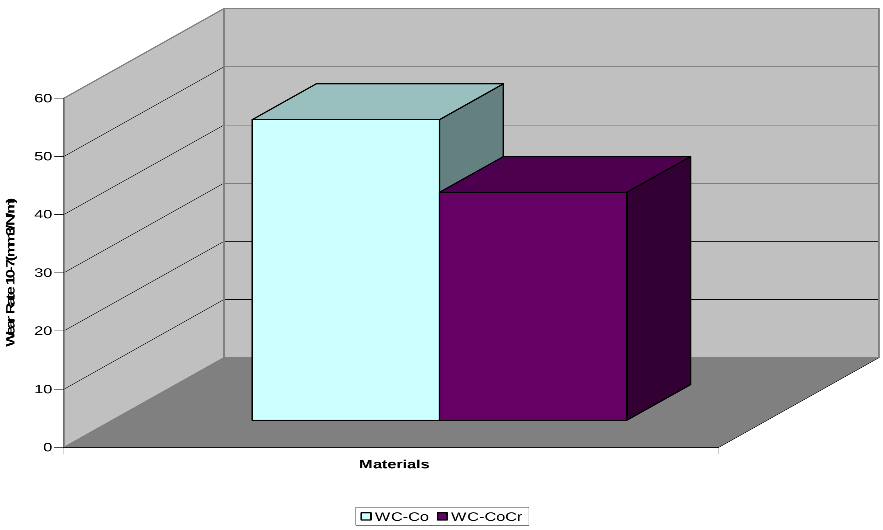


Fig. 5 Sliding wear rates of the tested samples

❖ CONCLUSION

Different HVOF coatings using WC-Co and WC-CoCr powders have been deposited onto the surface of a C45 steel substrate. The sliding wear resistance of the both coatings was analyzed using the pin on disk method.

Analyzing the obtaining results it was found that WC-Co coating has a higher wear rate in comparison with the WC-CoCr. This phenomenon can be explained by the fact that addition of Cr to WC-Co improves binding of the metallic matrix with the WC grains and provides better wear resistant coating.

In conclusion it can be said that WC-CoCr is considered to be a potential wear resistant coating material as compared to WC-Co coating.

❖ ACKNOWLEDGEMENT

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