A comparative study on wear property of WC-CoCr and WC-CrC-Ni coatingssprayed by HVOF

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Abstract : High velocity oxy-fuel (HVOF) thermal spraying coating has been used widely throughout the last 60 years mainly in defense, aerospace, and power plants. Recently this coating technique is considered as a promising candidate for the replacement of the traditional electrolytic hard chrome plating (EHC) which pollutes the environment and causes lung cancer by toxic hexa-valent Cr^{6+}. In this study, two kinds of cermet coatings, WC-CoCr and WC-CrC-Ni, are formed by HVOF spraying. The wear properties of coatings are evaluated comparatively by reciprocating sliding wear tests at 25 ℃, 250 ℃ and 450 ℃ respectively. Wear rates show that WC-CoCr coatings have better sliding wear resistance than WC-CrC-Ni coatings regardless of temperature due to more, compact and homogeneously distributed WC particles, less metal content, Co, Cr rich metallic bindermatrix with higher fracture strength and better adhesive strength with WC particles.

1. Introduction

Electrolytic hard chrome (EHC) has been extensively used for many years in applications that require wear and corrosion resistance, such as hydraulic cylinders, rotating shafts, aircraft landing gears, valves, rolls and machines tools. However, the toxicity of the galvanic bath and the hex valence chromium (Cr^{6+}) are environmental problems leading to high waste-disposal costs. Furthermore, the often required post-plate baking and if necessary, the grinding of an unevenly thick chrome layer also add to the cost. Additional disadvantages are the micro-crack network due to large internal tensile stresses, the low deposition rates and the limited corrosion protection of the substrate. Recently, high velocity oxy-fuel (HVOF) thermal spraying technique is considered as a promising candidate for the replacement of EHC. Typically, WC-Co coating is used due to its excellent wear resistance. However, this coating has lower corrosion resistance as compared to other cermet coatings. Therefore, more studies into other cermets coatings have been carried out. In addition, to satisfy a specific set of requirements, an in-depth knowledge of the various coatings' properties and performance is essential.

In this paper two kinds of cermet coatings, WC-CoCr and WC-CrC-Ni, are formed by HVOF spraying. The wear properties of coatings are evaluated comparatively by reciprocating sliding wear tests at 25 ℃, 250 ℃ and 450 ℃respectively.

2. Results and discussion

The wear and friction behaviors of WC-CoCr and WC-CrC-Ni coatings have been investigated by sliding wear test at 25 ℃, 250 ℃ and 450 ℃.

Fig.1 shows the SEM images of wear traces. The traces on WC-CrC-Ni coating are wider than WC-CoCr which indicates more surface area on WC-CrC-Ni is involved in the sliding tests at the three temperatures. It seems that the load applied to the counter-balls cause the abrasive effect on the coatings surface, hence few local plastic deformation like wear tracks and scratches can be seen on worn surface. And it is noticeable there are some cracks which are perpendicular to sliding direction on WC-CrC-Ni trace at 450 ℃ in terms of shear stress during reciprocating sliding contact.

Fig.2 reveals more details about wear traces by the magnified SEM images. Some white particles with diameter of several μm (indicated by black arrow) distribute disorderly on the surfaces especially at 25 ℃. EDS depicts that they are WC particles mixed with some metallic matrix and oxides. These hard particles may work as third-body particles between worn surfaces and counter-balls which scratch the surface and increase the amount of wear loss. It can be also seen that the higher the applied temperature, the less the white particles and the smoother the worn surface.

In Fig.3, the cross-sections of wear traces have been shown. At 25 ℃ and 250 ℃, the wear traces on WC-CoCr are shallowcompared with WC-CrC-Ni. And it can be observed that there is evidence of deep detachment and significant damage on both coatings probably due to the sliding abrasive hard particles. However, there is no distinct difference of depth between wear traces on both coatings at 450 ℃. Moreover, these worn surfaces without deep detachment or serious damage at 450 ℃ are smoother that at 25 ℃ and 250 ℃, which is consistent to the SEM images shown in Fig.2.

Table 5-1 also lists the wear rates of coatings which are calculated from the profiles of wear traces. On the one hand, it can be seen that the temperature has the same effect on wear rates, that is, when the temperature is raised the wear rates increase. On the other hand, WC-CoCr coatings own less wear rates than WC-CrC-Ni coatings at 25 ℃, 250 ℃ and 450

℃. It means that WC-CoCr coating has better sliding wear resistance than WC-CrC-Ni coating regardless of temperature.

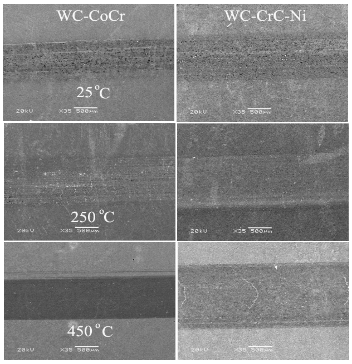

Figure.1 SEM images of wear trace after sliding wear test

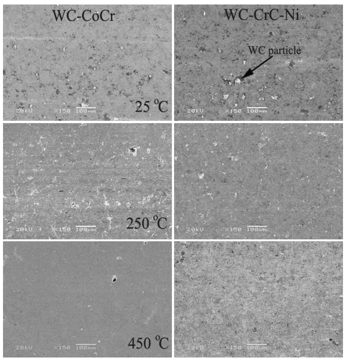

Figure.2 SEM images of high magnified wear trace after sliding wear test

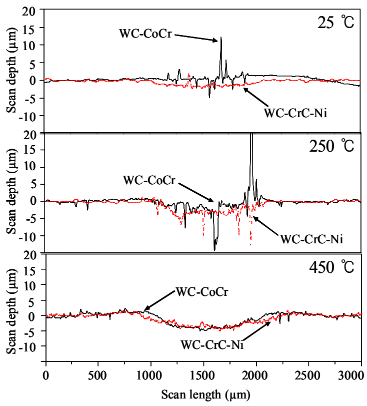

Figure.3 Depth profiles of wear trace after wear test at 25 ℃, 250 ℃ and 450 ℃.

Table.1 Average friction coefficient and wear rate of WC-CoCr and WC-CrC-Ni coatings.

Temp	Wear rate (mm^3/N●min)	
	WC-CoCr	WC-CrC-Ni
25 ℃	0.039	0.206
250 ℃	0.329	0.438
450 ℃	0.726	0.842

3. Conclusion

When the temperature is raised the wear rates increase for both coatings. But wear rates show that WC-CoCr coatings have better sliding wear resistance than WC-CrC-Ni coatings regardless of temperature due to more, compact and homogeneously distributed WC particles, less metal content, Co, Cr rich metallic binder matrix with higher fracture strength and better adhesive strength with WC particles and lower porosity.

Acknowledgement

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