PROPERTIES OF NANOSTRUCTURED COMPOSITE POWDER COATING

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ABSTRACT

The cumulative-detonation technology and equipment is created for deposition of nanocomposite powder coatings on samples of heat-resistant nickel-chrome alloys. The gas mixture consumption (propane-oxygen-air) is 5 м^3 per 1 kg of powder. The dense layer from lamellas and deformed particles is formed on the sample surface. It was established that hardness of the fine lamellae in the coating was 1384±120 $HV_{0,01}$, the deformed particles - 983,2±21 $HV_{0,01}$, the substrate material – 698±45 $HV_{0,01}$. Scratch-test has shown that the coating is superplastic and has the high adhesive and cohesive strength.

Key words: the cumulative-detonation technology, nanocomposite, lamellas, hardness, adhesive strength

INTRODUCTION

It is now widely used the following methods of spray coating: plating, metal and plasma spray. However, their properties, in some cases do not meet the requirements. So, because of the relatively low bond strength of such coatings to the substrate is limited by their use in machines and mechanisms operating at impact, and reaching 10% porosity makes it impossible for their operation in hostile environments [1]. In this regard the purpose of this study is to develop a power-saving technology and equipment for deposition of protective powder coatings on surfaces of heat-resistant nickel-chrome alloys. The main problem is to provide a high adhesion of thin coatings to the substrate.

METHODS OF SAMPLE MANUFACTURING AND ANALYSIS

The cumulative-detonation technology and equipment is created for deposition of nanocomposite powder coatings on samples. The device provides a high velocity of the powder materials (>800 m/s) without its overheating. Productivity 0.5÷1 kg/hour, gas mixture consumption (C_3H_8+O_2) – 2.84 m^3/hour, frequency – 17 Hz, the nozzle section to a specimen 30 mm.

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It is used CoCrNi powder with fraction 5-50 μm (*Fig.1*). Specimens of an alloy of heat-resistant nickel-chrome were used as a substrate. A uniform coating ~ 60 μm thick was deposited on the specimen surface.

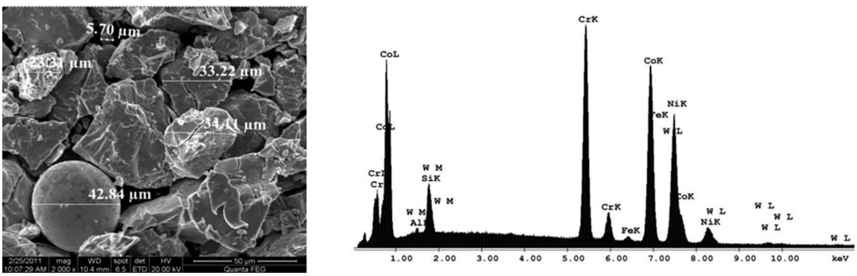


Fig. 1 – Morphology and elemental composition (energy dispersive spectrum) of titanium powder (SEM)

Morphological and compositional characterization of CoCrNi powder and coating surface were performed using electron ion microscope Quanta 200 3D equipped with integrated microanalysis system Pegasus 2000 (SEM-EDS). The Vickers hardness was measured by means of a microhardness tester under loads of 10-50 g. The hardness was calculated by the diagonal length ‘‘d’’. The time of indentation in the surface of the material had been 15 seconds. Adhesive, cohesive strength and the mechanism of coating destruction are defined by the scratch-tester REVETEST (CSM Instruments). Coating was deformed by a spherical diamond indenter of the “Rockwell C” type with a rounding radius of 200 μm at a continuously growing load in a range of 0.9-200 N. Results of the element analysis and defects in the deformed coating were studied.

RESULTS AND DISCUSSION

The microstructure and elemental composition showed that the coating (~0.6 mm thickness) is uniform, dense with a good adhesion to the substrate (Fig. 2). The bulk of the coating material is deformed and densely packed. The study of morphology of the coating-substrate boundary is established that the visible boundary has no defects and fixed penetration of the coating to the substrate. High-speed deformation of dispersed particles of CoCrNi leads to fragmentation of them into smaller particles. The analysis performed allows a conclusion that the fine powder particles were heated and deformed to a state of fine lamellae, and that they filled up the spacings between the coarse particles to form a dense coating. Thickness of the lamellae in the coating was 0,2÷1 μm.

It was established that hardness of the fine lamellae in the coating was 1384±120 $HV_{0,01}$, the deformed particles - 983,2±21 $HV_{0,01}$, the substrate material – 698±45 $HV_{0,01}$. The substrate under the coating is hardened.

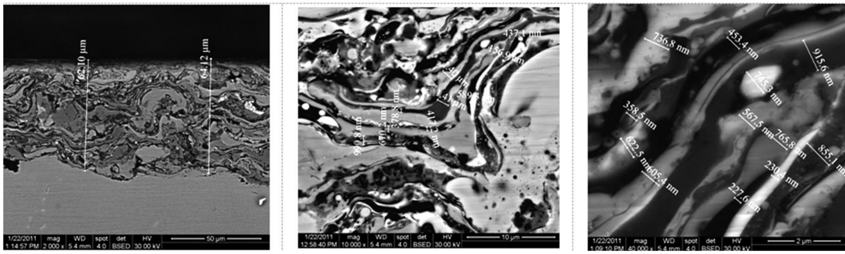


Fig. 2 – Structural analysis of CoCrNi coating (SEM)

In this study, adhesive strength was determined by optical microscope, critical load of L_C, which led to the destruction of the coating and the changing curves of the coefficient of friction and acoustic emission of the load (*Fig. 3*).

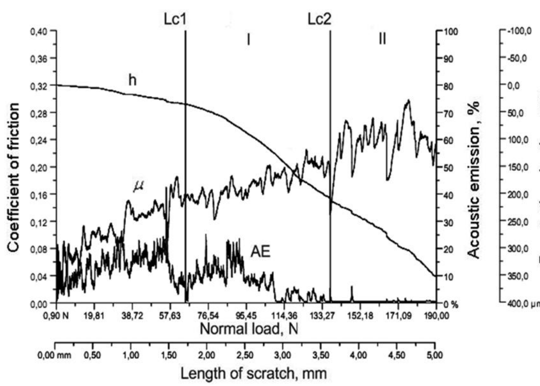
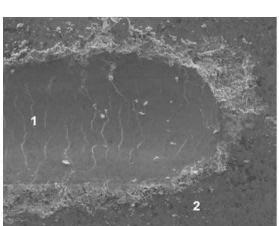


Fig. 3 – Results of adhesion tests

Figure 3 shows that with the increase of the load cover is pressed into the substrate material, which is accompanied by multiple chevron (transverse) cracks in the bottom of scratches and heavy cohesive failure of the material that forms the border sintering.

However, the elemental analysis of a trace of deformation was showed that at the maximum possible load on scratch-tester about 190 N was not a delamination of coating (Fig. 4). Elemental analysis of traces of deformation of the diamond indenter showed the same content of elements in the deformed parts of the coating and the coating.



Point	Wt.%			
	Al	**Cr**	**Co**	**Ni**
1	10,00	19,77	42,02	7,22
2	10,54	18,26	36,30	6,29

Fig. 4 – Elemental composition of system of "coating – substrate" at the point of contact with indenter; load 190 N.

CONCLUSIONS

The cumulative-detonation technology and equipment is created for deposition of nanocomposite hardening heat-resistant powder coatings on the heat-resistant samples. The gas mixture consumption (propane-oxygen-air) is up to 6.3 m^3 per 1 kg of powder. The dense layer from lamellas and deformed particles is formed on the sample surface. The technology provides high quality face-boundary between coating and substrate due to the interpenetration of the materials. Formed coating has high density, adhesive, cohesive strength, hardness of the fine lamellae in the coating.

Acknowledgements

Work is carried out by Joint Research Center of Belgorod State University in the framework of the federal target program under Grant application No 14.740.11.1017.

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