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Effect of tribological conditions for properties thermal spraying

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Abstract
The present contribution deals with the influence of tribological conditions on coating quality. Two types of coatings were selected for analysis WC-WB-CO and WC-FeCrAl, to advise that a new type of coating - carbide green. These coatings were applied to the base material AISI 316L of technology HVOF – High velocity oxygen fuel. The aim of the experimental study was to determine the quality coatings and its resistance to abrasive wear, depending on the number of thermal cycles. It was evaluated hardness, thickness, the resistance to abrasive wear in free abrasives and firmly bonded abrasives. Results of experiments showed a higher resistance of the coating WC-Co-WB.

1. Introduction

Thermal spraying process enables to create coatings on large areas and at high speed during the application of those coatings in comparison with other methods of renovation machine parts. High speed thermal spraying of flame is a suitable method for creating of coatings from different kinds of materials including metals, ceramics, cermet and many others. Technology HVOF (high velocity oxygen fuel) creates a homogeneous, dense coating with high strength, excellent adhesion, low oxide content and the pore. Machine parts are constantly exposed to factors that reduce their life, namely their functionality. These factors include, for example, high temperature, corrosion environments, adhesive wear and many others. The coating applied of HVOF technology may be applied to protect chemical tanks, repair of engine parts, in coastal areas due to corrosion, such as prevention adhesive, erosive and abrasive wear. Abrasive wear is the most common way of wear of parts which functional surfaces are brought into contact. A typical surface damage with abrasive wear is known as scratches (SAHRAOUI T. A. 2010, ALVARADO-OROZCOJ. E. A. 2016, BOLELLI G. A. 2014, BREZINOVÁ J. A. 2015, VIŇÁŠ J. A. 2013, GUILEMANY J. M A. 2011).

The article presents the results of research on the effects of tribological conditions on the properties of thermally sprayed coatings.

2. Methodology of research

The coatings were applied to the material steel AISI 361L. This material is resistant to corrosion and acids. The chemical composition of the base material shown in the Table 1.

Experimental studies were carried out on samples of circular cross-section diameter 25 mm and height 60 mm. The surface of the base material was before application blasted prior to in terms of air blasting, with the distance from the nozzle 300 mm blasting angle of 90° and used blast pressure of 0.4 MPa. The abrasive used was white corundum with a grain size 0.56 mm. Experimental work was carried out on two types of coatings, which have been specially developed for application of HVOF technology.

Table 1. The chemical composition of the AISI 316L, wt.%

C	**Si**	**Mn**	**P**
0.07	1	2	0.4
S	**Cr**	**Mo**	**Ni**
0.3	16.5 – 18.5	2 – 2.5	10.5 – 13.5

Coating WC-Co-WB resist erosive, cavitation and abrasive wear. The second coating of WC-FeCrAl which was applied has an excellent corrosion resistance, abrasive, erosive and cavitation wear. It does not contain cobalt nor nickel, is environmentally friendly and belongs to a group of new green carbides. The chemical composition of the evaluated coatings is shown in Table 2.

Table 2. The chemical composition of the coatings

wt (%)	C	Fe	Cr	Al	WC	WB	Co
WC-FeCrAl	5.4 – 5.9	10 – 12	2.5 – 3.8	0.6 – 1.2			
WC-WB-Co					60	30	10

Application device which was used is PRAXAIR Tafa JP 5000, with the system HP / HVOF and powder feeder HVOF System Powder Feeder 1264. After the application of coatings, thermal cyclic loading in chamber electric furnace were applied. The samples were heated to the temperature of 600°C and held for 10 minutes, followed by cooling in air. Selected number of cycles was 5 and 10.

The thickness of the coatings was evaluated on scratch pattern with used program the Quick PHOTO CAMERA 2.3. The hardness of the coatings was evaluated by Vickers method on cross sections of samples on the device HMV-2V Microhardness Tester SHIMADZU pursuant to EN ISO 9015-2:2016-04.

The resistance to abrasive wear was evaluated by weight loss W_h and in free abrasives and firmly bonded abrasives (abrasive cloth). The test was realised on a laboratory equipment APGi from the manufacturer VEB Leipzig. Alumina abrasive paper with different grain size 80 marked P80 and 120 marked P120 were used. During the experiment reacted on a sample contact force 10 N. The sample passed about abrasive paper track 40 m and circumferential speed was 0.33 m s^{-1}.

Resistance by evaluated coatings to abrasive wear in free abrasive was evaluated by modified tests in laboratory equipment Di-1, which was developed at the Department of Engineering Technology and materials, Faculty of mechanical engineering TUKE. Size of wear was determined by gravimetric method in determining the coating weight loss. The essence of this test is relative movement of test samples wading in free abrasive. For this test has been used abrasives brown aluminum oxide (Al_2O_3) used fraction d = 0.75 mm. Starting angle of abrasives on the surface of the coating was 45°. The weight loss was evaluated after 360 min.

3. Results and discussions

Based on the above methodology it was evaluated by coating hardness, thickness and resistance to abrasive wear. The thickness of coatings was from 154.2 to 159.7 µm. The measured hardness values of the coatings graphically represents the picture (Fig 1).

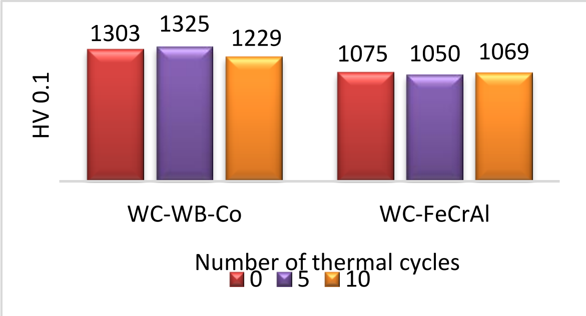

Fig. 1. The microhardness of coatings

From the measured values hardness of the coating it can be stated that the higher the average value of the hardness was measured for the coating WC-Co-WB. The average hardness values range from 1050 to 1325 HV 0.1. Thermal cycling slightly influenced the hardness of the coatings.

Based on the above methodology it was evaluated abrasive wear of coatings. The measured values of weight loss are diagrammatic in the pictures (Fig. 2, Fig. 3).

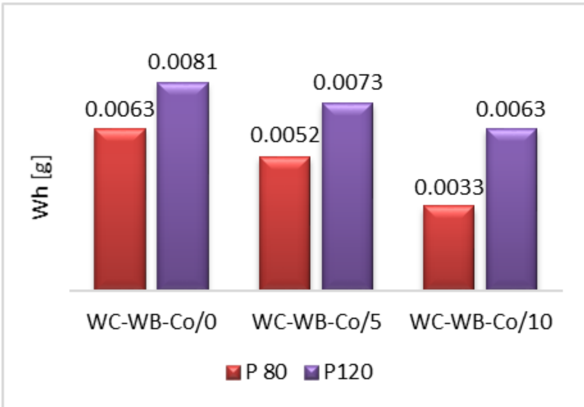

Fig. 2. Weight loss of coatings after abrasive wear – firlmy bonded abrasive

The greatest weight loss was recorded on the coating WC-FeCrAl without thermal cycles using abrasive cloth of grit 120. The smallest weight loss was recorded on the coating WC-Co-WB after ten thermal cycles using abrasive cloth of grit 80. Higher values of weight loss have been reported with the use of emery cloth grain size of 120, due to a larger number of grains which wear coating.

The results of abrasive wear of coatings in free abrasives are shown in Figure (Figure 4).

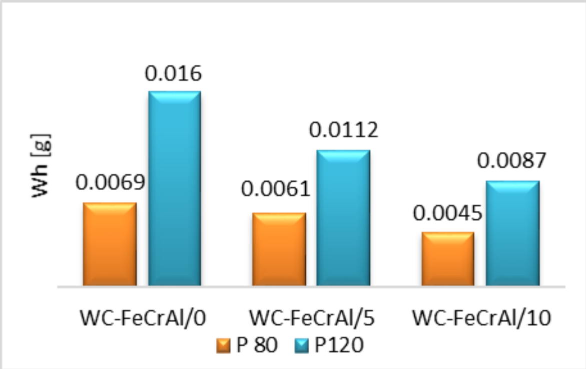

Fig. 3 Weight loss of coatings after abrasive wear – free abrassivum

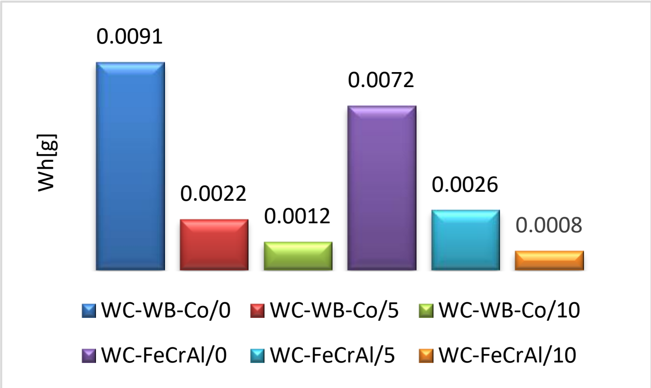

Fig. 4. Weight loss of coatings after abrasive wear – free abrasivum

From the measured results show that the evaluated coatings has high resistance to abrasive wear, and a small material removal. Higher wear resistance achieved samples subjected to thermal cyclic loading.

4. Summary and conclusions

The aimed of paper was to highlight the quality of the coatings evaluated in tribological conditions applied by HVOF technology. They were evaluated two types of coatings, coating WC-FeCrAl consisting of tungsten carbide and alloys. Second evaluation coating, the coating was WC-Co-WB. The coatings were subjected to thermal cyclic loading. The thickness, hardness and the resistance to abrasive wear under conditions of free abrasives and firmly bonded abrasives was evaluated. The thickness of the evaluated coatings was from 154.2 to 159.7 μm. The hardness of coatings was from 1050 to 1325 HV 0.1. Higher values of hardness were measured for the coating WC-Co-WB because this coating has higher proportion of carbide particles that form the coating. A higher weight loss in assessing the resistance of coatings to abrasive wear was recorded in conditions of firmly bonded abrasives with grain size 120. The lower loss weight was observed in conditions of free abrasives. In both cases, decreased weight loss by influence to the number of thermal cycles. On the basis of experimentation it can be stated that the coating WB-WC-Co is more resistant to abrasive wear. The measured results indicate that both rated coatings have a high resistance to abrasive wear.

Acknowledgements

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摩擦學條件對性能熱噴塗的影響

關鍵詞

HVOF，磨料磨損，
Wc-FeCrAl，
顯微硬度

摘要

本文介紹了摩擦學條件對塗層質量的影響。 選擇兩種類型的塗層用於分析WC-WB-CO和WC-FeCrAl，建議一種新型的塗層 - 碳化物綠色。 這些塗層應用於基礎材料AISI 316L技術HVOF - 高速氧燃料。
實驗研究的目的是確定質量塗層及其對磨料磨損的耐受性，這取決於熱循環的數量。
它評價了硬度，厚度，自由磨料中的磨料耐磨性和牢固粘結的磨料。 實驗結果表明，塗層WC-Co-WB的電阻較高