ZESZYTY NAUKOWE POLITECHNIKI RZESZOWSKIEJ Nr 270
Mechanika z. 78 2009

Daniel JANKURA, Pavol PAPCUN
Technical University in Košice

EVALUATION OF STRUCTURE OF CERAMICS AND COMPOSITE COATINGS PREPARED BY HEATING SPRYING

The contribution is focused on the possibility of creation of ceramic coatings (Al_2O_3) and composite coatings based on ceramic (Al_2O_3) – metal (Ni). Metallographic and microscopic observation of coatings was prepared in aspect of making their own layer, its bond to the base substrate and the bonds between individual particle coatings. Structure and chemical composition of the investigated coatings was carried out using the electron microscope JEOL JSM – 7000 F with microanalyzer INCA.

Keywords: coating, composite, ceramics

Introduction

Nowadays the spraying technologies bring new opportunities in the manufacturing and renovations. In a number of high sectors, for example in mechanical engineering, energy, aviation and automotive industry, chemistry and electrical engineering, these technologies are widely applied. The aim is to improve the quality of surface properties of individual components. The various ways of application of heating coatings to the forefront of technology gets plasma spraying. Plasma spraying technology allows virtually apply all technically usable materials with suitable properties for metal and non-metallic substrates. Metal, ceramic and metal-ceramics coatings have been applied. The majority of applied coatings form ceramic-based coatings, especially oxides (Al_2O_3, Cr_2O_3, ZrO_2, MgO, CaO), [3].

Experimental procedure

Properties of ceramic and composite coatings prepared by plasma spraying are dependent on the structure created, which is defined as the entirety of the coating, its adhesion to the base substrate, adhesion between the particle, cohesion, the internal defects (cracks, pores). For research was prepared the ceramic Al_2O_3 powder with grain size from 40 to 90 μm, composite powders with a volume ratio of the following components: Al_2O_3 + 5% K, Al_2O_3 + 12% K30. K30 – metal powder composition of the following: C max 0.1% max Si 3.5%, B max 2.5%, Cr 2.5% max, Fe 0.5% max, Ni remainder. Grain size in the range from 45 to 90 μm. The surface of the substrate before spraying was pretreating by blasting. On the basis of indigenous knowledge was elected sharp blasting equipment – corundum grit on the grain size d = 1÷1.2 mm. The speed of blasting grains in the process was v = 80 m/s. Blasting was carried by the laboratory devices Di-2 [5]. Steel samples which dimensions are 100 x 50 x 5 mm were applied to study the construction and structure of powder coatings.

Spraying coatings were made on plasma device with a water stabilization of the arc. Water stabilized plasma has higher performance than traditional methods as for example gas-stabilized devices and also significantly (approximately twice) higher temperature (30 000ºC), therefore it is suitable to apply of high-melting ceramics. The device is therefore suitable for the production of coatings on large areas or to create a greater thickness of coatings. In plasma spraying liquid stabilized plasma is generated from gas liquids, for example, from the water and ethanol or methanol [2]. Investigation of structure and chemical composition of the investigated coatings was carried out using the electron microscope JEOL JSM – 7000 F with a microanalyzer. Chemical analysis was carried out using the INCA analyzer. INCA analyzer – energy dispersive EDX analyzer allows local chemical analysis of material – microstructure analysis, the heterogeneity of composition and so on.

Results and discussion

Figure 1 shows the construction of the surface ceramic coating consisting of aluminum oxide (Al_2O_3). The surface coating is significantly heterogeneous, consisting of individual particle in the form of discs, non-melting and partially fused particles of different size and shape. On the surface there is hollow, which creates a low formability a new layer, which merely copies the rugged surface. Pores occurring in the coating dimensions are small but numerous. Dispersed particles are large-scale expansion due to freezing stress cracked. Figure 1b shows the dendritic structure of partially fused particles on the surface of the ceramic coating.

Overall view of the construction of the composite surface coating (Al_2O_3 + 12% K30) is presented in the Figure 2. In comparison with a ceramic coating, consisting of pure alumina, the construction of the coating does not change, but overall it can be stated that this film contains fewer defects in terms of the occurrence of pores and cavities, but most of cracks caused by expansion stresses in solidification. Presumably, the addition of the metal components

a) b)

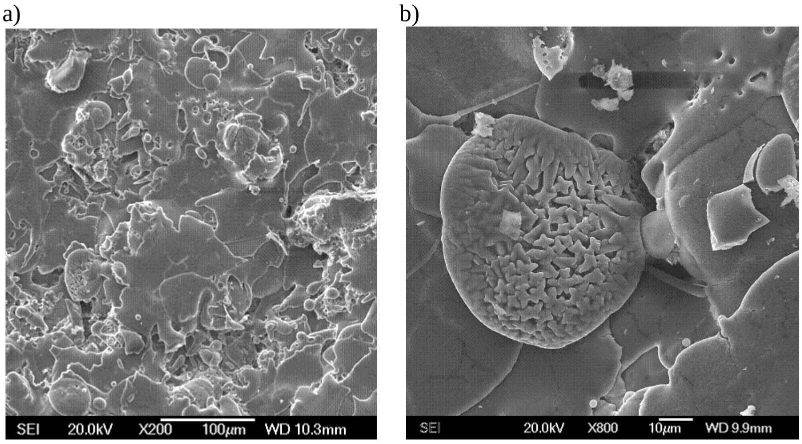


Fig. 1. Structure of the ceramics coating showing dispersed particles (a) and dendrite (b)

Rys. 1. Struktura powłoki ceramicznej Al_2O_3 z widocznymi cząstkami (a) oraz dendrytami (b)

a) b)

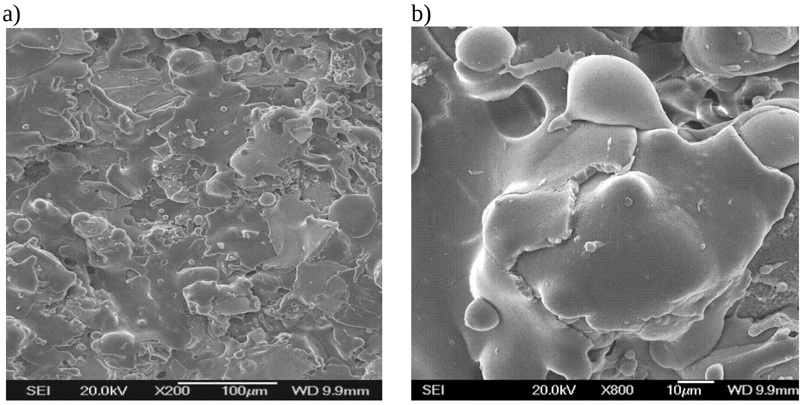


Fig. 2. Structure of composite coating Al_2O_3 + 12% K30 – smaller (a) and larger magnification

Rys. 2. Struktura powłoki z kompozytu Al_2O_3 + 12% K30 – mniejsze (a) i większe (b) powiększenie

of nickel-based K30 expansion eliminates tension, caused by a different coefficient of thermal expansion of steel grade 11 (11.1÷11.7.10-6 K-1), [6] and alumina (7÷8.10-6 -1), [7]. The coefficient of thermal expansion of nickel is 12÷13,5.10-6 K-1 [8], therefore the presence of nickel in the composite coatings can eliminate these expansion tension in coatings. On the surface can be observed little deformed oval particles, chemical analysis shown that it is a component based on nickel. In Figure 2b is shown more detailed view of the construction and structure of the composite surface coating on the basis of Al_2O_3 with an average of 12% addition of the metal components of nickel-based K30.

Figure 3a, b presents the typical lamellar structure of the composite coating that is similar to the ceramic coating, consisting of aluminum oxide (Al_2O_3). Splats on the basis of nickel (white areas), as compared to Al_2O_3 splats much thinner, whereas nickel is plastic so it perfectly replicate. These nickel splats create interlayer between Al_2O_3 layers and thus increase their cohesion. This probably increases the cohesion strength of the composite coating and adhesion to steel substrate. The complexity of microscopic examination was on the surface of a ceramic composite coating made chemical analysis to confirm the presence or absence of metallic components of K30-based nickel coatings. Figure 4 shows chemical spectral analysis of the surface composite coating Al_2O_3 + 12% K30 (spectrum 12). Chemical spectral analysis implemented using microanalyzer INCA confirmed the presence of metallic components of K30-based nickel in composite coating.

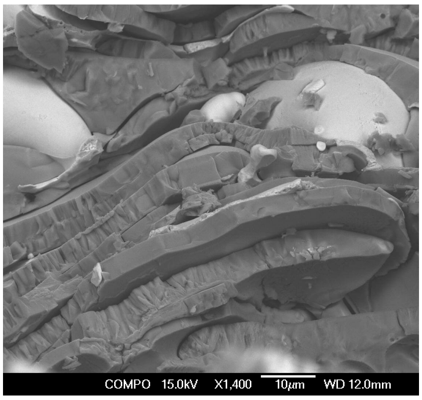
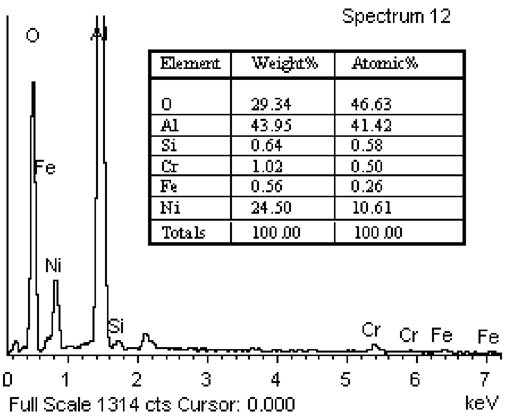


Fig. 3. Lamellar structure of the composite coatings
Rys. 3. Lamelarna struktura powłoki kompozytowej



Element	Weight%	Atomic%
O	29.34	46.63
Al	43.95	41.42
Si	0.64	0.58
Cr	1.02	0.50
Fe	0.56	0.26
Ni	24.50	10.61
Totals	100.00	100.00

Fig. 4. Chemical spectral analysis of the composite coatings Al_2O_3 + 12% K30
Rys. 4. Wynik analizy spektralnej składu chemicznego powłoki kompozytowej Al_2O_3 + 12% K30

Conclusions

The contribution was focused on the research of the composite coatings based on Al_2O_3 with the addition of metallic components K30 based on nickel. Coatings were developed by technology hot plasma spraying with water stabilization of the arc. First results from the study of the composite coatings Al_2O_3 + K30 showed, that addition of metal-based components within nickel ceramic matrix improves the building and the structure of the coating, but particularly in terms of minimizing the expansion stresses.

References

[1] Jankura D.: Abrazívne vlastnosti keramických povlakov na báze Al_2O_3, Acta Mechanica Slovaca, 10 (2006), 10-16.
[2] Matejka D., Benko B.: Plazmové striekanie kovových a keramických práškov, Alfa, Bratislava 1988.
[3] Papcun P.: Stavba a vlastností keramických žiarovo striekaných povlakov, PhD thesis, TU SjF, Košice 2006.
[4] Polak J.: Štúdium tvorby a vlastností nových kompozitných žiarovo striekaných materiálov, PhD thesis, TU SjF, Košice 2006.
[5] Sololenko O.P.: Thermal plasma torches and technologies. Cambridge International Science Publishing, Cambridge 2000.
[6] http://www.matnet.sav.sk/index.php/ID=158
[7] http://www.matnet.sav.sk/data/files/811.pdf
[8] http://www.matnet.sav.sk/index.php/ID=315

The contribution has been processed in the framework of grant the VEGA project No. 1/0144/08.

BADANIA STRUKTURY POWŁOK CERAMICZNYCH ORAZ KOMPOZYTOWYCH NANOSZONYCH POPRZEZ NATRYSKIWANIE TERMICZNE

Opracowanie dotyczy możliwości kształtowania powłoki ceramicznej oraz kompozytowej na bazie ceramika (Al_2O_3) – metal (Ni). Przeprowadzono badania metalograficzne powłok w celu zaobserwowania struktury utworzonych warstw, połączenia powłoki z materiałem bazowym, jak również połączeń pomiędzy poszczególnymi cząstkami powłoki. Badania struktury oraz składu chemicznego zrealizowano za pomocą mikroskopu elektronowego JEOL JSM – 7000 F z mikroanalizatorem INCA.

Słowa kluczowe: powłoka, kompozyt, ceramika

Received in November 2009.