EFFECT OF THE SHAPE OF TUNGSTEN CARBIDE PARTICLES ON THEIR MICROHARDNESS, CHEMICAL HETEROGENEITY AND WEAR RESISTANCE OF THE COMPOSITE DEPOSITED METAL

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Results of investigations of spherical and non-spherical particles of tungsten carbides $WC-W_2C$ produced by the method of thermal centrifugal spraying are described. Chemical and energy-dispersive spectral analyses of the particles were carried out. Wear resistance of clad samples was investigated. It was shown that part of the non-spherical particles can be used for deposition of composite coatings.

Keywords: *tungsten carbides, thermal centrifugal spraying method, spherical particles, non-spherical particles, composite deposited metal*

In production of granulated tungsten carbide powders by different technologies [1] the finished material contains certain amounts of non-spherical particles, the presence of which leads to substantial deterioration of flowability of the powders. This violates stability of operation of feeding devices in plasma powder, laser and other cladding methods.

Table 1. Data of X-ray spectral microanalysis of different shapes of powder particles

Shape of particles	Content of elements, wt.%		
	C	Fe	W
Non-spherical	3.70	–	96.30
	13.24	0.60	86.16
	9.27	0.73	90
Spherical	4.85	–	95.14
	4.79	0.31	94.90
	4.93	0.10	94.97

The special vibration table was developed, which can be used to separate particles of the non-spherical shape from total mass of the granulated powders, as well as to produce powders with their much lower content [2]. However, even the vibration table fails to fully separate particles of the non-spherical shape.

The task of the authors was to investigate chemical heterogeneity of tungsten carbide particles of different shapes produced by the thermal centrifugal spraying method and effect of the non-spherical particles on wear resistance of the composite deposited metal.

Samples of tungsten carbide powders of spherical and non-spherical shapes (particle size composition — 100–250 μm) produced by the thermal centrifugal spraying method were taken for the investigations.

Chemical heterogeneity of different shapes of the tungsten carbide powder particles was studied by using scanning electron microscope CAM SCAN 4 with LINK ENERGY 2000 system (energy-dispersive analyser) [3]. Figure 1 shows distribution of tungsten, carbon and iron in the investigated particles, and Table 1 gives results of the elemental analysis conducted at different local points.

It should be noted that the point analysis may involve the probability of deposition of carbon on the

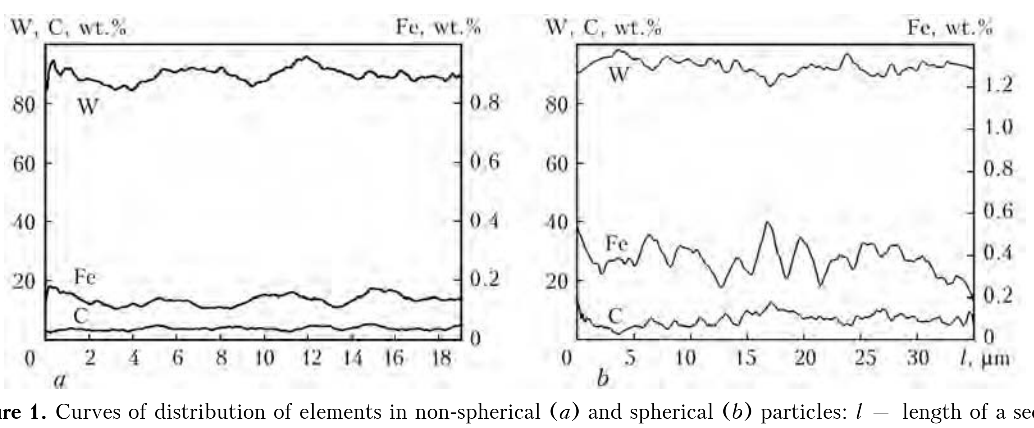

Figure 1. Curves of distribution of elements in non-spherical (*a*) and spherical (*b*) particles: *l* — length of a secant

Table 2. Content of carbon in particles and their microhardness

Shape of particles	Content of carbon, wt.%	$HV100$, MPa
Non-spherical	4.12	2764 ± 187
Spherical	3.96	2914 ± 254

surface of a particle being investigated. In this case the carbon indicators become overstated. These results will be much more accurate if a bigger surface area of the particle is scanned. However, the data obtained in determining the carbon content by the chemical analysis method should be considered most reliable (Table 2).

The investigations showed that particles of the spherical shape have more consistent values in terms of chemical composition and microhardness. The St3 steel samples with a diameter of 10 mm and 20 mm long were clad to study wear resistance of the composite coatings produced by using the tungsten carbide powder as a wear-resistant component. Nickel silver of the MNMts60-20-20 grade was used as a binder alloy for all the samples. Cladding of the samples was performed in graphite crucibles by the plasma arc method. Three samples each with a different content of particles of the non-spherical shape were clad.

Wear resistance was investigated by using unit NK-M [4]. According to this procedure, the semi-fixed abrasive was applied to cause wear, the quartz sand being used as the abrasive. The samples of annealed steel 45 served as a reference. To compare, the tests were also conducted on the samples clad with crushed tungsten carbide.

As shown by the investigations results (Figure 2), wear resistance of the clad samples, the reinforcing phase of which contains up to 20 % of particles of the non-spherical shape, was only 10–12 % lower than that of the samples with the spherical reinforcing phase. Thus, some content of non-spherical particles in the composite deposited metal with the tungsten carbide-base reinforcing phase is quite tolerable.

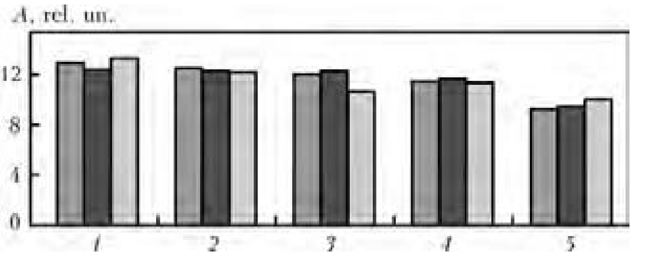

Figure 2. Diagram of wear resistance (A) of samples clad with composite alloys with different contents of non-spherical tungsten carbide particles: *1* — 100 % of spherical particles; *2* — 80 % of spherical particles + 20 % of non-spherical particles; *3* — 50 % of spherical particles + 50 % of non-spherical particles; *4* — 100 % of non-spherical particles; *5* — 100 % of crushed tungsten carbide particles; *1–4* — powders produced by thermal centrifugal spraying

Therefore, the tungsten carbide particles of the spherical shape produced by the thermal centrifugal spraying method have a more homogeneous chemical composition with regard to carbon and tungsten, while wear resistance of the clad samples, the reinforcing phase of which contains up to 20 % of the non-spherical particles, is only 10–12 % lower compared to the samples with the spherical reinforcing phase, which is acceptable for the composite deposited layers.

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