HIGH VOLTAGE CONSOLIDATION AND JOINING OF TUNGSTEN CARBIDE POWDER WITH STEEL SUBSTRATE

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Modern technology makes high demands on durability and operational strength of the bimetallic tungsten carbide cobalt tool (punches, chisels, cutting tool, etc.). The efficiency of such a cemented carbide alloy tool depends on the mechanical properties of tungsten carbide cobalt, and depends on bond strength of a tungsten carbide cobalt layer and steel substrate. High voltage consolidation (HVC) and simultaneously joining of tungsten carbide cobalt powder layer to steel substrate is very promising method of manufacturing stamping and cutting tools. High voltage electric discharge consolidation (HVC) [1] is a developed consolidation method which can produce near-net-shape products of high relative density much more rapidly than other conventional process such as pressure-less sintering, hot press and HIP. This method has demonstrated a potential to provide distinct technological and economical benefits in the consolidation of difficult-to-sinter powders, including short processing times, fewer processing steps, elimination of the need for sintering aids, and near net shape capabilities.

The formation of coating thickness of 1 - 2 mm from the commercial powder (VNIITS) on the surface of the hardened and tempered steel was investigated for various parameters of HVC method. This method uses the passage of the high-voltage pulse electric current to provide the resistive heating of the powder by the Joule effect. Joule heating occurs at the inter-particle contact to instantaneously weld powder particles, resulting in densification and bonding to steel substrate. The achieved WC-Co powder compact density as a result of HVC process depends on applied external pressure, magnitude and waveform of pulse current that depends on electrical parameters of the discharge circuit. The most important factor which determines the success of the HVC process is the current density amplitude in the powder specimen. We studied the influence of pulse current density on kinetics of electric discharge consolidation and joining of tungsten carbide – cobalt composite with steel substrate. The experimental dependence of WC-Co density has a maximum on fixed peak current density. The resultant WC–Co composite density increases within the current density region: from 90 kA/cm^2 to 100 kA/cm^2. The resultant density reaches the maximum value at ~ 100 kA/cm^2 and drastically decreases beyond 100 kA/cm^2.

The study of the microstructure of compounds were carried out on obtained by cross-sectional samples. We used optical metallography and high-resolution scanning electron microscope EVO 50 XVP manufactured by Carl Zeiss (Germany). Before examining the microstructure was carried out mechanically polished samples.

Microstructure analysis confirmed the preservation of the original grain size of tungsten carbide and lack of porosity on the contact surface between the cemented carbide layer and steel substrate. Measurement of the microhardness and the hardness of coatings showed that their values correspond to the values of industrial cemented carbide VC-10. Thus, microhardness of the coating has a value in the range of 14280 - 15200 МПа. Microhardness measurements of steel substrate have shown that the microhardness remained unchanged at a distance of 500 microns from the contact surface. Consequently, the zone of thermal influence in high-voltage electric discharge consolidation does not exceed 500 microns.

[1] E. G. Grigoryev and A. V. Rosliakov, The Electro-Discharge Compaction of Powder Tungsten Carbide - Cobalt - Diamond Composite Material, in: Advances in Sintering Science and Technology, edited by R. K. Bordia and E. A. Olevsky, Ceramic Transactions, Wiley, Vol. 209, 2010, p 205-209.