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Influence of Diamond–Matrix Transition Zone Structure on Mechanical Properties and wear of Sintered Diamond-Containing Composites Based on Fe–Cu–Ni–Sn Matrix with Varying CrB2 Content

Abstract: The influence of CrB2 additive (within the interval ranging from 0 to 8 wt%) on the formation of structure of the diamond–matrix transition zone and the matrix material, microhardness, elastic modulus, retention of diamond grains in Fe–Cu–Ni–Sn matrix material and wear resistance of sintered diamond-containing composites (DCCs) by the powder metallurgy method has been studied. Micro-mechanical and tribological tests were conducted using composite samples 10 mm in diameter and 5 mm thick. It has been established that the transition zone structure significantly depends on the CrB2 content in a composite and is of a different nature than that of the matrix material. The structure of DCCs transition zone based on 51Fe–32Cu–9Ni–8Sn matrix consists of Cu, α-Fe and Ni3Sn phases with graphite inclusions. The structure of DCCs transition zone based on 51Fe–32Cu–9Ni–8Sn matrix with CrB2 additives consists of the α-Fe phase and Fe3C, Cr7C3, Cr3C2 carbide layers without graphite inclusions.
It has been shown that the hardness and the elastic modulus of sintered composite matrix material increase linearly as the concentration of CrB2 in their content increases while the wear rate decreases. The addition of 2 wt% of CrB2 to 51Fe–32Cu–9Ni–8Sn composite contributes to an increase in its hardness from 4.475 to 7.896 GPa and elastic modulus from 86.6 to 107.5 GPa thus

reducing the wear rate from 21.61×10^{-6} to 10.04×10^{-6} mm^3 N^{-1} m^{-1}. The mechanism for enhancing the mechanical properties and wear resistance of DCCs samples containing CrB_2 additives consists in refining of matrix phases of iron and copper from 25 μm to 10 μm and binding the carbon released during the graphitization of diamond grains to Fe_3C, Cr_7C_3, Cr_3C_2 nanoscale carbides. This, in turn, increases the ability of matrix material to keep diamond grains from falling out during DCCs operation. Low values of mechanical properties and wear resistance of the initial (51Fe–32Cu–9Ni–8Sn) composite are attributed to the coarse-grained structure and formation of graphite inclusions in the diamond–matrix transition zone, causing its premature destruction and separation of diamond grains from the DCCs matrix.

Keywords: composite, diamond–matrix transition zone, content, concentration, structure, hardness, elastic modulus, wear rate