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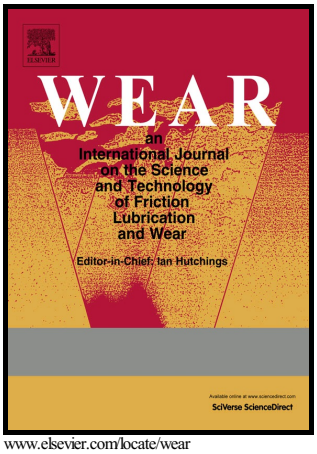

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Study of cracking mechanisms in multi-layered composite nano-structured coatings

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Abstract

The mechanisms of cracking in multi-layered composite nano-structured coatings deposited through the use of the technologies of filtered cathodic vacuum arc deposition (FCVAD) (coatings Zr-ZrN-(ZrCrAl)N, Cr-CrN-(TiCrAl)N, Zr-ZrN -(ZrNbTiAl)) and lateral rotating cathodes (coating Ti-TiAlN-TiAlN) are explored herein. The formed coatings are characterised by parameters such as hardness, adhesion strength to a substrate, elemental composition, microstructure, and the kinetics and mechanisms of wear. The microstructural studies have revealed the typical mechanisms of cracking and their influence on the kinetics of wear of coated carbide tools. The study also included extensive certification tests of cutting properties of tools equipped with cutting inserts of carbides with the coatings under study in thelongitudinalturningofsteelC45 (HB 200).The results of the studies have shown that all the coatings selected for study significantly increase the lifetime of carbide tools; the lifetimes were increased by up to 3–4 times in comparison with an uncoated tool and by1.5–2 times in comparison with a tool with a "reference" coating of TiN. The influence of ZrN on the cracking mechanisms of coatings and the kinetics of tool wear were also explored.

Keywords: wear-resistant coatings; wear; crack; fracture; tool life; PVD coatings.

Nomenclature

CI cutting insert
CF cutting fluid
NMCC nano-scale multi-layered composite coatings
FCVAD iltered cathodic vacuum arc deposition
FEM Finite Element Method
PCBN polycrystalline cubic boron nitride
REM rasterelectronmicroscope

σ_{ey} effective yieldstrength, GPa
K_1 factor of stress intensity
σ_1 maximum principaltension stress, GPa
K_{1C} critical factor of stress intensity of the 1st order (for bond-failure crack), $N/m^{3/2}$
r distance from crack tip to elementary area under study
μ Poisson's ratio
χ dimensionless ratio (defined for plane stress state as $\chi = \frac{3-\mu}{1+\mu}$).
v motion of crack face in the direction perpendicular to its growth
θ the angle of the considered point concerning the the direction of crack propagationΓ-surface energy, J/m^2
E modulus of elasticity of the 1st order (Young's modulus), GPa