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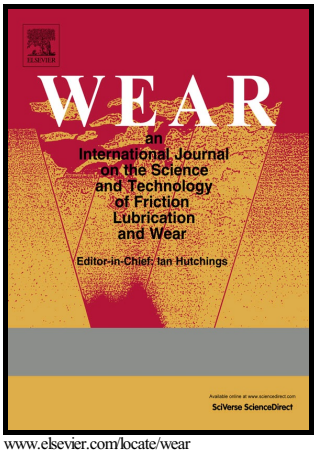

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Fatigue and surface spalling of cemented carbides under cyclic impact loading - Evaluation of the mechanical properties with respect to microstructural processes

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Abstract

Cemented carbides used in excavation tools have to feature particular mechanical properties to withstand impact loads and abrasive degradation processes. It is assumed that a high fracture toughness is important to counteract brittle material failure due to forced rupture (supercritical loads) or material fatigue caused by subcritical impacts or cyclic loads. The fatigue-induced failure mechanism on a microstructural scale (evolution of fracture) in cemented carbides is discussed controversially in the literature. We are thus focusing on fatigue-initiated surface degradation of cemented carbide grades during ground excavation. Various cemented carbide grades were loaded with cyclic subcritical impact loads that lead to microstructural damage. The crack path was analyzed by scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD). The number of endured load cycles is further correlated with the microstructural composition and the resulting mechanical properties of the tested grades. The results demonstrate that the commonly used correlation between resistance against fatigue load and fracture toughness K_{IC} does not seem to be suitable for describing subcritical crack growth in cemented carbides due to cyclic loads that lead to surface spalling and microfatigue. The cemented carbide grades with the highest K_{IC} values do not possess the highest resistance against surface spalling and thus the highest fatigue resistance. The influence of the microstructural properties (d_{WC}, V_{Co}, λ_{Co}) on the results has been shown. Furthermore, the correlation between fatigue sensitivity and crack path fractions was analyzed.

Keywords: cemented carbide, fatigue, surface spalling, wear resistance, cyclic impact

Introduction

Underground and surface mining, tunneling, and rock drilling are procedures that place high demands on excavation tools due to severe wear [1]. Therefore, most tools have inserts and areas made of cemented carbide (75-96 vol.-% of tungsten carbides embedded in a cobalt binder). The load spectrum on the cemented carbide varies according to the application. In