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PII: S0263-4368(18)30099-4
DOI: doi:10.1016/j.ijrmhm.2018.04.022
Reference: RMHM 4768

To appear in: *International Journal of Refractory Metals and Hard Materials*

Received date: 9 February 2018
Revised date: 26 April 2018
Accepted date: 29 April 2018

Please cite this article as: Jannica Heinrichs, Mikael Olsson, Karin Yvell, Staffan Jacobson , On the deformation mechanisms of cemented carbide in rock drilling – Fundamental studies involving sliding contact against a rock crystal tip. Rmhm (2018), doi:10.1016/j.ijrmhm.2018.04.022

On the deformation mechanisms of cemented carbide in rock drilling – fundamental studies involving sliding contact against a rock crystal tip

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Abstract

Cemented carbide is a composite material, most commonly consisting of tungsten carbide grains in a metallic matrix of cobalt. The combination of a hard ceramic phase in a ductile metallic matrix combines high hardness and ability to withstand plastic deformation with toughness to avoid cracking and fracturing. Since these properties are very important in rock drilling, cemented carbides are frequently used in such applications.

In earlier work, it was found that granite in sliding contact with considerably harder cemented carbides not only results in plastic deformation of the cemented carbide composite, but also in plastic deformation of some of the individual WC grains. The latter observation is remarkable, since even the two hardest granite constituents (quartz and feldspar) are significantly softer than the WC grains. This tendency to plastic deformation of the WC grains was found to increase with increasing WC grain size.

The present investigation aims to increase the understanding of plastic deformation of cemented carbides in general, and the individual WC grains in particular, in a situation representative for the rock drilling application. The emphasis is put on explaining the seemingly paradoxical fact that a nominally softer counter material is able to plastically deform a harder constituent in a composite material. The experimental work is based on a scratch test set-up, where a rock crystal tip slides against a fine polished cemented carbide surface under well-controlled contact conditions. The deformation and wear mechanisms of the cemented carbide are evaluated on the sub-micrometer scale; using high resolution FEG-SEM, EDS, EBSD, BIB and FIB cross-sectioning. The size of the Co-pockets, together with the shape and size of WC grains, turned out to be decisive factors in determining the degree of carbide deformation. The results are discussed with respect to their industrial importance, including rock drilling.

Keywords; Cemented carbides, sliding, wear, deformation, quartz, rock drilling

1. Introduction

Cemented carbides constitute an exceptionally successful material type in rock drilling tools. They are given the toughest role in the rotary/percussive drilling process, i.e. the role of the drill bit buttons that perform the impact and high-pressure contact needed to form a hole by crushing the rock. Cemented carbides excel in this job by being hard enough to fracture even the hardest rock types while suffering very limited wear, and at the same time being tough enough to avoid brittle fracture. This strong combination of properties is due to the composite structure of the