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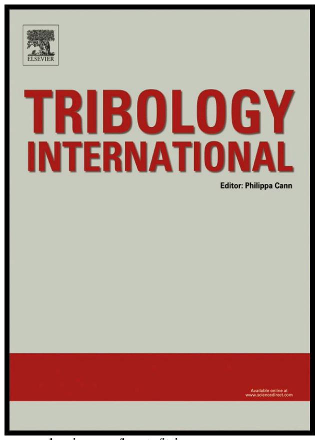

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MULTI-SCALE STUDY OF INITIAL TOOL WEAR ON TEXTURED ALUMINA COATING, AND THE EFFECT OF INCLUSIONS IN LOW ALLOYED STEEL

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ABSTRACT

When turning low alloyed steel with hard inclusions, scores and grooves have been observed in the wear of the alumina coating in CVD coated cutting tools. This study focuses on detailed understanding of flank wear in the textured alumina coating and the relation to the workpiece's inclusions.

For chip formation studies, a quick stop device has been used. A topography analysis for the worn coating was performed in the micro scale. Studies at lower scales were performed using TEM. This allowed the study of wear on the coating crystalline structure and the embedment of workpiece material on its surface.

Based on the results, the mechanism behind the initial wear was analyzed and an abrasion wear model is proposed.

1- Introduction

Alumina has been used as coating on cutting tools since the 1970s [1]. It can be used in many different application areas thanks to its chemical inertness and high wear resistance. A common concept for an alumina coated cutting tool is a cemented carbide core covered by 3-10 µm Ti(C,N) followed by 2-6 µm Al_2O_3 and with a thin TiN layer on top usually deposited using CVD technique. During the last decade, a lot of work has been done studying and manufacturing α-Al_2O_3-coatings with different texture and it has been concluded that α-Al_2O_3 coating with (0001)-texture is the most promising alumina coating for steel turning [2].

Regardless of the excellent properties of the alumina coating in terms of hardness and wear resistance, the coating will be worn during machining. At high cutting parameters the cutting edge is exposed to high temperature and high stresses (compressive and tensile). When the coatings are worn through, rapid diffusion wear of the cemented carbide will take place and the tool will soon be worn out. It is thus very important to increase the wear resistance of the coating materials and delay the time when the coating wears through. In order to improve the coating materials a good understanding of the wear mechanisms is needed. Two wear types that often limit the tool life are flank wear and crater wear. This paper will mainly focus on flank wear.

Flank wear occurs when the tool is in contact with the workpiece. It is often suggested to be a result of abrasive wear. Flank wear often appears as only a small color difference to the naked eye. At higher magnifications, scores can be seen within the flank wear area. Some different explanations for these scores have been given in literature. Dearnley proposed that scored wear patterns in worn alumina coatings are caused by plastic deformation. He dismissed abrasion as a wear mechanism for flank wear because the inclusions in the steels are not hard enough to abrade the coatings [3]. However, most authors suggest that the scores are related to an abrasive wear mechanism. Further it has been suggested that hard particles and inclusions present in the workpiece material are pressed into the coating material, causing material deformation and removal, forming scores in the coating material [4-8]. Faulring suggested that the abrasive wear of the cutting tool is greatly influenced by the properties of inclusions in the workpiece material [7]. Nordgren et.al. worked on characterization of workpiece material (34CrNiMo6) for size and types of inclusions and how the inclusions influence the wear on the tool [9-10]. More specifically, they compared conventional (Aluminum-treated) and Ca-treated steels. They suggested that the wear mechanism is abrasion due to hard oxide inclusions. According to their results, the wear rate is higher when machining Al-treated steels compared to Ca-treated steels and they suggested that this was related to a higher amount of oxide inclusions in the Al-treated steel. This result agrees with a later result from Ruppi [11].

In later years Park et al have studied wear on CVD-coatings including 3D evaluation of the wear scores when turning AISI 1045 (C45E). He related the size of the scores to the size of cementite lamellas in the workpiece material [12]. However, the influence of oxide inclusions was not studied. Also Kwon [13] has addressed flank wear and the influence of workpiece material. His attempt was to relate the flank wear to spheroids of cementite and the cementite part of pearlite.

Many attempts have been made to model abrasive wear but most models are related to different tribological systems and not to machining. A few researchers have compared results when machining and testing in tribology equipments. As an example, Fallqvist [14] has compared the ranking of the wear of different coatings in a pin-on-disc test to when machining