Deformation and Wear of Polycrystalline Cubic Boron Nitride

Increasing productivity when making metal parts requires both high cutting rates and, due to environmental concerns, cutting without lubricant. Temperatures at the tool/workpiece interface can rise to over 1000 °C. The use of increasingly lightweight materials is also increasing the hardness of the materials that must be cut, so that harder cutting tool materials are needed. Diamond might seem the natural choice, but is unstable at the temperatures required and reacts with both Fe-based materials, that constitute the vast bulk of metal being machined, and with speciality Ni-based alloys, used in aerospace applications.

In this project, an alternative based on polycrystalline boron nitride (PcBN), produced by sintering cubic boron nitride (c-BN) with various binder phases such as TiC or Ti(C,N), or Co will be studied. Although such materials give substantial improvements over carbide tools, the conditions of temperature and pressure are so extreme that the PcBN lasts only a few tens of minutes.

It is known that abrasion, spalling and chemical interaction with the workpiece and the environment can all degrade the PcBN, leading to failure. The aim of this project is to identify which of these dominates the degradation behaviour and how the processes might interact, in order to establish ways their effect might be minimised.

Model structures will be made at E6 and tested both at E6 and at Cambridge. Initial experiments will focus on spallation. Increasing the resistance to cracking is generally obtained by increasing the toughness, but in spallation this results in larger thicknesses of material being removed, suggesting that less tough PcBN microstructures may be helpful. Micro-mechanical tests will be used to characterise deformation and the nature of the bonding at binder/c-BN interfaces. Chemical interactions with the atmosphere and the workpiece will be studied by comparing conventional machining tests with tests carried out in an inert atmosphere and by using transmission and scanning electron microscopy to study the reaction products.

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