MECHANICAL PROPERTIES OF HOT PRESSED Al2O3-hBN CERAMIC COMPOSITE

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Introduction

Machining is still a major industrial activity and an increase of productivity implies here a lesser operation time required per part machined by application of higher cutting speeds. The cutting speed depends to a great extent on the cutting tool materials. In spite of their moderate strength and low fracture strength, ceramic cutting tool materials are essential in machining because they can be used at significantly higher cutting speeds than high-speed steel and tungsten carbide-based tools without being severely affected by deformation or dissolution wear processes. Ceramic cutting tool materials retain low wear rates and high hardness to the elevated temperatures that occur whilst machining; their reactivity with steel and other metals is relatively low. The performance of ceramic cutting tool materials has not reached its maximum intrinsic potential [1,2,3] and that major improvements can still be accomplished.

The reduction of wear resistance due to hardness degradation of the tools at high cutting speeds is typically minimized by use of liquid coolants. This is not an optimum solution because the heat evolution at high cutting speeds – which without cooling could rise the temperature in the cutting edge up to 1000ºC- - requires large amounts of the coolants. Increasing wear resistance by decreasing friction is usually accomplished by surface finishing , e.g. by applying coatings. The coatings reduce frictional heat and thereby promote longer tool life but only if they have a very high quality. Another potentially promising development is an application of sintered composite ceramic cutting tools without coatings but containing a solid lubricant like a h-BN to minimize wear at high cutting speeds [4-6]. This possibility has been examined in the present paper. Sintered polycrystalline alumina-matrix composites, containing dispersed hexagonal boron nitride as solid lubricant have been obtained and examined.. Alumina–based cutting tool materials are used primarily for grooving of gray and nodular cast iron and for continuous cutting at high cutting speeds, as well as for high speed finishing operations for steels. Their drawback is a low thermal shock resistance due to low thermal conductivity of alumina In the present paper hexagonal boron nitride (hBN) has been chosen as the solid (dry) lubricant. Alike graphite and molybdenum disulfide, the structure of hBN belongs to a hexagonal crystallographical system and the structural anisotropy of this system easily causes interlayer cleavage (exfoliation) on loading. This is considered as a primary factor of smooth sliping and lubrication, making hBN a good solid lubricant which has, in addition, an excellent thermal and chemical stability which are important for its application in cutting tool materials.

Experimental part

Al_2O_3 powder of 99.99 % - purity from Taimei Chemicals Co.Ltd (Japan) were used. The powders were mixed with, respectively, 0.5, 1, 2 and 5 vol.% of hBN. The mixtures were placed in a rotation-vibration mill containing, alumina grinding media and homogenized in there for 2 or 5.5 hours in isopropyl alcohol medium. The homogenized mixtures were next hot-pressed for one hour under a pressure of 25 MPa. The alumina-based mixtures were hot-pressed at 1400ºC. Obtained sintered discs having a diameter of 7.62 cm. The discs were cut into 3 x 5.5 x 50 mm beams. Flexural strength, σ, was determined for the beams, after surface polishing, by using three-point bending test. Fracture toughness, K_{Ic}, of the beams was determined by using single-edge notched bending test. For each sample composition five determinations of σ and K_{Ic} were made. Potential reactions occurring between entrance substrates, for the initially defined of sintering parameters. Modelling processes of the synthesis was carried basing on thermodynamic calculations concerning potential reactions occurring between entrance substrata, for burning the aptness initially defined. The pressure and the temperature examined in calculations aren't influencing the change in the composition of the phase product with respect to entrance mixture. Information from the literature pointing in reliable conditions a nitride of aluminium, being characterized by a big coefficient of linear expansion, being able to cause cracking could be formed in sinter, for this scope of parameters weren't confirmed computationally. As the basic computational tool a VCS algorithm was applied. The coefficient of friction, COF, was determined under dry conditions using a ball-on-disc standard tribometer UMT-2MT produced by CETR, USA. For each sample composition two determinations of COF were made.

Results and their discussion

Data for mechanical properties of the composites studied are illustrated in Figs.1,2. The most striking result is the very low coefficient of friction (0.1) observed already at dispersion of 1 vol% of hBN.

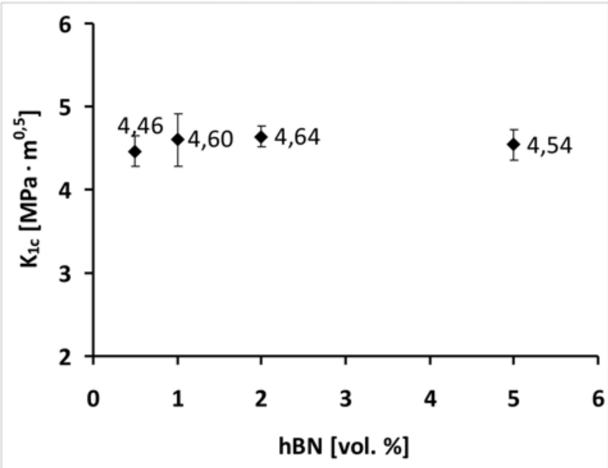

Fig. 1 Fracture toughness of Al_2O_3 - h.BN composite vs. hBN content

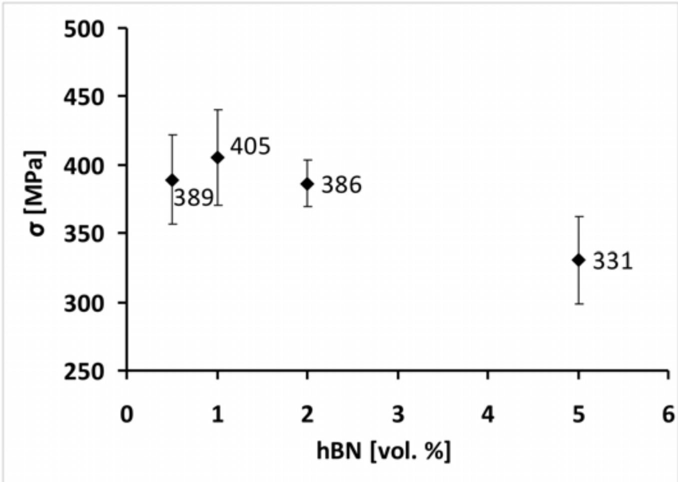

Fig. 2 Flexural strength of Al_2O_3 - h.BN composite vs. hBN content

Fracture toughness remained constant with increase of h-BN content while flexural strength changes with the hBN content have been found to depend upon the material homogeneity The results for fracture toughness and flexural strength are still not entirely satisfactory, however, that a better homogenization may bring about not a decrease but an increase in the flexural strength of the composite, at least at low hBN contents. This demonstrates the potential of improved processing in this case.

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