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If no classification is finished, Form P.9 should accompany this form.
The figure of the drawing to which the abstract refers is attached.

2003/2235

Abstract

An abrasive and wear resistant material comprises a mass of carbide particles, a mass of cubic boron nitride particles, and a bonding metal or alloy, bonded into a coherent, sintered form. The cubic boron nitride particle content of the material is from 10% to 18% inclusive by weight, the particle size of the cubic boron nitride is less than 20 micron or less, and the material is substantially free of hexagonal boron nitride. The abrasive material is of particular use in tool components or inserts for application in the abrading of wood and other lignocellulosic materials.

ABRASIVE AND WEAR RESISTANT MATERIAL

BACKGROUND TO THE INVENTION

THIS invention relates to an abrasive and wear resistant material containing cubic boron nitride and cemented carbide, and to a method of producing the material.

Cemented carbide is a material which is used extensively in industry for a variety of applications, both as an abrading material and as a wear resistant material. Cemented carbides generally consist of suitable carbide particles such as tungsten carbide, tantalum carbide or titanium carbide, bonded together by means of a bonding metal such as cobalt, iron or nickel, or an alloy thereof. Typically, the metal content of cemented carbides is about 3 to 35% by weight. They are produced by sintering the carbide particles and the bonding metal at temperatures of the order of 1400°C.

At the other end of the spectrum, ultrahard abrasive and wear resistant products are found. Diamond and cubic boron nitride compacts are polycrystalline masses of diamond or cubic boron nitride particles, the bonding being created under conditions of elevated temperature and pressure at which the ultrahard component, i.e the diamond or cubic boron nitride, is crystallographically stable. Polycrystalline diamond (PCD) and polycrystalline cubic boron nitride (PCBN) can be produced with or without a second phase or bonding matrix. The second phase, when provided, may be, in the case of diamond, a catalyst/solvent such as cobalt, or may be a carbide forming element such as silicon. Similar sintering mechanisms are utilised in PCBN synthesis with various carbides, nitrides and borides being common second phases.

PCD and PCBN have a far higher wear resistance than cemented carbides, but tend to be somewhat brittle. This brittleness can lead to edge chipping of the working surface which can present a problem in applications where fine finishes are required. Furthermore, ultrahard products such as PCD and PCBN can generally not be directly brazed onto a metallic support. They are therefore often sintered in combination with a cemented carbide substrate. The bi-layered nature of such ultrahard products can be problematic in terms of thermo-mechanical stresses between the two materials: differential expansion and shrinkage on heating and cooling due to different thermal expansion coefficients and elastic moduli can lead to crack formation or unfavourable residual stresses if the substrate and the ultrahard products are too dissimilar. Another potential problem of such bi-layered materials is that of undercutting, i.e preferential wear of the less abrasion resistant carbide support. Further, machining of ultrahard products is difficult and costly, where carbide products can be relatively easily ground to the final geometry.

Efforts have been made to solve some of these problems.

JP-A-57 116 742 discloses the preparation of a modified cemented carbide under hot pressing conditions, i.e temperatures of the order of 1400°C to

1500°C with little or no pressure being applied. These are not conditions at which cubic boron nitride is crystallographically stable.

European Patent No 0 256 829 describes a method of producing an abrasive and wear resistant material comprising a mass of carbide particles, a mass of cubic boron nitride particles and a bonding metal or alloy bonded into a coherent, sintered form, the cubic boron nitride particle content of the material not exceeding 20% by weight and the material being substantially free of hexagonal boron nitride, which comprises contacting appropriate amounts of a mass of carbide particles and a mass of cubic boron nitride particles with a bonding metal or alloy and sintering the particles and metal or alloy under temperature and pressure conditions at which the cubic boron nitride is crystallographically stable.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided an abrasive and wear resistant material comprising a mass of carbide particles, a mass of cubic boron nitride particles, and a bonding metal or alloy, bonded into a coherent, sintered form, wherein:

the cubic boron nitride particle content of the material is from 10% to 18% inclusive by weight;

the particle size of the cubic boron nitride is 20 micron or less; and

the material is substantially free of hexagonal boron nitride.

According to a second aspect of the invention there is provided a method of producing an abrasive and wear resistant material including the steps of providing a mixture of a mass of discrete carbide particles and a mass of cubic boron nitride particles, the cubic boron nitride particles being present in the mixture in an amount such that the cubic boron nitride content of the material is from 10% to 18% inclusive by weight, and wherein the cubic boron nitride particles have a particle size of 20 micron or less, and subjecting the mixture to elevated temperature and pressure conditions at which the cubic boron nitride is crystallographically stable and at which substantially no hexagonal boron nitride is formed, in the presence of a bonding metal or alloy capable of bonding the mixture into a coherent, sintered material.

The abrasive material of the invention or produced by the method of the invention may be used as an abrasive product for abrading materials, or as a wear resistant material, particularly in tool components or inserts which consist of an abrasive compact bonded to a cemented carbide support. The abrasive product is of particular application in the cutting of wood and like materials.

Thus, according to a third aspect of the invention there is provided a method of abrading a workpiece selected from wood and other lignocellulosic materials including the steps of providing a tool having a tool component or insert comprised of an abrasive and wear resistant material comprising a mass of carbide particles, a mass of cubic boron nitride particles and a bonding metal or alloy bonded into a coherent, sintered form, wherein the cubic boron nitride particle content of the material is from 10% to 18% inclusive by weight, the particle size of the cubic boron nitride is 20 micron or less, and the material is substantially free of hexagonal boron nitride; providing the workpiece; bringing the tool component or insert into contact with the workpiece and advancing the tool component or insert into the workpiece in an abrading manner.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a graph showing the maximum flank wear of various materials prepared according to Example 1;

Figure 2 is a graph showing the maximum flank wear of various materials prepared according to Example 2;

Figure 3 is a schematic drawing of a cutter blade design for use in Example 7; and

Figure 4 is a graph of tool flank wear as a function of linear meters machined according to Example 7.

DESCRIPTION OF EMBODIMENTS

The crux of the invention is an abrasive and wear resistant material which comprises a mass of carbide particles, a mass of cubic boron nitride particles and a bonding metal or alloy bonded into a coherent, sintered form, which is characterised in that the cubic boron nitride particle content of the material is from 10% to 18% inclusive by weight, the particle size of the cubic boron nitride is 20 micron or less, optionally less than 10 micron, and the material is substantially free of hexagonal boron nitride.

It has been found that the abrasive material of the invention, with a cubic boron nitride particle content in the range of 10% to 18% by weight, provides a material which is optimum in machining performance, impact resistance, brazeability and grindability. Lower cubic boron nitride particle contents resulted in wear resistance not much better than that of comparable conventional tungsten carbides, while cubic boron nitride particle contents in excess of 18% resulted in reduced brazing strengths, lower impact resistance and increased difficulty in tool preparation through grinding.

In addition, in the abrasive material of the invention, the cubic boron nitride particle size is preferably 20 micron or less. The use of such fine grained particles, in woodworking applications, revealed for some applications a more than tenfold increase in performance compared to conventional carbide materials. Whilst polycrystalline diamond has an even higher wear resistance, it was found that the material of the invention wears by progressive rounding of the edge whereas polycrystalline diamond wears by micro-chipping, which is a disadvantage in certain applications such as woodworking. The fine-grain microstructure of the abrasive material of the invention also promotes smooth and rapid electric discharge machining characteristics.

The abrasive material of the invention is thus particularly suited as a tool material for a variety of machining operations of moderately abrasive metallic and non-metallic workpieces and particularly of wood and like lignocellulosic products. The abrasive material of the invention combines improved machining performance over conventional tungsten carbide whilst also retaining the major positive aspects of conventional carbide such as high impact resistance, good brazeability and ease of tool preparation, for instance through grinding and electric discharge machining.

The abrasive material of the invention is produced by a method comprising providing a mixture of a mass of discrete carbide particles and a mass of cubic boron nitride particles, and subjecting the mixture to elevated temperatures and pressure conditions at which the cubic boron nitride is crystallographically stable and at which substantially no hexagonal boron nitride is formed, in the presence of the bonding metal or alloy capable of bonding the mixture into a coherent, sintered material.

The abrasive material produced must be substantially free of hexagonal boron nitride. The presence of a significant quantity of hexagonal boron nitride reduces the abrasive wear resistant properties of the material. In producing the material, it is important that conditions are chosen which achieve this.

The carbide particles may be any carbide particles used in the manufacture of conventional cemented carbides. Examples of suitable carbides are tungsten carbide, tantalum carbide, titanium carbide, niobium carbide and mixtures thereof. The presence of titanium carbide, niobium carbide and tantalum carbide can enhance the machineability of certain steels, for instance carbon-steels, free-machining steels, tool steels, ferritic steels and alloy steels.

The carbide particles may have a size greater than, less than or equal to the size of the cubic boron nitride particles.

The bonding metal or alloy may be any bonding metal or alloy used in the manufacture of conventional cemented carbides. Examples are cobalt, iron, nickel and alloys containing one or more of these metals.

The bonding metal or alloy content of the abrasive material of the invention is preferably an amount of from 3% to 15% inclusive by weight of the abrasive material. If a highly wear resistant material is desired, the metal content will be low. For higher impact resistance, as for instance required in interrupted cutting or circular sawing, a higher metal content is required to increase toughness of the abrasive material.

The bonding metal or alloy is preferably provided in powder form, but may also be added in the form of an organic precursor, a metal oxide or a salt precursor that is subsequently pyrolised and/or reduced to result in finely dispersed metal.

The bonding metal or alloy may be mixed with the carbide particles and with the cubic boron nitride particles and the mixture may then be sintered as such, or the mixture may first be cold-pressed to produce a weak but coherent body prior to sintering.

Alternatively, the bonding metal or alloy may be supplied in the form of a separate layer adjacent to the cubic boron nitride-carbide mixture and infiltrated during the high temperature/high pressure treatment step.

The sintering of the mixture of carbide and cubic boron nitride particles and the bonding metal or alloy preferably takes place at a temperature of from 1200°C, preferably at temperature in the range of from 1200°C to 1600°C inclusive, and at a pressure of from 30 to 70 kbar inclusive.

This step is carried out under controlled non-oxidizing conditions. The non-oxidizing conditions may be provided by a vacuum, for example a vacuum of less than 1 mbar.

The sintering of the mixture of carbide and cubic boron nitride particles and the bonding metal or alloy may be carried out in a conventional high temperature/high pressure apparatus. The mixture may be loaded directly into the reaction capsule of such an apparatus. Alternatively, the mixture may be placed on a cemented carbide support or a recess formed in a carbide support, and loaded in this form into the capsule.

In a preferred method of the invention, the carbide particles, the cubic boron nitride particles and the bonding metal or alloy have volatiles removed from them prior to sintering, e.g by heating them in a vacuum. These components are preferably then vacuum sealed by, for example, electron beam welding prior to sintering. The vacuum may, for example, be a vacuum of 1 mbar or less and the heating may be a temperature in the range of 500°C to 1200°C inclusive.

A further aspect of the invention is a method of abrading a workpiece selected from wood and other lignocellulosic materials which includes the steps of providing a tool having a tool component or insert comprised of the abrasive material as described above, providing the workpiece, bringing the tool component or insert into contact with the workpiece, and advancing the tool component or insert into the workpiece in an abrading manner.

Abrading in the context of the specification means cutting, drilling, routing, polishing, or any similar such abrading action. This action may take various forms, known in the art, such as rotation of the cutting edge or point, reciprocating movement of the cutting edge or point or the like. Of course, the abrading action can also be achieved by maintaining the edge or point stationary and moving the workpiece.

The workpiece is selected from wood and other lignocellulosic materials. Examples of wood and other lignocellulosic products are natural wood, either soft or hard wood, laminated and non-laminated chipboard and fibreboard, which contain wood chips or fibre bonded by means of binders, hardboard which is compressed fibre and sawdust, and plywood.

Examples of tools which may be used for abrading are multi-tip rotary tools such as circular saws, profile cutters, end mills, milling cutters and routers. The tool component or insert may be any suitable tool component or insert for use in such tools.

The invention will now be described in more detail with reference to the following examples.

Example 1

In order to evaluate the effect of cubic boron nitride (c-BN) grain size, varying amounts of cubic boron nitride in varying particle size were blended with a fine grained mixture of tungsten carbide in the size range 1 to 2 micron, containing 11 weight percent of cobalt. The powders were thoroughly mixed in a planetary ball mill to achieve a homogeneous blend of the materials. The blends were uniaxially compacted to form coherent pellets. The pellets were loaded into a metal canister and subsequently outgassed under vacuum at 1100°C and sealed by electron beam welding. The sealed containers were loaded into the reaction capsule of a standard high pressure/high temperature apparatus and the loaded capsules placed into the reaction centre of this apparatus. The contents of the capsule were exposed to a temperature of approximately 1450°C and a pressure of 50 kbar. These conditions were maintained for 10 minutes. After completion of the treatment, well-sintered, hard and wear resistant materials were recovered from the canister.

The wear resistance of the materials was tested using a turning test where silica flour filled epoxy resin was machined using the following conditions:

Sample format	90° quadrant 3,2 mm thick
Tool holder	neutral
Rake angle	0°
Clearance	6°
Cutting speed	10 m/min
Depth of cut	1,0 mm
Feed rate	0,3 mm/rev
Test duration	30 s

The maximum flank wear of the materials is shown in Figure 1. The graph shows that the highest wear resistance is achieved using a fine grained c-BN starting particle size.

Example 2

In order to assess the effect of cobalt content and c-BN content, a new batch of materials was prepared using the method of Example 1. The c-BN grain size was kept constant at 1-2 microns. The same turning test was used as in Example 1 with the duration increased to 60 seconds so as to improve the resolution of the measurement. The results of the test are shown in Figure 2.

It can be seen that the wear resistance is increased with increasing c-BN content and favoured by a lower cobalt content.

Example 3

Selected samples from Examples 1 and 2 were submitted for tool preparation. It was found that even with a relatively high c-BN content, the samples were easy to grind. Using a wheel normally used for polycrystalline diamond, the composite materials ground at a similar rate as cemented tungsten carbide and achieved an excellent edge quality of a similar standard as that of a typical cemented carbide tool. All materials were easy to grind with the finer grained materials showing slight advantages. Electric discharge machining was also fast and problem free. The materials generally cut at a similar rate as cemented carbide. Rates were seen to increase with decreasing c-BN grain content and grain size.

Example 4

A number of braze alloys were evaluated to determine the braze strength of typical materials of the invention. It was found that the braze strength is approximately proportional to the volume fraction of cemented carbide present in the material. All materials investigated were brazeable to both tungsten carbide and steel.

Using the method described in Example 1 a sintered material (designated C1) was prepared form a powder mixture of 14,9 wt % cubic boron nitride, 75,7 wt % tungsten carbide and 9,4 wt % cobalt, all in the size range 1 to 2 microns, and subjected to a matrix of brazing experiments. The resulting braze shear strengths of this material and a comparable cemented carbide are shown in Table 1. It can be seen that the braze strength is related to the volumetric amount of c-BN present

Table 1

	Braze Shear Strength (MPa)			
Braze Alloy	C1 brazed to steel	C1 brazed to cemented carbide	Cemented carbide brazed to steel	Cemented carbide brazed to cemented carbide
Degussa CH1	134.9	194.9	260.3	291.6
Degussa CH2		166.7	167.4	181.2
De Beers DBF1	108.0	468.8	352.1	
Degussa 21/80	40.7	129.8	143.3	143.3
Degussa 4900			268.7	363.0
Easy-Flo 45	172.4	344.7		

Note: DBF1 is an Au-Ni-Mn-Cu alloy.

Example 5

The material designated C1 in Example 4 was employed for routing tests on medium density board and comparisons were made with polycrystalline diamond, high speed steel and tungsten carbide tools. Single flute routers were prepared with a nominal diameter of 13 mm. A 0° top rake cutting geometry was used and relative wear rates were compared. The cutting speed was 1000 m/min obtained using a rotational speed of 21,120 rpm.

Panels with a geometry of approximately 1000 mm x 300 mm were prepared. Cutting was carried out on each board in an “up-cutting” mode and the cut pattern was arranged so that 100 m of cut could be obtained from each panel. The routers penetrated the panels to a depth of 10 mm and a constant feed rate of 0,1 mm/tooth (2122 mm/min) was used in all tests. At each pass the tool in-feed was 2 mm. Vacuum extraction was used to remove the wood dust. The cutters were removed periodically and the flank wear produced on the cutting edges measured.

Due to the low abrasiveness of the medium density fibreboard it was difficult to monitor the wear produced on the more resistant cutters. However, the high speed steel wore rapidly reaching a wear scar width of 0,2 mm after machining a distance of less than 50 m. The other materials were tested up to a total machining distance of 3000 m. The resulting flank wear scar widths were:

Cemented carbide	0,135 m
C1	0,063 mm
Polycrystalline diamond	0,037 mm

The appearance of the wear-scars after machining were examined using scanning electron microscopy. It was found that the wear of the C1 and the cemented carbide tools was by progressive rounding whereas the polycrystalline diamond tool showed some evidence of micro-chipping.

Example 6

The experiments described in Example 5 were repeated under the same conditions using chipboard as the workpiece.

With this more abrasive workpiece it was found that high speed steel wore very rapidly within one or two metres and cemented carbide showed a flank wear greater than 0,15 mm after only 100 m of cut. After this amount of flank wear the cutting process became unacceptably noisy and the laminate surface was heavily chipped by the dull tool. The material designated C1 in Example 4, on the other hand, showed a significantly lower wear rate and it was found that its tool life to a flank wear of 0,15 mm is of the order of 1500 m. This is a 15-fold life improvement over cemented carbide. The wear rate of polycrystalline diamond was also measured for comparison. PCD wear resistance was so high that it was not practical to run the tools to the tool life end point. A tool life of at least an order of magnitude higher than that of C1 can be expected.

Chipboard is characterised by a plastic laminate on top of approximately 1 mm thick, high density surface layers and a low density core. Wear scar analysis revealed that the greatest tool wear took place in the high density region near the surface of the board and that it is both this high density chipboard layer and the resin impregnated laminate which produce most wear. Negligible wear is produced by the low density interior of the board.

Wear scar analysis after completion of the test also showed that the edge of the material of the invention wears by progressive rounding rather than edge chipping. The wear mechanism is appreciated in the wood working industry since tools then impart a smooth finish to the wood as they wear without leaving "witness" marks. Tools which are too brittle, chip and leave unacceptable marks on the cut surface which then may require subsequent sanding. In the case of polycrystalline diamond, wear takes place by micro-chipping rather than uniform progressive wear and this can be a problem in certain applications. The progressive rounding rather than chipping wear of the material of the invention coupled with its enhanced wear resistance is one of its major advantages.

Example 7

The material designated C1 in Example 4 was evaluated in the edge milling of fibre cement board and comparisons were made with polycrystalline diamond and tungsten carbide tools. The cutter blade design is shown in Figure 3 and the machining conditions were:

Depth of Cut	125 mm jointing/rebating head
Depth of Cut	1 mm
Board feed	10 m/min
Spindle	3700 rpm
Width of Cut	2 mm

Figure 4 shows tool flank wear as a function of linear metres machined. The ranking is similar as that found for the machining of chipboard in the previous example. Again it was found that the material of the invention wore in a smooth progressive fashion whereas polycrystalline diamond showed evidence of micro-chipping.

Example 8

The experiment described in Example 7 was repeated with a material of lower cobalt content. The volume fraction of c-BN in the material was kept the same as that of the material designated C1 in Example 4, but the cobalt content of the cemented carbide was reduced to 6 weight percent.

The new material gave an approximately 30% improvement in performance over C1.

Example 9

The material designated C1 in Example 4 was tested in the circular sawing of cast iron swarf in epoxy resin.

Fifty pieces with dimensions of 6 mm x 4 mm x 2 mm were brazed to a steel saw blank (305 mm diameter, 3 mm thick) using a 50% silver low temperature brazing alloy. The cemented carbide saw had 100 teeth in comparison. No reduction in the feed rate was used to compensate for the higher tooth loading.

Whilst some teeth of the saw blade with the material of the invention broke in operation, resulting in a reduced tool life as compared with the standard WC blade, the cut was of very good quality. The amount of wear visible on those teeth which had survived was significantly less than for a comparable WC material.

Example 10

The material designated C1 in Example 4 was evaluated as a cutting tool for Inconel 718. The experimental parameters were as follows:

Material	Inconel 718, Solution treated

Insert Format	SPGN 090212F
Cutting geometry:	
top rake	-6°, i.e. positive insert in negative toolholder
effective clearance	13°
approach	45°
Cutting speed	50 m/min
Feed rate	0,2 mm/rev
Depth of cut	1,0 mm
Coolant	yes

After 40 minutes of cutting the flank wear was approximately 0,3 mm. A small amount of notching was observed but this was less than that produced on cemented carbide tools. The surface finish produced on the component was said to be of grinding quality. The normal cutting speed and feed rate used with cemented carbide is 25 m/min and 0,4 mm/rev, respectively. At this speed, a flank wear of 0,5 mm and a notch of 1,5 mm is produced in approximately 15 minutes. From these results, the performance can be seen to be significantly better than of conventional cemented carbide.

CLAIMS

1 An abrasive and wear resistant material comprising a mass of carbide particles, a mass of cubic boron nitride particles, and a bonding metal or alloy bonded into a coherent, sintered form, wherein:
the cubic boron nitride particle content of the material is from 10% to 18% inclusive by weight;
the particle size of the cubic boron nitride is 20 micron or less; and
the material is substantially free of hexagonal boron nitride.

2 A material according to claim 1 wherein the carbide particles are particles selected from the group consisting of tungsten carbide, tantalum carbide, titanium carbide, niobium carbide and mixtures thereof.

3 A material according to claim 1 or claim 2 wherein the bonding metal or alloy is selected from the group consisting of cobalt, iron, nickel and alloys containing one or more of these metals.

4 A material according to any one of claims 1 to 3 wherein the bonding metal or alloy content of the material is from 3% to 15% inclusive by weight of the material.

5 A method of producing an abrasive and wear resistant material including the steps of providing a mixture of a mass of discrete carbide particles and a mass of cubic boron nitride particles, the cubic boron nitride particles being present in the mixture in an amount such that the cubic boron nitride content of the material is from 10% to 18% inclusive by weight, and wherein the cubic boron nitride particles have a particle size of 20 micron or less; and subjecting the mixture to elevated temperature and pressure conditions at which the cubic boron nitride is

crystallographically stable and at which substantially no hexagonal boron nitride is formed, in the presence of a bonding metal or alloy capable of bonding the mixture into a coherent, sintered material.

6 A method according to claim 5 wherein the carbide particles are particles selected from the group consisting of tungsten carbide, tantalum carbide, titanium carbide, niobium carbide and mixtures thereof.

7 A method according to claim 5 or claim 6 wherein the bonding metal or alloy is selected from the group consisting of cobalt, iron, nickel and alloys containing one or more of these metals.

8 A method according to any one of claims 5 to 7 wherein the bonding metal or alloy content of the material is from 3% to 15% inclusive by weight of the material.

9 A method according to any one of claims 5 to 8 wherein the bonding metal or alloy is provided in powder form or is added in the form of an organic precursor, a metal oxide or a salt precursor that is subsequently pyrolised or reduced to result in finely dispersed metal.

10 A method according to any one of claims 5 to 9 wherein the bonding metal or alloy is mixed with the mass of discrete carbide particles and the mass of cubic boron nitride particles and the mixture is then sintered.

11 A method according to any one of claims 5 to 9 wherein the bonding metal or alloy is mixed with the mass of discrete carbide particles and the mass of cubic boron nitride particles, the mixture is then cold-pressed to produce a weak coherent body, and the body is then sintered.

12 A method according to any one of claims 5 to 9 wherein the bonding metal or alloy is supplied in the form of a separate layer adjacent to the mixture of the mass of discrete carbide particles and the mass of cubic boron nitride particles and infiltrated when the mixture is subjected to the elevated temperature and pressure conditions.

13 A method according to any one of claims 5 to 12 wherein the elevated temperature and pressure conditions are at temperature of from 1 200°C to 1 600°C inclusive and a pressure of from 30 to 70 kbar inclusive.

14 A method of abrading a workpiece selected from wood and other lignocellulosic materials including the steps of providing a tool having a tool component or insert comprised of an abrasive and wear resistant material comprising a mass of carbide particles, a mass of cubic boron nitride particles, and a bonding metal or alloy, bonded into a coherent, sintered form, wherein the cubic boron nitride particle content of the material is from 10% to 18% inclusive by weight, the particle size of the cubic boron nitride is less than 20 micron or less, and the material is substantially free of hexagonal boron nitride; providing the workpiece; bringing the tool component or insert into contact with the workpiece and advancing the tool component or insert into the workpiece in an abrading manner.

15 A method according to claim 14 wherein the carbide particles are particles selected from the group consisting of tungsten carbide, tantalum carbide, titanium carbide, niobium carbide and mixtures thereof.

16 A method according to claim 14 or claim 15 wherein the bonding metal or alloy is selected from the group consisting of cobalt, iron, nickel and alloys containing one or more of these metals.

17 A method according to any one of claims 14 to 16 wherein the bonding metal or alloy content of the material is from 3% to 15% inclusive by weight of the material.

Fig 1

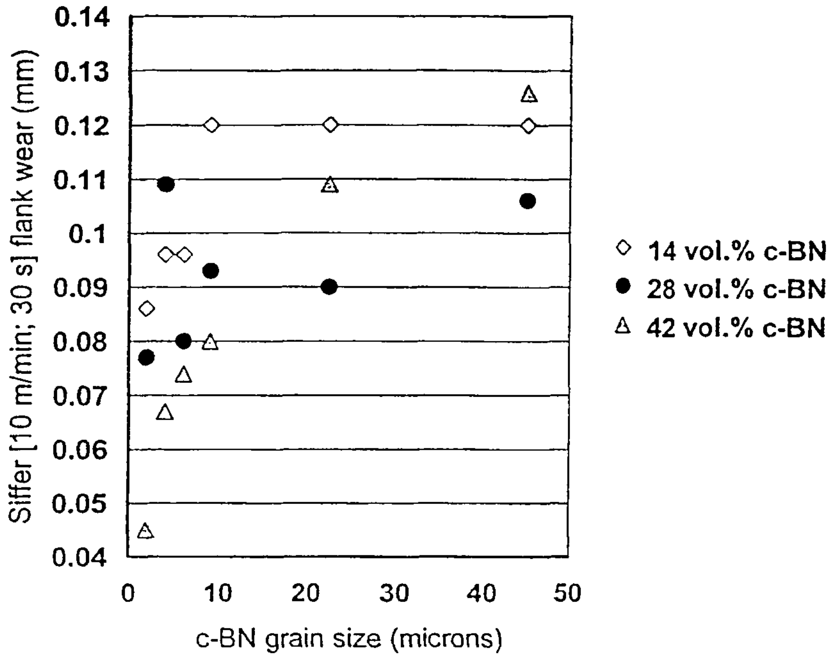

0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
Siffer [10 m/min; 30 s] flank wear (mm)
0
10
20
30
40
50
c-BN grain size (microns)
◇ 14 vol.% c-BN
● 28 vol.% c-BN
△ 42 vol.% c-BN

Fig 2

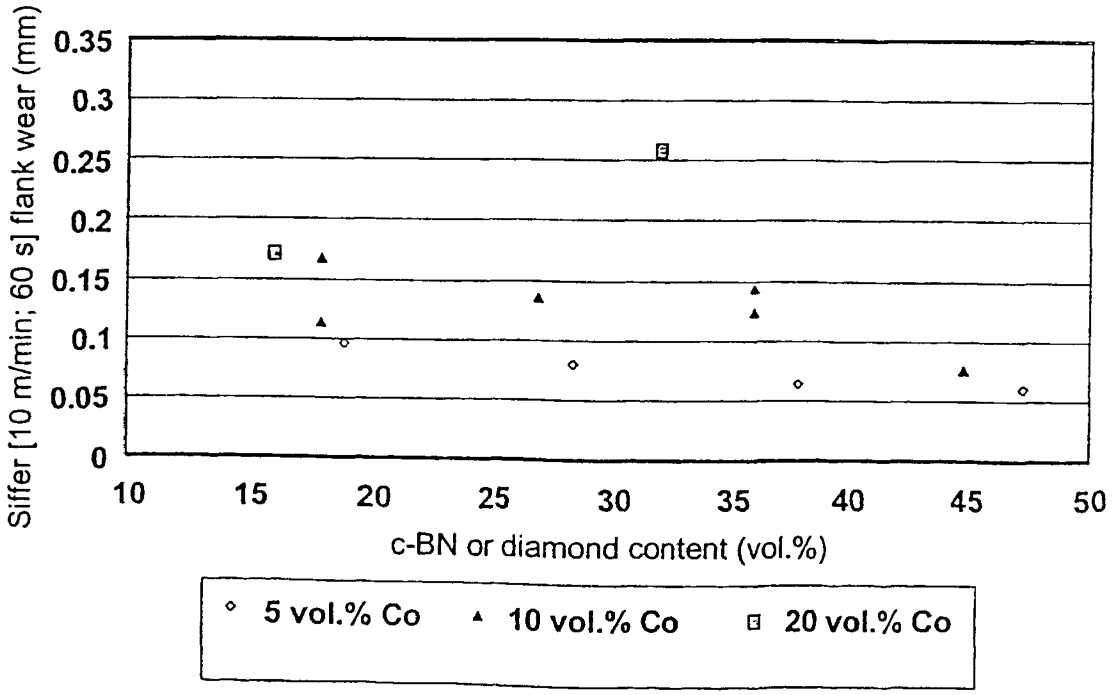

0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Siffer [10 m/min; 60 s] flank wear (mm)
10
15
20
25
30
35
40
45
50
c-BN or diamond content (vol.%)
◇ 5 vol.% Co
▲ 10 vol.% Co
▫ 20 vol.% Co

FIG 3

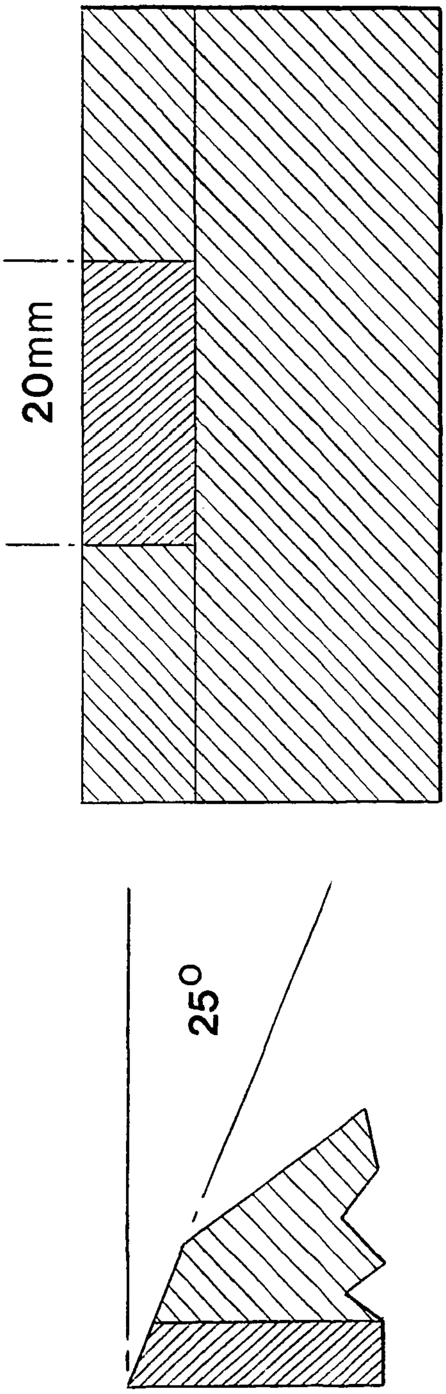
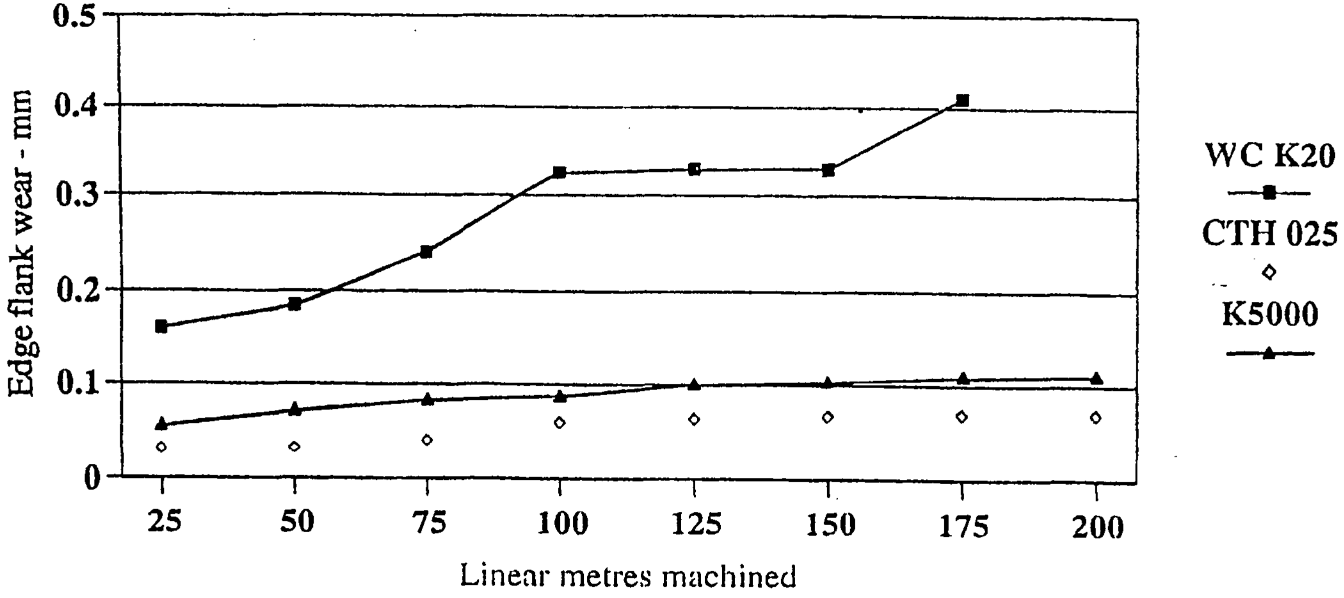


FIG 4


Edge flank wear - mm
0.5
0.4
0.3
0.2
0.1
0
25
50
75
100
125
150
175
200
Linear metres machined
WC K20
CTH 025
K5000