METHOD OF MAKING CUTTER ELEMENTS

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ABSTRACT

A method for making a cutter element, the method including combining a plurality of super-hard grains, a powder source of bond material for bonding the super-hard grains in the cutter element, and a fluid medium to form a paste, in which the content of the super-hard grains is sufficient for the content of the super-hard grains in the cutter element to be at least about 3 volume percent. The paste is introduced into an extrusion device and extruded to form a green body, which is sintered to provide the cutter element. In some examples, the cutter element may be for a saw blade or drill bit.
METHOD OF MAKING CUTTER ELEMENTS

[0001] This disclosure relates generally to a method for making cutter elements, particularly but not exclusively for drills and saw blades.

[0002] U.S. Pat. No. 6,102,140 discloses a method for forming inserts for ground engaging tools. A container is provided and a selected zone of the container is filled with one of a first mixture of powdered tungsten carbide and metallic cobalt and a second mixture of encrusted diamond pellets, powdered tungsten carbide and metallic cobalt. Thereafter another zone of the container is filled with the other of the first and second mixtures. The container is sealed and simultaneously heated and pressurized to a temperature and compaction for a time sufficient to sinter the tungsten carbide and metallic cobalt and fuse the mixture into a unitary body.

[0003] U.S. Pat. No. 6,319,460 discloses a method for manufacturing a super-hard composite material. The method comprises providing diamond grains representing about 40 percent to 85 percent of the volume of the super-hard composite material; providing a metal matrix component representing about 15 percent to 60 percent of the volume of the super-hard composite material; milling the metal matrix component with the metal matrix component to achieve a uniform mixture; and compacting the uniform mixture to an actual density at least 95 percent of the theoretical maximum density of the mixture.

[0004] There is a need for an alternative method for making cutter elements for tools such as drill bits for boring into the earth and saw blades.

[0005] Viewed from a first aspect, there is provided a method for making a cutter element, the method including combining a plurality of super-hard grains (grains comprising super-hard material), a powder source of bond material for bonding the super-hard grains in the cutter element, and a fluid medium to form a paste; introducing the paste into an extrusion device, extruding the paste to form a green body and sintering the green body to provide the cutter element; in which the content of the super-hard grains in the paste is sufficient for the content of the super-hard grains in the cutter element to be at least about 3 volume percent.

[0006] The bond material will be suitable for providing material capable of bonding together the super-hard grains as well as other possible constituents in the sintered cutter element.

[0007] Various combinations and arrangements are envisaged by this disclosure for the method, non-limiting and non-exhaustive examples of which include the following, which may apply to either or both the first and or second pastes in example methods including combining first and second pastes.

[0008] In some examples, the super-hard grains may comprise diamond (natural or synthetic diamond) or cubic boron nitride (cBN).

[0009] In some examples, the plurality of super-hard grains may have a mean size of at least about 100 microns and at most about 2,000 microns, or fall within the 12/200 US Mesh band.

[0010] In some examples, the content of the diamond grains may be selected to be sufficient for their content in the sintered cutter element to be at least about 3 volume percent and at most about 60 volume percent.

[0011] In some examples, the powder source of bond material may comprise grains of the bond material and or precursor material for the bond material, the precursor material capable of being transformed or of reacting to release bond material. Examples of bond material include cobalt (Co), iron (Fe), nickel (Ni) and or suitable alloy materials including any of these. In some examples, the bond material may comprise cobalt (Co).

[0012] In some examples, the method may include combining particulate metal carbide material with the super-hard grains, bond material and fluid medium. For example, the hard material may comprise ceramic material such as metal carbide material or metal oxide material, and the bond material will be selected to be capable of bonding the diamond grains and the hard material together in the finished cutter element. Examples of metal carbide include tungsten carbide (WC) or titanium carbide (TiC). The weight ratio of the bond material and the metal carbide material may be at least 10:90 and at most 90:10.

[0013] In some examples, the method may include combining fluid thickening material with the super-hard grains, bond material and the fluid medium, operatively to increase the viscosity of the fluid medium; and or the method may include treating the paste mechanically or aging the paste to increase the viscosity of the paste, operatively to increase the viscosity of the fluid medium. The fluid thickening material may be referred to as binder material and may comprise organic or inorganic material. Examples of organic binder material include methyl cellulose and polyethylene glycol (PEG), and examples of fluid medium include water or ethanol. The viscosity of the paste may be altered by introducing more of the fluid medium or by removing fluid medium.

[0014] In some examples, the method may include introducing the paste into a mould chamber and pressurising the paste to form the green body.

[0015] In some examples, the method may include extruding the paste to form an intermediate body, introducing the intermediate body into the extrusion device and pressurising the intermediate body to extrude the paste comprised in the intermediate body.

[0016] In some examples, the method may include forming the paste into an intermediate body and processing the intermediate body into at least one green body. The method may include processing the intermediate body includes cutting it.

[0017] In some examples, the method may include at least three extrusion cycles, each extrusion cycle including extruding the paste.

[0018] In some examples, the density of the green body may be at least 40 percent and at most 70 percent of the maximum combined theoretical density of the constituent materials apart from the fluid medium.

[0019] In some examples, at least part of the green body may be cylindrical or rhombohedral in shape.

[0020] In some examples, the method may include subjecting the green body to an elevated temperature and pressure to form the cutter element.

[0021] In some examples, the method may include providing a first paste according to this disclosure; providing a second paste comprising powder capable of being sintered to form a part of a cutter element, the second paste having a different material composition from the first paste; combining the first and second pastes to form a green body and sintering the green body to form a cutter element. In general, the second paste will have a substantially different material composition from that of the first paste; the composition of
each of the first and second pastes being selected to be suitable for combining and sintering to form at least a part of the cutter element.

0022 In some examples that include combining first and second pastes, the second paste may comprise super-hard grains having a different size distribution from the super-hard grains in the first paste.

0023 In some examples, the second paste may comprise different content of super-hard grains than the first paste. In some examples, the second paste may be substantially free of super-hard grains.

0024 In some examples, the second paste may comprise a second powder source of second bond material, the second paste may comprise substantially the same kind of source of the same bond material as does the first paste; or the second paste may be substantially free of the bond material comprised in the first paste.

0025 In some examples, the method may include combining a plurality of super-hard grains, a powder source of bond material for bonding the super-hard grains in the cutter element, and a fluid medium to form a first paste, in which the content of the super-hard grains is sufficient for the content of the super-hard grains in the cutter element to be at least about 3 volume percent or at least about 10 volume percent;

0026 providing a second paste comprising powder capable of being sintered to form a part of a cutter element; combining the first and second pastes to form a green body and sintering the green body to form a cutter element.

0027 In various examples, the super-hard grains may be provided uncoated, coated or clad with material capable of bonding with the bond material.

0028 In some examples, at least some of the super-hard grains may be provided encapsulated within pellets. The volume of each pellet may be at least double the volume of the super-hard grain.

0029 In some examples, each pellet may comprise a super-hard grain, an inner encapsulation zone at least partially enclosing the super-hard grain and an outer encapsulation zone at least partially enclosing the inner encapsulation zone; the inner encapsulation zone being substantially more resistant to abrasive wear than the outer encapsulation zone. The volume of the inner encapsulation zone may at least about 20 percent of the volume of the pellet and or the volume of the inner encapsulation zone may be at most about 75 percent of the volume of the pellet.

0030 In some examples, at least some of the super-hard grains may be encapsulated or otherwise embedded within pellets comprising a relatively large volume of aggregated powder, which may be sintered or unsintered, and or may be held together by a binder material, such as an organic binder. Each pellet may contain a single super-hard grain or more than one super-hard grain.

0031 In some examples, the pellets may comprise bond material suitable for the cutter element and they may contain grains of ceramic material such as metal carbide.

0032 In some examples, the method may include re-introducing the paste or pasties and repeating the extrusion process. This may have the aspect of enhancing the uniformity of the super-hard grain distribution within the cutter element. The intermediate body or bodies may be cut to a desired length to form a green body or bodies. At least a part of the green body may be substantially cylindrical in shape. The density of the green body may be at least about 40 percent of the maximum theoretical density and or at most about 70 percent of the maximum theoretical density of the powder mixture (apart from the fluid medium). The green body may be subjected to an elevated temperature and may be pressurized to sinter the powders to form a sintered body for a cutter element or a substantially finished cutter element. In some examples, fluid medium may be removed from the green body prior to sintering. The sintered body may be processed to form the cutter element.

0033 In some examples, at least some of the hard material and or the source of the bond material may be in the form of particulate material or coating structures adhered to the diamond grains.

0034 Example methods may include combining additive material with the super-hard grains, the bond material and the fluid medium, and or hard material (if present). The additive material may be selected for enhancing certain characteristics of the cutter element, such as the quality of sintering, density, hardness, strength, elastic modulus, wear resistance, thermal properties, purity, and so forth. Examples of additive material may include copper (Cu) and or manganese (Mn), or suitable alloy material including any of these. In some examples, the combined content of the additive material in the powder mixture other than the diamond grains may be at most about 20 weight percent.

0035 In some examples, the cutter element may be for a drill bit for boring into the earth or for a saw blade. In some example arrangements, at least part of the cutter element and the body may have a generally cylindrical shape, such as a right cylindrical shape, and or an end of the body or the cutter element may be substantially flat, domed, conical or frusto-conical. The cutter element may be for a saw blade for cutting stone, composite material or other abrasive material. In some arrangements, the cutter element may be generally rhombohedral in shape.

0036 Cutter elements, such as for saw blades or drill bits, as well as tools comprising the cutter elements made according to a method of this disclosure can be provided.

0037 Non-limiting example arrangements will be illustrated below with reference to the accompanying drawings, of which

0038 FIG. 1A shows a schematic perspective view of an example segment for a diamond saw blade;

0039 FIG. 1B shows schematic side views of composite paste strips and a green body for an example segment for a saw blade; and

0040 FIG. 2 shows a schematic cross section view of an example pellet containing a super-hard grain.

0041 FIG. 1A illustrates a cutter element in the form of a composite segment 300 for a circular saw blade for cutting stone, the segment 300 obtained by a method according to this disclosure. The segment 300 comprises three layers: a pair of outer layers 310 bonded to opposite sides of an inner layer 320 between them. The outer layers 310 may contain a higher content of diamond grains than does the inner layer 320. In use, the segment 300 will be driven by a blade to which it will be joined, in the cutting direction C.

0042 A method for making example cutter elements of the kind illustrated in FIG. 1A will now be described with reference to FIG. 1B. Diamond grit and metal matrix powder comprising metal or alloy suitable for sintering and bonding to the diamond grit to form the cutter element will be provided. The diamond grit will be selected to be suitable for the cutting operation to be performed by the cutter element and may be in the size band 120/18 US Mesh, for example, for
cutting stone or rock. A first paste for making the inner layer and a second paste for making the outer layers will be prepared. The first and second pastes will be substantially different in some aspect of their composition, such as diamond content, diamond size distribution or binder material, for example. Both pastes may be prepared by mixing the diamond grains with the metal powder, the mass ratio of the diamond grains and the metal powder being selected according to the desired content of diamond in each paste. Organic binder material such as methyl cellulose and or polyethylene glycol (PEG) may be introduced into the mixture of diamond grains and metal powder and water may then be introduced slowly while mixing proceeds, to form a paste. The paste may be kneaded, bagged and or stored for a sufficient period for the methyl cellulose to reach substantially its full viscosity. Each of the pastes may be separately and sequentially introduced into an extrusion mould chamber and extruded to form respective strips, which are substantially rectangular in this example. A strip 520 consisting of the first paste may be “sandwiched” between a pair of outer strips 510 consisting of the second paste to form a three-layer composite strip 500. An extrusion apparatus having an extrusion outlet with reduced dimensions may be used for densifying the strip 500, which may then be introduced into the extrusion chamber and extruded to provide an intermediate three layer composite strip having substantially reduced width and height. The intermediate strip may be cut to provide several green bodies 400 for sintering. Each green body 400 may be placed in a graphite mould and treated at elevated temperature and pressure to sinter the metal powder and provide a respective cutter segment 300.

Variations on the described methods will be apparent and may include rolling the paste to form the strips instead of extruding it, for example. In examples where the body to be sintered has a non-rhombohedral shape, such as a bead for a diamond wire saw or a cylindrical insert for an earth boring drill bit, the paste may be extruded in other shapes such as cylindrical rods or concentric tubes.

In some example arrangements the super-hard grains may be encapsulated within pellets. With reference to FIG. 2, an example pellet 600 has a super-hard core 610 comprising a diamond grain, an inner encapsulation zone 620 completely enclosing the super-hard core 610 and an outer encapsulation zone 630 completely enclosing the inner encapsulation zone 620. The inner encapsulation zone 620 is harder and more wear resistant than the outer encapsulation zone 630. In one example, the diamond grain 610 may have a diameter dimension of at least about 100 microns and the pellet 600 may be generally spherical and have a diameter of at least about 200 microns and at most about 5,000 microns. The inner encapsulation zone 620 may have a mean thickness of at least about 100 microns and the outer encapsulation zone 630 may have a thickness of at least about 25 microns. The inner encapsulation zone 620 may comprise super-hard or ceramic material, such as tungsten carbide, titanium carbide, silicon carbide, niobium carbide, molybdenum carbide, hafnium carbide or tantalum carbide, or a hard oxide material such as alumina or zirconia, or a hard nitride material such as silicon nitride or cubic boron nitride, or a hard carbonitride material such as titanium carbonitride. In some examples, the outer encapsulation zone 630 may be substantially free of the super-hard or ceramic material comprised in the in the inner encapsulation zone 620, or outer encapsulation zone 630 may contain super-hard or ceramic material at a lower concentration than does the inner encapsulation zone 620. Example methods of making pellets are described in EP0012631, EP1894983, EP2059617, EP2176372, EP2240549, GB1014295, U.S. Pat. No. 4,770,907, U.S. Pat. No. 5,143,523 and U.S. Pat. No. 5,405,573.

An example drill bit may be for boring into the earth as in oil and gas drilling, and may comprise a plurality of rib structures and a plurality of cutter elements obtained by a method according to this disclosure. The cutter elements may be embedded in pockets formed into a rib structure, part of each cutter element being exposed for cutting rock. Each cutter element may comprise diamond grains embedded within a cemented carbide matrix comprising WC grains and binder material comprising Co. The diamond grains may have a size distribution that falls within the 18/35 US Mesh band and the content of the diamond grains may be from about 20 volume percent to about 30 volume percent in some examples. The content of the WC grains in the matrix material may be about 80 weight percent, the content of the binder material in the matrix material may be about 20 weight percent. In use, the drill bit may rotate and be driven into rock formations in the earth and the cutter elements will engage the rock formation and cut it. As the cutting progresses, matrix material will wear away faster than the diamond, resulting in the protrusion of diamond grains from the exposed part of each cutter element, which enhances the cutting efficiency. As the cutting progresses further, some of the protruding diamond grains are likely to get pulled out and lost and other diamond grains will become newly exposed. In general, there is likely to be a complex trade-off between the working life of the tool on the one hand and the cutting speed on the other, which may be influenced by various factors such as the uniformity of the distribution of the diamond grains within each cutter element, the abrasion resistance of the matrix material and the strength of the bond between the diamond grains and the matrix. At least some of these factors are likely to be affected by the method used to manufacture the cutter elements, although details of this link are not well understood.

In general, if the content of the super-hard grains in the cutter element is substantially less than 3 volume percent, the cutting efficiency of the cutter element is likely to be too low in some applications. In general, the content of the super-hard grains and the composition of the element is likely to be selected according to the needs of various applications, such as boring into the earth or cutting concrete or stone.

Inclusion of grains of ceramic material such as metal carbide in the paste and consequently in the cutter element may have the aspect of enhancing the abrasion resistance of the cutter element. Surprisingly, extrusion of paste containing a sufficient content of super-hard grains for use in practical applications does not appear to result in uneconomically rapid abrasion of the extrusion equipment. While wishing not to be bound by a particular theory, it may be that a layer of fluid or other material forms between the super-hard grains and the extrusion equipment when the paste is being extruded, thereby potentially providing some protection for the equipment. Protection of the equipment may be further enhanced by encapsulating the super-hard grains within a harder inner zone and a relatively softer outer zone, and or by coating or cladding the super-hard grains with relatively thin coating layer. Increasing or decreasing the viscosity of the paste may facilitate its extrusion, and increasing the viscosity may increase the robustness of the green body.
Non-limiting examples are provided below in more detail.

EXAMPLE 1

An example method for making example cutter elements comprising about 25 volume percent diamond grains will be described. The diamond grains in this example will be embedded in cemented tungsten carbide matrix material comprising 50 weight percent WC, about 43 weight percent Co and about 7 weight percent addition of Cu and Mn.

A plurality of diamond grains was provided by blending about 0.36 g of uncoated diamond grains within the 25/30 US mesh size band and 0.24 g of uncoated diamond grains within the 30/35 US mesh size band. The diamond grains and the metal bond powder were mixed together with organic binder material comprising methyl cellulose and PEG 200 by means of a planetary mixer. The content of the methyl cellulose was 1.5 weight percent of the diamond weight (i.e. 7.5 g in this example) and the content of the PEG 200 was 33 percent of cellulose addition (i.e. 2.5 ml for this example). The metal powders were initially mixed in a dry condition while methyl cellulose and PEG powders were added. Water was introduced slowly until the mixture formed a paste. The paste was kneaded for a short while, bagged and stored for a sufficient period for the methyl cellulose to reach substantially its full viscosity. The paste was introduced into an extrusion mould chamber and extruded by means of a hydraulically-activated plunger to form rod-like lengths. The lengths were then re-introduced into the extrusion mould and the extrusion process was repeated about five times to ensure uniform distribution of the diamond grains, and the rods produced in the final extraction cycle were cut to the desired length. At this stage, the estimated density of the rods was about 50 percent of the maximum theoretical density. The rods were inserted into the chamber of a graphite mould, plungers inserted and the mould assembly was inserted into a sintering press, in which the rods were sintered a high density to produce the cutter elements.

The cutter element was mounted onto an “impregn” type drill body for boring into the earth, in which the drill body comprised diamond grains dispersed in a tungsten carbide. In this specific field test, the rate of penetration of the drill was substantially greater than that of a comparative state of the art drill for the type of rock formation bored.

EXAMPLE 2

A composite cutter segment for a circular saw blade can be produced, the segment comprising three bonded layers, arranged with an inner layer between a pair of outer layers. The inner layer has a lower diamond concentration than the outer layers, which both have substantially the same diamond concentration. The segment may be 5 mm wide and 12 mm long, each outer layer being about 1 mm thick and the inner layer being about 3 mm thick. A method for making the composite cutter segment will be described.

Diamond grit within the size band 40/50 US Mesh and metal matrix powder comprising copper, cobalt and iron were provided. A first paste for making the inner layer was prepared, comprising 1,915 kg of the metal matrix powder and 85 g of the diamond grit, and a second paste for making the outer layers was prepared, comprising 1,870 g kg of the metal matrix powder and 130 g of the diamond grit. The pastes were prepared substantially as described in Example 1.

The first paste was placed into an extrusion chamber and a first rectangular strip consisting of the first paste was extruded, the first strip being 100 mm long, 60 mm wide and 30 mm thick. The second paste was placed in the extrusion chamber and second and third rectangular strips consisting of the second paste were extruded, each of the strips being 100 mm long, 60 mm wide and 10 mm thick. The first strip was “sandwiched” between the second and third strips to form a three-layer composite strip having length 100 mm, width 60 mm and thickness 50 mm. The dimensions of extrusion outlet of the extrusion apparatus were reduced by a factor of 5, to provide an opening having dimensions 10 mm by 12 mm. The composite strip was inserted into the extrusion chamber and extruded to provide a three layer composite strip having width 12 mm and height 10 mm. The strip was cut to provide several lengths of the strip, each having length of 40 mm, each being a green body for sintering. Each green body was placed in a graphite mould configured to receive green bodies having these dimensions and was treated at elevated temperature and pressure to provide a respective sintered cutter segment.

EXAMPLE 3

A composite cutter segment for a circular saw blade can be produced, the segment comprising seven bonded layers and having thickness of 10.5 mm and width of 15 mm, each layer being 1.5 mm thick.

Diamond grit within the size band 40/50 US Mesh and metal matrix powder comprising copper, cobalt and iron were provided. A first paste containing the diamond grains and a second paste free of diamond grains were prepared substantially as described in Example 1. The first paste comprised 1,825 kg of the metal matrix powder and 175 of the diamond grains, and the second paste comprised the matrix metal powder but no diamond. The first paste was placed in an extrusion chamber and four diamond-containing strips were extruded, each strip having length 100 mm, height 15 mm and width 75 mm. The second paste was placed in an extrusion chamber and three diamond-free strips were extruded, each having the same dimensions as the diamond-containing strips. The seven strips were stacked onto one another in an alternating, inter-leaved arrangement in which diamond-containing strips were arranged at the bottom and the top of the stack. The resulting seven layered composite strip had a height of 105 mm, a width of 75 mm and a length of 100 mm. The outlet of the extrusion resistance was changed to be 21 mm by 15 mm and the composite strip was introduced into the extrusion chamber and extruded to provide a strip having these dimensions. Several lengths of the strip were cut to provide several green bodies, each length being 30 mm. These green bodies were subjected to elevated temperature and pressure to provide sintered composite segments.

Certain terms and concepts as used herein will be briefly explained.

A paste is a substance that behaves as a solid until a sufficiently large load or stress is applied, at which point it flows like a viscous fluid, viscosity being a measure of the resistance of a fluid to deformation by shear or tensile stress. For example, a paste cannot be substantially extruded unless sufficient pressure is applied to it. As used herein, a paste comprises a suspension of grains in a fluid medium. The content of the grains in suspension is sufficiently great that they contact one another and cause the suspension to behave like a paste.
Super-hard material has a Mohs hardness of at least about 9.5, including natural or synthetic diamond, polycrystalline diamond (PCD), cubic boron nitride (cBN) or polycrystalline cubic boron nitride (PCBN). Hard material has a Mohs hardness of at least 9 or an elastic modulus of at least about 300 GPa, and includes tungsten carbide and titanium carbide.

A green body is a self-supporting article comprising powder material capable of being sintered to form a bonded element. Example green bodies may comprise powder material held together by means of binder material or by interlocking among the powder particles.

1. A method for making a cutter element, the method including combining a plurality of super-hard grains falling within the 12/200 U.S. mesh band, a powder source of bond material for bonding the super-hard grains in the cutter element, and a fluid medium to form a paste; introducing the paste into an extrusion device, extruding the paste to form a green body and sintering the green body to provide the cutter element; in which the content of the super-hard grains in the paste is sufficient for the content of the super-hard grains in the cutter element to be 3 to 60 volume percent.

2. A method as claimed in claim 1, in which the super-hard grains are diamond or cubic boron nitride (cBN).

3. A method as claimed in claim 1, in which the bond material comprises cobalt.

4. A method as claimed in claim 1, including combining particulate metal carbide material with the super-hard grains, the bond material and the fluid medium.

5. A method as claimed in claim 4, in which the weight ratio of the bond material and the metal carbide material is at least 10:90 and at most 90:10.

6. A method as claimed in claim 1, including combining fluid thickening material with the super-hard grains, the bond material and the fluid medium, operative to increase the viscosity of the fluid.

7. A method as claimed in claim 1, including treating the paste mechanically or aging the paste to increase the viscosity of the paste.

8. A method as claimed in claim 1, including introducing the paste into a mould chamber and pressurising the paste.

9. A method as claimed in claim 1, including extruding the paste to form an intermediate body, introducing the intermediate body into the extrusion device and pressurising the intermediate body to extrude the paste comprised in the intermediate body.

10. A method as claimed in claim 1, including at least three extrusion cycles, each extrusion cycle including extruding the paste.

11. A method as claimed in claim 1, including forming the paste into an intermediate body and processing the intermediate body into at least one green body.

12. A method as claimed in claim 11, in which processing the intermediate body includes cutting it.

13. A method as claimed in claim 1, in which the density of the green body is at least 40 percent and at most 70 percent of the maximum combined theoretical density of the constituent materials apart from the fluid medium.

14. A method as claimed in claim 1, in which at least part of the green body is cylindrical or rhombohedral in shape.

15. A method as claimed in any of the preceding claims claim 1, including subjecting the green body to an elevated temperature and pressure to form the cutter element.

16. A method as claimed in claim 1, including providing a second paste comprising powder capable of being sintered to form a part of a cutter element, the second paste having a different material composition from the paste, combining the paste with the second paste to form a green body and sintering the green body to form a cutter element.

17. A method as claimed in claim 16, in which the second paste comprises super-hard grains having a different size distribution from the super-hard grains in the paste.

18. A method as claimed in claim 16, in which the second paste comprises a different content of super-hard grains than the first paste.

19. A method as claimed in claim 16, in which the second paste is free of super-hard grains.

20. A method as claimed in claim 1, in which at least some of the super-hard grains are provided encapsulated within pellets.

21. A method as claimed in claim 20, in which the volume of each pellet is at least double the volume of the super-hard grain.

22. A method as claimed in claim 20, in which each pellet comprises a super-hard grain, an inner encapsulation zone at least partially enclosing the super-hard grain and an outer encapsulation zone at least partially enclosing the inner encapsulation zone; the inner encapsulation zone being substantially more resistant to abrasive wear than the outer encapsulation zone.

23. A method as claimed in claim 22, in which the volume of the inner encapsulation zone is at least 20 percent of the volume of the pellet.

24. A method as claimed in claim 1, in which the cutter element is for a drill bit for boring into the earth.

25. A method as claimed in claim 1, in which the cutter element is for a saw blade.

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