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Description

This invention relates to abrasive products which generate high temperatures during use or are subjected to high temperatures during manufacture. Abrasive compacts are well known in the art and are used extensively in industry for the abrading of various workpieces. They consist essentially of a mass of abrasive particles present in an amount of at least 70 percent, preferably 80 to 90 percent, by volume of the compact bonded into a hard conglomerate. Compacts are polycrystalline masses and can replace single large crystals in many applications. The abrasive particles of compacts are invariably ultra-hard abrasives such as diamond and cubic boron nitride.

Abrasive compacts generally contain a second phase or bonding matrix which contains a catalyst (also known as a solvent) useful in synthesising the particles. In the case of cubic boron nitride, examples of suitable catalysts are aluminium or an alloy of aluminium with nickel, cobalt, iron, manganese or chromium. In the case of diamond, examples of suitable catalysts are metals of Group VIII of the Periodic Table such as cobalt, nickel or iron or an alloy containing such a metal.

As is known in the art, diamond and cubic boron nitride compacts are manufactured under conditions of temperature and pressure at which the abrasive particle is crystallographically stable.

Abrasive compacts may be bonded directly to a tool or shank for use. Alternatively, they may be bonded to a backing such as a cemented carbide backing prior to being mounted on a tool or shank. Such backed compacts are also known in the art as composite abrasive compacts.

United States Patent Specification No. 4,224,380 describes a method of leaching out a substantial quantity of the catalyst from a diamond compact. The product so produced comprises self-bonded diamond particles comprising between about 70 percent and 95 percent by volume of the product, a metallic phase infiltrated substantially uniformly throughout the product, the phase comprising between about 0,05 percent and 3 percent by volume of the product, and a network of interconnected, empty pores dispersed throughout the product and defined by the particles and the metallic phase, the pores comprising between 5 percent and 30 percent by volume of the product. Leaching may be achieved by placing a diamond compact in a hot concentrated nitric-hydrofluoric acid solution for a period of time. This treatment with the hot acid leaches out the catalyst phase leaving behind a skeletal diamond structure. The leached product is said to be thermally more stable than the unleached product.

United States Patent No. 4,124,401 describes and claims a polycrystalline diamond body comprised of a mass of diamond crystals adherently bonded together by a silicon atom-containing bonding medium comprised of silicon carbide and a carbide and/or silicide of a metal component which forms a silicide with silicon, the diamond crystals ranging, in size from 1μm(micron)to about 1 000μm(microns), the density of the crystals ranging from at least about 70 percent by volume up to at least about 90 percent by volume of said body, said silicon atom-containing bonding medium being present in an amount ranging up to about 30 percent by volume of said body, said bonding medium being distributed at least substantially uniformly throughout the body, the portion of the bonding medium in contact with the surfaces of the diamond crystals being at least in a major amount silicon carbide and the diamond body being at least substantially pore-free. The metal component for the diamond body is selected from a wide group of metals consisting of cobalt, chromium, iron, hafnium, manganese, molybdenum, niobium, nickel, palladium, platinum, rhenium, rhodium, ruthenium, tantalum, thorium, titanium, uranium, vanadium, tungsten, yttrium, zirconium and alloys thereof. The polycrystalline diamond body is made under relatively mild hot pressing conditions and such that diamond intergrowth will not occur.

United States Patent No. 4,151,686 describes a polycrystalline diamond body similar to that of United States Patent No. 4,124,401 save that the bonding medium is comprised of silicon carbide and elemental silicon and the density of diamond crystals in the body ranges from 80 percent by volume to about 95 percent by volume of the body. Moreover, the polycrystalline abrasive bodies of this United States patent are made under higher applied pressure conditions, i.e. applied pressures of at least about 2.5 GPa (25 kilobars).

US-A-4 241 135 discloses a polycrystalline diamond body comprised of a dense mass of diamond crystals bonded to a silicon carbide substrate, the diamond crystals being bonded together and to the silicon carbide substrate by a silicon atom-containing bonding medium.

United States Patent No. 3,239,321 describes diamond compacts having a second phase of titanium, vanadium, zirconium, chromium or silicon or an alloy of any of these metals with nickel, manganese or iron. The compacts are made by mixing the diamond particles with the metal, in powdered form, and subjecting the mixture to elevated conditions of temperature and pressure. One example uses silicon as the metal; other examples use chromium or titanium/chromium alloys, in an amount of 31.5% by volume of the compact. European Patent Publication No. 0116403 describes an abrasive body which has high strength and an ability to withstand high temperatures making it suitable as a tool insert for dressing tools and surface set drill bits. The body comprises a mass of diamond particles present in an amount of 80 to 90 percent by volume of the body and a second phase present in an amount of 10 to 20 percent by volume of the body, the mass of diamond particles containing substantial diamond-to-diamond bonding to form a coherent skeletal mass and the second phase containing nickel and silicon, the nickel being in the form of nickel and/or nickel silicide and the silicon being in the form of silicon, silicon carbide and/or nickel silicide. The abrasive bodies are made under conditions of elevated temperature and pressure suitable for diamond compact manufacture.

SUMMARY OF THE INVENTION

An abrasive body used in the invention consists essentially of a mass of diamond particles present in an amount of 80 to 95 percent by volume of the body and a second phase present in an amount of 5 to 20 percent by volume of the body, the mass of diamond particles containing substantial diamond-to-diamond bonding to form a coherent skeletal mass, characterised in that the second phase contains chromium and a second metal selected from the group of nickel, iron and cobalt. The chromium is present in the form of the metal, chromium carbide and/or in the form of an intermetallic compound with the second metal. The second metal is in the form of the metal and/or the intermetallic compound referred to above.

According to the invention there is provided a dressing tool comprising a tool shank and an abrasive body as defined above mounted in one end thereof to present a dressing edge.

Further according to the invention there is provided a surface set drill bit comprising a rotatable body presenting at one end thereof a cutting face, the cutting face having a plurality of abrasive bodies as defined above mounted therein to present cutting edges for the face.

The invention includes a tool comprising an abrasive body as defined above, which body generates a high temperature during use and/or is subjected to a high temperature during manufacture, as well as abrasive bodies adapted exclusively for the tools of the invention.

Still further according to the invention there is provided a method of producing a tool or an abrasive body as defined above including the steps of:

(a) placing a mass of diamond particles in a reaction vessel ;

(b) placing a mass of chromium and the second metal or an alloy of chromium and the second metal in contact with the mass of diamond particles;

(c) placing the loaded reaction vessel in the reaction zone of a high temperature/high pressure apparatus;

(d) subjecting the contents of the reaction vessel to conditions of elevated temperature and pressure in the diamond stable region of the carbon phase diagram for a time sufficient to produce an abrasive body: and

(e) recovering the abrasive body from the reaction zone.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a fragmentary side view of a dressing tool of the invention;

Figure 2 is a perspective view of a surface set drill bit of the invention;

Figure 3 is a perspective view of a portion of the cutting face of the bit of Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

It has been found that the abrasive bodies used in the invention have substantial strength due, at least in part, to the substantial diamond-to-diamond bonding which forms a coherent skeletal mass. The diamond-to-diamond bonding includes both diamond intergrowth and physical diamond-to-diamond interlocking and bonding created by plastic deformation of the diamond particles during manufacture of the body. Furthermore, the abrasive bodies have been found to be capable of withstanding a temperature of 1200°C under a vacuum of 133 x 10^{-4} Pa (10^{-4}Torr)or better without significant graphitisation of the diamond occurring. Indeed, it has been noted that the thermal stability of the abrasive bodies used in this invention is better than that of the abrasive bodies described and claimed in European Patent Publication No. 0116403. The strength of the abrasive bodies and their ability to withstand high temperatures makes them ideal as tool inserts for tools where high temperatures are generated during use thereof, as for example in dressing tools, or where high temperatures are required during manufacture of the tool, as for example in surface set drill bits.

The second phase will be uniformly distributed through the coherent, skeletal diamond mass.

The weight ratio of the chromium to the second metal will typically be in the range 90:10 to 20:80.

The abrasive bodies used in the invention may take on a variety of shapes depending on the use to which they are put. Examples of suitable shapes are disc, triangular, cube and rectangular.

The abrasive bodies used in the invention are manufactured, in the manner described above, using temperatures and pressures in the diamond stable region of the carbon phase diagram. The preferred conditions of temperature and pressure are temperatures in the range 1400 to 1600°C and pressures in the range 5-7 GPa (50 to 70 kilobars). These elevated conditions of temperature and pressure will be maintained for a time sufficient to produce the abrasive body. Typically, these elevated conditions of temperature and pressure are maintained for a period of 5 to 20 minutes. The chromium and the second metal may be provided in the form of a mixture or alloy or in the form of discrete layers. The chromium and second metal may be provided in the form of powders or in the form of sheets or foils.

The diamond particles used in the manufacture of the abrasive body used in the invention may vary from coarse to fine particles. Generally the particles will be less than 100 μm (microns) in size and typically have a size in the range 60 to 75 μm (microns).

High temperature/high pressure apparatus is well known in the art-see, for example, U.S. patent No. 2,941,248. Figure 1 illustrates the use of an abrasive body used in the invention in a dressing tool. Referring to this Figure, there is shown a dressing tool comprising a shank 10 having an abrasive body 12 mounted in one end thereof. The abrasive body presents a dressing edge 14. High temperatures are generated at the dressing edge 14 during use of the tool. However, it has been found that the excellent thermal stability of the abrasive body 12 enables the body to withstand these high temperatures.

Figures 2 and 3 illustrate a surface set drill bit (also referred to as a coring bit) using abrasive bodies used in the invention. Referring to these Figures, there is shown a surface set drill bit comprising a rotatable core 16 having one end 18 threaded for engagement in a coring drill and a cutting face 20 at the other end thereof. The cutting face 20 comprises a plurality of cutting elements 22 firmly held in a suitable metal matrix. The cutting elements 22 each comprise triangular shaped abrasive bodies of the invention, as illustrated in greater detail in Figure 3. The triangular abrasive bodies 22 are so mounted in the cutting face 20 that the base of the triangle is located in a recess 24 and the top pointed edge 26 stands proud of the general plane of the cutting face to present a cutting edge. Located immediately behind the triangular abrasive body 22 is a support 28 made of the same metal as the cutting face. The direction of rotation of the bit is shown by the arrow.

In surface set drill bits, the cutting elements are set into the cutting face using standard high temperature infiltration techniques. The excellent thermal stability of the abrasive bodies used in the invention enables them to withstand such temperatures without significant degradation thereof.

The invention is further illustrated by the following example.

EXAMPLE 1

A mass of diamond particles (16,0 g) was placed in a tantalum cup. A disc (2,6g) of a nickel/chromium alloy was placed on top of the mass of diamonds.Thus, the weight ratio of nickel/chromium was 85:15. The nickel/chromium constituted 14 percent by weight of the contents of the loaded tantalum cup.

The loaded cup was placed in the reaction zone of a conventional high temperature/high pressure apparatus and subjected to 1500°C temperature and 5.5 GPa (55 kilobars) pressure and these conditions were maintained for a period of 10 minutes. Recovered from the reaction zone was a disc-shaped abrasive body which comprised a mass of diamond particles in which there was a substantial amount of diamond-to-diamond bonding forming a coherent skeletal diamond mass and a second phase containing chromium and nickel as metals and in various combined forms uniformly distributed through the diamond mass.

Claims

1. A dressing tool comprising a tool shank (10) and an abrasive body (12) mounted in one end thereof to present a dressing edge (14), wherein the abrasive body (12) consists essentially of a mass of diamond particles present in an amount of 80 to 95 percent by volume of the body and a second phase present in an amount of 5 to 20 percent by volume of the body, the mass of diamond particles containing substantial diamond-to-diamond bonding to form a coherent skeletal mass, characterised in that the second phase contains chromium and a second metal selected from the group of nickel, iron and cobalt, the chromium being in the form of the metal, chromium carbide and/or in the form of an intermetallic compound with the second metal and the second metal being in the form of the metal and/or the intermetallic compound with the chromium.

2. A dressing tool as claimed in claim 1 wherein in the abrasive body the ratio of chromium to the second metal in the second phase is in the range 90:10 to 20:80 on a weight basis.

3. A surface set drill bit comprising a rotatable body (16) presenting at one end thereof a cutting face (20), the cutting face having a

plurality of abrasive bodies (22) mounted therein to present cutting edges (26) for the face (20), wherein the abrasive bodies (22) are as defined in claim 1 or claim 2.

4. A method of abrading a workpiece with a tool comprising an abrasive body (12,22) and wherein a high temperature is generated, characterised in that the abrasive body is as defined in claim 1 or claim 2.

5. A method of manufacturing a tool which comprises an abrasive body (12,22) and in which method the abrasive body (12,22) is exposed to a high temperature, characterised in that the abrasive body is as defined in claim 1 or claim 2.

6. A method of producing a tool as claimed in claim 1 or claim 2, which method includes the steps of:

(a) placing a mass of diamond particles in a reaction vessel;
(b) placing a mass of chromium and the second metal or an alloy of chromium and the second metal in contact with the mass of diamond particles;
(c) placing the loaded reaction vessel in the reaction zone of a high temperature/high pressure apparatus;
(d) subjecting the contents of the reaction vessel to conditions of elevated temperature and pressure in the diamond stable region of the carbon phase diagram for a time sufficient to produce an abrasive body; and
(e) recovering the abrasive body (12,22) from the reaction zone.

Revendications

1. Un outil de taille comportant un manche d'outil (10) et un corps abrasif (12) monté a une des extrémités de ce dernier de manière à présenter un bord coupant (14), dans lequel le corps abrasif (12) consiste essentiellement en une masse de particules de diamant présentes dans une proportion de 80 à 95 pour cent du volume du corps et une seconde phase présente dans une proportion de 5 à 20 pour cent du volume du corps, la masse de particules de diamant contenant une liaison importante diamant à diamant pour former une masse squelettique cohérente, caractérisé par le fait que la seconde phase contient du chrome et un second métal choisi dans le groupe du nickel, du fer et du cobalt, le chrome étant sous forme de métal, de carbure de chrome et/ou sous forme d'un composé intermétallique avec le second métal et le second métal étant sous forme de métal et/ou de composé intermétallique avec le chrome.

2. Un outil de taille tel que revendiqué dans la revendication 1 dans lequel le corps abrasif présente dans la seconde phase un rapport en poids du chrome au second métal se situant dans la gamme de 90:10 à 20:80.

3. Un élément de coupe superficiel d'un assemblage de forage comportant un corps rotatif (16) qui présente à une de ses extrémités une face de coupe (20), la face de coupe étant munie d'une pluralité de corps abrasifs (22) montés dans cette face (20) de manière à y présenter des bords coupants (26), dans lequel les corps abrasifs sont de ceux définis dans la revendiction 1 ou la revendication 2.

4. Une méthode d'abrasion d'une pièce à usiner grâce à un outil comportant un corps abrasif (12,22) et dans laquelle une température élevée est engendrée, caractérisée en ce que le corps abrasif est de ceux définis dans la revendication 1 ou dans la revendication 2.

5. Une méthode de fabrication d'un outil qui comporte un corps abrasif (12,22) et expose le corps abrasif (12,22) à une température élevée, caractérisée par le fait que le corps abrasif est de ceux définis dans la revendication 1 ou dans la revendication 2.

6. une méthode de production d'un outil tel que revendiqué dans la revendication 1 ou dans la revendication 2, qui inclut les étapes suivantes :

(a) Introduction d'une masse de particules de diamant dans une enceinte de réaction ;
(b) Introduction d'une masse de chrome et d'un second métal ou d' un alliage de chrome et du second métal pour les mettre en contact avec la masse de particules de diamant;
(c) Placement de l'enceinte de réaction chargée dans une zone de réaction d' un appareil à température/pression élevées ;
(d) Soumission du contenu de l'enceinte de réaction à des conditions de température et pression élevées correspondant à la région du diagramme de phases du carbone où le diamant est stable et ceci pendant un temps suffisant pour obtenir un corps abrasif;
(e) Récupération du corps abrasif (12,22) de la zone de réaction.

Patentansprüche

1. Abrichtwerkzeug, umfassend einen Werkzeugschaft (10) und einen auf dessen einem Ende befestigten Schleifkörper (12), so daß dieser eine Abrichtkante (14) darbietet, worin der Schleifkörper im wesentlichen aus einer Masse von Diamant-Teilchen, die in einer Menge von 80 bis 95 Volumen-% des Körpers vorliegen, und einer zweiten Phase, die in einer Menge von 5 bis 20 Volumen-% des Körpers vorliegt, besteht, wobei die Masse der Diamant-Teilchen im wesentlichen Diamant-zu-Diamant-Bindungen umfaßt, wodurch eine zusammenhängende Gerüstmasse gebildet wird, dadurch gekennzeichnet, daß die zweite Phase Chrom und ein zweites Metall enthält, das aus der Gruppe Nickel, Eisen und Cobalt ausgewählt ist, wobei das Chrom als Metall, als Chromcarbid und/oder als intermetallische Verbindung mit dem zweiten Metall vorliegt und das zweite Metall als Metall und/oder als intermetallische Verbindung mit dem Chrom vorliegt.

2. Abrichtwerkzeug nach Anspruch 1, worin in dem Schleifkörper das Verhältnis Chrom zu dem zweiten Metall in der zweiten Phase im Bereich von 90:10 bis 20:80, auf Gewichts-Basis, liegt.

3. Oberflächenbesetzte Bohrkrone, umfassend einen drehbaren Körper (16), der an seinem einen Ende eine Schneidfläche (20) darbietet, wobei die Schneidfläche eine Mehrzahl von Schleifkörpern (22) umfaßt, die darin befestigt sind, um Schneidkanten (26) für die Fläche (20) darzubieten, worin die Schleifkörper (22) so sind, wie sie in Anspruch 1 oder Anspruch 2 definiert sind.

4. Verfahren zum Abtragen eines Werkstücks mit einem einen Schleifkörper (12, 22) umfassenden Werkzeug, wobei eine hohe Temperatur erzeugt wird, dadurch gekennzeichnet, daß der Schleifkörper so ist, wie er in Anspruch 1 oder Anspruch 2 definiert ist.

5. Verfahren zum Fertigen eines einen Schleifkörper (12, 22) umfassenden Werkzeugs, wobei der Schleifkörper einer hohen Temperatur ausgesetzt wird, dadurch gekennzeichnet, daß der Schleifkörper so ist, wie er in Anspruch 1 oder Anspruch 2 definiert ist.

6. Verfahren zur Herstellung eines Werkzeugs nach Anspruch 1 oder Anspruch 2, umfassend die Schritte des

(a) Einbringens einer Masse von Diamant-Teilchen in ein Reaktionsgefäß;
(b) In-Berührung-Bringens einer Masse aus Chrom und dem zweiten Metall oder einer Legierung von Chrom und dem zweiten Metall mit den Diamant-Teilchen;
(c) Einbringens des beschickten Reaktionsgefäßes in die Reaktionszone einer Hochtemperatur/Hochdruck-Apparatur;
(d) Einwirkenlassens von Bedingungen hoher Temperatur und hohen Druckes in demjenigen Bereich des Phasendiagramms des Kohlenstoffs, in dem Diamant stabil ist, auf den Inhalt des Reaktionsgefäßes für die Dauer einer Zeitspanne, die ausreicht, um einen Schleifkörper zu erzeugen; und
(e) Gewinnens des Schleifkörpers (12, 22) aus der Reaktionszone.

Fig. 1

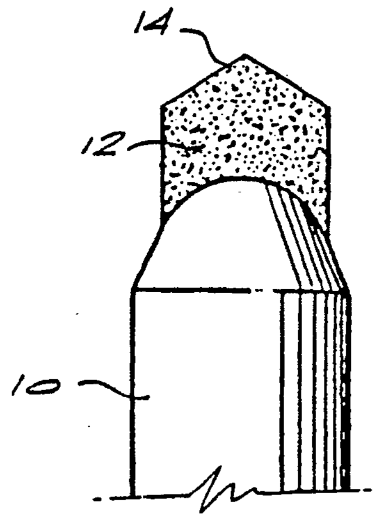

Fig. 2

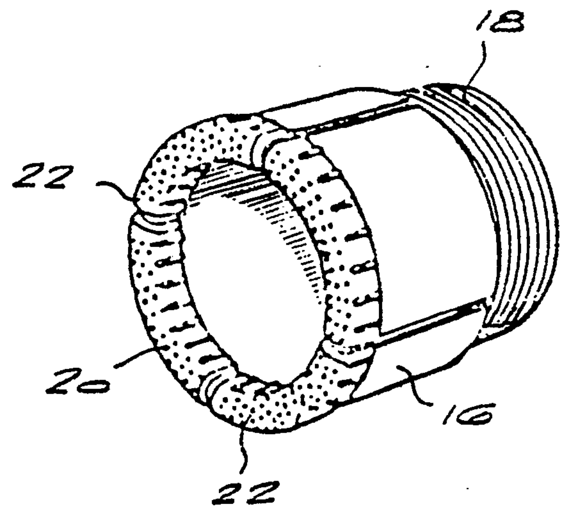

Fig. 3