DIAMOND TIP POINT-ATTACK BIT

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Abstract

A rotatable point-attack bit retained for rotation in a block bore, and used for impacting, fragmenting and removing material from a mine wall. An improved elongated tool body having at the front end a diamond-coated tungsten carbide wear tip that is rotationally symmetric about its longitudinal axis and contiguous with a second section steel shank at the rear end. The two distinct parts are joined by a high impact resistant braze at ratios that prevent tool breakage.

The method of making such a diamond-coated section comprises of 1) placing within a reaction cell, the diamond powder and the carbide substrate and 2) simultaneously subjecting the cell and the contents thereof to temperature and pressure at which the diamond particles are stable and form a uniform polycrystalline diamond surface on the tip of the carbide substrate thus forming a diamond-coated insert providing both cutting edge and steel body protection for increased durability and extended cutting tool life.
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REFERENCES CITED

U.S. Patent Documents

3,519,309 July 1970 Engle et al. 299/86
4,065,185 December 1977 Elders 299/86
4,497,520 February 1985 Ojanen 299/86
4,502,433 June 1986 Dennis 175/329
4,604,106 August 1986 Hall et al. 51/203
4,784,023 November 1988 Dennis 379/428 X
4,865,392 September 1989 Pennunas 299/86
4,911,503 March 1990 Stufler et al. 290/70
5,011,515 April 1991 Fraubour 51/307
5,101,627 November 1991 Bushett 379/427
5,857,071 November 1998 Anderson et al. 46/528
6,029,760 February 2000 Hall 175/432
6,051,079 April 2000 Anderson et al. 148/318

BACKGROUND OF THE INVENTION

The invention is directed to a rotatable cutting tool having an enlarged diamond-coated cemented carbide protective tip and a second steel body segment. The design of the invention is to provide improved performance and safety characteristics. These characteristics include a longer performance cycle through increased wear and fracture resistance resulting in a more efficient continuously penetrating material removal cycle and an improvement in safety, due to a full diamond tipped carbide segment, that results in less chance for methane gas ignition and explosion. The large protective carbide substrate has a high temperature and high pressure bonded diamond-coated tip covering the entire exposed carbide surface that not only results in increased wear life of the bit body but also serves to protect the lower steel shank in tougher milling conditions.

Examples of rotatable cutting tools are on applications with long wall miners, continuous miners, and road planers. A long wall mining machine is used for mining coal seams underground. The machine includes two rotating drums having a plurality of blocks affixed thereto. Long wall mining tools typically comprise an elongated steel body with a hard cemented carbide tip brazed into a socket contained in the forward end of the steel body. One such point attack bit is described in U.S. Pat. No. 4,065,185. Attempts to improve performance have been made by hardening the insert tips of mining attack tools by the use of diamond compacts. One such diamond compact for use in cutting, machining, drilling and like operations is disclosed in Hall et al U.S. Pat. No. 4,604,106. Mining bits incorporating diamond tips brazed onto steel inserts and subsequently brazed into steel bodies are shown in Anderson et al U.S. Pat. Nos. 5,857,071 and 6,051,079.

During the milling operation, the drums rotate so as to cause the rotatable cutting tools to impact the mine wall surface. The tools impact and fracture the wall surface. The surface fragments of coal chunks and powder are collected by a continuously moving conveyor belt and carried to the surface of the mine for processing. During the rotation of a drum, each rotatable cutting tool rotates about its central longitudinal axis. It is important that the tools continue to rotate because without adequate rotation a conventional tool will be locked into position and start an uneven wear pattern that leads to rapid tool degradation and ultimate tool failure. Due to the higher wear resistance of the large diamond-coated cemented carbide body segment of the present invention, if the tool fails to rotate, the uneven wear pattern shown by conventional tools is greatly diminished or not noticeable when the tool clears and resumes its rotation.

The steel cutting tool body includes a reduced diameter portion adjacent to the rearward end thereof. A retainer is adjacent the reduced diameter portion of the steel body. The retainer functions to retain the rotatable cutting tool within the bore of the mounting block during the milling operation. Each block contains a central bore therein. This and other resilient retainer means useful with the present invention are described in U.S. Pat. Nos. 3,519,309 and 4,201,421.

A common mode of failure of polycrystalline diamond compacts, is the delamination of the diamond from the metal carbide substrate. Different attempts have been made to find a true bond that would resist delamination under the severe conditions employed. U.S. Pat. No. 5,011,515 discusses numerous attempts by previous inventors to solve the problem of delamination of the diamond layer from the carbide substrate. U.S. Pat. Nos. 4,592,433 and 4,784,023 teach parallel grooving of substrates to form ridges for increased bonding. U.S. Pat. No. 6,029,760 teaches the use of rounded cylindrical posts as support for diamond surfaces in rock drilling and machining wear resistant materials. These designs actually produce higher stresses in some portions of the cutter than that exhibited in the planar interface mounted PCD to carbide. However, all of the previous patents refer to rock and oil drilling or machining of parts where the stresses are not the same as for the application of this invention. This invention specifically addresses the use of diamond-coated picks, usually mounted on a rotating drum, for road pavement removal and recycling and coal mining, such as for continuous and long wall mining machines. A feature of this invention is the enlarged diamond tip supported by rounded radiused protuberances located near the tip of the carbide substrate. The diamond tip is fully immersed into the cutting media, thus serving to decrease the frictional forces placed on the load stress concentrations and distribute them evenly over the surface, thereby minimizing the potential for diamond delamination.

Other features of this invention are provided by a method for making a fully coated diamond carbide, which method comprises the placing within a reaction cell pressurized forms of diamond particles affixed to the tip of the carbide substrate and simultaneously subjecting the cell and the contents thereof to temperature and pressure conditions at which the diamond particles solidify and are permanently reaction bonded to the cemented carbide substrate. The methods of making polycrystalline diamond in high temperature, high-pressure presses are well known in the art and further detailed description thereof is not considered necessary.

Another method of failure of previous inventions that use a small carbide, or small diamond-coated carbide tip bonded to a steel shank is braze failure at the carbide tip to steel shank junction, where the severe application forces exceed the tensile strength of the braze alloy causing bond failure of the small contact area between two dissimilar metals. This invention, having a diamond tipped larger and
longer extended carbide portion, makes the surface area where the carbide post is brazed to the steel shank of much larger diameter than previous inventions further increasing the surface area with a partial continuously varying radius that matches the profile of the steel shank pocket where it is bonded by a medium to high impact resistant braze. The larger brazed surface area ensures that the braze joint will not fail under most severe loading conditions, thus extending the life of the bit and contributing to safety by minimizing catastrophic tool failure.

Another method of failure is due to using diamond-coated carbide tips limited in size as compared to the size of the diamond tip of the present invention. Having only a limited size carbide or diamond-coated carbide tip results in bit failure when the steel holding the carbide or diamond-coated insert is eroded away during application, exposing the cutting insert and allowing fracture thereof followed by catastrophic failure of the bit. In addition to the much larger protective surface area, the profile of this invention is so designed as to guide the cuttings away from the ferrous shank preventing erosion of the steel body below the diamond tip, thus significantly extending the life of the tool.

0010 The present invention reduces the potential of sparking and explosion from ignition of methane gas. The ignition of methane gas, which is released from pockets where the gas has been trapped in the material being mined, is a safety problem. The causes of ignition are believed to be due to the heat generated through friction as the bits move through the coal and rock during the mining operation or due to sparking, which may occur when the steel base portions of the bits strike rock. Since the coefficient of friction of diamond is substantially lower than that of steel, less heat is generated as the diamond tipped body of the present invention cuts through coal and rock, thus reducing the possibility of gas ignition.

0011 The large protective diamond tip is preferably formed onto a unitary member of cemented carbide or other material, which provides suitable hardness and toughness characteristics. The term "cemented carbide" refers to the type of material resulting when grains of carbide of the group IVB, VB, or VIB metals are pressed and sintered in the presence of a binder such as cobalt, nickel, or iron as well as alloys thereof. The term "diamond" refers to polycrystalline diamond, cubic boron nitride or wurtzite boron nitride and mixtures thereof.

SUMMARY OF THE INVENTION

0012 The present invention overcomes the shortcomings associated with known rotatable cutting tools and teaches the construction and operation of an insert for road construction or mining attack tools. The present invention of a large fully diamond tipped cemented carbide body segment, joined to the steel shank at a specified braze area ratio, serves to channel the flow of material away from the steel shank so as to significantly reduce premature washout wear and failure, which are the most common modes of failure with all smaller diamond tipped previous inventions.

0013 Since the coefficient of friction of diamond is substantially lower than that of steel, less heat is generated as the protective body of the present invention cuts through coal and rock thus increasing the safety of operation by reducing the potential of sparking and explosion from ignition.

DETAILED DESCRIPTION

0014 Referring to the drawings more particularly by reference numbers wherein like numerals refer to like parts. FIG. 1 identifies a rotatable diamond tipped mining bit constructed according to the teachings of the present invention. FIG. 2 shows prior art with a bit having a typical tungsten carbide tip 1 and a steel body 2. Shown in FIG. 3 is a preferred segmented embodiment of the invention of a rotatable cutter bit having a diamond-coated cemented tungsten carbide tip 3 and a steel body 2. The carbide base 4 of the diamond-coated tip 3 is joined to the steel shank 2 at the matching recessed pocket 9 by a medium to high strength braze alloy. The head portion 3, and the shank 2 are coaxially aligned. The shank 2 having at its widest diameter, an enlarged section 5, which prevents the tool from being forced into the opening of the mounting block. The rearward steel member 2 may be seen to include a generally cylindrical shank portion 6 having an annular groove 7 near the rearward end and a frusto conical portion 8 adjacent forward to the shank portion 6. The frusto conical portion 8 has a partial continuously radius socket 9 at its forward end.

0015 FIG. 4 shows the present invention diamond-coated cemented tungsten carbide tip 3, which includes a circular diamond tipped head end portion 10 and a partial continuously varying radiused tail end carbide section 11 which is brazed into a matching partial continuously varying radiused socket 9 of the steel shank 2.

0016 FIG. 5 shows the cemented carbide substrate portion of the diamond-coated body prior to affixing the diamond. The surface 12 serves as a substrate onto which the diamond is applied. The diamond is applied and covers the entire rounded tip surface until it meets the widest part band 13. The nodular frusto conical retention surface contains one or more layers of rounded radiused protuberances 14, and the frusto conical planar surface 15 that extends rearward until it meets a step in the carbide substrate at a band 13.

0017 FIG. 6 shows a longer version of a substrate of this invention. The front includes a circular diamond tipped head end portion 20 and a partial continuously varying radiused tail end carbide section 11 which is brazed into a matching partial continuously varying radiused socket 9 of the steel shank 2. The diamond layer 20 is shown superimposed onto the carbide substrate.

0018 FIG. 7 shows the longer carbide substrate portion of the diamond-coated tip prior to affixing the diamond. The diamond is applied and covers the rounded tip surface 16, the nodular frusto conical retention surface containing one or more layers of rounded radiused protuberances 14, and the angular frusto conical vanes 17 leading down the side of the body until they meet the widest point 18 at band 19.

What I claim as my invention is:

1. A rotatable cutting bit for impacting, fragmenting and removing material such as asphalt, concrete, rock, and minerals, the rotatable cutting bit comprised of:
   a polycrystalline diamond tip, affixed to a cemented carbide substrate by high temperature and pressure bonding, forming a diamond-coated unitary body, positioned at the forward central axis extremity of the cutter bit, having coaxially aligned, rotationally symmetric about its longitudinal axis a tip section, and a base section, having a maximum diameter at said base...
section, and having a flat surface or a convex protrusion or partial continuously varying radiused extension at its rearward section.

a ferrous body with a head section and elongated shank having a circular cross section, said body depending from said protective diamond-coated unitary body along a longitudinal axis, said head portion having a flat surface or concentric seat or partial continuously varying radiused socket at the forward end.

2. The rotatable cutting tool of claim 1 wherein the forward section is coated with polycrystalline diamond, cubic boron nitride, wurtzite boron nitride or mixtures thereof formed by a method that comprises the placing within a reaction cell pre-pressed forms of abrasive particles affixed to the tip of the cemented carbide substrate and simultaneously subjecting the cell and the contents thereof to temperature and pressure conditions at which the diamond, cubic boron nitride or wurtzite boron nitride particles form a super hard abrasion resistant polycrystalline layer permanently sinter reaction bonded to the tip of the cemented carbide substrate.

3. The rotatable cutting tool of claim 1 wherein the forward section has a cemented carbide substrate, which at its forward end has from 1-5 staggered concentrically layered rounded radiused protuberances that serve to support the diamond layer.

4. The rotatable cutting tool of claim 1 wherein the forward end of the steel shank contains a flat surface or seat or partial continuously radiused socket defining a surface area, having an overall depth of 0.001 to 2.00 inches.

5. The rotatable cutting tool of claim 1 wherein the axially rearward section of said diamond-coated insert has a flat surface or protruding or radiused extension that generally corresponds to, and fits into the shape of the flat surface or seat or partial continuously radiused socket of said steel shank.

6. The rotatable cutting tool of claim 1 with a braze joint joining the surface area of the flat or protruding or radiused extension axially rearward section of said diamond-coated insert body to the flat surface, mating seat or radiused socket of the axially forward section of said ferrous shank by means of a medium to high impact resistant braze alloy.

7. The brazed surface areas in claim 6 of said steel shank axially forward section flat surface, seat or radiused socket and said rearward diamond-coated insert body section flat surface, protruding or radiused extension to be at a ratio of steel shank surface area to diamond-coated insert body lateral cross sectioned area of 1.0 to 6.5.

8. The rotatable cutting tool of claim 1 wherein the tip is made of a polycrystalline diamond affixed in situ to the carbide substrate by high temperature and high pressure.

9. The rotatable cutting tool of claim 1 wherein the tip is made of a polycrystalline cubic boron nitride affixed in situ to the carbide substrate by high temperature and high pressure.

10. The rotatable cutting tool of claim 1 wherein the diamond-coated insert cemented carbide substrate is made of a composition containing grains of carbide of group IVB, VB, or VIB metals pressed and sintered in the presence of a binder such as 5.0 to 18.0% cobalt, nickel, iron or alloys thereof.

11. The rotatable cutting tool of claim 1 wherein the diamond-coated insert cemented carbide substrate is made of a composition containing carbide of group IVB, VB, or VIB metals having grain sizes from 0.01 to 50 microns as measured on a sintered, polished and etched part at 100 to 1500× optical magnification.

12. The rotatable cutting tool of claim 1 wherein said diamond-coated insert protective cemented carbide substrate has an overall length of 0.01 to 3.0 inches.

13. The rotatable cutting tool of claim 1 wherein said diamond-coated insert cemented carbide substrate section has a plurality of even numbered peripherally spaced, laterally projecting surfaces or vanes extending generally longitudinally along the bit, each surface or vane being substantially triangular with a narrow leading end and a wider trailing end, and having relatively diverging sides that extend from the leading end to the trailing end, the purpose of which is to effect a positive rotation of the bit upon contact with material being impacted, fragmented or removed.

14. The rotatable cutting tool of claim 1 wherein said steel shank has a means for holding a loosely resilient retainer on the steel body that allows the cutter bit to rotate about its longitudinal axis in a mounting block.

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