ABSTRACT

An earth boring bit comprising, a bit body, a cantilevered bearing shaft depending from the bit body, a cutter mounted for rotation on the bearing shaft, a plurality of cutting elements disposed on the cutter, and hardfacing affixed to the bit, wherein the hardfacing comprises a mixture of carbide materials, a matrix of iron, nickel, cobalt and alloys thereof, and an amount of fullerene material. The amount of fullerene material added to the mixture may range from up to about 0.05 percent by weight to about 15 percent by weight.
HARDFACING CONTAINING FULLERENES
FOR SUBTERRANEAN TOOLS AND
METHODS OF MAKING

BACKGROUND

[0001] 1. Field of Invention
[0002] The present disclosure relates generally to earth-boring bits and particularly to improved head sections for such bits.
[0003] 2. Description of Prior Art
[0004] The earliest rolling cutter earth-boring bits had teeth machined integrally from steel, conically shaped, earth disintegrating cutters. These bits, commonly known as “steel-tooth” or “mill-tooth” bits, are typically used for penetrating relatively soft geological formations of the earth. The strength and fracture-toughness of steel teeth permits the effective use of relatively long teeth, which enables the aggressive gouging and scraping action that is advantageous for rapid penetration of soft formations with low compressive strengths. FIG. 1 provides an example of a drilling system 1 with a bit 5 drilling into a formation 4. A rotary drive 6, shown in schematic form, is used for rotating the drill string 2 to provide the crushing action of the bit 5 needed for drilling and creating a resulting wellbore 3.
[0005] However, it is rare that geological formations consist entirely of soft material with low compressive strength. Often, there are streaks of hard, abrasive materials that a steel-tooth bit should penetrate economically without damage to the bit. Although steel teeth possess good strength, abrasion resistance is inadequate to permit continued rapid penetration of hard or abrasive streaks.
[0006] Consequently, it has been common in the art since at least the early 1930s to provide a layer of wear resistant metallurgical material called “hardfacing” over those portions of the teeth exposed to the severest wear. In addition to the teeth, other portions of the bit body are hardfaced, those include the gage surfaces of the rolling cutters and the shifftails of the bit legs. For the purposes of discussion herein, the term hardfacing refers to the material provided to the bit body. Hardfacing composition refers to the materials which make up the hardfacing. The hardfacing composition typically consists of extremely hard particles, such as sintered, cast or macrocrystalline tungsten carbide dispersed in a steel, cobalt or nickel alloy binder or matrix. The composition is typically packaged in a tube and applied by heating with a torch to weld hardfacing to the subject surface. Thus a surface having been hardfaced has a dispersion of hard particles in the matrix disposed thereon.
[0007] After hardfacing, the cone is preferably heat treated, which typically includes carburizing and quenching from a high temperature to harden the cone. The particles are much harder than the matrix but more brittle. After hardening, the matrix has a hardness value preferably in the range from 53 to 68 Rockwell C (RC). The mixture of hard particles with a softer but tougher steel matrix is a synergistic combination that produces a good hardfacing.
[0008] There have been a variety of different hardfacing materials and patterns, including special tooth configurations, to improve wear resistance or provide self sharpening. Generally, the hardfacing applied to the teeth of new bits is in a pre-application ratio range of 50 to 80 percent carbide particles, typically about 70 percent, in a matrix material of iron, nickel, cobalt or their alloys. Typically the carbide particles are carbides of Groups IV, V, and VI. The thickness of the hardfacing deposit on new bits is usually about 1/16 to 1/8 inch over the flanks, end portions and top of the crest of the tooth. Portions of the hardfacing may be somewhat thicker. The thicker portions are generally where the flanks intersect the crest. These thicker portions may be up to double that of other areas.
[0009] Commonly, a mixture of sintered, macrocrystalline, or cast tungsten carbides is captured within a mild steel tube. The steel tube containing the carbide mixture is then used as a welding rod to deposit hardfacing onto the desired surface, usually with a deoxidizer, or flux.

SUMMARY OF INVENTION

[0010] The present disclosure includes an earth boring bit comprising, a bit body, a cantilevered bearing shaft depending from the bit body, a cutter mounted for rotation on the bearing shaft, a plurality of cutting elements disposed on the cutter, and hardfacing affixed to the bit, wherein the hardfacing comprises a mixture of carbide materials, a matrix of iron, nickel, cobalt and alloys thereof, and an amount of fullerene. The fullerenes considered for use with the present invention include spheres made of carbon atoms (buckyballs), elliptical bodies made with carbon atoms, and tubes made of carbon atoms (carbon nanotubes). The fullerene materials can be doped or undoped. Moreover, the fullerene material may comprise compounds referred to as C60, C70, C80, to name but a few. The carbide materials considered include crushed cast tungsten carbide, crushed sintered tungsten carbide, spherical sintered tungsten carbide, spherical cast carbide, macrocrystalline tungsten carbide, and combinations thereof. The mixture may further comprise a carbon steel niobium alloy, boron, silicon, and mixtures thereof. Also included is a drilling system employing the earth boring bit.

[0011] The amount of fullerene material included with the mixture may range from up to about 0.05 percent by weight of mixture to about 15 percent by weight of the mixture. Other weight percents include up to about 0.1 percent by weight of the mixture, to about 0.5 percent by weight of the mixture, up to about 1.0 percent by weight of the mixture, up to about 5 percent by weight of the mixture, and up to about 10 percent by weight of the mixture.

[0012] The scope of the disclosure herein also includes a method of hardfacing an earth boring bit comprising forming a hardfacing composition comprising a mixture of carbide materials, a matrix of iron, nickel, cobalt and alloys thereof, and an amount of carbon fullerene material and applying the hardfacing composition to a portion of the bit.

[0013] The method may further comprise forming a tube rod by filling a tube with the mixture. Rods may also be formed by sintering the material in a graphite form. Optionally, the rod may be formed by first extruding then sintering. The carbide materials include sintered tungsten carbide, crushed cast tungsten carbide, spherical cast carbide, macrocrystalline tungsten carbide, and combinations thereof. The amount of fullerene material has similar ranges and amounts as noted above.

BRIEF DESCRIPTION OF DRAWINGS

[0014] Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:
FIG. 1 is a side cross sectional view of an embodiment of a drilling system.

FIG. 2 is a side perspective view of an earth boring bit having hardfacing in accordance with the present disclosure.

FIG. 3 is a perspective view of a tooth from a cutter with hardfacing being applied.

FIG. 4 is a side perspective view of a head section of an earth drilling bit having hardfacing in accordance with the present disclosure.

While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF INVENTION

The present invention will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Referring to FIG. 1, an earth-boring bit 11 modified in accordance with the present invention is depicted. Earth-boring bit 11 includes a bit body 13 having threads 15 at its upper extent for connecting bit 11 into a drill string (not shown). Each leg of bit 11 is provided with a lubricant compensator 17. At least one nozzle 19 is provided in bit body 13 for directing pressurized drilling fluid from within the drill string and bit 11 against the bottom of the bore hole.

Cones 21, 23, generally three (one of which is obscured from view in FIG. 2), are rotatably secured to respective legs 14 of body 13. A plurality of inner row teeth 25 and outer row teeth 27 are arranged in generally circumferential rows on cones 21, 23, being integrally formed on the cutters, usually by machining. Outer or heel row teeth 27 are located at the outer edges of each cone 21, 23 adjacent gage surfaces 29. Each bit leg has a shirrtail portion 31 on its outer side adjacent gage surface 29 of cones 21, 23. Typically, hardfacing will be applied to inner row teeth 25, heel row teeth 27, gage surface 29 and also to shirrtail 31.

One embodiment of a hardfacing composition in accordance with the present disclosure comprises a mixture of carbide materials combined with a metal matrix along with an amount of fullerene material. The fullerenes considered for use with the present invention include spheres made of carbon atoms (buckyballs), ellipsoidal bodies made with carbon atoms, tubes made of carbon atoms (carbon nanotubes— including single and multi-walled tubes), Endohedral fullerenes, and combinations thereof. Fullerenes may be described as a collection of carbon atoms formed into a three dimensional cage like fused-ring polycyclic system. Moreover, the fullerene material may comprise compounds commonly referred to as C20, C40, C60, C70, C80, C84, C86, C90, C100, and C540 to name but a few. The fullerene materials can be doped or undoped. The doping materials may include, but are not limited to, scandium, yttrium lanthanides, barium, strontium, alkali metals such as potassium, and tetravalent metals such as, zirconium and hafnium.

The matrix material may comprise iron, nickel, cobalt and alloys thereof. The carbide materials considered for use with the present mixture include crushed east tungsten carbide, crushed sintered tungsten carbide, spherical sintered tungsten carbide, spherical east carbide, macrocrystalline tungsten carbide, and combinations thereof.

The amount of fullerene material may range from around 0.05% by weight of the mixture to in excess of about 15% by weight of the mixture. Specific amounts of fullerene making up the mixture include 0.075% by weight, 0.1% by weight, 0.5% by weight, 1.0% by weight, 5% by weight, 10% by weight, and 15% by weight. Additionally, any of the above referenced percentage values may make up either the minimum or the maximum of fullerene material in the mixture. Moreover, weight percent ranges of an amount of fullerene in the mixture are available using all possible combinations of the above referenced percentage values.

Referring to FIG. 3, a perspective view of a representative bit tooth 28 is shown to illustrate how any tooth on a bit could be hardfaced. Thus the tooth 28 can be from the inner or outer row of teeth. As shown, the tooth 28 has a leading flank 33, considering the direction of rotation of cutters 21, 23, and a trailing flank 35. Leading flank 33 faces into the direction of rotation. Leading flank 33 and trailing flank 35 incline and converge toward each other, joining at a crest 37. An outer or gage end 39 is located at the outer side adjacent gage surface 29 (FIG. 2), and an inner end 41 is located opposite outer end 39. In the embodiment shown, hardfacing is applied to the tooth 28 by a torch 52, which is used to melt the steel alloy of a rod 50. Encased in the rod 50 a hardfacing composition in accordance with the present disclosure.

Referring now to FIG. 4, a side view of a head section 56 is shown. Here the head section 54 includes a layer of hardfacing 58 formed essentially along shirrtail 56. Optionally, the hardfacing 58 may be applied to additional portions of the bit, including the head section 54 using the method shown in FIG. 3. Other methods of applying hardfacing with the novel material described herein include TIG (tungsten inert gas), MIG (metal inert gas), plasma transfer (PTA), and laser; these aforementioned methods may be performed continuously or in a pulsed manner. Other methods include HVOF (high velocity oxygen fuel) and any other known or later developed method of applying hardfacing.

It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation. Accordingly, the invention is therefore to be limited only by the scope of the appended claims.

1. An earth boring bit comprising:
   a bit body;
   a cantilevered bearing shaft depending from the bit body;
   a cutter mounted for rotation on the bearing shaft;
   a plurality of cutting elements disposed on the cutter; and
hardfacing affixed to the bit, wherein the hardfacing comprises a mixture of carbide materials, a matrix of iron, nickel, cobalt and alloys thereof, and an amount of fullerene material.

2. The earth boring bit of claim 1, wherein the fullerene material is selected from the list consisting of a doped material, an undoped material, spherical carbon nanomaterial, an elliptical carbon nanomaterial, a carbon nanotube, and combinations thereof.

3. The earth boring bit of claim 1, wherein the carbide materials are selected from the list consisting of, crushed cast tungsten carbide, crushed sintered tungsten carbide, spherical sintered tungsten carbide, spherical cast carbide, macrocrystalline tungsten carbide, and combinations thereof.

4. The earth boring bit of claim 1, wherein the mixture further comprises a carbon steel niobium alloy, boron, silicon, and mixtures thereof.

5. The earth boring bit of claim 1, wherein the amount of fullerene material is selected from the list consisting of, up to about 50 percent by weight of the mixture, up to about 10 percent by weight of the mixture, up to about 0.5 percent by weight of the mixture, up to about 0.1 percent by weight of the mixture, up to about 0.05 percent by weight of the mixture.

6. The earth boring bit of claim 1, wherein the hardfacing material is affixed to the body.

7. The earth boring bit of claim 1, wherein the hardfacing material is affixed to a cutter.

8. The earth boring bit of claim 1, wherein the hardfacing material is affixed to a cutting element.

9. A method of hardfacing an earth boring bit comprising: forming a hardfacing composition comprising a mixture of carbide materials, a matrix of iron, nickel, cobalt and alloys thereof, and an amount of fullerene material and applying the hardfacing composition to a portion of the bit.

10. The method of hardfacing of claim 9, wherein the fullerene material is selected from the list consisting of a doped material, an undoped material, spherical carbon nanomaterial, an elliptical carbon nanomaterial, a carbon nanotube, and combinations thereof.

11. The method of hardfacing of claim 9 further comprising forming a tube rod and filling the tube with the mixture.

12. The method of claim 11 further comprising heating the rod and mixture and sintering materials in a form.

13. The method of claim 9 wherein the hardfacing composition is sintered.

14. The method of claim 9 wherein the hardfacing composition is extruded.

15. The method of hardfacing of claim 9 wherein the carbide materials are selected from the list consisting of crushed cast tungsten carbide, crushed sintered tungsten carbide, spherical sintered tungsten carbide, spherical cast carbide, macrocrystalline tungsten carbide, and combinations thereof.

16. The method of hardfacing of claim 9 wherein the amount of fullerene material is selected from the list consisting of, up to about 0.05 percent by weight of the mixture, up to about 0.1 percent by weight of the mixture, up to about 0.5 percent by weight of the mixture, up to about 1.0 percent by weight of the mixture.

17. The method of hardfacing of claim 9 wherein the hardfacing composition is applied to a leg of the bit body.

18. The method of hardfacing of claim 9 wherein the hardfacing composition is applied to a cutting element.

19. A subterranean drilling system for drilling a wellbore comprising:

- a drill string;
- a rotary drive rotatingly coupled to the drill string; and
- an earth boring bit disposed on an end of the drill string, wherein the bit includes hardfacing comprising a mixture of carbide materials, a matrix of iron, nickel, cobalt and alloys thereof, and an amount of fullerene material.

20. The subterranean drilling system of claim 14, wherein the fullerene material is selected from the list consisting of a doped material, an undoped material, spherical carbon nanomaterial, an elliptical carbon nanomaterial, a carbon nanotube, and combinations thereof.

21. The subterranean drilling system of claim 16, wherein the carbide materials are selected from the list consisting of sintered tungsten carbide, crushed sintered carbide, spherical sintered carbide, crushed cast tungsten carbide, spherical cast carbide, macrocrystalline tungsten carbide, and combinations thereof.

22. The subterranean drilling system of claim 16, wherein the mixture further comprises a carbon steel niobium alloy, boron, silicon, and mixtures thereof.

23. The subterranean drilling system of claim 16, wherein the amount of fullerene material is selected from the list consisting of, up to about 0.05 percent by weight of the mixture, up to about 0.1 percent by weight of the mixture, up to about 0.5 percent by weight of the mixture, up to about 1.0 percent by weight of the mixture.

24. The subterranean drilling system of claim 16, wherein the hardfacing material is affixed to the bit body.

25. The subterranean drilling system of claim 16, wherein the hardfacing material is affixed to a cone.

26. The subterranean drilling system of claim 16, wherein the hardfacing material is affixed to a cutting element.