

Description

This invention relates generally to conical cutters utilised in roller bits employed in the oil well drilling industry and in mining and, more particularly concerns unique combinations including materials, that make up the composite cone and a unique manufacturing process by which the said composite cones are formed. The description of the invention that follows relates to three-cone rolling cutter bit manufactured for the oil and gas industry; however, the invention is applicable to other types of bits utilising conical rolling cutters, such as two-cone rolling cutter bits, geothermal and mining bits.

Of primary importance from bit manufacturing and design points of view is the assurance that the bit will exhibit the desired cutting action, that it will leave no rings of uncut formation on the hole bottom, that it will be capable of drilling at an economically-acceptable rate of penetration (into the rock formation), and that the bearing and cutting structures are sufficiently durable so that the bit can achieve maximum drilling footage at its maximum rate of penetration. Among these, rate of penetration and structural durability to achieve drilling depths are the most important factors from the user's point of view and are related to the subject matter of this invention.

The conical cutters of the invention incorporate cutting elements which are integral with the cone structure, as opposed to carbide cutting elements which are fitted into holes drilled into the cone, as is the practice presently. As the bit is rotated, the cones roll around the bottom of the hole, each tooth intermittently penetrating into the rock, crushing, chipping and gouging it. The cones are designed so that the teeth intermesh, to facilitate cleaning. In soft rock formations, long, widely-spaced steel teeth are used which easily penetrate the formation.

The present state-of-the-art manufacturing methods usually involve forging, then machining, of the cone followed by hardfacing of the steel teeth. Hardfacing is applied in a way to provide not only a hard-wear resistant layer to reduce the rate at which the cutting elements (teeth) are worn off, but to provide a sharp cutting edge as the tooth wears. This manufacturing scheme, however, is heavily labour dependent, and imprecise in that hardfacing deposit thickness, as well as its chemical composition, is not normally uniform. This is a consequence of several factors which the conventional manufacturing methods cannot, in a practical and commercially-viable sense, control.

Consider first how the hardfacing operation is performed. A rod of the hard-wear resistant alloy is fed into a jet of hot welding arc or flame. Heat causes the rod to melt and deposit onto the steel tooth which also becomes hot and partially molten. Then, the deposit is allowed to solidify. Even if one assumes that the hardfacing alloy is introduced uniformly and the heat is applied uniformly, both of which are usually not achieved, the natural phenomena that determine the way the molten deposit freezes, are not controlled. For example, the rate of removal of heat from the molten puddle is not uniform, because the steel tooth shape is not uniform. Consequently, tooth tips remain hot longer due to insufficient chilling action of the tooth section there, while at the root of the tooth, the massive steel cone body extracts heat quickly and solidification occurs rapidly. This can easily produce a deposit that is non-uniform in thickness and non-uniform in chemistry in a micro-structural sense. Additionally, gravity, surface tensional forces and environmental reactions, such as oxidation, play complicated roles in preventing the formation of a uniform structurally-sound hard-faced deposit.

Methods of manufacturing employed by different bit manufacturers are similar in their major operations. Typically, steel bars are cut to size, heated and forged to a preform which is later machined to form the outer cutting structure and inner-bearing bore. After further grinding to finalise the shape, cutter teeth are hardfaced by using any one of several fusion welding techniques, and the cone is carburised at localised surface areas. The inner radial bearing is then either weld deposited or force fitted. Finally, the cutter is heat treated and bearings are finished machined.

The milled-tooth cone body normally requires surface hardening to withstand the erosive/abrasive effects of rock drilling. This may be accomplished by any of the widely used surface hardening, carburising, nitriding or hard metal coating.

In addition, interior surfaces of the cone are required in certain areas to be hard, wear and impact resistant to accommodate loading from both the thrust and the radial directions (with respect to the journal pin axial direction). Consequently, these surfaces are also hardened by a surface hardening process. On the journal side, the pin surfaces likely to contact "thrust bearing" surfaces are usually hardfaced and run against a hardened cone or a hardened nose button insert in the cone or a carburised tool steel bushing. In most roller cones, a row of uncapped balls run in races between the nose pin and the roller or journal bearing. These balls may carry some thrust loading, but their primary function is to retain the cone on the journal pin when not pressing against the bottom of the hole.

The major load is the radial load and is carried substantially either by a full complement of cylindrical rollers, or a sealed journal bearing, mostly used in oil-field drilling. The journal bearings are sometimes operated with grease lubrication and employ additional support to prolong bearing life; e.g. self-lubricating porous floating rings as in US-A-3,984,158, beryllium-copper alloy bearing coated with a soft metal lubricating film as in US-A-4,074,922 and US-A-3,721,307, a bearing with inlays of soft metal to provide lubrication and heat transfer as in US-A-3,235,316, or an aluminium bronze inlay, as in US-A-3,995,017, in the cone as the soft lubricating member of the journal-cone bearing couple.

The main body of the cone is usually a forging that is milled to create protruding, sharp, wide chisel-shaped teeth, as the cutting elements.

Most recently, certain powder metallurgy produced conical cutters have been proposed. Eric Drake, in US—A—4,368,788 and US—A—4,372,404 suggests cutting elements and conical cutters to be produced by powder metal mixing of two or more phases, and consolidation techniques where the composition could be changed gradually from surface to centre. Such composite structures are stated to have a substantially continuous mechanical property gradient.

As described above, milled-tooth cutters are machined from a single piece of a hardenable metal, yet various portions of the cone require differing properties which are difficult to achieve in an optimised manner using the same material and allowing it to respond to heat treatments. The additional materials are, therefore, sometimes applied through welding which results in layers of non-uniform thickness and chemistry. Thus, the existing milled-tooth cone manufacturing art provides a compromised set of engineering properties.

A further difficulty with the existing art is its large labour content, since all of the exterior and interior shapes, including cutting elements and bearings, are developed by milling and grinding from a simple forging. These milling and grinding operations, and the associated quality inspections, lengthen the manufacturing operations, thus adding substantially to the final manufacturing cost. Cone surfaces may be treated to impart the desired localised properties; however, these treatments are usually long or inadequate, or have side effects that compromise overall properties of the cone.

In addition, hardfacing of the milled teeth, as discussed earlier, results in a non-uniform deposit thus compromising the self-sharpening effect (expected only when one side of the tooth is hardfaced), and occasionally creates "notch-like" intrusions of the deposited alloy into the forged cone body, thus weakening it.

The recently provided powder metallurgy methods to produce conical cutters suffer from several disadvantages as well. The compositional gradient, to produce a properties gradient, suggested by Drake (US—A—4,368,788) is not only complicated and time consuming to produce, but could, in fact, produce the opposite effect, namely create a region of inferior properties within the gradient zone. The compositional gradient, after all, is a continual dilution of the alloys present at the extremities. "Dilution", as is well known by those who are familiar with the metallurgical arts, is a major problem where a high-hardness, high-carbide content alloy is fusion-welded onto an alloy of differing, yet purer, composition. The "diluted" region is the region between the two alloys and is formed by mixing of the two alloys, thus creating a layer of high brittleness and low strength. Such is the danger associated with the conical cones provided by Drake.

As contrasted with such prior techniques, the present invention deliberately avoids alloy gradients, in view of the problem referred to. This is accomplished through applications of discrete layers of differing materials and by use of the short-time hot-pressing technique where atomic diffusion is limited only to the interface to form a strong metallurgical bond, but not to cause excessive mixing (dilution).

US—A—4,172,395 discloses a roller bit cutter having an interior radial bearing comprising a layer of sintered porous alloy infiltrated with anti-galling material.

Nederveen and Verbergh in EP—A—30,055, suggest a drill bit cone having a solid-core member comprising the bearing surrounded by a powder-consolidated, partially-dense cone body onto which a hard metal is applied by thermal spraying. The composite cone is then hot isostatically pressed. The three layers are said to be solidly bonded providing a drill bit of superior mechanical properties including high resistance to wear and chipping.

Additionally, Nederveen and Verburgh (EP—A—30,055) refer to the use of a single, solid-interior metal member to be used as the bearings portion of the cone. This expectably creates a compromise in properties needed for the radial bearing where the alloy is to be soft and malleable as against the alloy layer for the thrust and ball bearings where the surface needs to be more rigid to prevent slackening of the clearance between the cone and the journal pin. A tight maintenance of the tolerances is a must especially if the bearings are protected by a sealed-in lubricant. An increase in the "clearance" or the "tolerances" in service can shorten the seal life. The present invention, on the other hand, provides different materials for the different bearing surfaces in the interior of the cone.

Thus, EP—A—30,055 discloses a roller bit cutter comprising a tough, metallic, generally conical fracture-resistant core having hollow interior metallic teeth protruding outwardly from the core at least some of the teeth being spaced about an axis of rotation of the core, and an impact and wear-resistant layer on each tooth to provide hard cutting edges thereon.

In one aspect the present invention provides a roller bit cutter wherein said teeth being integral with said core and the core including an annular metallic radial bearing layer carried by said core at the interior thereof to support the core for rotation, said bearing layer extending about said axis, and an impact and wear-resistant thrust bearing layer on the interior of the core which constitutes an axial thrust bearing, and wherein said teeth protrude through a wear-resistant outer metallic layer covering the exterior of the core body between said teeth.

Furthermore the roller bit cutters of EP—A—30,055 are produced by a method comprising the steps:
a) providing a tough, metallic generally conical and fracture-resistant core having a hollow interior, the

core having metallic teeth protruding outwardly therefrom, at least some of said teeth being spaced apart about an axis of rotation of the core, and

b) providing an impact and wear-resistant layer on each tooth to provide hard cutting edges thereon.

In another aspect, the invention provides a method of producing a roller bit cutter characterised by:

5 c) forming said teeth integrally with the body of said core,

d) subsequently providing a wear-resistant outer metallic layer on the exterior of the core body between said teeth,

e) providing an annular metallic radial bearing layer which is carried by said core at the interior thereof, said bearing layer extending about said axis, and

10 f) providing an impact and wear-resistant metallic thrust bearing layer on the interior of the core to form an axial thrust bearing.

Nederveen and Verburgh's powder metallurgy cutters as disclosed in EP—A—30,055 utilise high-temperature spraying techniques to apply powders to form surface layers. This approach most readily incorporates oxides into the alloy layer and the alloy layer/cone interface, which weaken the structure.

15 In a preferred method in accordance with the present invention, on the other hand, the cladding (applying a layer of one metal on the other) is accomplished by room-temperature painting, spraying or dipping in a slurry of the powder metal, and thus provides a means to produce conical cutters of superior quality.

In preferred embodiments, the invention dispenses with separate surface hardening or modification treatments for different cone surfaces and replaces them with single, low-temperature painting, or slurry dipping or spraying, or inserting operations. Desired localised properties are obtained by applications of selected powders or shaped inserts rather than by thermal treatments, thus providing a wider selection of property variation for a more precise means of meeting external wear, impact or simple loading requirements.

25 The preferred embodiments involve near isostatic hot pressing of cold-formed powders. See US—A—3,356,496 and 3,689,259. The basic process, isostatically hot presses near net-shape parts in a matter of a few minutes, producing properties similar to those produced by the conventional Hot Isostatic Pressing (HIP) process without the lengthy thermal cycle required by HIPing.

Other preferred features of the invention are defined in the dependent claims.

30 The core in preferred cutter bits of the invention typically consist of steel alloyed with elements that include carbon, manganese, silicon, nickel, chromium, molybdenum and vanadium, or the core may for example, consist of cast alloy steel, or of ultra high strength steel. The outer layer may consist of a composite mixture of refractory particles in a binder metal such particles typically having micro hardness in excess of 1,000 kg/mm², and melting point in excess of 1,600°C. Also, the refractory particles are typically selected from the group consisting of Ti, W, Al, V, Zr, Cr, Mo, Ta, Nb, Hf and carbides, oxides, nitrides and borides thereof. As an alternative, the outer layer may consist of tool steel initially in powder form, or of a hardfacing alloy, as will be seen, or of wear resistant, intermetallic Laves phase materials, as will appear.

35 These and other objects and advantages of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following description by way of example only, with reference to the accompanying drawings, in which:

Drawing description

Figure 1 is an elevation, in section, showing a two-cone rotary drill bit, with intermeshing teeth to facilitate cleaning;

45 Figure 2 is an elevation, in section, showing a milled tooth conical cutter;

Figure 2a is a cross section taken through a tooth insert;

Figure 3 is a flow diagram showing steps of a manufacturing process for the composite conical drill bit cutter;

50 Figures 4(a) and 4(c) are perspective views of a conical cutter tooth according to the invention, respectively before and after downhole service use; and

Figures 4(b) and 4(d) are perspective views of a prior design hardfaced tooth, respectively before and after downhole service;

Figures 5(a)—5(d) are elevations, in section showing various bearing inserts employed to form interior surfaces of proposal conical cutters; and

55 Figure 6 is an elevation, in section, showing use of powdered metal bonding layer between a bearing insert and the core piece, and

Figures 7 and 8 show process steps.

Detailed description

60 In Figure 1 the illustrated improved roller bit cutter 10 incorporating the invention includes a tough, metallic, generally conical and fracture resistant core 11. The core has a hollow interior 12, and defines a central axis 13 of rotation. The bottom of the core is tapered at 14, and the interior includes multiple successive zones 12a, 12b, 12c and 12e concentric to axis 13, as shown. An annular metallic radial (sleeve type) bearing layer 15 is carried by the core at interior zone 12a to support the core for rotation. Layer 15 is

attached to annular surface 11a of the core, and extends about axis 13. It consists of a bearing alloy, as will appear.

An impact and wear resistant metallic inner layer 16 is attached to the core at its interior zones 12b—12e, to provide an axial thrust bearing; as at end surface 16a. A plurality of hard metallic teeth 17 are carried by the core, as for example integral therewith at the root ends 17a of the teeth. The teeth also have portions 17b that protrude outwardly, as shown, with one side of each tooth carrying an impact and wear-resistant layer 17c to provide a hard cutting edge 17d as the bit cutter rotates about axis 13. At least some of the teeth extend about axis 13, and layers 17c face in the same rotary direction. One tooth 17' may be located at the extreme outer end of the core, at axis 13. The teeth are spaced apart.

Finally, a wear resistant outer metallic skin or layer 19 is on and attached to the core exterior surface, to extend completely over that surface and between the teeth 17.

In accordance with an important preferred aspect of the invention at least one or two layers, 15, 16 and 19 consists of consolidated powder metal, and preferably all three layers consist of such consolidated powder metal. A variety of manufacturing schemes are possible using the herein disclosed hot pressing technique and the alternative means of applying the surface layers indicated in Figure 2. It is seen from the previous discussion that surface layers 15, 16 and 19 are to have quite different engineering properties than the interior core section 11. Similarly, layers 16 and 19 should be different than 15, and even 16 should differ from 19. Each of these layers and the core piece 11 may, therefore, be manufactured separately or applied in place as powder mixtures prior to cold pressing. Thus, there may be a number of possible processing schemes as indicated by arrows in Figure 3. The encircled numbers in this Figure refer to the possible processing steps (or operations) listed in below Table 1. Each continuous path in the Figure, starting from Step No. 1 and ending at Step No. 15, defines separate processing schemes which, when followed, are capable of producing integrally consolidated composite conical cutters.

TABLE 1

A list of major processing steps which may be included in the processing:

1. Blend powders.
2. Cold press powder to pre-form green interior core piece 11 (see Figure 2 for location), which includes teeth 17.
3. Cold press and sinter or hot press powder to preform, less than fully dense, core piece 11. Sintering or hot pressing can usually be done at a preferred temperature range 982°C to 677°C (1800°F to 1250°F). If sintered, typical sintering times may be 0.5 to 4 hours depending on temperature.
4. Forge or cast fully dense core piece 11.
5. Apply powdered hard metal compound skin 19; i.e. by painting, slurry dipping or cold spraying a hard metal powder mixed with a fugitive organic binder and a volatile solvent.
6. Place tungsten carbide inserts 17c on teeth faces.
7. Apply thrust-bearing alloy powder layer 16; i.e. by painting, slurry dipping or cold spraying an alloy-binder mixture as in Step 5 above.
8. Apply powdered radial bearing alloy 15 in the core piece; i.e. by painting, slurry dipping or cold spraying an alloy-binder mixture as in Step 5 above.
9. Apply powdered radial bearing alloy 15 in the cold piece; i.e. by painting, slurry dipping or cold spraying an alloy-binder mixture as in Step 5 above.
10. Place wrought, cast or sintered powder metal radial bearing alloy 15 in the core piece 11.
11. Bake or dry to remove binder from powder layers 15, 16 and/or 19. Drying may be accomplished at room temperature overnight. If slurry applied layers are thick the preform may be baked in non-oxidising atmosphere at 21°C to 149°C (70 to 300°F) for several hours to assure complete volatilisation of the volatile portion of the binder.
12. Hot press to consolidate the composite into a fully dense (99+ of theoretical density) conical cutter. Typically, hot pressing temperature range of 1038°C—1260°C (1900 to 2300°F) and pressures of 308 to 770 MPa (20 to 50 tons per square inch) may be required.
13. Weld deposit radial-bearing alloy 15 in the densified cone.
14. Final finish; i.e. grind or machine ID profile, finish grind bearings, finish machine seal seat, inspect etc.

The processing outlined include only the major steps involved in the flow of processing operations. Other secondary operations that are routinely used in most processing schemes for similarly manufactured products, are not included for sake of simplicity. These may be cleaning, manual patchwork to repaint small defects, grit blasting to move loose particles or oxide scale, dimensional or structural inspections etc.

All of the processing steps are unique, as may easily be recognised by those whose are familiar with the metallurgical arts in the powder metals processing field. Each scheme provides a number of benefits from the processing point of view, and some of which are listed as follows:

(1) All assembly operations, i.e. painting, spraying placing etc., in preparing the composite cutter structure for the hot-pressing operation (Step No. 12 in Table 1) are performed at or near room

temperature. Thus, problems associated with thermal property differences or low strength, unconsolidated
 10 fictions can be met by the following classes of materials:

(1) Hardening grades of low-alloy steels (ferrous base) with carbon contents ranging nominally
 5 between 0.1 and 0.65%, manganese 0.25 to 2.0%, silicon 0.15 to 2.2%, nickel to 3.75% chromium to 1.2%,
 molybdenum to 0.40%, vanadium to 0.3% and remainder substantially iron, total of all other elements to
 be less than 1.0% by weight.

(2) Castable alloy steels having less than 8% total alloying element content; most typically
 ASTM-A148-80 grades.

(3) Ultra-high strength steels most specifically known in the industry in USA as: D-6A, H-11, 9Ni-4Co,
 10 18-Ni maraging, 300-M, 4130, 4330 V, 4340. These steels nominally have the same levels of C, Mn and Si as
 to the low-alloy steels described in (1) above. However, they have higher contents of other alloying
 elements: chromium up to 5.0%, nickel to 19.0%, molybdenum to 5.0%, vanadium to 1.0%, cobalt to 8.0%,
 with remaining substantially iron, and all other elements totalling less than 1.0%.

(4) (Ferrous) powder metal steels with nominal chemistries falling within: 79 to 98% iron, 0—20%
 15 copper, 0.4 to 1.0 carbon, and 0.4.0% nickel.

(5) Age hardenable and martensitic stainless steels whose compositions fall into the limits described in
 (3) above, except that they may have chromium up to 20%, aluminium up to 2.5%, titanium up to 1.5%,
 copper up to 4.0% and columbian plus tantalum up to 0.5%.

In all cases, the core piece mechanical properties should exceed the following:

20 897,52 MPa (130 ksi) ultimate tensile strength

552,32 MPa (80 ksi) yield strength

5% tensile elongation

15% reduction in area

13.6 Nm (10ft-lb) (izod) impact strength.

25 Wear resistant exterior skin 19, which may have a thickness within 0.254 to 5.08 mm (0.01 to 0.20 inch)
 range, need not be uniform in thickness. Materials suitable for the cone exterior include:

(1) A composite mixture of particles of refractory hard compounds in a binding metal or alloy where
 the refractory hard compounds have a micro-hardness of higher than 1,000 kg/mm² (50—100 g testing
 load), and a melting point of 1600°C or higher in their commercially pure forms, and where the binding
 30 metal or alloy may be those based on iron, nickel, cobalt or copper. Examples of such refractory hard
 compounds include carbides, oxides, nitrides and borides (or their soluble mixtures) of the Ti, W, Al, V, Zr,
 Cr, Mo, Ta, Nb and Hf.

(2) Speciality tool steels, readily available in powder form, having large amounts of strong carbide
 formers such as Ti, V, Nb, Mo, W and Cr, and a carbon content higher than 2.0% by weight.

35 (3) Hardfacing alloys based on transition elements Fr, Ni, or Co with the following general chemistry
 ranges:

		Cobalt base	Nickel base	Iron base
40	Chromium	25—30% (*)	10—30%	0—27%
	Carbon	0.1—3.5%	0.4—3.0%	0.1—4.0%
	Tungsten	4—13%	0—5.0%	—
45	Molybdenum	0—5%	0—17.0%	0—11%
	Boron	0—2.5%	0—5.0%	—
50	Iron	0—3.0%	329%	Balance
	Nickel	0—3.0%	Balance	0—1.75%
	Cobalt	Balance	0—12%	—
55	Silicon	0—2.0%	0—4.5%	0—1.5%
	Manganese	0—1.0%	0—1.0%	0—1.0%

60 (*) percentage by weight

(4) Wear-resistant intermetallic (Laves phase) materials based on cobalt or nickel as the primary
 constituent and having molybdenum (25—35%), chromium (8—18%), silicon (2—4%) and carbon 0.08%
 maximum.

65 Thrust-bearing 16 may be made of any metal or alloy having a hardness above 35 R_c. They may, in

such cases, have a composite structure where part of the structure is a lubricating material such as molybdenum disulfide, tin, copper, silver, lead or their alloys, or graphite.

Cobalt-cemented tungsten carbide inserts 17c cutter teeth 17 in Figure 2, are to be readily available cobalt-tungsten carbide compositions whose cobalt content usually is within the 5—18% range.

- 5 Bearing alloy 15, if incorporated into the cone as a separately-manufactured insert, may either be a hardened or carburized or nitrided or borided steel or any one of a number of readily available commercial non-ferrous bearing alloys, such as bronzes. If the bearing is weld deposited, the material may still be a bronze. If, however, the bearing is integrally hot pressed in place from a previously applied powder, or if the insert is produced by any of the known powder metallurgy techniques, then it may also have a
10 composite structure having dispersed within it a phase providing lubricating properties to the bearing.

Examples

- An example for the processing of roller cutters includes the steps 1, 3, 5, 6, 7, 10, 11, 12 and 14 provided in Table 1. A low alloy steel composition was blended to produce the final chemical analysis: 0.22%
15 manganese, 0.23% molybdenum, 1.84% nickel, 0.27% carbon and remainder substantially iron. The powder was mixed with a very small amount of zinc stearate, for lubricity, and cold pressed to the shape of the core piece 11 (Figure 2) under a 85 ksi pressure. The preform was then sintered for one hour at 1121°C (2050°F) to increase its strength.

- A slurry was prepared of Stellite No. 1 alloy powder and 3% by weight cellulose acetate and acetone in
20 amounts adequate to provide the desired viscosity to the mixture. The Stellite No. 1 nominal chemistry is as follows: 30% chromium (by weight), 2.5% carbon, 1% silicon, 12.5% tungsten, 1% maximum each of iron and nickel with remainder being substantially cobalt. The slurry was applied over the exterior surfaces of the core piece using a painter's spatula, excepting those teeth surfaces where in service abrasive wear is desired in order to create self-sharpening effect. Only one side of the teeth was thereby covered with the
25 slurry and before the slurry could dry to harden, 2,032 mm (0.08") thick cobalt cemented (6% cobalt) tungsten carbide inserts (Figure 4, a) were pressed into the slurry. Excess slurry at the carbide insert edges were removed and interfaces smoothed out using the spatula.

- A thin layer of an alloy steel powder was similarly applied, in a slurry state, on thrust bearing surfaces identified as 16 in Figure 2. The thrust bearing alloy steel was identical in composition to the steel used to
30 make the core piece, except the carbon content was 0.8% by weight. Thus, when given a hardening and tempering heat treatment the thrust bearing surfaces would harden more than the core piece and provide the needed wear resistance.

- An AISI 1055 carbon steel tube having 2.54 mm (0.1") wall thickness was fitted into the radial bearing portion of the core piece by placing it on a thin layer of slurry applied alloy steel powder used for the core
35 piece.

- The preform assembly, thus prepared, was dried in an oven overnight, driving away all volatile constituents of the slurries used. It was then induction heated to about 1232°C (2250°F) within four minutes and immersed in hot ceramic grain, which was also at 1232°C (2250°F), within a cylindrical die. A pressure of 616MPa (40 tons per square inch) was applied to the grain by way of an hydraulic press. The pressurised
40 grain transmitted the pressure to the preform in all directions. A peak pressure was reached within 4—5 seconds, and the peak pressure was maintained for less than two seconds and released. The die content was emptied, separating the grain from the now consolidated roller bit cutter. Before the part had a chance to cool below 871°C (1600°F) it was transferred to a furnace operating at 852°C (1565°F), kept there for one hour and oil quenched. To prevent oxidation the furnace atmosphere consisted of non-oxidising cracked ammonia. The hardened part was then tempered for one hour at 538°C (1000°F) and air cooled to assure toughness in the core.

- A similarly processed tensile test bar when tensile tested exhibited 1049,41 MPa (152 ksi) ultimate tensile strength, 973,46 MPa (141 ksi) yield strength, 12% elongation and 39% reduction of area. Another test bar which was processed in the same manner as above, except tempered at 232°C (450°F), exhibited
50 1484,36 MPa (215 ksi) ultimate tensile strength, 1277,24 MPa (185 ksi) yield strength, 7% elongation and 21% reduction of area. Thus it is apparent that one may easily develop a desired set of mechanical properties in the consolidated core piece by tempering at a selected temperature.

- In another example, powder slurry for the wear resistant exterior skin and the thrust bearing surface was prepared using a 1.5% by weight mixture of cellulose acetate with Stellite alloy No. 1 powder. This
55 preform was dried at 38°C (100°F) overnight instead at 121°C (250°F) for two hours, and the remaining processing steps were identical to the above example. No visible differences were detected between the two parts produced by the two experiments.

- In yet another example, radial bearing alloy was affixed on the interior wall of the core through the use of a nickel powder slurry similarly prepared as above. Once again, the bond between the radial bearing
60 alloy and the core piece as extremely strong as determined by separately conducted bonding experiments.

Other pertinent information

- The term "composite" is used both in the microstructural sense or from an engineering sense, whichever is more appropriate. Thus, a material made up of discrete fine phase(s) dispersed within another
65 phase is considered a composite of phases, while a structure made up of discrete, relatively large regions

joined or assembled by some means, together is also considered a "composite". An alloy composed of a mixture of carbide particles in cobalt, would micro-structurally be a composite layer, while a cone cutter composed of various distinct layers, carbide or other inserts, would be a composite part.

The term "green" in Table 1, line 2, refers to a state where the powder metal part is not yet fully densified but has sufficient strength to be handled without chipping or breakage. Sintering (the same table, line 3) is a process by which powdered (or otherwise) material is put in intimate contact and heated to cause a metallurgical bond between them.

Preferred embodiments of this invention introduce, for the first time, the following novel features to a drill bit cone:

(1) A "high-temperature — short-heating cycle" means of consolidation of a composite cone into a nearly finished product, saving substantial labour time, and allowing the use of multiple materials tailored to meet localised demands on their properties.

(2) Application of material layers at or near room temperature, which eliminates thermally-induced structural damage if a thermally-activated process were to be used.

(3) A "high-temperature — high pressure — short-time processing scheme, as outlined in Figure 3, where time-temperature dependent diffusion reactions are substantially reduced.

(4) A rock bit conical cutter having a hard, wear-resistant exterior skin and an interior profile which may consist of a thin layer bearing alloy or two different alloys, one for each radial and thrust bearings; all of which substantially surround a high-strength, tough core piece having protruding teeth.

(5) A conical cutter same as in Item (4), but having teeth partially covered on one side with an insert, preferably a cobalt-cemented tungsten carbide insert, which is bonded onto the interior core piece 11 by a thin layer of carbide-rich hard alloy similar to those used in for the exterior skin 19. This is illustrated in Figures 4(a) and 4(c), and is intended to provide a uniform, hard-cutting edge to the cutting teeth as they wear in downhole service i.e. self-sharpening of teeth (see Figure 4(c)). This is to be contrasted with problems of degradation of the cutting edge encountered in hardfaced teeth (see Figures 4(b) and 4(d)).

(6) A conical cutter, as in Item (5), but having interior bearing surfaces provided by pre-formed and shaped inserts prior to hot consolidation of the composite cone. These inserts may be one or more pieces, at least one of which is the radial-bearing piece. Thrust bearing may be provided in the form of a single insert, or two or more inserts, depending on the cone interior design. These variations are illustrated in Figures 5(a)—5(d). Figure 5(a) shows one insert 30; Figure 5(b) shows a second insert 31 covering all interior surfaces, except for insert 30; Figure 5(c) shows a third insert 32 combined with insert 30 and a modified second insert 31'; and Figure 5(d) shows modified second and third inserts 31" and 32".

(7) A conical cutter, as in Item (6), but having interior bearing inserts 33 and 34 bonded onto the interior core piece 11 by a thin layer or layers 33a and 34a of a ductile alloy, as illustrated in Figure 6.

(8) A conical cutter same as in (5), but interior bearings surface is provided by a powder metallurgically applied layer of a bearing alloy.

Figure 1 shows a bit body 40, threaded at 40a, with conical cutters 41 mounted to journal pins 42, with ball bearings 43 and thrust bearings 44.

Step 3 of the process as listed in Table 1 is for example shown in Figure 7, the arrows 100 and 101 indicating isostatic pressurisation of both interior and exterior surfaces of the core piece 11. Note that the teeth 17 are integral with the core-piece and are also pressurised. Pressure application is effected for example by the use of rubber moulds or ceramic granules packed about the core and teeth, and pressurised. Step 12 of the process as listed in Table 1 is for example shown in Figure 8. The part as shown in Figure 2 is embedded in hot ceramic grain or particulate 102, contained within a die 103 having bottom and side walls 104 and 105. A plunger 106 fits within the cylindrical bore 105a and presses downwardly on the hot grain 102 in which consolidating force is transmitted to the part, generally indicated at 106. Accordingly, the core 11 all components and layers attached thereto as referred to above are simultaneously consolidated and bonded together.

Claims

1. A roller bit cutter comprising a tough, metallic generally conical fracture-resistant core (11) having a hollow interior (12), metallic teeth (17) protruding outwardly from the core at least some of the teeth being spaced about an axis of rotation (13) of the core, and an impact and wear-resistant layer (17c) on each tooth to provide hard cutting edges (17d) thereon, said teeth (17) being integral with said core (11) and the core (11) including an annular metallic radial bearing layer (15) carried by said core at the interior thereof to support the core for rotation, said bearing layer (15) extending about said axis (13), and an impact and wear-resistant thrust bearing layer (16) on the interior of the core which constitutes an axial thrust bearing, characterised in that said teeth protrude through a wear-resistant outer metallic layer (19) covering the exterior of the core body between said teeth.

2. A roller bit cutter as claimed in claim 1 wherein said layer (17c) on each tooth (17) consists essentially of tungsten carbide.

3. A roller bit cutter as claimed in claim 1 or claim 2 wherein at least one of said layers (15, 16, 17c, 19) consists essentially of consolidated powder metal.



joined or assembled by some means, together is also considered a "composite". An alloy composed of a mixture of carbide particles in cobalt, would micro-structurally be a composite layer, while a cone cutter composed of various distinct layers, carbide or other inserts, would be a composite part.

The term "green" in Table 1, line 2, refers to a state where the powder metal part is not yet fully densified but has sufficient strength to be handled without chipping or breakage. Sintering (the same table, line 3) is a process by which powdered (or otherwise) material is put in intimate contact and heated to cause a metallurgical bond between them.

Preferred embodiments of this invention introduce, for the first time, the following novel features to a drill bit cone:

(1) A "high-temperature — short-heating cycle" means of consolidation of a composite cone into a nearly finished product, saving substantial labour time, and allowing the use of multiple materials tailored to meet localised demands on their properties.

(2) Application of material layers at or near room temperature, which eliminates thermally-induced structural damage if a thermally-activated process were to be used.

(3) A "high-temperature — high pressure — short-time processing scheme, as outlined in Figure 3, where time-temperature dependent diffusion reactions are substantially reduced.

(4) A rock bit conical cutter having a hard, wear-resistant exterior skin and an interior profile which may consist of a thin layer bearing alloy or two different alloys, one for each radial and thrust bearings; all of which substantially surround a high-strength, tough core piece having protruding teeth.

(5) A conical cutter same as in Item (4), but having teeth partially covered on one side with an insert, preferably a cobalt-cemented tungsten carbide insert, which is bonded onto the interior core piece 11 by a thin layer of carbide-rich hard alloy similar to those used in for the exterior skin 19. This is illustrated in Figures 4(a) and 4(c), and is intended to provide a uniform, hard-cutting edge to the cutting teeth as they wear in downhole service i.e. self-sharpening of teeth (see Figure 4(c)). This is to be contracted with problems of degradation of the cutting edge encountered in hardfaced teeth (see Figures 4(b) and 4(d)).

(6) A conical cutter, as in Item (5), but having interior bearing surfaces provided by pre-formed and shaped inserts prior to hot consolidation of the composite cone. These inserts may be one or more pieces, at least one of which is the radial-bearing piece. Thrust bearing may be provided in the form of a single insert, or two or more inserts, depending on the cone interior design. These variations are illustrated in Figures 5(a)—5(d). Figure 5(a) shows one insert 30; Figure 5(b) shows a second insert 31 covering all interior surfaces, except for insert 30; Figure 5(c) shows a third insert 32 combined with insert 30 and a modified second insert 31'; and Figure 5(d) shows modified second and third inserts 31" and 32".

(7) A conical cutter, as in Item (6), but having interior bearing inserts 33 and 34 bonded onto the interior core piece 11 by a thin layer or layers 33a and 34a of a ductile alloy, as illustrated in Figure 6.

(8) A conical cutter same as in (5), but interior bearings surface is provided by a powder metallurgically applied layer of a bearing alloy.

Figure 1 shows a bit body 40, threaded at 40a, with conical cutters 41 mounted to journal pins 42, with ball bearings 43 and thrust bearings 44.

Step 3 of the process as listed in Table 1 is for example shown in Figure 7, the arrows 100 and 101 indicating isostatic pressurisation of both interior and exterior surfaces of the core piece 11. Note that the teeth 17 are integral with the core-piece and are also pressurised. Pressure application is effected for example by the use of rubber moulds or ceramic granules packed about the core and teeth, and pressurised. Step 12 of the process as listed in Table 1 is for example shown in Figure 8. The part as shown in Figure 2 is embedded in hot ceramic grain or particulate 102, contained within a die 103 having bottom and side walls 104 and 105. A plunger 106 fits within the cylindrical bore 105a and presses downwardly on the hot grain 102 in which consolidating force is transmitted to the part, generally indicated at 106. Accordingly, the core 11 all components and layers attached thereto as referred to above are simultaneously consolidated and bonded together.

Claims

1. A roller bit cutter comprising a tough, metallic generally conical fracture-resistant core (11) having a hollow interior (12), metallic teeth (17) protruding outwardly from the core at least some of the teeth being spaced about an axis of rotation (13) of the core, and an impact and wear-resistant layer (17c) on each tooth to provide hard cutting edges (17d) thereon, said teeth (17) being integral with said core (11) and the core (11) including an annular metallic radial bearing layer (15) carried by said core at the interior thereof to support the core for rotation, said bearing layer (15) extending about said axis (13), and an impact and wear-resistant thrust bearing layer (16) on the interior of the core which constitutes an axial thrust bearing, characterised in that said teeth protrude through a wear-resistant outer metallic layer (19) covering the exterior of the core body between said teeth.

2. A roller bit cutter as claimed in claim 1 wherein said layer (17c) on each tooth (17) consists essentially of tungsten carbide.

3. A roller bit cutter as claimed in claim 1 or claim 2 wherein at least one of said layers (15, 16, 17c, 19) consists essentially of consolidated powder metal.



4. A roller bit cutter as claimed in claim 3 wherein at least two of said layers (15, 16, 17c, 19) consist essentially of consolidated powder metal.
5. A roller bit cutter as claimed in claim 4 wherein at least three of said layers (15, 16, 17c, 19) consist essentially of consolidated powder metal.
- 5 6. A roller bit cutter as claimed in claim 5 wherein all of said layers (16, 16, 17c, 19) consist essentially of consolidated powder metal.
7. A roller bit cutter as claimed in any preceding claim wherein said core (11) consists essentially of steel alloyed with elements that include carbon, manganese, silicon, nickel, chromium, molybdenum and vanadium.
- 10 8. A roller bit cutter as claimed in claim 7 wherein said elements have the following weight percents:
- | | | |
|----|------------|--------------|
| | carbon | 0.1 to 0.65 |
| | manganese | 0.25 to 2.0 |
| 15 | silicon | 0.15 to 2.2 |
| | nickel | 0.01 to 3.75 |
| 20 | chromium | 0.01 to 1.2 |
| | molybdenum | 0.01 to 0.40 |
| | copper | 0 to 0.3. |
- 25 9. A roller bit cutter as claimed in any of claims 1 to 6 wherein said core (11) consists essentially of cast alloy steel.
10. A roller bit cutter as claimed in any of claims 1 to 6 wherein said core (11) consists of ultra high strength steel.
- 30 11. A roller bit cutter as claimed in claim 10 wherein said steel is selected from the group consisting of D-6A, H-11, 9Ni-4Co, 18-Ni maraging, 300-M, 4134, 4330V and 4340.
12. A roller bit cutter as claimed in any of claims 1 to 6 wherein said core (11) consists of consolidated ferrous powder metal steel having the following composition, indicated percentages being by weight:
- | | | |
|----|--------|-------------|
| 35 | iron | 79 to 98% |
| | copper | 0 to 20% |
| | carbon | 0.4 to 1.0% |
| 40 | nickel | 0 to 4.0% |
13. A roller bit cutter as claimed in any preceding claims wherein at least one tooth (17') is proximate the conical core tip.
- 45 14. A roller bit cutter as claimed in any preceding claim wherein the core has mechanical properties in excess of the following lower limits:
- 897,52 MPa (130 ksi) ultimate tensile strength
 - 552,32 MPa (80 ksi) yield strength
 - 5% tensile elongation
 - 15% reduction in area
 - 13.6 Nm (10ft-lb) (izod) impact strength.
- 50 15. A roller bit cutter as claimed in any of claims 1 to 5 wherein said outer layer (19) covering the exterior of the core body between said teeth (17) consists of a composite mixture of refractory particles in a binder metal.
- 55 16. A roller bit cutter as claimed in claim 15 wherein said refractory particles have micro hardness in excess of 1,000 kg/mm², and a melting point in excess of 1,600°C.
17. A roller bit cutter as claimed in claim 15 or claim 16 wherein said refractory particles are selected from the group consisting of Ti, W, Al, V, Zr, Cr, Mo, Ta, Nb, Hf and carbides, oxides, nitrides, and borides thereof.
- 60 18. A roller bit cutter as claimed in any of claims 1 to 5 wherein said radial bearing layer (15) or said outer layer (19) covering the exterior of the core body between said teeth (17) consists of tool steel initially in powder form.
19. A roller bit cutter as claimed in any of claims 1 to 5 wherein said radial bearing layer (15), or said outer layer (19) covering the exterior of the core body between said teeth (17) consists of a hardfacing alloy having a composition selected from one of the following three columnar groups:
- 65



		Cobalt base	Nickel base	Iron base
	Chromium	25—35% (*)	10—30%	0—27%
5	Carbon	0.1—3.5%	0.4—3.0%	0.1—4.0%
	Tungsten	4—13%	0—5.0%	—
	Molybdenum	0—5%	0—16.0%	0—11%
10	Boron	0—2.5%	0—5.0%	—
	Iron	0—3.0%	3—29%	Balance
15	Nickel	0—3.0%	Balance	0—1.7%
	Cobalt	Balance	0—12%	—
	Silicon	0—2.0%	0—4.5%	0—1.5%
20	Manganese	0—1.0%	0—1.0%	0—1.0%

(*) percentage by weight

25 20. A roller bit cutter as claimed in any of claims 1 to 5 wherein said radial bearing layer (15) or said outer layer (19) covering the exterior of the core body between said teeth (17) consists of wear resistant, intermetallic Laves phase, materials based on a primary constituent selected from the group consisting of cobalt and nickel, and having the following alloying elements, with indicated weight percents:

30	molybdenum	25 to 35%
	chromium	8 to 18%
	silicon	2 to 4%
35	carbon	0 to 0.08%

21. A roller bit comprising a roller bit cutter as claimed in any preceding claims mounted for rotation on a mounting of the roller bit.

40 22. A method of producing a roller bit cutter, the method comprising the steps:

- a) providing a tough, metallic generally conical and fracture-resistant core (11) having a hollow interior (12), the core having metallic teeth (17) protruding outwardly therefrom, at least some of said teeth being spaced about an axis of rotation (13) of the core; and
- b) providing an impact and wear-resistant layer (17c) of each tooth to provide hard cutting edges

45 thereon, characterised by:

- c) forming said teeth (17) integrally with the body of said core (11),
- d) subsequently providing a wear-resistant outer metallic layer (19) on the exterior of the core body between said teeth,
- e) providing an annular metallic radial bearing layer (15) which is carried by said core at the interior
- 50 thereof, said bearing layer extending about said axis (13), and
- f) providing an impact and wear resistant metallic thrust bearing layer (16) on the interior of the core to form an axial thrust bearing.

23. A method as claimed in claim 22 wherein at least one of said layers (15, 16, 17c, 19) is provided by application of powder metal which is subsequently consolidated at ambient temperature by application of

55 pressure via a flowable granular matrix covering said layer.

24. A method as claimed in claim 23, wherein said core (11) together with said layer or layers (15, 16, 17c, 19) are simultaneously consolidated by said pressure application via said granular matrix in a die, said core and said layer or layers having been previously embedded in said matrix.

25. A method as claimed in any of claims 22 to 24 wherein at least one of said layers (15, 16, 17c, 19) is

60 formed by a process involving room temperature painting, spraying or dipping of the core (11) in a slurry of powdered metal.

Patentansprüche

65 1. Rollenmeißelschneidkopf mit einem widerstandsfähigen, metallischen, insgesamt konischen und



- bruchfesten Kern (11), der einen hohlen Innenraum (12) hat, mit von dem Kern nach außen vorstehenden metallischen Zähnen (17), von denen wenigstens einige im Abstand um eine Drehachse (13) des Kerns angeordnet sind, mit einer stoß- und verschleißfesten Schicht (17c) auf jedem Zahn, um daran harte Schneidkanten (17d) zu schaffen, wobei die Zähne (17) mit dem Kern (11) ein Stück bilden, der Kern (11) eine ringförmige, metallische radiale Lagerschicht (15) aufweist, die von dem Kern an seinem Innenraum getragen wird, um den Kern für die Rotation zu lagern, und sich die Lagerschicht (15) um die Achse (13) erstreckt, und mit einer stoß- und verschleißfesten Drucklagerschicht (16) am Innenraum des Kerns, die ein axiales Drucklager bildet, dadurch gekennzeichnet, daß die Zähne durch eine verschleißfeste äußere metallische Schicht (19) vorstehen, welche das Äußere des Kernkörpers zwischen den Zähnen bedeckt.
2. Rollenmeißelschneidkopf nach Anspruch 1, bei welchem die Schicht (17c) an jedem Zahn (17) im wesentlichen aus Wolframkarbid besteht.
3. Rollenmeißelschneidkopf nach Anspruch 1 oder Anspruch 2, bei welchem wenigstens eine der Schichten (15, 16, 17c, 19) im wesentlichen aus verfestigtem Pulvermetall besteht.
4. Rollenmeißelschneidkopf nach Anspruch 3, bei welchem wenigstens zwei der Schichten (15, 16, 17c, 19) im wesentlichen aus verfestigtem Pulvermetall bestehen.
5. Rollenmeißelschneidkopf nach Anspruch 4, bei welchem wenigstens drei der Schichten (15, 16, 17c, 19) im wesentlichen aus verfestigtem Pulvermetall bestehen.
6. Rollenmeißelschneidkopf nach Anspruch 5, bei welchem alle Schichten (15, 16, 17c, 19) im wesentlichen aus verfestigtem Pulvermetall bestehen.
7. Rollenmeißelschneidkopf nach einem vorhergehenden Anspruch, bei welchem der Kern (11) im wesentlichen aus Stahl besteht, der mit Elementen legiert ist, die Kohlenstoff, Mangan, Silizium, Nickel, Chrom, Molybdän und Vanadium einschließen.
8. Rollenmeißelschneidkopf nach Anspruch 7, bei welchem die Elemente die folgenden Gewichtsprozentage haben:
- | | | |
|----|-------------|---------------|
| 25 | Kohlenstoff | 0,1 bis 0,65 |
| | Mangan | 0,25 bis 2,0 |
| | Silizium | 0,15 bis 2,2 |
| 30 | Nickel | 0,01 bis 3,75 |
| | Chrom | 0,01 bis 1,2 |
| 35 | Molybdän | 0,01 bis 0,40 |
| | Kupfer | 0 bis 0,3 |
9. Rollenmeißelschneidkopf nach einem der Ansprüche 1 bis 6, bei welchem der Kern (11) im wesentlichen aus Gußlegierung besteht.
10. Rollenmeißelschneidkopf nach einem der Ansprüche 1 bis 6, bei welchem der Kern (11) aus ultrahochfestem Stahl besteht.
11. Rollenmeißelschneidkopf nach Anspruch 10, bei welchem der Stahl aus der Gruppe ausgewählt wird, die aus D-6A, H-11, 9Ni-4Co, 18-Ni mit Martensithärtung, 300-M, 4134, 3440V und 4340 besteht.
12. Rollenmeißelschneidkopf nach einem der Ansprüche 1 bis 6, bei welchem der Kern (11) aus verfestigtem Eisenpulvermetallstahl besteht, der die folgende Zusammensetzung hat, wobei die Prozentsätze Gewichtsprozentage sind:
- | | | |
|----|-------------|--------------|
| 50 | Eisen | 79 bis 98% |
| | Kupfer | 0 bis 20% |
| | Kohlenstoff | 0,4 bis 1,0% |
| 55 | Nickel | 0 bis 4,0% |
13. Rollenmeißelschneidkopf nach einem vorhergehenden Anspruch, bei welchem wenigstens ein Zahn (17') direkt an der konischen Kernspitze liegt.
14. Rollenmeißelschneidkopf nach einem vorhergehenden Anspruch, bei welchem der Kern mechanische Eigenschaften hat, die über die folgenden unteren Grenzen hinausgehen:
- | | |
|----|--|
| 60 | 897,52 MPa (130 ksi) Zugfestigkeit |
| | 552,32 MPa (80 ksi) Streckgrenze |
| | 5% Zugdehnung |
| | 15% Einschnürung |
| 65 | 13,6 Nm (10ft-lb) (izod) Schlagfestigkeit. |



15. Rollenmeißelschneidkopf nach einem der Ansprüche 1 bis 5, bei welchem die äußere Schicht (19), die das Äußere des Kernkörpers zwischen den Zähnen (17) bedeckt, aus einer Verbundmischung aus feuerfesten Teilchen in einem Bindemetall besteht.

16. Rollenmeißelschneidkopf nach Anspruch 15, bei welchem die feuerfesten Teilchen eine Mikrohärtigkeit von mehr als 1000 kg/mm² und einen Schmelzpunkt von mehr als 1600°C haben.

17. Rollenmeißelschneidkopf nach Anspruch 15 oder Anspruch 16, bei welchem die feuerfesten Teilchen aus der Gruppe ausgewählt sind, die aus Ti, W, Al, V, Zr, Cr, Mo, Ta, Nb, Hf und ihren Karbiden, Oxiden, Nitriden und Boriden besteht.

18. Rollenmeißelschneidkopf nach einem der Ansprüche 1 bis 5, bei welchem die radiale Lagerschicht (15) oder die äußere Lagerschicht (19), die das Äußere des Kernkörpers zwischen den Zähnen (17) bedeckt, aus ursprünglich in pulverform vorliegendem Werkzeugstahl besteht.

19. Rollenmeißelschneidkopf nach einem der Ansprüche 1 bis 5, bei welchem die radiale Lagerschicht (15) oder die äußere Schicht (19), die das Äußere des Kernkörpers zwischen den Zähnen (17) bedeckt, aus einer Aufschweißlegierung besteht, die eine Zusammensetzung hat, welche aus einer der folgenden drei, in Kolonnen aufgeführten Gruppen ausgewählt ist:

		Kobaltbasis	Nickelbasis	Eisenbasis
20	Chrom	25—35% (*)	10—30%	0—27%
	Kohlenstoff	0,1—3,5%	0,4—3,0%	0,1—4,0%
	Wolfram	4—13%	0—5,0%	—
25	Molybdän	0—5%	0—16,0%	0—11%
	Bor	0—2,5%	0—5,0%	—
30	Eisen	0—3,0%	3—29%	Rest
	Nickel	0—3,0%	Rest	0—1,7%
	Kobalt	Rest	0—12%	—
35	Silizium	0—2,0%	0—4,5%	0—1,5%
	Mangan	0—1,0%	0—1,0%	0—1,0%

(*) Gewichtsprozent

20. Rollenmeißelschneidkopf nach einem der Ansprüche 1 bis 5, bei welchem die Radiallagerschicht (15) oder die äußere Schicht (19), die das Äußere des Kernkörpers zwischen den Zähnen (17) bedeckt, aus verschleißfesten, intermetallischen Laves-Phasen-Materialien besteht, die auf einem Grundbestandteil basieren, der aus der Gruppe ausgewählt wird, die aus Kobalt und Nickel besteht, und die die folgenden Legierungselemente haben, welche in Gewichtsprozent ausgedrückt sind:

	Molybdän	25 bis 35%
	Chrom	8 bis 18%
50	Silizium	2 bis 4%
	Kohlenstoff	0 bis 0,08%

21. Rollenmeißel mit einem Rollenmeißelschneidkopf nach einem vorhergehenden Anspruch, der für die Rotation an einer Halterung des Rollenmeißels angebracht ist.

22. Verfahren zur Herstellung eines Rollenmeißelschneidkopfs, welches die Schritte aufweist:

a) Schaffen eines widerstandsfähigen metallischen insgesamt konischen und bruchfesten Kerns (11), der einen hohlen Innenraum (12) und metallische Zähne (17) aufweist, die nach außen davon vorstehen, wobei wenigstens einige der Zähne im Abstand um eine Drehachse (13) des Kerns angeordnet sind; und
b) Schaffen einer stoß- und verschleißfesten Schicht (17c) eines jeden Zahns zur Bildung einer harten Schneidkante daran, gekennzeichnet, durch:

c) Ausbilden der Zähne (17) in einem Stück mit dem Körper des Kerns (11),

d) danach Schaffen einer verschleißfesten äußeren metallischen Schicht (19) an der Außenseite des Kernkörpers zwischen den Zähnen,



- e) Schaffen einer ringförmigen metallischen Radiallagerschicht (15), die von dem Kern an seinem Innenraum getragen wird, wobei sich die Lagerschicht um seine Achse (13) erstreckt, und
 f) Schaffen einer stoß- und verschleißfesten metallischen Drucklagerschicht (16) an dem Innenraum des Kerns zur Bildung eines axialen Drucklagers.
23. Verfahren nach Anspruch 22, bei welchem wenigstens eine der Schichten (15, 16, 17c, 19) durch Aufbringen eines Pulvermetalls geschaffen wird, das anschließend bei Umgebungstemperatur durch Anlegen eines Drucks über eine fließfähige körnige Grundmasse, welche die Schicht bedeckt, befestigt wird.
24. Verfahren nach Anspruch 23, bei welchem der Kern (11) zusammen mit der Schicht oder den Schichten (15, 16, 17c, 19) gleichzeitig das Anlegen des Drucks über die körnige Grundmasse in einer Form verfestigt wird, wobei der Kern und die Schicht oder die Schichten vorher in die Grundmasse eingebettet worden sind.
25. Verfahren nach einem der Ansprüche 22 bis 24, bei welchem wenigstens eine der Schichten (15, 16, 17c, 19) durch einen Prozeß gebildet wird, zu dem das Bestreichen bei Raumtemperatur, das Besprühen oder das Eintauchen des Kerns (11) in eine Aufschlämmung aus Pulvermetall gehören.

Revendications

1. Outil de coupe tournant pour trépan comprenant un noyau (11) dur, métallique, de forme générale conique et résistant à la rupture comportant un intérieur creux (12), des dents métalliques (17) faisant saillie vers l'extérieur à partir du noyau, au moins certaines des dents étant espacées par rapport à un axe de rotation (13) du noyau, et une couche (17c) résistant à l'usure et au choc sur chacune des dents pour constituer des bords (17d) durs coupants sur ladite dent, lesdites dents (17) étant solidaires dudit noyau (11) et le noyau (11) comportant une couche (15) formant palier radiale annulaire métallique portée par ledit noyau à l'intérieur de celui-ci pour supporter le noyau en rotation, ladite couche formant palier (15) s'étendant par rapport audit axe (13) et une couche formant palier de butée (16) résistant à l'usure et au choc à l'intérieur du noyau qui constitue un palier de butée axiale, caractérisé en ce que les dents font saillie à travers une couche (19) métallique externe résistant à l'usure qui recouvre l'extérieur du corps du noyau entre lesdites dents.
2. Outil de coupe tournant pour trépan tel que revendiqué dans la revendication 1 dans lequel ladite couche (17c) prévue sur chacune des dents (17) consiste essentiellement en du carbure de tungstène.
3. Outil de coupe tournant pour trépan tel que revendiqué dans la revendication 1 ou la revendication 2 dans lequel au moins l'une desdites couches (15, 16, 17c, 19) consiste essentiellement en du métal en poudre compacté.
4. Outil de coupe tournant pour trépan tel que revendiqué dans la revendication 3 dans lequel au moins deux desdites couches (15, 16, 17c, 19) consistent essentiellement en du métal en poudre compacté.
5. Outil de coupe tournant pour trépan tel que revendiqué dans la revendication 4 dans lequel au moins trois desdites couches (15, 16, 17c, 19) consistent essentiellement en du métal en poudre compacté.
6. Outil de coupe tournant pour trépan tel que revendiqué dans la revendication 5 dans lequel toutes lesdites couches (15, 16, 17c, 19) consistent essentiellement en du métal en poudre compacté.
7. Outil de coupe pour trépan tel que revendiqué dans l'une quelconque des revendications précédentes dans lequel ledit noyau (11) consiste essentiellement en de l'acier allié avec des éléments qui comportent le carbone, le manganèse, le silicium, le nickel, le chrome, le molybdène et le vanadium.
8. Outil de coupe tournant pour trépan tel que revendiqué dans la revendication 7 dans lequel lesdits éléments se présentent avec les pourcentages suivants en poids:

Carbone	0,1 à 0,65
Manganèse	0,25 à 2,0
Silicium	0,15 à 2,2
Nickel	0,01 à 3,75
Chrome	0,01 à 1,2
Molybdène	0,01 à 0,40
Cuivre	0 à 0,3

9. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications 1 à 6 dans lequel ledit noyau (11) consiste essentiellement en de l'acier allié moulé.
10. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications 1 à 6 dans lequel ledit noyau (11) consiste en de l'acier à résistance très élevée.
11. Outil de coupe tournant pour trépan tel que revendiqué à la revendication 10 dans lequel ledit acier est choisi dans le groupe consistant en D-6A, H-11, 9Ni-4Co, 18-Ni maraging, 300-M, 4134, 4330V et 4340.



12. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications 1 à 6 dans lequel ledit noyau (11) consiste en de l'acier se présentant sous la forme de poudre métallique ferreuse compactée ayant la composition suivante, indiquée en pourcentages en poids:

5	Fer	79 à 98%
	Cuivre	0 à 20%
	Carbone	0,4 à 1,0%
10	Nickel	0 à 4,0%

13. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications précédentes dans lequel au moins une dent (17') est voisine de l'extrémité du noyau conique.

14. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications précédentes dans lequel le noyau a des propriétés mécaniques supérieures aux limites inférieures suivantes:

	987,52 MPa résistance maximum à la traction
	552,32 MPa résistance à la fatigue
20	5% d'allongement à l'attraction,
	15% de réduction de section,
	13,6 Nm (izod) résistance au choc.

15. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications 1 à 5 dans lequel ladite couche extérieure (19) recouvrant l'extérieur du corps de noyau entre lesdites dents (17) consiste en un mélange composite de particules réfractaires dans un métal formant liant.

16. Outil de coupe tournant pour trépan tel que revendiqué dans la revendication 15 dans lequel lesdites particules réfractaires ont une microdureté supérieure à 1 000 kg/mm² et un point de fusion dépassant 1 600°C.

17. Outil de coupe tournant pour trépan tel que revendiqué dans la revendication 15 ou la revendication 16 dans lequel lesdites particules réfractaires sont choisies dans le groupe qui comporte Ti, W, Al, V, Zr, Cr, Mo, Ta, Nb, Hf et les carbures, oxydes, nitrures, et borures de ces derniers.

18. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications 1 à 5 dans lequel ladite couche radiale formant palier (15) ou ladite couche extérieure (19) recouvrant l'extérieur du corps de noyau entre lesdites dents (17) consiste en de l'acier à outil se présentant initialement sous forme de poudre.

19. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications 1 à 5 dans lequel ladite couche radiale formant palier (15) ou ladite couche extérieure (19) recouvrant l'extérieur du corps de noyau entre lesdites dents (17) consiste en un alliage à surface dure ayant une composition choisie parmi l'un des groupes des trois colonnes ci-dessous

	Base cobalt	Base nickel	Base fer
40	Chrome	25—35% (*)	10—30%
			0—27%
45	Carbone	0,1—3,5%	0,4—3,0%
			0,1—4,0%
	Tungstène	4—13	0—5,0%
			—
	Molybdène	0—5%	0—16,0%
50			0—11%
	Bore	0—2,5%	0—5,0%
			—
	Fer	0—3,0%	3—29%
			reste
55	Nickel	0—3,0%	reste
			0—1,7%
	Cobalt	reste	0—12%
			—
	Silicium	0—2,0%	0—4,5%
			0—1,5%
60	Manganèse	0—1,0%	0—1,0%
			0—1,0%

(*) pourcentages en poids

20. Outil de coupe tournant pour trépan tel que revendiqué dans l'une quelconque des revendications 1



à 5 dans lequel ladite couche radiale formant palier (15) ou ladite couche extérieure (19) recouvrant l'extérieur recouvrant l'extérieur du corps de noyau entre lesdites dents (17) consiste en des matériaux en face intermétallique résistant à l'usure basés sur un constituant primaire sélectionné dans le groupe consistant en le cobalt et le nickel et ayant les éléments d'alliage suivants avec les pourcentages indiqués en poids suivants:

Molybdène	25 à 35%
Chrome	8 à 18%
Silicium	2 à 4%
Carbone	0 à 0,08%

21. Trépan tournant comprenant un outil de coupe pour trépan tel que revendiqué dans l'une quelconque des revendications précédentes monté pour tourner sur un moyen de montage dudit trépan.

22. Procédé pour fabriquer un outil de coupe tournant pour trépan, ledit procédé comprenant les phases suivantes:

a) on utilise un noyau (11) dur, métallique de forme générale conique et résistant à la rupture ayant un intérieur creux (12), le noyau comportant des dents métalliques (17) faisant saillie vers l'extérieur de celui-ci, au moins certaines desdites dents étant espacées par rapport à l'axe de rotation (13) dudit noyau; et

b) on dispose une couche (17c) résistant au choc et à l'usure sur chaque dent de façon à réaliser des bords coupants durs sur celle-ci, caractérisé par les phases suivantes:

c) on réalise lesdites dents (17) solidaires avec le corps dudit noyau (11),

d) on réalise subséquemment une couche (19) métallique extérieure résistant à l'usure sur l'extérieur du corps de noyau entre lesdites dents;

e) on réalise une couche (15) annulaire métallique radiale formant palier qui est portée par ledit noyau à l'intérieur de celui-ci, ladite couche formant palier s'étendant autour dudit axe (13) et,

f) on réalise une couche (16) métallique résistant à l'usure et au choc formant palier de butée à l'intérieur dudit noyau pour former un palier de butée axiale.

23. Procédé tel que revendiqué dans la revendication 22 dans lequel au moins l'une desdites couches (15, 16, 17c, 19) est obtenue par application de métal pulvérulent qui est ensuite compacté à la température ambiante par application de pression par l'intermédiaire d'une matrice granulaire susceptible de fluer qui recouvre ladite couche.

24. Procédé tel que revendiqué dans la revendication 23 dans lequel ledit noyau (11) en même temps que ladite couche ou lesdites couches (15, 16, 17c, 19) sont compactés simultanément au moyen d'une application de ladite pression par l'intermédiaire d'une matrice granulaire dans un moule, ledit noyau et ladite couche ou lesdites couches ayant été au préalable noyés dans ladite matrice.

25. Procédé tel que revendiqué dans l'une quelconque des revendications 22 à 24 dans lequel au moins l'une desdites couches (15, 16, 17c, 19) est réalisée par un procédé qui comporte une opération de peinture à la température ambiante, une pulvérisation ou un trempage du noyau (11) dans un métal pulvérulent sous forme de boue.