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(12) # EUROPEAN PATENT APPLICATION

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(54) **A method of producing a steel body comprising hard material inserts.**

(57) A method of producing a steel body (1) comprising hard material inserts, (2) particularly a drill bit for rock drilling, in which steel powder is compacted at least partially around the inserts from a cold state to a high density preform. The preform is then sintered and because of the choice of alloy the steel powder shrinks substantially during the sintering. A high strength drill bit is produced in which the inserts may have almost any form, in particular a form optimized for a particular application.

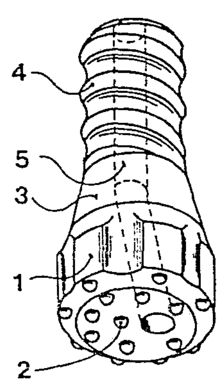

Fig.1

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A method of producing a steel body comprising hard material inserts

The present invention relates to a method of producing a steel body comprising hard material inserts, e.g. producing drill bits for rock drilling.

According to prior art hard metal inserts have been fixed to steel either by brazing or press fits. Both these methods present difficulties which are overcome only by care during manufacture. Brazing tends to cause tensional stress during the subsequent cooling so that a weakening of the steel and the hard metal may occur. Press fits require that both the hardened steel and the hard metal inserts are machined to close tolerances. Furthermore, the hard metal inserts will not be fully supported at the base of the hole.

One attempt of overcoming the machining requirement, particularly regarding the hard metal inserts for drill bits , is described in US patents 3 749 190 and 3 805 364. According to these patents a sleeve of a soft material is provided around the hard metal insert to fill the space between the insert and the steel body. If this fixation method is properly used the strength of the fit is entirely depending on the shear strength of the soft material.

The object of the present invention is to provide a method of producing a steel body comprising hard material inserts which method avoids machining to close tolerances and where the strength of the final product is not limited by the strength of a soft material between the steel body and the hard material inserts. In addition, no machining marks are present on the inside of the steel hole to act as stress raisers and fatigue initiators. The invention also guarantees full support of the bottom of the buttons. The invention also makes it possible to reduce the amount of hard metal inside the steel , resulting in improved economy.

The invention, which is defined by the subsequent claims, fulfills the above mentioned object by prescribing that steel powder is compacted from a cold state to a high density preform comprising the hard material inserts and that the composition of the steel powder is chosen such that it undergoes substantial shrinkage during the subsequent sintering.

According to a preferred embodiment of the invention the steel powder is compacted by the impact of a high velocity punch, whereby a considerably higher and more uniform density is obtained than with conventional pressing techniques. This applies especially to the regions nearest to the hard material inserts where an adequate powder flow is not obtained with conventional techniques.

The hard material inserts may, furthermore, be advantageously provided with surface irregularities, e.g. being rough as compacted and sintered, or otherwise such shaped that they become mechanically locked in the steel body through the compaction.

It has been determined to be advantageous to use a steel powder comprising 4-16 % Ni, 0.25-1.5 % Cu, 0.2-0.5 % Mo and 0.3-0.9 % C to obtain the desired shrinkage during the sintering.

To further improve the fixing of the hard material inserts in the steel body it is advantageous to metallurgically bond a layer of metal, e.g. electro-plated nickel, iron or cobalt, first to the hard material inserts and then during sintering to the steel. The metal layer may be deposited on the hard material inserts in any suitable way.

A further advantage with the present invention is obtained if the composition of the steel powder is varied so that a sub-surface layer of lower hardness is obtained. Such a layer would be rapidly removed during operation after the surface layer of normal hardness has been worn down, whereby the self-sharpening of the drill bit is improved. This lower hardness may be obtained through decreasing the copper or carbon content of the alloy, or increasing the nickel content. Variation in hardness may also be used to increase resistance to gauge wear.

Even though hard material in the present application mostly refers to hard metals, e.g. various metal carbides, the term also includes other suitable hard materials e.g. other carbides or diamonds. One example is in rotary drilling where it has turned out to be advantageous to use hard material inserts which comprise hard metal discs having a surface layer of sintered diamonds. This diamond layer is protected during sintering by nickel plating of the hard metal and the diamonds. Alternatively, the sintering temperature may be reduced.

A further advantage obtained with the present invention is that the hard material inserts can have almost any form. This means that they can be given a form which is optimized for a particular application. Furthermore, it is possible to obtain a steel body comprising hard material inserts with an overall strength which up to now has been believed to be unobtainable with powder metallurgy.

The method according to the present invention is performed in the following way. The preformed hard material inserts are placed on a conventional die in the desired pattern. The die is then placed in a compaction chamber. Steel powder, preferably with the above mentioned composition, is then added around the inserts. Normally the lowermost part of the inserts will extend outside the volume of powder. Then the steel powder is covered by another die or a thin disc. After this the powder is compacted from a cold state to a high density preform. This is preferably performed by means of a high velocity punch, which impacts the powder. Experiments have shown that good results are obtainable in the speed range 100-600 m/s. After compaction the preform is sintered. Sintering should take place at a temperature in the range 1100 to 1250°C and last for 1/2-3 hours. These values depend somewhat on the composition of the alloy and the type of fixation required. A steel powder with the above mentioned composition will, during sintering, undergo a substantial shrinkage, 0.5-2 %. In order to improve the fixation of the inserts a chemical bond between the hard material and the steel may be produced by the use of a flux on the interface of the two materials. After sintering the compact may be either furnace cooled or air cooled or quenched in an oil bath or similar.

If the compact is intended to be used in a drill bit the back face is machined flat and then friction welded to a steel tube. No special techniques are required for the friction welding. Good results have been obtained with a rotation speed of 1500 rpm, a welding time of 10 seconds and a contact pressure of 20 bar. After this the part is machined to get rid of the weld burr and to obtain the flushing holes. The part is also provided with a thread or other suitable fitment for connection to a drill rod . It is desirable, although not necessary, to temper the finished bit at a temperature of about 200°C.

Below are three specific examples of the invention.

1. Hard metal buttons were placed on a die in a 70 mm diameter compaction chamber and 120 cm^3 of steel powder was placed around the buttons. This was then compacted by a plastic punch with an impact velocity of 300 m/s. The length of the punch was 100 mm. The composition of the steel powder was 0.4 % C, 8 % Ni, 1.5 % Cu, 0.5 % Mo, the rest was iron. The compact was then sintered at 1200°C for 1 hour in a protective atmosphere of 10 % hydrogen in nitrogen. A Ma 4 high temperature brazing flux from Castolin S.A. was placed over the exposed carbide buttons before sintering. After sintering the compact was furnace cooled to 900°C in the sinter furnace and then air quenched. The part was then tempered at 180°C for 1 hour.

2. Hard metal buttons were plated with pure nickel using a standard commercial technique. These were then placed in recesses machined for them in a die. The die was then placed in a 70 mm diameter compacttion chamber. 240 cm^3 of steel powder was added. The composition of the steel powder was 0.6 % C, 16 % Ni, 0.75 % Cu, 0.5 % Mo, the rest was iron. This was compacted by the impact of a 120 mm punch at 330 m/s. The compact was sintered in a protective atmosphere for 1/2 hour and then air cooled. The compact was then tempered for 1 hour at 220°C.

3. Hard metal buttons having a negative taper were placed in recesses machined in a die. This was then placed in a 70 mm diameter compaction chamber and 160 cm^3 of steel powder added around the buttons. The composition of the steel powder was 0.7 % C, 4 % Ni,

0.5 % Cu, 0.5 % Mo, the rest was iron. This was compacted by the impact of an 80 mm plastic punch at 250 m/s. The compact was sintered for 2 hours at 1140°C under a protective atmosphere. A high temperature flux was provided on the interfaces between the carbides and the steel powder . The part was furnace cooled down to 800°C and then oil quenched. The piece was then tempered at 200°C.

In the accompanying drawing fig. 1 shows a drill bit for rock drilling produced according to the invention. Figs . 2-5 show different embodiments of the drill bit from below. Figs. 6-11 show a number of alternative shapes of hard material inserts for drill bits.

The drill bit according to Fig. 1 comprises a head portion 1 comprising a number of hard metal inserts 2. This part of the drill bit has been manufactured with the method according to the invention. Head portion 1 has been connected with a steel tube 3 by friction welding. The drill has further been provided with a thread 4 for the connection with a drill string and a channel 5 for flushing fluid. As can be seen in figs. 2-5 virtually any cross-sectional form can be used for the inserts. In addition to the forms shown almost any prior art form may be used. In figs. 6-11 a number of alternative inserts are shown. These inserts, which are only a few examples of possible forms, have circular cross-sectional areas although they may have other cross-sectional forms, e.g. any of those shown in figs. 2-5. Fig. 6 shows an insert having negative taper.Fig. 7 shows an insert having a rough surface. In fig. 8 the insert is provided with a neck or waist. In fig. 9 the insert is provided with several necks. The insert in fig. 10 has a form similar to that of a human tooth. The insert shown in fig. 11 is additionally provided with a neck.

Claims.

1. A method of producing a steel body comprising hard material inserts in which preformed hard material inserts are placed in a die in a desired pattern, steel powder is added to at least partially surround the inserts and the powder is compacted, c h a r a c t e r i z e d t h e r e b y that the steel powder is compacted from a cold state to a high density preform, that said preform is subsequently sintered, whereby for said steel powder is chosen a steel alloy which undergoes substantial shrinkage during the sintering to produce a firm fixation of the hard material inserts in the steel body.

2. A method according to claim 1, c h a r a c t e r i z e d t h e r e b y that the steel powder is impacted by a high velocity punch to effect said compaction.

3. A method according to claim 1 or 2, c h a r a c t e r i z e d t h e r e b y that said sintering comprises sinter forging.

4. A method according to any of the preceding claims, c h a r a c t e r i z e d t h e r e b y that the steel powder is compacted around irregularities on the hard material inserts to mechanically lock the inserts in the steel body.

5. A method according to any of the preceding claims, c h a r a c t e r i z e d t h e r e b y that said hard material inserts comprise a part having a larger cross-sectional area than the cross -sectional area at the surface of said steel body and that the steel powder is compacted around said part to mechanically lock the inserts in the steel body.

6. A method according to any of the preceding claims, c h a r a c t e r i z e d t h e r e b y that a steel powder comprising 4-16 % Ni, 0.25-1.5 % Cu, 0.2-0.5 % Mo and 0.3-0.9 % C is used.

7. A method according to any of the preceding claims, c h a r a c t e r i z e d t h e r e b y that a layer of metal is metallurgically bonded, first to the hard material inserts and then during the sintering to the steel.

8. A method according to any of the preceding claims, c h a r a c t e r i z e d t h e r e b y that the steel powder has varying composition whereby a sub-surface layer of lower hardness is obtained.

9. A method according to any of the preceding claims, c h a r a c t e r i z e d t h e r e b y that the hard material inserts comprise hard metal discs having a surface layer of sintered diamonds.

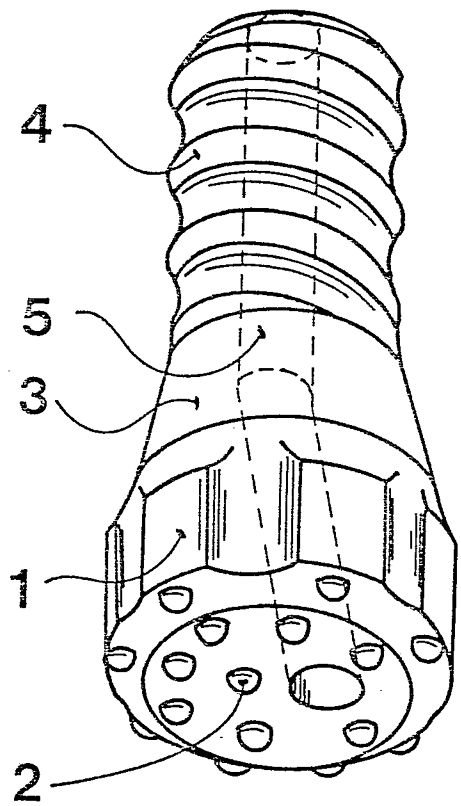

Fig.1

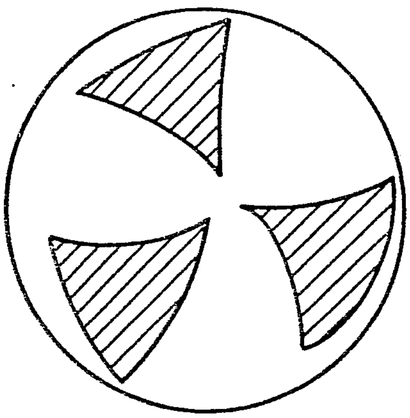

Fig. 2

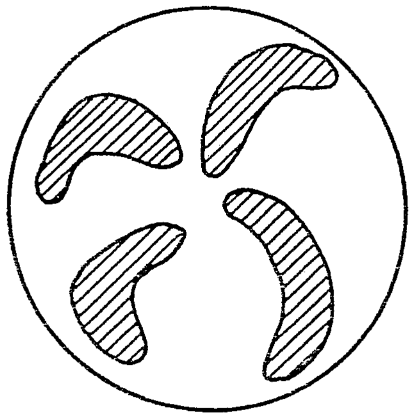

Fig. 3

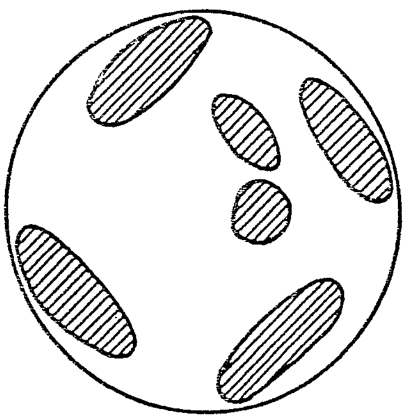

Fig. 4

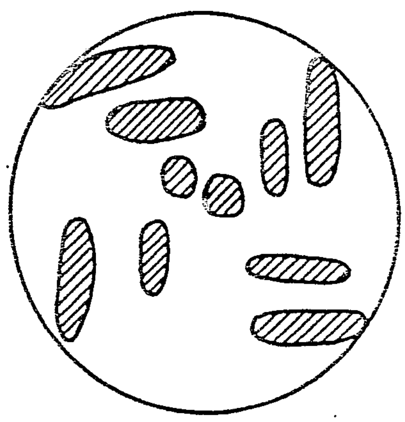

Fig. 5

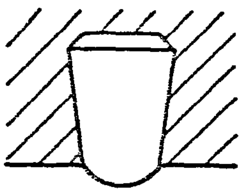

Fig.6

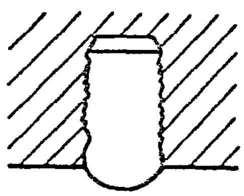

Fig.7

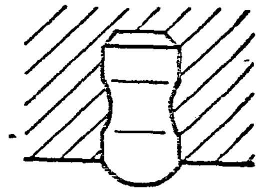

Fig.8

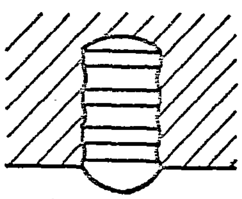

Fig.9

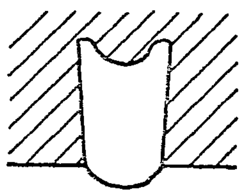

Fig.10

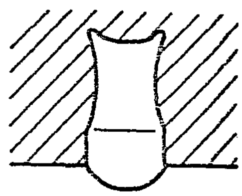

Fig.11

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EUROPEAN SEARCH REPORT

Application number
EP 81 85 0192

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
Y	GB - A - 2 017 153 (F. KRUPP) * Claim 1; page 2, lines 102-124 * --	1
Y	FR - A - 2 384 574 (SKF) * Claims 1,6,7 * --	1,4,5
Y	US - A - 3 673 676 (E.H. LOCK et al.) * Claim 1; column 5, lines 51-68; column 6, line 51 - column 7, line 1 * --	1
Y	US - A - 4 164 527 (V.N. BAKUL et al.) * Claim 1 * --	1,9
Y	US - A - 3 837 068 (W.M. DUNN) * Claim 1 * --	2,3
Y	GB - A - 530 639 (MEUTSCH, VOIGTLANDER & CO.) * Claims 1,3; page 2, lines 34-60 * ----	6,7

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

B 22 F 7/06
E 21 B 10/56

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

B 22 F 7
E 21 B 10/56

CATEGORY OF CITED DOCUMENTS

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X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18-02-1982	SCHRUERS

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