Title: A ONE-PIECE DRILL BIT FOR SINGLE-PASS ANCHOR BOLTING AND SINGLE PASS DRILLING APPARATUS

Abstract: The present invention relates to a drill bit (16) and a single pass drilling apparatus (10). The one-piece drill bit (16) has a connection portion, adapted to be rigidly connected to a drill steel, a pilot part (14) and a reamer part (19). The pilot part has first rock machining means (17). The reamer part has a first center line (CL2) and second rock machining means (18A, 18B, 18C). The second rock machining means is provided axially between said connection portion and said first rock machining means and to one side of the pilot part. The drill bit has a rotational direction (R). The pilot part (14) has a length (L). The pilot part (14) is generally inclined relative to the first center line (CL2). The length (L) of the pilot part (14) is at least 10 mm.
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
A one-piece drill bit for single-pass anchor bolting and single pass drilling apparatus

Background of the invention

The present invention relates to a drill bit and a single pass drilling apparatus according to the preambles of the independent claims.

The installation of anchor bolts to reinforce excavations is usually carried out in two distinct steps. Usually, a bore is drilled and the drill steel and bit extracted before the bolt is inserted into the bore and tightened or grouted. Single pass anchor bolting involves carrying out these two steps simultaneously, with the task of removing the drill steel to insert the bolt being eliminated. The advantages of single pass bolting include minimizing the time required for bolt installation, improving safety for drilling equipment operators, when comparing with manual or semi manual bolting, and enhancing prospects for full automation of the process. A further advantage is improved quality and precision of anchor bolt installation, when comparing with manual or semi manual bolting. The diameter of the bore is critical for anchor bolt performance in the case of friction, e.g. Split set bolts. Still a further advantage with single pass bolting is that the bore cannot collapse when retracting the drill bit since the bolt is already in the bore. This leads to much better efficiency as the bolt is always installed; i.e. there will be no lost holes.

Prior attempts at single pass bolting have generally been targeted at innovative anchor bolts, which also act as the drill steel, having a drill bit provided about an end thereof. Such apparatus are used via a rotational drilling method or a rotary/percussive drilling method and are generally unsuitable for hard ground conditions. Existing hard ground percussive anchor bolts that do not reuse the drill bit suffer from cost problems. A wide variety of roof bolts exist and one particular form is tubular (e.g. split-sets, Swellex, etc.), having a central bore formed lengthwise through the bolt. Drill bits adapted to be extracted through a casing have been complex and accordingly expensive. Cost competitiveness of drilling speed versus bit cost are complicated in prior single pass anchor bolts
due to the use of specialized anchor bolts and the exclusive use of either complex retractable bits. It nevertheless remains the case, that the installation advantages of a self-drilling roof bolt outweigh those of the non-self-drilling type.

**Objects of the invention**

The drill bit according to the present invention has as one object to substantially overcome the above-mentioned problems associated with the prior art, or at least to provide an alternative thereto.

Another object of the present invention is to provide a single pass drill bit.

Still another object of the present invention is to provide a drill bit and a single pass drilling apparatus that are less costly to use and so to make use of single pass bolting in the mining industry more attractive.

Still another object of the present invention is to provide a drill bit providing favorable guiding in the bore.

Throughout the specification, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusions of any other integer or group of integers.

**Brief description of the drawings**

The attached drawings show an example embodiment of the invention of the foregoing kind. The particularity of those drawings and the associated description does not supersede the generality of the preceding broad description of the invention.

Figs. 1A – 1G schematically show a sequence of single pass roof bolting using a drill bit according to the present invention. Fig. 2A shows the drill bit according to the present invention and a rod portion in a side elevational view. Fig. 2B shows the drill bit in a front view. Fig. 3A shows the drill bit during drilling
of a hole in the rock in a side elevational view. Fig. 3B shows the drill bit in a front view during drilling of the hole in the rock.

**Detailed description of the invention**

Figs. 1A – 1G show a single pass drilling apparatus 10 according to the present invention using a drill bit 16 according to the present invention and Figs. 2A-3B more closely show the drill bit 16 according to the present invention. The single pass drilling apparatus 10 comprises several parts; e.g. an elongated drill steel 11 having a leading end 12 and a trailing end, not shown, reference being had to a drilling direction F. The leading end 12 has a connection portion comprising a thread 15, a taper or a bayonet connection, not shown. A one-piece drill bit 16 is provided having rock machining means 17 and 18A, 18B, 18C. The drill bit 16 is connectable to the drill steel via a connection portion 20 comprising a thread, a taper or a bayonet connection (not shown). The drill steel 11 and the drill bit constitute drilling means. The single pass drilling apparatus 10 further comprises an anchor bolt 21 adapted to at least partially enclose the drill steel 11. The anchor bolt 21 has open ends. The greatest diametrical dimension of the drill bit is smaller than the smallest diameter of the anchor bolt 21.

The basic idea of the single pass drilling apparatus 10 is to drill the bore while the bolt encloses the drill steel, and then to retract the bit to be used again. There are no losses of bit parts. The single pass drilling apparatus 10 has been more closely described in Swedish Patent Application No. 0400597-1, the disclosure of which is hereby incorporated by reference.

The drill bit 16 can be designed as follows, reference being had to Figs. 2A and 2B. The one-piece drill bit 16 has two integral parts, i.e. a pilot part 14, long enough, i.e. the length L, to guide the entire apparatus 10 properly, and a reamer part 19. The center line or middle line CL1 of the pilot part 14 forms an acute second angle α with an axis CL3 extending parallel to a first center line CL2 of the reamer part. The angle α is -20° to +20°, excluding 0°, preferably not less than +0.1° and not more than +15°, index “+” being shown in Figs. 2A and 3A. The middle line CL1 will during drilling substantially coincide with the axis of the bore 22. The middle line CL1 of the pilot part 14 also substantially coincides with
the center line of the anchor bolt 21 during drilling, but not during retraction of the drill bit. The center line or middle line CL2 of the reamer part 19 and the center line of the drill steel 11 coincide when not drilling. It should be noted that neither the pilot part 14 nor the reamer part 19 has to be circular or symmetrical in radial cross-section, so the reference to lines CL1 and CL2 shall be understood as a reference to general or average middle lines in the respective parts.

The one-piece rock drill bit 16 comprises a body 25 and cemented carbide means, i.e. chisels and/or buttons 17, 18A, 18B and 18C. The body of the drill bit is made of steel. The body 25 comprises the substantially cylindrical pilot part 14 and the substantially conical reamer part 19. The pilot part 14 can have a conical shape and the reamer part 19 can have a cylindrical shape. The pilot part has a front face carrying a diametrically extending chisel 17 or two or more diametrically substantially aligned front buttons, not shown. The reamer part 19 can have a circular radial cross-section. The reamer part has a front face carrying one or more front buttons; in this case three front buttons 18A, 18B and 18C. The front faces may be convex or substantially planar. The buttons 18A, 18B and 18C may form a peripheral arch on the reamer part. The buttons 18A, 18B and 18C may project somewhat outside the periphery of the reamer part in order to machine a bore 22 during drilling which has a bigger diameter than the steel body 25. The number of cemented carbide buttons in the reamer part can be varied depending on how great the diameter of the drill bit is. Chipways or recesses can be provided in areas between adjacent reamer buttons, through which flush medium can pass. The rock drill bit 16 is to be coupled to the drill steel 11 by means of a connection portion, so as to transfer rotational movement and percussion in the usual manner. The drill steel 11 includes a channel for conveying a flush medium. A main channel for flush medium is provided inside the drill bit. This main channel communicates at its forward end with a number of branch channels, which exit in the front faces. The flush medium will in practice be water, cement or air. The pilot part drills a pilot bore 22A of less diameter and length in relation to the bore 22. The length L of the pilot part 14 is defined as the distance between the forward most portion and the rearward most portion (where the reamer part 19 starts) of the pilot part, in a direction parallel to the reamer
part center line CL2. The length L is at least 10 mm and preferably not more than 60 mm to provide good guidance of and good service life for the drill bit. The reamer buttons in this embodiment comprises a leading button 18A, an intermediate button 18B and a trailing button 18C. During drilling, the greatest reactional forces on the reamer 19 act on the leading and intermediate rock machining means 18A, 18B. Therefore, an axial plane through the chisel 17 is angled such that it passes between the leading and intermediate rock machining means 18A, 18B. Stated another way, an imaginary line S, preferably a midline through the rock machining means or chisel 17 and perpendicular to the center line CL2 of the reamer part 19, forms an acute first angle B with a normal N to the center line CL2. The normal N intersects the rock machining means or button 18A that leads in the rotational direction R of the drill bit 16. The angle B is preferably not less than 0° and not more than 20°. If the leading rock machining means in the reamer part 19 is a button then the normal N intersects its center line. If the leading rock machining means in the reamer part 19 has another shape then the normal N intersects its forward most point in the rotational direction R. During drilling, the greatest reactional forces on the reamer 19 act on the leading and intermediate buttons 18A, 18B. The rock machining means 17 will inter alia extend at least to the envelope surface 50. Therefore, by positioning the rock machining means 17 in a certain relation to the leading button 18A the envelope surface 50 of the pilot part the rock machining means 17 will form a wear resistant means 17' during drilling at the position of the reamer most subjected to wear. A tangent T, touching the envelope surface 50 or a skirt 51 of the drill bit and being parallel to the center line CL2, forms a radial distance X with the periphery of the pilot part at its forward end. The distance X is not zero and is preferably not less than -5 mm and preferably not more than +5 mm. The discussed shape gives good drilling results and a better contact surface between the pilot hole 22A and the pilot part 14. By having the pilot part inclined towards the reamer part by some degrees better drilling results are achieved because the drill steel always bends in the same direction when drilling, and the bending of the drill steel 11 is limited by a contact at the axially lower end 52 of the skirt 51 axially below the buttons 18A-18C. The pilot part 14 is thus generally
inclined relative to the first center line CL2. The lower end 52 of the skirt, where it
is supposed to be in contact with the rock, can be either harder than the rest of
the steel body 25 by means of surface treatment, or be provided with hard inserts
to reduce wear.

The operation of the single pass rock bolting apparatus 10 is shown in Figs.
1A – 1G. Figs. 3A and 3B corresponds to for example Fig. 1C. The degree of
bending of the drill steel 11 is exaggerated in Fig. 3A. The drill bit 16 is
connected, for example threaded, to the drill steel 11. A drilling machine such as
a standard drill jumbo holds the drill steel. The bolt 21 is preferably automatically
fed around the drill steel and positioned behind the drill bit 16 in the drilling
direction F. In Fig. 1A the pilot part 14 primarily will abut against the rock such
that for a short while it will machine the rock surface during circular interpolation.
Then the pilot part 14 will find its correct center and begin to drill centrally while
the drill steel 11 simultaneously starts wobbling about the pilot part middle line
CL1 1B. Then the reamer part 19 gets in contact with the rock surface and
begins to ream the hole made by the pilot part 14. After a short while, the bolt 21
reaches the hole and is forced into the hole as shown in Fig. 1C. Usually the bolt
21 is spaced axially from the drill bit 16. The bolt 21 diameter is preferably less
than that of the bore 22. The drill bit 16 will continue to drill and ream the bore
22, while the bolt is pushed forwardly by a coupling sleeve 26 of the drilling
machine, see Fig. 1D, until feed of the different parts is stopped. The depth of
the bore 22 is substantially determined by the length of the bolt 21, i.e. when a
washer 23 positioned at the trailing end of the bolt reaches the rock face or
entrance of the bore further feed will be stopped, see Fig. 1E. There is an anchor
bolt pusher on the drilling machine. The bolt pusher is a coupling sleeve 26 or a
dolly tool, which is driven by the drill steel. The dolly tool usually rotates together
with the drill steel and the bolt during insertion. However, for instance the bolt
may be held such that it does not rotate during insertion, e.g. in the case of a
mechanical anchor bolt. The dolly tool can torque the anchor bolt when fully
inserted. The dolly tool can also slide along the drill steel to allow an easier
installation of mechanical shell bolts and grouted bolts. Fig. 1E shows the anchor
bolt 21 fully inserted, with the drill steel and drill bit still in the anchor bolt. A
pusher pushes the plate to the rock face. The washer could be a loose conventional plate having a central hole that cooperates with a bulge 24 at the trailing end of the bolt. Then the drill bit is retracted from the pilot hole 22A, see Figs. 1F. It is preferable that the axial space between the bolt and the drill bit is greater than the depth of the pilot bore 22A such that the leading end of the bolt does not interfere with the retraction of the drill bit. The drill bit and the drill steel can be completely retracted and can be reused for repeated drilling operations.

The machine driving the apparatus 10 can be a top hammer drilling machine, a pure rotary machine or a down-the-hole equipment. The drill bit according to the present invention provides good guiding and provides favorable drilling results.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the scope of the claims.
Claims:

1. A one-piece drill bit designed for single-pass anchor bolting, said drill bit (16) having a connection portion, adapted to be rigidly connected to a drill steel, a pilot part (14) and a reamer part (19), said pilot part having first rock machining means (17), said reamer part having a first center line (CL2) and second rock machining means (18A, 18B, 18C), said second rock machining means being provided axially between said connection portion and said first rock machining means and to one side of the pilot part, said drill bit having a rotational direction (R), said pilot part (14) having a length (L), characterized in that the pilot part (14) is generally inclined relative to the first center line (CL2) and in that the length (L) of the pilot part (14) is at least 10 mm.

2. The drill bit according to claim 1, wherein said length (L) is not more than 60 mm.

3. The drill bit according to claim 1 or 2, wherein a middle line (CL1) of the pilot part (14) forms an acute second angle (α) with an axis (CL3) extending parallel to the first center line (CL2) and wherein the second angle (α) is -20° to +20°, excluding 0°.

4. The drill bit according to claim 1, 2 or 3, wherein a tangent (T), touching the envelope surface (50) or a skirt (51) of the drill bit and being parallel to the first center line (CL2), forms a radial distance (X) with the periphery of the pilot part at its forward end, and wherein said distance (X) is not zero and is preferably not less than -5 mm and preferably not more than +5 mm.

5. The drill bit according to claim 1, 2, 3 or 4, wherein a side of the pilot part (14) facing away from the reamer part (19) is provided with a wear resistant means (17').
6. The drill bit according to claim 5, wherein an imaginary line (S), extending through the first rock machining means (17) and being perpendicular to the first center line (CL2) of the reamer part (19), forms an acute first angle (β) with a normal (N) to the first center line and wherein the normal (N) intersects a rock machining means (18A) that leads in the rotational direction (R) of the drill bit (16).

7. The drill bit according to claim 6, wherein the first angle (β) is not less than 0° and not more than 20°.

8. The drill bit according to to claim 6, wherein the leading rock machining means (18A) in the reamer part (19) is a button and wherein the normal (N) intersects its center line.

9. The drill bit according to claim 6, wherein the normal (N) intersects the forward most point of the leading rock machining means in the rotational direction (R).

10. A single pass drilling apparatus comprising drilling means and an anchor bolt (21), characterized in that the apparatus comprises a one-piece drill bit (16) as defined in claims 1-9.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: E21B, E21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic database consulted during the international search (name of database and, where practical, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

See patent family annex.

Date of the actual completion of the international search
5 October 2006

Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International patent classification (IPC)

E21B 10/64 (2006.01)
E21B 10/40 (2006.01)
E21B 10/26 (2006.01)
E21D 21/00 (2006.01)

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Cited literature, if any, will be enclosed in paper form.
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