

DRILLING AND GROUTING METHOD AND APPARATUS

FIELD OF THE DISCLOSURE

5 The present disclosure generally relates to the field of ground drilling and grouting, and more particularly to reverse circulation rotary drilling.

 More specifically, the present disclosure concerns a drilling and grouting device, a drilling and grouting machine comprising such drilling
10 and grouting device, and a drilling and grouting method using such machine.

 The apparatus and method according to the present disclosure are particularly intended to improve poor-quality ground to facilitate tunnelling or excavating. The apparatus and method may also be used in dam
15 rehabilitation or remedial work on or around dams among other things. Due to its versatility, the apparatus can be utilized when drilling directly from ground level or from a barge on off shore applications.

BACKGROUND OF THE DISCLOSURE

20 Reverse Circulation rotary drilling, also known as "RC Drilling" or "Dual Wall Drilling", has been used to sink boreholes into the ground for example, for mineral exploration.

 Figure 13 shows an exemplary device for such Reverse Circulation rotary drilling, employing a dual wall pipe 122 comprising an outer drill rod
25 124 with an inner rod 126 located inside said outer drill rod 124 and provided with a drill bit 140 at its distal end.

 A drilling fluid, which may be high pressure air or water, is passed in the outer flow path defined between the outer and inner rods 124, 126,
30 down to the drill bit 140. Once the drilling fluid hits said drill bit, the cuttings mixed with the said fluid are forced up to the center of the bit and back up the inner tube 126. Cuttings are so returned to the surface and collected for later use.

 This kind of tooling, however, is not appropriate for grouting operations.

Injection of the grout through the annular space between the outer and inner rod is undesirable, particularly when the grout has a high viscosity and is of low mobility. Due to the large 'wetted-perimeter' of this annular space, there is a high risk that the grout may plug the device.

5 Injection of the grout through the inner rod can damage and/or destroy the drill bit. Also, the drill bit prevents free flow of grout into the drill hole, particularly when the grout is of low mobility.

Taking the inner rod and the drill bit out of the outer drill rod, to allow for the free flow of grout into the outer drill rod is time-consuming and presents problems when drilling and grouting operations must happen
10 very quickly. Likewise, removing the dual wall pipe for introducing a separate injection device in the drill hole also necessitates much time and additional equipment.

15 SUMMARY OF THE DISCLOSURE

In view of the foregoing, there is a need for a method and apparatus which enable both drilling the ground and injecting grout into the obtained borehole efficiently, in particular quickly and easily while preventing plugging. It is an object of the present disclosure to provide
20 such method and apparatus.

According to embodiments of the present disclosure, there is provided a drilling and grouting device, comprising a drill string including a hollow elongate outer rod having a central axis and a hollow elongate inner rod located coaxially within said outer rod, wherein a first outer flow
25 path is defined between said inner and said outer rod, and a first central flow path is defined inside said inner rod, a drill bit aligned with said inner rod along said central axis and including a second central flow path, and a crossover part interposed between said inner rod and said drill bit along said central axis, said crossover part being configured to connect the first
30 central flow path with a second outer flow path surrounding the drill bit to form a main path and to connect said first outer flow path with said second central flow path to form a secondary path.

The present disclosure thus provides a single device suitable for drilling the ground and subsequently injecting grout into the ground,
35 without removing the device between the drilling and grouting stages.

Drilling fluid, usually air, water or a mix of both, injected in the annular space between the outer and inner rod is deviated by the crossover part towards the inside of the drill bit.

When entering into the drill hole, drilling fluid is mixed with the cuttings produced by rotation of the drill bit. In a normal case, in which the ground is relatively impermeable, the mix of cuttings and drilling fluid is returned back to the surface by being pushed by drilling fluid constantly entering the drill hole. The mix of cuttings and fluid enters the second outer flow path surrounding the drill bit and moves upwards through the crossover and through the first central flow path, generally towards a waste-collection tank.

After drilling has been completed, grout is pumped down through the main path. It passes through the first central flow path, crosses-over and flows around the drill bit and into the ground formation.

Rates of drilling and grouting production can be greatly increased over conventional drilling methods.

Another benefit of the disclosure is that during the grouting phase, the grout is separated from the environment with a 'double-protection' system. The grout or the cuttings flowing through the inner rod of the drill string are 'double-protected' in that they do not flow into the surrounding ground or sea even if the inner or the outer rod breaks. This might be important in situations where the system drills through contaminants, or in environmentally sensitive areas.

Moreover, both cuttings and grout flow through the inner rod, which circular section is much more adapted to avoid plugs and facilitate the flow than the annular space defined between the outer and the inner rod.

It is further to be noted that the drilling and grouting device according to the present disclosure can be used on projects where inclined drilling is required. It could even be used in horizontal drilling.

As an example, the application of this type of drilling for remedial drilling/grouting work on, and surrounding, dams is particularly advantageous.

Generally, the crossover part comprises at least one main connecting duct for connecting the first central flow path with the outside

of the drill bit and at least one secondary connecting duct for connecting the first outer flow path with the second central flow path.

Advantageously, the crossover part comprises at least two main connecting ducts, regularly distributed circumferentially.

5 In the same manner, the crossover part preferably comprises at least two secondary connecting ducts, regularly distributed circumferentially.

As indicated above, in a case where the ground is relatively impermeable, the cuttings are forced to move upwards in the main path
10 by being pushed by the drilling fluid.

According to embodiments of the disclosure, a bypass is provided between the secondary path and the main path for deviating a part of the fluid circulating through said secondary path towards said main path. For example, such bypass may be provided between the secondary path and
15 the second outer flow path for deviating a part of the fluid circulating through said secondary path towards said second outer flow path. This is particularly adapted to cases where the ground is moderately permeable, that is, a part of the drilling fluid moves upwards with the cuttings, but not sufficiently to avoid plugging of the cuttings in the main path. The bypass
20 ensures that at least a predetermined amount of water is not lost in the ground but mixed with the cuttings which enter the second outer flow path.

The bypass can be provided with a check valve.

Also the drill bit is advantageously provided with a check valve.
25 Such check valve can prevent the flow of grout up into the crossover part and into the annular space between the outer and inner rod, that is, into the first outer flow path.

The crossover part and the hollow elongate outer rod are adapted to rotate as a single unit.

30 According to another aspect of the disclosure, there is provided a drilling and grouting machine, comprising

a drilling and grouting device having a drill string including a hollow elongate outer rod having a central axis and a hollow elongate inner rod located coaxially within said outer rod, wherein a first outer flow path is
35 defined between said inner and said outer rod, and a first central flow

path is defined inside said inner rod, a drill bit aligned with said inner rod along said central axis and including a second central flow path, and a crossover part interposed between said inner rod and said drill bit along said central axis, said crossover part being configured to connect the first central flow path with a second outer flow path surrounding the drill bit to form a main path and to connect said first outer flow path with said second central flow path to form a secondary path;

5 a first moving device for rotating said drilling and grouting device about its central axis;

10 a second moving device for vertically moving said drilling and grouting device in a direction parallel to the central axis;

a drilling fluid supplying device connected to the secondary path for supplying said secondary path with drilling fluid; and

15 a grout supplying device connected to the main path for supplying said main path with grout.

According to still another aspect of the disclosure, there is provided a drilling and grouting method, comprising the steps of

providing a drilling and grouting machine comprising a drilling and grouting device having a drill string including a hollow elongate outer rod having a central axis and a hollow elongate inner rod located coaxially within said outer rod, wherein a first outer flow path is defined between said inner and said outer rod, and a first central flow path is defined inside said inner rod, a drill bit aligned with said inner rod along said central axis and including a second central flow path, and a crossover part interposed between said inner rod and said drill bit along said central axis, said crossover part being configured to connect the first central flow path with a second outer flow path surrounding the drill bit to form a main path and to connect said first outer flow path with said second central flow path to form a secondary path a first moving device for rotating said drilling and grouting device about its central axis; a second moving device for vertically moving said drilling and grouting device in a direction parallel to the central axis; a drilling fluid supplying device connected to the secondary path for supplying said secondary path with drilling fluid; a grout supplying device connected to the main path for supplying said main path with grout,

20
25
30
35

rotating said drilling and grouting device about its central axis,
moving said rotating device downwardly in the ground, and
controlling said drilling fluid supplying device for supplying the
secondary path with drilling fluid,

- 5 collecting the cuttings moved upwards through the main path, and
controlling said grout supplying device for supplying the main path
with grout, to inject grout in the ground.

In some cases, when the ground is very permeable, the drilling fluid
can be lost in the ground, and may not move upwards with the cuttings
10 through the main path. Consequently, part of the cuttings is left in the
ground. In some cases, the circulation of drilling fluid (downwards through
the secondary path and then upwards, mixed with the cuttings, through
the main path) is stopped when the main path is already partially or fully
filled with cuttings. Attempts to pump grout back down the main path may
15 then lead to plugging of the drill bit and the crossover part.

According to the disclosure, by injecting drilling fluid both through
the main and the secondary paths during drilling, plugs of cuttings in the
main path may be avoided.

According to some embodiments, the method may comprise
20 bypassing part of the drilling fluid supplied to the secondary path to said
second outer flow path. As indicated above, this may be particularly
advantageous in cases where the ground is moderately permeable, that is,
a part of the drilling fluid moves upwards with the cuttings, but not
sufficiently to avoid plugging of the cuttings in the main path.

25 According to some aspects of the disclosure, there is provided a
crossover part configured for being assembled to a drill string of a drilling
and grouting device including a hollow elongate outer rod and a hollow
elongate inner rod located coaxially within said outer rod, said crossover
part comprising a central axis and, at one axial end, at least a first
30 centered opening adapted to be connected to said first inner rod and at
least a first offset opening adapted to be connected to a flowpath defined
between said outer rod and said inner rod, and at its axially opposed end,
at least a second centered opening and at least a second offset opening,
the first centered opening being connected to the second offset opening

and the first offset opening being connected to the second centered opening.

The first centered opening may be connected to the second offset opening by at least one main connecting duct. In the same manner, the first offset opening may be connected to the second centered opening by at least one secondary connecting duct.

It is to be understood that, except in cases of clear incompatibility and unless otherwise stated, features of one embodiment or example described herein can similarly be applied to other embodiments or examples described herein.

Other features and advantages of the disclosure will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the disclosure.

15

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, like reference signs generally refer to the same parts throughout the different views.

FIG. 1 is a schematic illustration of a drilling and grouting device according to embodiments of the present disclosure, with arrows showing the flow of water and cuttings during the drilling phase,

FIG. 2 shows the device of claim 1 during the grouting phase,

FIG. 3 is a schematic illustration of a drilling and grouting device according to embodiments of the present disclosure,

FIG. 4 shows still another device according to embodiments of the present disclosure,

FIG. 5 is a schematic flow diagram during a typical drilling phase,

FIG. 6 is a schematic flow diagram during a grout flushing phase,

FIG. 7 is a schematic flow diagram during a grouting phase,

FIG. 8 is a schematic flow diagram during a drilling phase, in a case where the ground is very permeable and the drilling fluid is mainly lost therein,

FIG. 9 is a schematic illustration of a drilling and grouting machine according to the present disclosure,

FIG. 10 shows different steps of a drilling and grouting method according to embodiments of the present disclosure, and

FIG. 11 illustrates an embodiment of the disclosure, particularly adapted for drilling on water sites,

5 FIGS. 12A to 12C illustrate the positioning of the protection casing shown in figure 11,

FIG. 13 illustrates a drilling device known from the prior art.

DETAILED DESCRIPTION

10 The following detailed description refers to the accompanying drawings showing examples of the drilling and grouting device according to the present disclosure. It is intended that these examples be considered as illustrative only, the scope of the disclosure not being limited thereto.

Figure 9 is a schematic illustration of an exemplary drilling and
15 grouting machine according to the disclosure, for improving and/or sealing the ground.

The drilling machine 10 includes a frame or tracked vehicle 12 which may be disposed on an offshore platform or on land. A drilling mast 14 is mounted on said frame, in an articulated way, as well as other
20 equipment such as a control console 16 of the drilling machine 10.

A carriage 19 slides along the drilling mast 14. Said carriage 19 supports a drill head 18 to which the drilling and grouting device 20 is mounted.

The drilling and grouting device 20, which will be described in more
25 detail hereafter, comprises a drill string 22 composed of a hollow elongate outer rod 24 and a hollow elongate inner rod 26 located coaxially within said outer rod (see figure 1).

The drill string 22 is connected to a plurality of supplying or collecting devices 90, 91, 92, 93.

30 The annular space defined between the inner and outer rods 24, 26 communicates with a drilling fluid supplying device 93 provided with a controllable valve D (see figure 5 for example). A swivel 32 mounted just below the drill head 18 is provided to connect said annular space with said drilling fluid supplying device 93.

The interior of the inner rod 26 communicates with a central pipe 30 connected to the drill head 18 and to a grout supplying device 90, a water supplying device 91 and a discharge device 92. Each of said devices 90, 91, 92 are also provided with controllable valves, respectively C, B, A.

5 The drilling and grouting device 20 may be rotated about its axis A by means of the drill head 18, and moved jointly with the carriage 19, in a direction parallel to its axis A.

For the following description, the axis A of the drilling and grouting device is the common central axis of the inner and outer rod of the drill string (hereafter also "central axis"). The axial direction corresponds to the direction of said central axis, and a radial direction is a direction perpendicular to said central axis. Similarly, an axial plane is a plane containing the central axis, and a radial plane is a plane perpendicular to said central axis. Finally, unless specified to the contrary, 10 adjectives such as "inner" and "outer" are used relative to a radial direction such that an inner portion (i.e. a radially inner portion) of an element is closer to the central axis than is an outer portion (i.e. the radially outer portion) of the same element.

In the present application, "upstream" and "downstream" are also 20 defined relative to the direction of drilling (from upstream to downstream).

To achieve the desired drilling depth, several assemblies each comprising an outer and an inner drill tube disposed coaxially and linked together, for example by discrete welding points, are attached 25 successively, one to the other. The link between two successive outer tubes 241, 242 (see figures 9 and 10) may preferably be performed by screwing a threaded end of an outer rod 241 to the threaded end of a contiguous outer rod 242. The inner tubes may fit to each other through O-ring press fit for example.

30 When possible/practical, the drilling and grouting device of the disclosure may be used in conjunction with a leader-system long enough to allow for 'single-pass' drilling and grouting, with no need to add or remove each assembly as the drill bit is advanced or withdrawn from the drill-hole. Figure 1 shows the lower end of the drill string 22 of figure 9

and illustrates in more details the drilling and grouting device 20 according to the present disclosure.

The drilling and grouting device 20 comprises, downstream of the drill string 22, disposed along the central axis A, a drill bit 40, for example
5 in the form of a tricone bit, configured to cut the ground.

The drilling and grouting device further comprises a crossover part 50 axially interposed between the drill string 22 and the drill bit 40.

In the example shown in figures 1 and 2, the outer rod 24 of the drill string 22 is extended by means of an outer drilling casing 28 threaded thereto and provided with drilling teeth 29 at its end. In other possible
10 configurations, the outer casing 28 may be formed in one piece with the outer rod 24 of the drill string 22.

The outer casing 28 serves to surround the crossover part 50 and, eventually, a part or the entirety of the drill bit 40.

15 In the example shown in figures 1 and 2, the crossover part 50 has a generally elongated shape, with tapered portions 52, 54 at each end.

In the illustrated example, the crossover part 50 comprises, between those tapered portions, a central part 56 forming a circumferential protrusion. This central part 56 is adapted to cooperate
20 with an aperture formed in the outer casing 28. Crossover part 50 and outer casing 28 may further be fixed by fixing means such as welds, thereby ensuring that they move as a single piece.

Any other configuration or shape allowing that the crossover part has an external maximum diameter at least equal to the inner diameter of
25 the outer casing is also acceptable.

The first upstream end 52a of the crossover part 50 is connected to the lower end of the inner rod 26 by O-ring press fit connections 27 for example.

More generally, the system according to the present disclosure
30 advantageously uses a drill string 22 with threaded connections from outer-tubes to outer-tubes (for torque) and a built-in inner rod with 'floating' connections (O-ring press-fit, see o-ring 27 on figure 1 for example).

The crossover part 50, connecting the outer rod 24 with the inner
35 rod 26, allows that the torque be transferred from the single drill head 18

to the outer rod 24 only. There is no need to transfer torque to the inner rod 26, no need for a double-head drill, and no need for a duplexing system. The inner rod is less mechanically strained, and therefore less inclined to break.

5 At its first end 52a oriented upstream, the crossover part 50 comprises a first centered opening 60 (here aligned with the central axis A) adapted to be connected to the first inner rod 26 of the drill string 22. This first centered opening 60 is connected by a first oblique connecting duct 62 to an offset opening (hereafter second offset opening) 64 formed
10 on the periphery of the downstream tapered portion 54 of the crossover part 50.

 At the periphery of its first upstream tapered portion 52, the crossover part 50 further comprises an offset opening (hereafter first offset opening) 66 connected by a second oblique connecting duct 68 to a
15 second centered opening 70 (here aligned with the central axis A) formed at its opposite end and adapted to be connected to the drill bit 40.

 With the above described configuration, the passages formed in the drilling and grouting device 20 according to the present disclosure are as follows:

20 Upstream from the crossover part 50, a first central flow path 82 is defined inside the inner rod 26, and a first outer flow path 80, usually in the form of an annular area, is delimited by the inner rod 26, the upper part of the crossover part 50, the outer rod 24 and the outer casing 28, and communicates with the first offset opening 66 of the crossover part
25 50. In the illustrated example, the first outer flow path 80 terminates between the outer casing 28 and the first tapered portion 52 of the crossover part 50.

 Downstream from the crossover part 50, a second central flow path 84 is defined inside the drill bit 40. A second outer flow path 86 is further
30 defined radially outside the drill bit, between the outer casing 28 and both the second tapered part 54 of the crossover part 50 and the drill bit 40.

 The crossover part 50 allows the first central flow path 82 to be brought into direct communication with the second outer flow path 86. The path comprising the first central flow path 82, the connecting duct(s)
35 of the crossover parts connected thereto and the second outer flow path

86 is referred to, in the present description, as the main path 110. This main path has, on its almost entire length (all along the drill string), a circular section which is optimal for the flow of materials, in particular materials having a moderate or high viscosity.

5 In the same manner, the crossover part 50 allows the first outer flow path 80 to be brought into direct communication with the second central flow path 84. The path comprising the first outer flow path 80, the connecting duct(s) of the crossover parts connected thereto and the second central flow path 84 is referred to, in the present description, as
10 the secondary path 112. The secondary path 112 has, over almost its entire length (all along the drill string), a general annular section.

The drilling and grouting operations, completed with the above described device, will now be explained in more detail with reference to the figures.

15 Figure 10 schematically illustrates the main steps of a drilling and grouting method according to an embodiment of the present disclosure.

In a first step referenced S1 on figure 10, the drill string 22 is rotated jointly with the drill head 18 (see figure 10), about its central axis A, and moved downwards along the mast 14, jointly with the carriage 19,
20 until the drill bit reaches a depth D2.

Figure 1 shows the drilling and grouting device of the disclosure during this typical drilling phase, corresponding to the configuration of figure 5.

Drilling fluid (DF), usually water, is injected into the annular area 80
25 between the outer and inner rod 24, 26, that is, in the secondary path 112, by controlling a valve D of the first drilling fluid supplying device. The valve A provided on the cuttings discharge flow path is also open (see the corresponding flow diagram of figure 5).

Compressed air can advantageously be added to the water that is
30 pumped into the swivel 32 during the drilling operation. This combination of water and air could aid in the upward 'circulation' of the cuttings – creating a type of air-lift.

Drilling fluid enters the first offset opening(s) of the crossover part 50 and is led by said crossover part 50 towards the center of the drill bit

40, where it helps cooling the drill bit 40 and softening and cutting the ground.

Drill cuttings mixed with drilling fluid (CU), travel around the outside of the tricone bit 40, crossover and travel upwards through the inner rod 26. Cuttings flow up through the drill head's central passage and are directed down to the discharge device 92, for example a waste-collection tank.

Once the drilling operation has been completed, the drilling and grouting device 20 is slowly moved upwards up to a depth D1 and, simultaneously, the grouting operation is performed.

Before grouting, the main path 110 may be flushed with water (W). As illustrated on figure 6, the valve C controlling the water supplying device 91 is open while other valves A, B and D are closed.

The main path 110 is thereby cleaned and the operator can determine that said main path 110 is not plugged and that grouting can be performed.

In a second step S2, grout is then pumped down through the main path 110. It flows through the circular passage 82 of the inner drill rod 26, then crosses-over and flows around the tricone bit 40 and into the ground formation.

As shown in figure 7, the valve B of the grout supplying device 90 is open while the other valves A, C and D are closed.

A check-valve 42 is installed inside the tri-cone bit 40 for preventing the flow of grout up into the secondary path.

The drilling and grouting device 20 according to the disclosure has the advantage that during this grouting phase, the grout is separated from the environment with a type of 'double-protection' system. The pumping of grout through the inner rod 26 of the drill string 22 provides protection from a rupture from the inner rod 26 or from the outer rod 24. Also the drilling spoils are 'double-protected' from the environment during the drilling phase of the operation, which might be important in situations where the system might drill through contaminants. Also, because the torque is transferred from the drill head directly and only to the outer rod 24 (that is, to the succession of outer tubes forming the outer rod), the risk that the inner rod 26 breaks is reduced.

Once grouting has been completed between the depths D1 and D2, the drilling and grouting device 20 is lowered again to the bottom of the grouted layer (here, depth D2), and drilling is started again down to a depth D3.

5 The drilling and grouting steps are then repeated until the bottom of the desired grouting area is reached.

The device is finally removed from the ground as shown as step S5 on figure 10.

10 In a particular embodiment illustrated in figure 8, when the ground is very permeable, the drilling fluid is lost therein and cannot push the cuttings back to the surface. In order to avoid that the cuttings start moving upwards and get stuck inside the device, it is preferable that the cuttings be prevented from entering the device. With this aim, during the drilling step, water may be supplied not only to the secondary path, but
15 also to the main path, by the water supplying device 91.

The embodiment described hereabove is not limitative of the present disclosure.

Figure 3 shows another device according to embodiments of the disclosure.

20 This device comprises a bypass 51 between the secondary path 112 and the second outer flow path 86 for deviating a part of the fluid circulating through said secondary path 112 towards said second outer flow path 86.

25 In the illustrated example, the bypass 51 is arranged to connect the secondary connecting duct with the second outer flow path 86. Such bypass 51 enables that sufficient water be provided to the cuttings, notably in case of moderate permeable ground, when part of the drilling fluid is lost in the ground. It may advantageously be provided with a check valve 53 to avoid return of the drilling fluid into the crossover part 50.

30 Preferably, the bypass passage angles upwards (in the upstream direction), otherwise the flow of drilling fluid may conflict with the circulation of the cuttings that should be flowing 'up'. In such case, drilling fluid may advantageously comprise drilling water and added compressed air.

Figure 4 shows another device according to embodiments of the disclosure.

In this device, the crossover part 50' and the outer casing are in one single piece. The crossover part 50' comprises an outer casing part 55
5 that is threaded to the end of the outer rod 24'.

In some cases, the ground to be improved is under water. In such over-water drilling applications, a tertiary isolation/protection system may be used as shown in figure 11. This protection system may comprise an oversized protection casing 94 that is drilled into the sea-floor, for
10 example 1-2-m.

This protection casing or tertiary containment pipe 94 surrounds the drill-string 22 and is fitted at its upper end with a diverter-head 97 for capturing any spoils or grout that may have migrated around the outside of the drill-string, and up into the water. The diverter-head 97 may be
15 sealed around the drill-string 22 using a conventional rubber seal 98. It may be further connected to an evacuation pipe 103, for evacuating the spoils (see figure 11).

The protection casing 94 may be installed using a clamping system 96 as illustrated in figure 11.

20 The clamping system comprises a U-shaped clamping part 96, each leg 99a, 99b thereof having a planar contact surface adapted to come into contact with a flat outer surface of the outer rod 24 of the drill string. In the illustrated example, both planar surfaces are parallel and opposed to each other.

25 The clamping part 96 further comprises a protrusion 100 extending from one of its legs 99a, forming a stopper.

As shown in figure 11, a bolt-flange 95 is connected to the upper end of the diverter-head 97. A lug 102 protrudes from the upper face of said bolt-flange 95.

30 The clamping part 96 is adapted to be disposed on the bolt-flange 95 in such a manner that the stopper 100 cooperates with said lug 102. Thereby, once the drill string 22 is introduced between the legs 99a, 99b of the clamping part 96, the rotary movement of the drill string 22 is transferred, through the clamping part 96, to the bolt-flange 95 and
35 therefore also to the diverter head 97 and to the protection casing 94.

Figures 12A to 12C schematically illustrate how this protection casing is set up.

As illustrated in figure 12A, the protection casing 94 is firstly introduced in the water down to the sea bottom. The diverter head 97 is, at this point, disposed a few meters above the sea level.

The drilling and grouting device is then introduced, in part, inside the protection casing (figure 12B). The clamping device 96 is disposed on the bolt-flange 95, the evacuation pipe 103 is disconnected from the diverter head 97 and the drill head 18 is rotated and moved downwards along the mast 14 (figure 12C).

Due to the clamping device, the protection casing 94 is so to say "drilled" into the sea-floor. In order to better penetrate the sea floor, the protection casing 94 is preferably supplied with cutting teeth welded to its lower end (not shown).

Throughout the description, including the claims, the term "comprising a" should be understood as being synonymous with "comprising at least one" unless otherwise stated. In addition, any range set forth in the description, including the claims should be understood as including its end value(s) unless otherwise stated. Specific values for described elements should be understood to be within accepted manufacturing or industry tolerances known to one of skill in the art, and any use of the terms "substantially" and/or "approximately" and/or "generally" should be understood to mean falling within such accepted tolerances.

Where any standards of national, international, or other standards body are referenced (e.g., ISO, etc.), such references are intended to refer to the standard as defined by the national or international standards body as of the priority date of the present specification. Any subsequent substantive changes to such standards are not intended to modify the scope and/or definitions of the present disclosure and/or claims.

Although the present disclosure herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present disclosure.

CLAIMS

1. A drilling and grouting device, comprising:
 - 5 a drill string including a hollow elongate outer rod having a central axis and a hollow elongate inner rod located coaxially within said outer rod, wherein a first outer flow path is defined between said inner and said outer rod, and a first central flow path is defined inside said inner rod,
 - 10 a drill bit aligned with said inner rod along said central axis and including a second central flow path, and
 - a crossover part interposed between said inner rod and said drill bit along said central axis, said crossover part being configured to connect the first central flow path with a second outer flow path surrounding the drill bit to form a main path and
 - 15 to connect said first outer flow path with said second central flow path to form a secondary path.
2. The drilling and grouting device according to claim 1, wherein
 - 20 said crossover part comprises at least one main connecting duct for connecting the first central flow path with the second outer flow path and at least one secondary connecting duct for connecting the first outer flow path with the second central flow path.
- 25 3. The drilling and grouting device according to claim 1 or 2, wherein said crossover part comprises at least two main connecting ducts, regularly distributed circumferentially.
- 30 4. The drilling and grouting device according to any one of claims 1 to 3, wherein said crossover part comprises at least two secondary connecting ducts, regularly distributed circumferentially.

5. The drilling and grouting device according to any one of claims 1 to 4, wherein said crossover part and said hollow elongate outer rod are adapted to rotate as a single unit.
- 5 6. The drilling and grouting device according to any one of claims 1 to 5, wherein a bypass is provided between said secondary path and said second outer flow path for deviating a part of the fluid circulating through said secondary path towards said second outer flow path.
- 10 7. The drilling and grouting device according to claim 6, wherein said bypass is provided with a check valve.
8. The drilling and grouting device according to any one of claims 1 to 7, wherein the drill bit is provided with a check valve.
- 15 9. A drilling and grouting machine, comprising :
a drilling and grouting device according to any one of claims 1 to 8,
20 a first moving device for rotating said drilling and grouting device about its central axis;
a second moving device for vertically moving said drilling and grouting device in a direction parallel to the central axis;
a drilling fluid supplying device connected to the secondary path for supplying said secondary path with drilling fluid;
25 a grout supplying device connected to the main path for supplying said main path with grout.
10. The drilling and grouting machine according to claim 9, further comprising a water supplying device connected to the main path for supplying the main path with drilling fluid.
- 30 11. A crossover part configured for being assembled to a drill string of a drilling and grouting device including a hollow elongate outer rod and a hollow elongate inner rod located coaxially
- 35

within said outer rod, said crossover part comprising a central axis and, at one axial end, at least a first centered opening adapted to be connected to said first inner rod and at least a first offset opening adapted to be connected to a flowpath defined between said outer rod and said inner rod, and at its axially opposed end, at least a second centered opening and at least a second offset opening, the first centered opening being connected to the second offset opening and the first offset opening being connected to the second centered opening.

12. The crossover part of claim 11, wherein the first centered opening is connected to the second offset opening by at least one main connecting duct.

13. The crossover part of claim 11 or 12, wherein the first offset opening is connected to the second centered opening by at least one secondary connecting duct.

14. A drilling and grouting method, comprising the steps of:

providing a drilling and grouting machine according to claim 9 or 10,

rotating said drilling and grouting device about its central axis,

moving said rotating device downwardly in the ground, and

controlling said drilling fluid supplying device for supplying the secondary path with drilling fluid,

collecting the cuttings moved upwards through the main path,

controlling said grout supplying device for supplying the main path with grout, to inject grout in the ground.

15. The drilling and grouting method of claim 14, further comprising injecting drilling fluid both through the main and the secondary paths during drilling.

16. The drilling and grouting method of claim 14 or 15, further comprising bypassing part of the drilling fluid supplied to the secondary path by the drilling fluid supplying device to said second outer flow path.

5

10

15

20

25

30

35