

Rotary drilling tool, drilling apparatus and method for producing a bore in the ground

5 The invention relates to a rotary drilling tool for producing a bore in the ground with a tubular base body, a cutting means arranged on an underside of the base body for removing ground material, a receiving space in the base body for receiving ground material and an end plate which is arranged on an upper side of the base body and has at least one through-opening, in accordance with the preamble of claim 1.

10 The invention further relates to a drilling apparatus for producing a bore in the ground with a mast and a drill drive for driving a drilling tool in a rotatable manner, in accordance with the preamble of claim 14.

15 Furthermore, the invention also relates to a method for producing a bore in the ground with a drilling tool, in accordance with the preamble of claim 15.

Rotary drilling tools are employed in different types of ground material, especially also in loose and hard rock material, in order to carry out bores in particular in a building ground. Generally, core drills, drilling buckets and augers are known as rotary drilling tools, in which case the cutting effect of a core drill is limited to a ring-shaped cutting area and drilling buckets and augers basically remove the ground material in the entire drilling cross-section. Such a rotary drilling tool designed as a core drill is known from DE 36 11 014 C2 for example.

25 In the case of greater drilling depths, core drills and drilling buckets are normally employed with the addition of flush liquid in the borehole. Significant reasons and advantages of the addition of flush liquid in bores produced in different ground material reside in particular in the improved conveyance of the removed ground material, the stabilization of the borehole wall and the cooling of the cutting means with its individual cutting instruments. From DE 1 256 598 a rotary drilling tool can be taken, in which a flow of flush liquid for improved conveyance and a receiving space in the interior of the base body for receiving the removed ground material are provided.

Rotary drilling tools, especially when employed with the addition of flush liquid, permit an altogether efficient and secure removal of ground material for the production of a borehole, especially in a building ground. In this way, stable boreholes can be produced economically in great drilling depths and in different types of ground material. However, an efficient and targeted conveyance of the flush liquid proves to be problematic in rotary drilling tools with cylindrical base bodies due to the limited space available.

The invention is based on the **o b j e c t** to provide a rotary drilling tool, a drilling apparatus and a method for producing a bore in the ground, with which a bore can be carried out in a particularly efficient manner.

According to the invention the object is achieved on the one hand by a rotary drilling tool having the features of claim 1, a drilling apparatus having the features of claim 14 and on the other hand by a method for producing a bore in the ground having the features of claim 15. Preferred embodiments of the invention are stated in the respective dependent claims.

The rotary drilling tool according to the invention is characterized in that in the area of the at least one through-opening a pump means is arranged, by which a flow of flush liquid through the at least one through-opening can be generated and which extends radially along the end plate. By way of the pump means, which is located in the area of the at least one through-opening and extends radially along the end plate, an efficient flow of flush liquid through the through-opening of the base body can be generated. As a result of this particularly efficient and at the same time space-saving arrangement of the pump means a supply of liquid in the interior of the base body, in particular reaching as far as the cutting means on the underside of the base body, is basically possible without any further flow-inducing or flow-assisting means. Thus, a bore can also be carried out in a particularly efficient manner with a rotary drilling tool having a partially closed tubular base body.

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Basically, the pump means can be arranged in any chosen manner in the area of the at least one through-opening. According to the invention a particularly preferred embodiment resides in the fact that the pump means is arranged on an upper or underside of the end plate. In particular, the pump means can be fixed and/or supported in a rotatable manner on the end plate. In the first variant it has the same rotational speed as the rotary drilling tool itself. In the second variant a rotational speed independent of the rotational speed of the rotary drilling tool can be transmitted to the said pump means by a gear mechanism. Thus, an especially space-saving spatial arrangement of the pump means is attained which has hardly any influence on the removal of the ground material by the cutting means arranged on the underside of the base body and does not significantly hinder the reception of the ground material in the receiving space of the base body. This leads to a high receiving capacity for removed ground material in the base body of the rotary drilling tool.

According to a further development of the invention a particularly purposeful operation results from the fact that the pump means is designed for conveying the flush liquid into the receiving space of the base body or out of the receiving space of the base body. The overpressure or underpressure, which is present in the base body filled with flush liquid and which is required for flushing the cutting means with flush liquid, is generated by a suction effect of the pump means directed into the base body or out of the said base body. A flow of the flush liquid into the receiving space or out of the receiving space is generated.

An especially preferred embodiment of the invention resides in the fact that the pump means is designed as a screw pump. A screw pump in the form of a spiral wound at least partially or in sections around a shaft produces a targeted and even flow of flush liquid through the through-opening solely on the basis of the rotational movement of the rotary drilling tool. Together with the surrounding base body or borehole wall the spiral forms compartments, in which, due to the continuous rotation about the shaft that constitutes the center axis of the screw pump, flush liquid is conveyed. On account of the fact that compartments continuously dissolve at the first end of the spiral and are formed at the second end of the spiral the pumping effect necessary for the flow of the flush liquid is

accomplished. Another advantageous aspect of this embodiment is that the screw pump substantially extends in the radial direction, thereby constituting a particularly space-saving design of the pump means by being especially well adapted to the tubular base body.

- 5 For the flow of the flush liquid before and after the cutting means along the inner and outer side of the base body it is advantageous in accordance with another embodiment variant of the invention that on an outer and/or inner side the tubular base body has a conveyor flight for conveying flush liquid and/or removed ground material. On account of the fact that the supply and/or discharge of flush liquid for flushing the cutting means is  
10 assisted in particular by an inner and/or outer conveyor flight, the targeted flow of flush liquid in the interior and/or exterior of the base body is assisted especially in areas, in which ground material in the form of a drill core or the borehole wall is located at a small distance with respect to the rotary drilling tool.
- 15 Basically, the flush liquid can emerge from the borehole in a known manner in an upper area thereof or it can be discharged therefrom and, where applicable, led back into the flush liquid cycle to the pump means after the ground material has been separated.

- In principle, the cutting means can have any suitable cutting instrument which can be  
20 selected as being removal-effective and wear resistant depending on the ground material. Especially suitable embodiments of the invention reside in the fact that the cutting means has at least one rotatably supported roller bit and/or at least one stationary round shank bit and/or at least one stationary removal tooth. By preference, a plurality of roller bits is arranged for loosening harder ground material. Moreover, a plurality of round shank bits  
25 or removal teeth, used alone or in combination with the roller bits, are suitable to achieve an effective force application and removal effect depending on the hardness and composition of the ground material.

- In a further embodiment of the invention any arrangement of cutting instruments on the  
30 cutting means can basically be chosen. To form a drill core such a preferred embodiment of the invention resides in the fact that several rotatably supported roller bits and/or stationary round shank bits and/or stationary removal teeth are mounted in a ring-shaped

arrangement on the underside of the base body. A rotational movement of the drilling tool and the ring-shaped arrangement of the cutting instruments bring about a ring-shaped removal of ground material and, upon corresponding drilling progress, the formation of a drill core in the interior of the base body, which can be separated from the borehole bottom and pulled out of the borehole in further operating steps.

For the extensive loosening of ground material another advantageous embodiment of the invention results from the fact that several rotatably supported roller bits and/or stationary round shank bits and/or stationary removal teeth are mounted at least in a partially planar and/or conical manner in a radial arrangement on the underside of the base body. By way of an at least partially radial arrangement of cutting instruments in the entire drilling cross-section a plurality of punctiform force applications enables the removal of the ground material in partial areas or in the entire area of the underside of the base body. In this embodiment of the invention the formation of a drill core is not intended.

Basically, the cutting instruments can be mounted in any chosen manner on the base body. According to an embodiment variant of the invention it is especially purposeful that the at least one or several rotatably supported roller bits and/or the at least one or several stationary round shank bits and/or the at least one or several stationary removal teeth are mounted in an exchangeable manner on the base body. In particular, the cutting means can be provided with holders, into which the respective cutting instruments are inserted in a releasable and force-locking manner. Since the cutting instruments, more particularly the roller bits, the round shank bits or the removal teeth, are exposed to potential damage or to a high degree of wear caused by abrasion on the ground material, it is possible for the said cutting instruments to be exchanged rapidly from the outer or inner side of the base body depending on the embodiment of the holders, thereby permitting an efficient operation and a rapid maintenance of the rotary drilling tool.

Another purposeful embodiment of the invention resides in the fact that a connecting means for connecting the tubular base body to a drill drive instrument is mounted on the upper side of the base body. The connecting means can be designed as a Kelly box in particular, with which a drill rod, especially a Kelly bar for transmitting a torque and a feed

force, can be fixed in a releasable and force-locking manner. The rotary drilling tool can thus be employed on customary drilling apparatuses.

For the design of the pump means provision is made in accordance with another particularly advantageous embodiment variant of the invention in that the screw pump has at least one helical conveyor flight and/or at least one inclined turbine blade. Conveyance of the flush liquid, in particular in the interior of the base body and towards the cutting means, can in this case be brought about by the at least one rotating conveyor flight or by the at least one inclined turbine blade. A combination of conveyor flights and turbine blades allows for an improved flow of flush liquid.

In principle, the tubular base body and the pump means can have any chosen dimensions. However, an especially preferred embodiment of the invention resides in the fact that the screw pump has an axial length which is smaller than the axial length of the tubular base body, in particular having a ratio ranging between 1:4 and 1:2.5. Through this, an advantageous distribution of space and position of the center of gravity of the rotary drilling tool can also be achieved in particular.

According to the invention a particularly preferred embodiment resides in the fact that the rotary drilling tool is a core drill which is designed for producing a drill core and for receiving it in the interior of the base body. In this case, the ground material is purposefully removed in a ring-shaped fashion by the cutting means that has a ring-shaped configuration of cutting instruments. As a result of the ring-shaped removal of solid ground material a cylindrical drill core is thus produced in an especially efficient manner in the borehole.

Once a drill core has formed in the receiving space of the base body from the ground material present at the borehole bottom, the said core is, in a known manner, retained in a force-locking manner by a core catcher means, such as a core catcher ring, in the interior of the base body and is subsequently separated from the borehole bottom under the application of force and conveyed along with the rotary drilling tool in the form of the core drill to the surface of the building ground.

According to the invention another particularly preferred embodiment resides in the fact that the rotary drilling tool is a drilling bucket which is designed for receiving extensively removed ground material in the interior of the base body. The ground material is removed  
5 by the cutting means through an extensive arrangement of cutting instruments in the entire drilling cross-section and fed via receiving openings of a closable bottom plate on the underside of the base body into the receiving space in the base body. The borehole continues to be produced in an economical manner by emptying the receiving space on the surface of the building ground. On purposeful closing and reopening of flaps on the receiving openings the received ground material can be captured during conveyance to the  
10 building ground surface where it is released again.

With regard to the drilling apparatus the object stated at the beginning is achieved in accordance with the invention in that a rotary drilling tool according to any one of the  
15 preceding claims is provided. By connecting the rotary drilling tool according to the invention to a drill drive, which is mounted on a mast of a drilling apparatus and drives the rotary drilling tool in a rotating manner, boreholes can be produced with such a drilling apparatus in a particularly efficient manner in the building ground and in all ground materials present therein and basically in all technically attainable drilling depths.

Furthermore, with regard to the method the object stated at the beginning is achieved in accordance with the invention in that a rotary drilling tool according to any one of the preceding claims is used. In this connection, the rotary drilling tool according to the invention can in particular also be employed with the above-described drilling apparatus for  
20 producing a bore in the ground in order to carry out such bores efficiently and economically, as set out beforehand.

In the following the invention is explained further by way of preferred embodiments illustrated schematically in the accompanying drawings, wherein show:

30 Fig. 1 a side view of a first rotary drilling tool according to the invention;

Fig. 2 a perspective view of the rotary drilling tool of Fig. 1;

Fig. 3 a side view of a second embodiment of a rotary drilling tool according to the invention;

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Fig. 4 a perspective view of the rotary drilling tool of Fig. 3;

Fig. 5 a view from above of the rotary drilling tool according to the invention of Fig. 3.

10 A first embodiment of a rotary drilling tool 10 according to the invention is explained in the following in conjunction with Figures 1 and 2. The rotary drilling tool 10 has a tubular base body 12 which can typically have a diameter ranging between 0.5 m and 4.0 m. On an underside of the base body 12 a cutting means 30 is arranged. In this embodiment the cutting means 30 has a plurality of roller bits 32 in a ring-shaped and mutually offset  
15 arrangement. The roller bits 32 are in particular directed radially inwards and outwards in an alternating fashion. Furthermore, in this embodiment the roller bits 32 are fixed in a releasable manner on the underside of the base body 12. In addition to the plurality of roller bits 32 a plurality of removal teeth 34 are also fixed in a releasable manner on the underside of the base body 12. In the interior of the base body 12 a receiving space 14  
20 is located which is bordered by an inner tube wall 13 of the base body 12, by the cutting means 30 on the underside of the base body 12 and by an end plate 16 on the upper side of the base body 12 together with a pump means 20 arranged thereon. The end plate 16 has four through-openings 18. Furthermore, a connecting means 40 is firmly connected to the end plate 16 of the base body 12.

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The pump means 20 which is designed as a screw pump in this embodiment has two conveyor flights 22 that are arranged so as to be offset by 180° with respect to each other. The first and second conveyor flights 22 extend radially along the end plate 16 of the base body 12 up to the inner tube wall 13. In this embodiment the conveyor flights 22 are firmly  
30 connected, in particular welded, to the upper side of the base body 12. The above-stated conveyor flights 22 are arranged and connected to the end plate 16 of the base body 12 in such a manner that they form an axial section of a double helix. The volume enclosed

in the inner tube wall 13, the end plate 16 and the cutting means 30 minus the volume taken by the pump means 20 defines the receiving space 14 which is provided for receiving a drill core, not shown, that has been separated from the ground by the cutting means 30.

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As already mentioned above, the tubular base body 12 has the tube wall 13 which is arranged such that it is offset inwards in a parallel manner, in which case this has recesses 15 in pairwise arrangement on the underside. Thus, with its inner tube wall 13 and the cutting means 30 the tubular base body 12 is on the one hand flush with the borehole  
10 bottom while on the other hand it permits a flow of flush liquid along the borehole bottom through the recesses 15 and towards the cutting means 30.

Moreover, on its upper side the tubular base body 12 has the end plate 16 already mentioned above, which is flush with the tubular base body 12 on the outer side thereof. To  
15 ensure an access of flush liquid to the base body 12 and further on to the cutting means 30 four through-openings 18 in the form of four uniform circular recesses are provided in the end plate 16. In the center of the end plate 16 a connecting means 40 is located which is designed in the present embodiment as a Kelly box for connecting the rotary drilling  
20 tool 10 to a drill drive instrument which is purposefully provided in this case as a Kelly bar. The Kelly bar is not depicted in Fig. 1 and Fig. 2. To receive the Kelly bar the connecting means 40 is designed in a substantially rectangular construction. For the torque transmission from the drill drive instrument to the rotary drilling tool 10 four reinforcing  
25 elements 41 are arranged for static reasons on the connecting means 40 and the end plate 16 between the individual through-openings 18 and are firmly connected, in particular welded, to the end plate 16 and the connecting means 40. In their center the reinforcing elements 41 have recesses that are of no static relevance. Hence, in the present embodiment the end plate 16 serves for the constructional connection of the base body  
30 12 to the connecting means 40 whilst enabling at the same time a flow of flush liquid through the through-openings 18 to the pump means 20 mounted on the end plate 16.

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During rotating operation of the rotary drilling tool 10 the in-situ ground material is removed in a ring-shaped manner by the ring-shaped cutting means 30, whereby a drill

core is formed gradually within the inner tube wall 13 that projects into the receiving space 14. For improved conveyance of the removed ground material, for stabilization of the borehole wall and in particular also for cooling the cutting means 30 flush liquid is led from the already existing borehole through the through-openings 18 to the pump means 20  
 5 and conveyed from the said pump means 20 into the receiving space 14 and further on between the inner tube wall 13 and the drill core to the cutting means 30 and in particular also to the roller bits 32 and the removal teeth 34. An outer and/or inner conveyor flight, not depicted, on the outer side of the tubular base body 12 or on the inner tube wall 13 assist the flow of the flush liquid from the pump means 20 to the cutting means 30 and  
 10 back to the building ground surface.

In Figures 3 to 5 a second embodiment of a rotary drilling tool 10 according to the invention is shown. The basic structure of this rotary drilling tool 10 with a tubular base body 12, a cutting means 30 on the underside of the tubular base body 12, a pump means 20,  
 15 an end plate 16 with through-openings 18 and a connecting means 40 corresponds to the structure of the rotary drilling tool 10 according to Figures 1 and 2.

However, a first major difference resides in the fact that the rotary drilling tool 10 according to Figures 3 to 5 has a pump means 20 that is mounted on the upper side of the end  
 20 plate 16 and does not project into the tubular base body 12. Furthermore, the pump means 20 is a screw pump just as in the first embodiment, whereas in this embodiment two inclined turbine blades are provided. Since the embodiment illustrated here is not a core drill but a drilling bucket provision is not made for an inner tube wall 13.

25 A second major difference to the first embodiment resides in the fact that the cutting means 30 substantially has an extensive arrangement of round shank bits 33 in radial partial arrangements. Furthermore, the embodiment according to the invention illustrated here is designed to receive extensively removed ground material in the interior of the base body 12 which is in this case fully available as receiving space 14.

30 The pump means 20 which, as already set out above, is designed as a screw pump has two turbine blades 24 arranged on opposite sides. The turbine blades 24 extend radially

along the end plate 16 of the base body 12 up as far as the continued wall of the tubular base body 12. In this embodiment the turbine blades 24 are firmly connected, in particular welded, to the end plate 16 arranged on the upper side of the base body 12. In addition, the turbine blades 24 are firmly connected, in particular also welded, to the connecting means 40. The turbine blades 24 are arranged in such a manner that upon a corresponding rotational direction of the rotary drilling tool 10 an inflow of the flush liquid takes place via the through-openings 18 provided.

Basically, the cutting means 30 is designed in such a manner that the cutting instruments provided in radial partial arrangements, in this case round shank bits 33, remove the ground material extensively at the borehole bottom in the entire drilling cross-section and feed the said material via receiving openings, not shown, into the receiving space 14.

Corresponding to the rotary drilling tool 10 of the first embodiment the connecting means 40 is designed as a Kelly box and provided for receiving a Kelly bar. Analogous to the first embodiment reinforcing elements 41 are connected, more particularly welded, to the connecting means 40 and the end plate 16, in which case the said elements are arranged so as to be offset by 90° with respect to the turbine blades 24.

Due to the spatial arrangement of the pump means 20 outside the tubular base body 12 and an extensive arrangement of cutting instruments of the cutting means 30 the entire inner space of the base body 12 is available as receiving space 14 for receiving removed ground material. Compared to a core drill, as shown in the first embodiment, a drilling bucket, as shown in this embodiment, is suitable for the removal of less hard ground material as compared to ground material suitable for the first embodiment.

By way of the pump means 20 explained in accordance with the invention in both embodiments, in particular in the form of the screw pump, the efficiency during the production of a borehole can thus be increased to a considerable extent, in particular by means of a core drill or a drilling bucket.

## Claims

1. Rotary drilling tool (10) for producing a bore in the ground with
  - 5       - a tubular base body (12),
  - a cutting means (30) arranged on an underside of the base body (12) for removing ground material,
  - a receiving space (14) in the base body (12) for receiving ground material and
  - an end plate (16) which is arranged on an upper side of the base body (12)
  - 10       and has at least one through-opening (18),
  - characterized in that
  - in the area of the at least one through-opening (18) a pump means (20) is arranged, by which a flow of flush liquid through the at least one through-opening (18) can be generated and which extends radially along the end plate (16), the pump means
  - 15       (20) is designed as a screw pump, and a connecting means (40) for connecting the tubular base body (12) to a drill drive instrument is mounted on the upper side of the base body (12).
2. Rotary drilling tool according to claim 1,
  - 20       characterized in that
  - the pump means (20) is arranged on an upper side or underside of the end plate (16).
3. Rotary drilling tool according to claim 1 or 2,
  - 25       characterized in that
  - the pump means (20) is designed for conveying the flush liquid into the receiving space (14) of the base body (12) or out of the receiving space (14) of the base body (12).
4. Rotary drilling tool according to any one of claims 1 to 3,
  - 30       characterized in that

on an outer and/or inner side the tubular base body (12) has a flight for conveying flush liquid and/or removed ground material.

- 5 5. Rotary drilling tool according to any one of claims 1 to 4,  
characterized in that  
the cutting means (30) has at least one rotatably supported roller bit (32) and/or at least one stationary round shank bit (33) and/or at least one stationary removal tooth (34).
- 10 6. Rotary drilling tool according to claim 5,  
characterized in that  
several rotatably supported roller bits (32) and/or stationary round shank bits (33) and/or stationary removal teeth (34) are mounted in a ring-shaped arrangement on the underside of the base body (12).
- 15 7. Rotary drilling tool according to claim 5 or 6,  
characterized in that  
the at least one or several rotatably supported roller bits (32) and/or the at least one or several stationary round shank bits (33) and/or the at least one or several station-  
20 ary removal teeth (34) are mounted in an exchangeable manner on the base body (12).
- 25 8. Rotary drilling tool according to any one of claims 1 to 7,  
characterized in that  
the screw pump has at least one helical conveyor flight (22) and/or at least one inclined turbine blade (24).
- 30 9. Rotary drilling tool according to any one of claims 1 to 8,  
characterized in that  
the screw pump has an axial length which is smaller than the axial length of the tubular base body (12).

10. Rotary drilling tool according to any one of claims 6 to 9,  
characterized in that  
the rotary drilling tool (10) is a core drill which is designed for producing a drill core  
and for receiving the drill core in the interior of the base body (12).

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11. Rotary drilling tool according to any one of claims 7 to 9,  
characterized in that  
the rotary drilling tool (10) is a drilling bucket which is designed for receiving extensively removed ground material in the interior of the base body (12).

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12. Drilling apparatus for producing a bore in the ground with a mast and a drill drive for driving a drilling tool in a rotatable manner,  
characterized in that  
a rotary drilling tool (10) according to any one of the preceding claims is provided.

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13. Method for producing a bore in the ground with a drilling tool,  
characterized in that  
a rotary drilling tool (10) according to any one of the preceding claims is used.