ROTARY DRIVES FOR CIVIL ENGINEERING

The invention relates to rotary drives for civil engineering, in particular multiple rotary drive arrangements and drilling or mixing devices for civil engineering, as well as a method for operating a multiple rotary drive arrangement for civil engineering.

Multiple rotary drive arrangements or working devices for driving several tools in common drilling and/or mixing applications for civil engineering (multiple or double-head drilling methods, soil mixing methods) are known in various sizes and power classes, and designs.

In the multiple or double-head drilling method, a drilling system is used that has coordinated with each other but independently from each other drivable drilling tools and enables the simultaneous drilling of a tool, for example a drilling auger, a drilling bucket or a percussive drill, and a casing pipe. A first rotary drive here provides for the rotational movement of an outer tube and another rotary drive provides for a rotational movement of an inner tool, preferably in opposite directions of rotation, wherein the drive, for example of the outer tube, can in each case also be operated intermittently. The inner tool can be driven as a percussive drill with a percussive drilling drive or a rotary-percussive drilling drive.

In the soil mixing method, a special mixing tool is drilled into the ground, which consists of a single or multiple drill string, paddles, and a drill head. Drilling in and withdrawing the mixing tool is supported by the addition of a binding agent suspension that exits from nozzles at the end of the drill head or respectively along the paddles. The mixing tool is moved up and down to improve the homogeneity of the soil mixture.

Although in the strict sense a mixing tool does not always also have to have a drill head, in the following, reference will always be made to drilling tools, and the invention is also described with reference to a drilling rotary drive and a double-head rotary drive. It is expressly pointed out, however, that the multiple rotary drive arrangement according to the invention, in the sense of a rotary drive arrangement in the broader sense, is also intended to be disclosed for the rotary drive of purely mixing tools and can be used in the field of civil engineering.

For the mentioned multiple or double-head drilling methods, suitable generic rotary drive arrangements have a first mechanical rotation gearbox, which has one or more, for example, two gearbox inputs, each for the parallel introduction of an input torque and is configured to add the input torques and provide them as output torque at a gearbox output for driving the respective drilling tool (outer tube), as well as a separate and independently operable second mechanical rotation gearbox, which likewise has one or more, for example, also two gearbox inputs, each for the parallel introduction of an input torque and is configured to add the input torques and provide them as output torque at a gearbox output for driving the respective further drilling tool (inner drill string or inner tool). In each case, a drive motor unit for generating and providing a motor torque as input torque for the rotation gearbox is mounted on each of the gearbox inputs of the two rotation gearboxes. As a rule, the drive motor units used on a rotary drive arrangement are those that use a hydraulic motor as the drive source. The most common type is based on hydraulic motors, because these can provide the required drive torques and most carrier machines for the civil engineering have a corresponding on-board hydraulic supply, since hydraulic motors are also used in a multitude of different attachment tools of the carrier machines, such as vibrators, hammers, rotary drills, or diaphragm wall cutters. The drilling tools here are arranged concentrically and are preferably driven in opposite directions.

The mixing device for use in soil mixing methods comprises at least two of such rotary drive arrangements, and the tools respectively driven by them (drill strings with paddles and/or drill head) are arranged parallel to one another.

In the context of the present disclosure, the components or respectively tools driven in rotation by the respective rotary drive arrangement, regardless thereof whether they are drilling tools of any kind or mixing tools or pipes to be turned into or pulled out of the ground (casing pipes), or combination tools for drilling and mixing, are referred to as civil engineering tools.

Certain working methods, such as soil mixing methods in which, in addition to creating the borehole, mixing energy must be applied in the borehole to form a soil mortar, or hard soils, require particularly high powers outputs that can exceed the capacity of an existing rotary drive arrangement or respectively a standard working equipment or a standard drilling rig.

The reasons for a limitation of power in drilling or respectively mixing can be:

- the installed drive power at the rotary drive arrangement or respectively the working equipment is too low (e.g. number/size of the motors or an allowable operating pressure of the hydraulic motors is too low);
- the power of the hydraulic power unit, for example a diesel engine for driving the hydraulic pump for the hydraulic motors, is too low; and
- the maximum transferable power of the hydraulic system of the on-board hydraulic supply of the drilling rig (number/size of hydraulic pumps and/or valve and line technology and/or maximum possible system pressure) is too low.

In order to compensate for such power deficits, an obvious approach is to initially provide for the installation of at least one additional hydraulic motor on the rotation gearbox of the rotary drive arrangement or the working device. However, this has the consequence that either the hydraulic system and the primary drive of the drilling rig on which the working device is to be used, must be expanded, or an external hydraulic power unit must be connected to the working device or drilling rig. The first measure has the disadvantage that an intervention in the existing machine is necessary or a larger and more powerful carrier machine must be used and brought in. With low power demands on a powerful carrier machine, however, a poorer efficiency is to be expected, and a large or respectively powerfully dimensioned carrier machine is more expensive

than a smaller one and thus uneconomical if the available power is not needed. The second measure, while leaving the carrier machine essentially untouched, leads, however, to drawbacks in handling and, anyhow in the case of diesel-driven units, to additional noise and CO_2 emissions on site due to the additional exterior hydraulic unit.

The invention is based on **object** to provide a multiple rotary drive arrangement and a drilling or mixing apparatus for civil engineering and a method for operating the same, with which, despite an increase in power, a particularly economical, efficient, and environmentally friendly operation of the multiple rotary drive arrangement is made possible.

The object is achieved on the one hand by a multiple rotary drive arrangement for civil engineering having the features of claim 1, on the other hand by a drilling or mixing apparatus for civil engineering having the features of claim 12, as well as by a method for operating a multiple rotary drive arrangement for civil engineering having the features of claim 13. Preferred embodiments are specified in the respective dependent claims.

Accordingly, the multiple rotary drive arrangement according to the invention for driving civil engineering tools, in particular drilling and/or mixing tools for the civil engineering, comprises a first rotation gearbox which has at least one gearbox input for introducing an input torque and is configured to provide the input torque or, in the case of multiple gearbox inputs, the added input torques as an output torque at a first gearbox output for driving a first civil engineering tool, and a second rotation gearbox which has at least one gearbox input for introducing an input torque and is configured to provide the input torque or, in the case of multiple gearbox inputs, the added input torques as an output torque at a second gearbox output for driving a second civil engineering tool. A drive motor unit for generating and providing a motor torque as input torque for the respective rotation gearbox is mounted on each of the gearbox inputs of the first and second rotation gearboxes, and the drive motor unit or at least one of the drive motor units of the first rotation gearbox has/have a hydraulic motor. The multiple rotary drive arrangement is characterized in that the drive motor unit(s) of the second rotation gearbox exclusively each has an/have electric motor(s).

A fundamental idea of the invention is to configure a multiple rotary drive arrangement, i.e. in particular a working device, with at least two rotation gearboxes that can be operated and controlled independently of one another, such that at least one of the rotation gearboxes (the first rotation gearbox) has one (or more) hydraulic drive motor(s), and at least one further of the rotation gearboxes (the second rotation gearbox) has one (or more) electric drive motor(s), i.e. exclusively electric drive motors, so that the multiple rotary drive arrangement as a whole is quasi hybridized and the energy required for the rotation gearboxes combined therein (hydraulic energy and electrical energy) can fundamentally be provided from two different energy sources and does not have to come solely from a single energy source.

This has particularly the advantage that the multiple rotary drive arrangement according to the invention can also carry out tasks with higher power requirements using a carrier machine whose on-board hydraulic supply and hydraulic power unit do not have a power and equipment in order to supply the hydraulic motors of two (or more) rotation gearboxes, for example, because the power of a diesel engine for driving the hydraulic pump is too low, or because the maximum transferable power of the hydraulic system of the on-board hydraulic supply of the drilling rig (number/size of hydraulic pumps and/or valve and line technology and/or maximum possible system pressure) is too low.

According to the invention, namely, the energy required for the electric drive motor(s) of the second rotation gearbox (i.e. electrical energy) can be supplied from an alternative source. For example, the electrical energy supply of the electric drive motor(s) can be provided by a supply from an electrical energy source or voltage source of the construction machine (generator, battery storage) or from an external electrical energy source or voltage source with a cable connection to the construction machine, which likewise can be a generator, a mains connection or a battery storage unit.

In addition to the fundamental increase in the maximum achievable power at the rotary drive arrangement, the invention yields further advantages:

- a smaller or less powerful base machine can have an on-board hydraulic system sufficient for many applications, and an increased power demand that is only rarely required can be covered by additionally supplying electric energy in a simple manner; and
- power peaks can be provided solely by the multiple rotary drive arrangement and a simple external electrical power supply without elaborate modifications of the base machine or the hydraulic system on site or the use of an alternative larger base device, since a so-called “construction electricity” is available about almost everyone construction sites;
- by using the environmentally friendly electric motor, the energy contribution of the diesel engine to the work process can be reduced, which leads to a reduction of (local) CO_2 emissions and also of the noise. With a low torque requirement, a purely hydraulic or even a purely electric rotational operation can take place, for example when cleaning the drilling tool or in processes with low power demand.

In a preferred configuration, the hybridization can also be realized within a rotation gearbox, by at least one of the drive motor units of the first rotation gearbox, in addition to the hydraulic motor(s), having at least one electric motor or multiple electric motors.

By combining hydraulic motor(s) and electric motor(s) for parallel torque input in one of the rotation gearboxes, this gearbox can, on the one hand, be upgraded in terms of power, and the energy required for the electric drive motor(s) (i.e. electrical energy) of this rotation gearbox can be supplied from an alternative source.

In the load ranges of a work process, in the correspondingly equipped hybridized first rotary drive, the respective drive motor that is suitable based on its performance characteristics, or respectively a combination of drive motors, can be selectively used to provide the required torque. In a partial-load range, for example, the drive can preferably be effected by the electric motor, which can be modulated relatively easily, i.e. the power of the electric motor can first be increased stepwise or continuously, and the at least one hydraulic motor can only then be "switched on" when the application requires even higher power or torque (the control can also take place in the reverse

manner, in which the hydraulic motor(s) provide a base load and the electric motor(s) are switched on upon reaching a load limit of the hydraulic system).

The delivered power of the electric motor can be directly converted at the multiple rotary drive arrangement and provided as output torque at the gearbox output of the hybridized first rotary drive. The electrical energy supply of the electric drive motor is possible, for example, by a supply from an electrical energy source or respectively voltage source of the construction machine (generator, battery storage) or from an external electrical energy source or respectively voltage source with a cable connection to the construction machine, which likewise can be a generator, a mains connection or a battery storage unit.

The term "switching on" of the hydraulic motor when the electric motor is primarily driving in a hybridized rotary drive is not only to be understood in practice merely such that the hydraulic motor initially stands still and is then, for example, is engaged. Rather, a more technically feasible solution is one in which an output rotational speed of the rotary drive is specified by an oil volume flow and thus in fact by the hydraulic motor(s). The electric motor is operated in a torque control mode. The specified torque is determined by the hydraulic pressure, since the electric motor torque must be limited such that a certain minimum pressure (for example 10 bar) is given. This then causes, put simply, a torque-free co-rotation of the hydraulic motors. In this way it can be prevented that the electric motor(s) "haul up" the hydraulic motor(s) and operate(s) it/them as a pump, which would entail the risk of cavitation. This case occurs during free rotation (no load) or when the drilling or mixing torque is so low that the maximum electric motor torque is not utilized. If the drilling or mixing torque then increases during the process, the control described above causes the electric motor torque to increase, namely up to its maximum torque. If the drilling torque increases further, a pressure increase is established in the hydraulic system. From the outside, this then appears as the "switching on" of the hydraulic motor.

Preferably, a control device is provided for the multiple rotary drive arrangement, which is configured to variably control the operation of the drive motor units and thereby their respective contribution to the output torque of the respective rotation gearbox,

preferably in dependence on a torque requested at the respective gearbox output. Such a control device can be integrated into a control unit of the drilling or mixing apparatus (base machine) on which the multiple rotary drive arrangement is operated, or it can be configured as an independent control unit, which in turn can be arranged in whole or in part on the multiple rotary drive arrangement. The integration of the control functions for both types of drive motors enables a selective and coordinated control of the motors depending on the torque requirement at the tool.

For example, a control unit with the power electronics for the at least one of the drive motor units of the hybridized rotary drive that has the electric motor, can be arranged on the multiple rotary drive arrangement. This can significantly shorten the cable lengths between the power electronics and the electric motor, which reduces the losses and increases the efficiency in operation and the safety.

This control device can furthermore be configured to always supply the at least one drive motor unit that has the hydraulic motor, with a minimum hydraulic pressure during operation of the multiple rotary drive arrangement or respectively the hybridized rotary drive, in order to prevent the hydraulic motor from running empty of hydraulic fluid if it is not significantly required for driving in certain phases of operation but is being "carried along" by the drive of the electric motor(s) via the engagement with the rotation gearbox and is operating as a pump (see the explanations above).

The control device can further be configured to control the at least one drive motor unit or respectively the drive motor units that each has/have the electric motor, in a torque-guided/torque-controlled manner. The detection of the requested drilling or respectively rotational or mixing torque usually takes place in the base machine, and this information can be used as input into the control device.

Preferably, the electric motor of the drive motor unit(s) that each has/have an electric motor is designed as a permanently excited synchronous machine. In contrast to an electrically separately excited synchronous machine, the current or voltage supply for excitation is omitted in this type of electric motor, which makes the machine more robust.

The multiple rotary drive arrangement can have a connection for an external supply of the drive motor unit(s) that has/have the hydraulic motor, with a hydraulic fluid, and a connection for an external supply of the drive motor unit(s) that has/have the electric motor, with electrical energy. This means that the multiple rotary drive arrangement, which sits on one or more feed carriage(s) that is/are held or moved either by a feed cylinder or by a feed rope, can easily be supplied with the operating media required for operation, including electrical energy.

To expand the control range of the torque provided at the output of the rotary drive, at least one of the drive motor units can have an integrated reduction gear with a fixed or switchable transmission and/or a switchable idle stage or clutch. In particular, the switchable idle stage or clutch allows, in a hybridized (first) rotary drive, the complete decoupling of the respective drive motor unit that is not needed from the respective rotation gearbox, so that even when the other drive motor unit(s) are operating, it is not "dragged along" and does not cause losses through friction or respectively resistance, or – in the case of the hydraulic motor – act as a pump and lead to an undesirable backflow of hydraulic fluid and a running empty of the hydraulic motor of hydraulic fluid.

In a configuration of the multiple rotary drive arrangement that is particularly preferred for the civil engineering as a double rotary drill head, the gearbox output of the first rotation gearbox can have a drive hollow shaft or driver socket for releasably coupling and driving a receptacle, i.e. a part of the first civil engineering tool to be driven, in particular a Kelly bar, a drilling auger, a drilling bucket or a percussive drill. Furthermore, the drive hollow shaft or driver socket can be interchangeable in order to adapt the construction type (for example the inner or outer diameter and/or positive locking drivers) for use with different types of drilling tools. The gearbox output of the second rotation gearbox can, in this case, have a drive hollow shaft for releasably coupling and driving a part of the second civil engineering tool to be driven, in particular a casing pipe. Here too, the drive hollow shaft or driver socket can be interchangeable in order to adapt the construction type (for example the outer diameter and/or positive locking driver) for use with different casing pipes.

The rotational axes of the drive hollow shafts of the first and second rotation gearboxes can be arranged concentrically (in a typical double drill head) or parallel to each other (in a soil mixing device). In particular, in a soil mixing drive, more than two rotation gearboxes can also be installed.

Finally, the multiple rotary drive arrangement can have a first rotary or respectively drilling drive carriage, which is configured to be slidably mounted along a mast of a drilling rig for the civil engineering, with the first rotation gearbox being mounted on the first rotary or drilling drive carriage. The multiple rotary drive arrangement can also have a second rotary or drilling drive carriage, which is configured to be slidably mounted along the mast of the drilling rig, with the second rotation gearbox mounted on the second rotary or drilling drive carriage. Alternatively, the multiple rotary drive arrangement can have a single common rotary or drilling drive carriage, which is configured to be slidably mounted along a mast of a drilling rig for the civil engineering, with the first rotation gearbox and the second rotation gearbox being mounted on the rotary or drilling drive carriage, in particular being installed in a common housing. Additional components, such as a cooling unit or the control unit, if provided, can be mounted on the first and/or the second rotary or drilling drive carriage or the common carriage.

Arranging these components on the rotary or drilling drive carriage(s) makes on-site commissioning easier by installing only the rotary or respectively drilling drive carriages, as functional units, on the mast of the drilling or respectively base machine and the supply lines for the operating media (electrical energy, hydraulic fluid) have to be connected.

The invention also relates to a drilling or mixing apparatus for the civil engineering, with a base machine, which is preferably mobile and constructed with an undercarriage, a mast arranged on the carrier machine, and a multiple rotary drive arrangement according to the invention, which is arranged with the first and second rotary or respectively drilling drive carriages so as to be movable along the mast.

Finally, the invention also relates to a method for operating a multiple rotary drive arrangement according to the invention for the civil engineering, characterized in that the operation of the drive motor unit(s), and thus their respective contribution to the output torque of the respective rotation gearbox, is variably controlled, preferably in dependence on a drilling or rotation torque requested at the respective gearbox output. The drive of the drive motor units is effected preferably such that the rotation gearboxes, and via these the concentric axes of the civil engineering tools, are driven in opposite directions of rotation. In mixing devices, the drive of each axes lying next to each other, is effected likewise preferably in opposite directions of rotation.

In the method, in the hybridized rotation gearbox(es) that comprise(s) at least one drive motor unit with a hydraulic motor and at least one drive motor unit with an electric motor, the respective drive motor unit with a hydraulic motor is always supplied with a minimum hydraulic pressure during operation of the multiple rotary drive arrangement, in order to prevent the hydraulic motor from running empty when this is not needed to provide a drive torque but cannot be completely uncoupled drive-wise from the respective rotation gearbox, for example, by a clutch or idle stage.

Using the drilling or mixing apparatus or the method, the advantages and effects explained in connection with the multiple rotary drive arrangement can accordingly be achieved.

The invention is explained in more detail below on the basis of preferred exemplary embodiments, which are schematically illustrated in the drawings. In the drawings show:

Fig. 1: a side view of a drilling rig with a drilling drive arrangement, illustrating some features of the invention;

Fig. 2: a perspective view of a rotary drive of a single rotary drive arrangement for a drilling drive, mounted on a drilling drive carriage, illustrating further features of the invention;

Fig. 3: a perspective view of a multiple rotary drive arrangement according to the invention in the form of a double drill head; and

Fig. 4: a perspective view of a multiple rotary drive arrangement according to the invention in the construction type of a mixing device.

A drilling drive arrangement 80, mounted on a mobile carrier machine 12 as an example of a drilling rig 10 that is configured as a deep foundation machine, is shown in Fig. 1 and serves to illustrate features of the invention. The carrier machine 12 can preferably include a crawler undercarriage as a undercarriage 14, on which an upper-carriage 16 can be rotatably mounted, in particular. In an operator's cab of the upper - carriage 16, a control unit 60 can be located, with which functions of the carrier machine 12 and the drilling drive arrangement 80 can be controlled. In particular, via an articulation mechanism 18, a mast 20 can be mounted on the upper-carriage 16 so as to be adjustable, which, in operation has an essentially vertical position.

According to the illustrated exemplary embodiment, the mast 20 can preferably be configured as a leader 21 with a linear guide 24 on its front side. Along the linear guide 24, in the example of Fig. 1, a drilling drive carriage 38 with a single rotary drive 36 is mounted so as to be vertically movable, wherein a rotary table 81 with a thereon flanged perforated cylinder is arranged below the drilling drive carriage 38 and is driven together with a drilling tool via a hollow shaft 48 of the rotary drive 36. Such a rotary table 81 serves to screw-in a casing pipe into a borehole. In the drawing, a middle position of the rotary drive 36 as well as a lower position with dashed lines are illustrated.

Via a mast head 22 at the upper end of the mast 20, a cable 40 can be guided, at one end of which a preferably telescopic Kelly bar 32 can be provided with an exemplary drilling tool 34 to form a civil engineering tool 30. The Kelly bar 32 can be guided through the annular or respectively sleeve-shaped drive hollow shaft 48 of the rotary drive 36 on the drilling drive carriage 38, so that a torque from the rotary drive 36 can be transmitted in positive engagement, for example, via drivers 54 to drive strips (not shown) of the Kelly bar 32. At the lower end of the Kelly bar 32, the drilling tool 34 for

creating a borehole in the ground can be arranged. The drilling tool 34 can fundamentally be of any design and, in particular can have a drilling auger or a drilling bucket.

From the Kelly bar 32, the cable 40 can be guided over deflection pulleys 26 at the mast head 22 along the mast 20 up to a cable winch 46 in or on the upper-carriage 16. The cable winch 46 is driven by a motor 50. Via the cable winch 46, the Kelly bar 32 with the drilling tool 34 can be raised and lowered by means of the cable 40.

Via an actuator 28 with a winch on the mast 20, the drilling drive carriage 38 with the rotary drive 36 can be pulled upward by another feed rope 29. By according driving the actuator 28 in the opposite direction, the drilling drive carriage 38 with the rotary drive 36 can also be lowered or pulled or respectively pushed downward. The actuator 28 can be equipped with a hydraulic or electric motor (not shown), or can be configured as a hydraulic drive with feed cylinder(s).

In the illustrated exemplary embodiment, a force-measuring device 62 is preferably arranged at a deflection pulley 26 on the mast head 22. The force-measuring device 62 can be designed, for example, as a force measuring bolt by which a rope tension in the cable 40 can be detected. The force-measuring device 62 is connected to the control unit 60 on the upper-carriage 16.

Via the control unit 60, the at least one motor 50 for operating the cable winch 46, the actuator 28 and preferably also the later still described drive motors for operating the rotary drive 36 or respectively the multiple rotary drives are controlled. It is pointed out at this point that the above description serves to explain the components of the civil engineering machine essential to the invention and that the single rotary drive 36 is shown merely by way of example, but in a civil engineering machine according to the invention it is replaced by a multiple rotary drive arrangement.

Fig. 2 shows a perspective view of the single rotary drive 36 of a drilling drive arrangement 80 for the rotational driving of a single drilling tool 34, which is connected, for example, via bolts to a drilling drive carriage 38 movable at the mast 20.

The rotary drive 36 comprises a per se known ring-shaped rotation gearbox 41 that has at least one, preferably at least two, gearbox inputs, each for introducing an input torque, and is configured with a gear arrangement to, in the case of multiple gearbox inputs and parallel introduction of the input torques, sum the individual input torques and provide them as a unified total output torque at a gearbox output 49 for driving the drilling tool 34. A drive motor unit 42, 43 for generating and providing a motor torque as input torque for the rotation gearbox 41 is attached to the or respectively each of the gearbox inputs.

Such a rotary drive can be configured as a purely electric rotary drive with drive motor units that each exclusively have an electric motor, or as a purely hydraulic rotary drive with drive motor units that each exclusively have a hydraulic motor. Both construction types are known per se. The concept according to the invention now provides to combine, in a multiple rotary drive arrangement, a purely electric rotary drive with a hydraulically driven rotary drive that can be operated independently of it, in order to provide so a hybridized multiple rotary drive arrangement. The hydraulic rotary drive can, in turn, be a purely hydraulic rotary drive in which all drive motor units have a hydraulic motor, or it can, in a further embodiment, be a hybridized electric/hydraulic rotary drive in which at least one of multiple gearbox inputs of a rotation gearbox is installed a drive motor unit that has a hydraulic motor, and at least one of multiple gearbox inputs of the rotation gearbox is installed a drive motor unit that has an electric motor.

In the example shown of such a hybridized electric/hydraulic rotary drive, two drive motor units 42 with hydraulic motor and one drive motor unit 43 with electric motor are provided, wherein further drive motor units with hydraulic motor and multiple drive units with electric motor can be provided. The respective drive units 42, 43 are modular units that are connected via flange connections to a housing 47 of the rotation gearbox and coupled with the gear arrangement of the rotation gearbox.

The electric motor of the respective electric drive motor unit 43 is preferably designed as a permanently excited synchronous machine. Each of the drive motor units 42, 43 can, in a per se known manner, have an integrated reduction gear 55 with a fixed or

switchable transmission and preferably a switchable idle stage or clutch between the motor and an output element that engages into the gear arrangement of the rotation gearbox. Such a reduction gear can be differently between electric motors and hydraulic motors.

The gearbox output 49 here is connected to a drive hollow shaft 48 for the rotary driving of the drilling tool 34, wherein the drive hollow shaft 48 transmits the drive torque via drivers 54 in positive engagement to a drilling tool not shown here (for example, the Kelly bar 32 shown in Fig. 1).

A ring-shaped spring pot 45 with springs 51 and hydraulic dampers 52, on whose support ring 53 a surrounding radial collar of the Kelly bar 32 can support, dampens vertical shocks during operation and protects the material.

The rotary or respectively drilling drive arrangement has a control device (not shown here) which is configured to variably control the operation of the drive motor units 42, 43 mounted on the rotation gearbox and thereby their respective contribution to the output torque, preferably in dependance of a drilling or rotation torque requested at the gearbox output 49.

The control device is preferably configured to always supply the at least one drive motor unit 42 that has the hydraulic motor with a minimum hydraulic pressure during operation of the drilling drive arrangement 80, in order to prevent the hydraulic motor(s) from running empty of hydraulic fluid when this/these is/are not significantly required for drive in certain phases of operation, and if necessary cannot be completely uncoupled from the rotation gearbox.

Further, the control device is preferably configured to control the drive motor unit(s) 43 with the electric motor in a torque-controlled manner.

The control device for the drive motor unit(s) 43 with the electric motor also comprises a control unit with power electronics. While the control device for the motors of the rotary or drilling drive arrangement can be integrated into the control unit 60 of the drilling rig 10, this control unit with the power electronics can be arranged as a separate

functional unit on the rotary or drilling drive arrangement at a protected location and, if necessary, in its own housing near the rotary drive, for example on the drilling drive carriage 38, in order to route the electrical energy to the electric motors in as short a path as possible.

The supply of the motors of the rotary drive (and possibly other components) with energy (pressurized hydraulic fluid as well as electrical energy) is effected via respective connections for an external supply, which allow a quick and secure detachable coupling with external supply lines.

The rotary or drilling drive arrangement can further have a cooling unit, which is assigned to the electric motor(s) and/or, if present, the control unit with the power electronics for actively dissipating the operating heat, wherein the cooling unit can be configured as a liquid cooling and a heat exchanger/cooler, possibly with a fan, of a cooling circuit of the cooling unit can preferably be carried on the rotary or respectively drilling drive arrangement, for example also on the drilling drive carriage 38. This cooling unit can, in particular be configured to work autonomously, in particular independently of a cooling circuit of the drilling rig 10 on which the rotary or respectively drilling drive arrangement is used.

In the multiple rotary drive arrangement 90 according to the invention in the construction type of a double rotary head, shown in Fig. 3, two rotation gearboxes 41, 61 are used to drive two civil engineering tools independently of each other, i.e. with different rotational speeds and/or directions of rotation.

The multiple rotary drive arrangement 90 accordingly include a first, here upper, rotation gearbox 41, which is part of a first rotary drive 36 and, like the gearbox described earlier with reference to the rotary drive 36 shown in Fig. 2, has at least one, preferably at least two, gearbox inputs each for introducing an input torque and is configured to (with two or more gearbox inputs) sum the input torques and provide them as a modified output torque at a first gearbox output 49 for driving a first civil engineering tool 30.

The multiple rotary drive arrangement 90 also includes a second, here lower, rotation gearbox 61, which is part of a second rotary drive 37 and likewise has at least one, preferably at least two, gearbox inputs each for introducing an input torque and is configured to (with two or more gearbox inputs) sum the input torques and provide them as a modified output torque at a second gearbox output 49 for driving a second civil engineering tool 30. A drive motor unit for generating and providing a motor torque as input torque for the respective rotation gearbox 41, 61 is attached to each of the gearbox inputs of the first and second rotation gearboxes 41, 61, wherein only drive motor units 43 with electric motor are mounted on the second rotation gearbox 61.

In a simplest form of the hybridized multiple rotary drive arrangement according to the invention, the at least one drive motor unit 42 of one of the rotation gearboxes (for example of the first rotation gearbox 41) in any case has a hydraulic motor, or all drive motor units 42 of this rotation gearbox each have a hydraulic motor, so that the rotation gearbox is a purely hydraulically driven gearbox. Further, the at least one drive motor unit 43 of another of the rotation gearboxes (for example of the second rotation gearbox 61) in any case has an electric motor, or all drive motor units 43 of this rotation gearbox each have an electric motor, so that this rotation gearbox is a purely electrically driven gearbox.

In another variant, in one of the rotation gearboxes (for example in the first rotation gearbox), at least one of several drive motor units can have a hydraulic motor and at least one further drive motor unit can have an electric motor (so that this rotation gearbox can be called as a hybridized rotation gearbox). Such a hybridized rotation gearbox can, with regard to its basic structure, be built analogous to the rotation gearbox 41 that has been described earlier with reference to the drilling drive arrangement 80, and it can differ only in the configuration of the output or respectively the torque transmission to the respective civil engineering tool to be driven, for what reason, reference is made to the above description regarding of the structure and the further functions of the components and their control, and the same reference numerals are also used for better understanding to denote corresponding components, even if these are not visible in detail in the illustration of Fig. 3.

According to the invention, however, at least one of the rotation gearboxes (for example the second rotation gearbox 61) in any case exclusively has one or more drive motor unit(s) 43 with electric motor (so that this rotation gearbox is a purely electrically driven rotation gearbox). The configurations and power data of the first and second rotation gearboxes (as well as further rotation gearboxes) do not have to be identical, but can be designed according to the respective civil engineering tool to be driven. In this sense, rotation gearboxes with only a single drive motor unit can also be combined with one (or more) rotation gearbox(es) with multiple drive motor units within a multiple rotary drive arrangement, provided at least one of the rotation gearboxes is a purely electrically driven rotation gearbox and at least one further rotation gearbox in any case has at least one hydraulic drive (which, in the hybridized case can be combined with an electric drive). The arrangement as the upper or lower rotation gearbox can also be swapped between the first and second gearbox.

It is pointed out that the drive motor units of the rotation gearboxes 41, 61 are partially obscured by parts of a rotary or respectively drilling drive carriage 38, 39 in the illustration of Fig. 3.

The gearbox output 49 of the second rotation gearbox 61 has a drive hollow shaft 48 for releasably coupling and driving a part of the first civil engineering tool 30 to be driven, here in the construction type of a casing pipe 35. The gearbox output 49 of the first rotation gearbox 41 likewise has a drive hollow shaft 48 for releasably coupling and driving a part of the second civil engineering tool 30 to be driven, here in the construction type of a drilling auger 34.

The drive hollow shafts 48 and thus the axes of the first and second rotation gearboxes 41, 61 are arranged concentrically to each other, so that the drilling auger 34 runs through the drive hollow shaft 48 of the lower (second) rotation gearbox 61 and further concentrically to the outer pipe 35 and inside the same. In a double rotary drill head, the drive motor units are preferably controlled such that the rotation gearboxes 41, 61 are driven in opposite directions of rotation relative to each other, possibly at different rotational speeds and intermittently, as needed, but wherein although a corotating and, possibly simultaneous drive can also be provided.

The multiple rotary drive arrangement 90 has a first rotary or drilling drive carriage 38, which is configured to be slidably mounted along a mast 20 constructed as a leader 21 of a drilling rig for the civil engineering (for example the base machine 10 shown in Fig. 1), with the first rotation gearbox 41 mounted on the first rotary or drilling drive carriage 38 and, via this, can be advanced and retracted with the attached civil engineering tool 30 in the longitudinal direction of the mast/leader, for example via a support cable attached to the carriage. The multiple rotary drive arrangement 90 also has a second rotary or respectively drilling drive carriage 39, which is likewise configured to be slidably mounted along the mast 20 constructed as a leader 21 of the drilling rig 10, with the second rotation gearbox 61 mounted on the second rotary or respectively drilling drive carriage 39 and, via this, can be advanced and retracted with the attached civil engineering tool 30 in the longitudinal direction of the mast/leader, for example via the support cable attached to the first carriage 38 and guided along the mast, by mechanically coupling the two carriages 38, 39 with one another.

In the illustrated embodiment, the first and second rotary or respectively drilling drive carriages 38, 39 are indeed rigidly coupled to each other, but they can also be configured to be independently of each other moveable along the mast.

In the multiple rotary drive arrangement 91 according to the invention in the construction type of a mixing device, shown in Fig. 4, a total of four rotary drives 92 are mounted on a common carriage 93, here respectively two at two different height positions and offset laterally such that the civil engineering tools 30 driven by the rotary drives 92, here in the form of drive rods 31, are positioned in a line next to one another and parallel to each other as well as spaced apart from each other. The carriage 93 is arranged so as to be movable on a (not shown) mast constructed as a leader via a feed device in the longitudinal direction of the mast/leader.

The number, design and arrangement of the rotary drives depends on the specific processing situation, whereby in a mixing device typically at least two rotary drives are provided. The civil engineering tools can be purely drilling tools or rods provided only with mixing paddles, or can be a combination of drilling tools provided with mixing paddles. A binding agent suspension can be introduced into the drive rods or drilling

tools and exits from nozzles at the end of the drill head or along the paddles. The mixing device is moved up and down via the carriage 93 to improve the homogeneity of the soil mix.

Each of the rotary drives 92 has a rotation gearbox 41, whereby here too, in a simplest form of the hybridized multiple rotary drive arrangement according to the invention, one or more rotation gearboxes each have only drive motor units with hydraulic motor (and thus is a purely hydraulically driven rotation gearbox) and one or more rotation gearboxes each have only drive motor units with electric motor (and thus is a purely electrically driven rotation gearbox). In one variant, at least one purely electrically driven rotation gearbox can be combined with at least one purely hydraulically driven rotation gearbox and/or at least one hybridized rotation gearbox(es), whose construction and function were described beforehand, in particular with reference to the drilling drive arrangements 80 and 90. Thus, in any case, (at least) one of the rotation gearboxes in the multiple rotary drive arrangement 91 is a purely electrically driven rotation gearbox, while at least one further rotation gearbox has at least one drive motor unit 42 with a hydraulic motor (in combination with further drive motor units with hydraulic motor in the sense of a purely hydraulically driven rotation gearbox or, possibly in combination with at least one drive motor unit with electric motor in the sense of a hybridized hydraulic/electric driven rotation gearbox) .

With regard to the construction and the further functions of the components of such a hybridized rotation gearbox, reference can therefore be made to the preceding description, and the same reference numerals are used to denote corresponding components for better explanation, even if these are partially not individually visible in the illustration of Fig. 4.

Each of the multiple rotation gearboxes 41 of the multiple rotary drive arrangement 91 has respectively at least two gearbox inputs each for introducing an input torque and is configured to sum the input torques and to provide the sum torque as output torque at a respective gearbox output 49 for driving a respective civil engineering tool 30.

As described above, a drive motor unit 42, 43 for generating and providing a motor torque as input torque for the respective rotation gearbox 41 is mounted at each of the at least two gearbox inputs of the respective rotation gearbox 41. It is pointed out to this that in the multiple rotary drive arrangement 91, shown in Fig. 4, four identical rotary drives 92 are provided to simplify the illustration, each of which is equipped with two drive motor units with hydraulic motor 42. However, according to the invention as already described, at least one rotary drive has a rotation gearbox 41 with exclusively drive motor units 43 with electric motor and is a purely electrically driven rotation gearbox, while at least one further rotary drive has a rotation gearbox with a purely hydraulic drive or with a hybridized drive, that is, at least one drive motor unit 43 with electric motor and at least one drive motor unit 42 with hydraulic motor. The drive motor units of each rotary drive 92 can be selectively controlled (be switched on, switched off, and modulated in terms of rotational speed and direction of rotation) as described beforehand with reference to the drilling drive arrangements 80 and 90. Furthermore, multiple rotary drives – for example, those with the same power and/or of the same type of drive, electric motor or respectively hydraulic motor – can be grouped together and controlled uniformly within a respective group.

CLAIMS

1. A multiple rotary drive arrangement (90; 91) for driving civil engineering tools (30), in particular drilling and/or mixing tools (34) for civil engineering, comprising

a first rotation gearbox (41), which comprises at least one gearbox input for introducing an input torque and is configured to provide the input torque or, in the case of multiple gearbox inputs, the added input torques as an output torque at a first gearbox output (49) for driving a first civil engineering tool (30), and

a second rotation gearbox (61), which comprises at least one gearbox input for introducing an input torque and is configured to provide the input torque or, in the case of multiple gearbox inputs, the added input torques as an output torque at a second gearbox output (49) for driving a second civil engineering tool (30),

wherein a drive motor unit (42, 43) for generating and providing a motor torque as input torque for the respective rotation gearbox (41, 61) is mounted on each of the gearbox inputs of the first and second rotation gearboxes (41, 61), and

wherein the drive motor unit or at least one of the drive motor units (42) of the first rotation gearbox (41) comprise(s) a hydraulic motor,

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the drive motor unit(s) (43) of the second rotation gearbox (61) exclusively each comprise(s) (an) electric motor(s).

2. The multiple rotary drive arrangement (90; 91) according to claim 1,

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at least one of the drive motor units (42, 43) of the first rotation gearbox (41) comprises an electric motor.

3. The multiple rotary drive arrangement (90; 91) according to claim 1 or 2, wherein

a control device is provided for the multiple rotary drive arrangement (90; 91), which is configured to variably control the operation of the drive motor units (42, 43) and thereby their respective contribution to the output torque of the respective rotation gearbox (41, 61), preferably in dependance of a torque requested at the respective gearbox output (49).

4. The multiple rotary drive arrangement (90; 91) according to claim 3, wherein the control device is configured to always supply the at least one drive motor unit (42) of the first rotation gearbox (41) that has the hydraulic motor with a minimum hydraulic pressure during operation of the multiple rotary drive arrangement (90; 91).

5. The multiple rotary drive arrangement (90; 91) according to claim 3 or 4 in combination with claim 2,

wherein

the control device is configured to control the at least one drive motor unit (43) of the first rotation gearbox (41) that has the electric motor in a torque-guided/torque-controlled manner.

6. The multiple rotary drive arrangement (90; 91) according to any one of claims 1 to 5,

wherein

a control unit with power electronics for the drive motor unit(s) (43) that comprise(s) the electric motor is arranged on the multiple rotary drive arrangement (90; 91).

7. The multiple rotary drive arrangement (90; 91) according to any one of claims 1 to 6,
wherein
the multiple rotary drive arrangement (90; 91) comprises a connection for an external supply of the drive motor unit(s) (43) that comprise(s) the electric motor, with electrical energy.

8. The multiple rotary drive arrangement (90; 91) according to any one of claims 1 to 7,
wherein
at least one of the drive motor units (42, 43) comprises an integrated reduction gear with a fixed or switchable transmission and/or a switchable idle stage or clutch.

9. The multiple rotary drive arrangement (90; 91) according to any one of claims 1 to 8,
wherein
the gearbox output (49) of the first rotation gearbox (41) comprises a drive hollow shaft or a driver (48) for releasably coupling and driving a part of the first civil engineering tool (30) to be driven, in particular a Kelly bar (32), a drilling auger (35), a drilling bucket or a hammer drill,
the gearbox output (49) of the second rotation gearbox (61) comprises a drive hollow shaft (48) for releasably coupling and driving a part of the second civil engineering tool (30) to be driven, in particular a casing pipe (34), and
rotation axes of the drive hollow shafts (48) of the first and second rotation gearboxes (41, 61) are arranged concentrically or parallel to each other.

10. The multiple rotary drive arrangement (90) according to any one of claims 1 to 9, wherein
the multiple rotary drive arrangement (90) has a first rotary or drilling drive carriage (38) which is configured to be slidably mounted along a mast (20) of a drilling rig (10) for civil engineering, wherein the first rotation gearbox (41) is mounted on the first rotary or respectively drilling drive carriage (38),

the multiple rotary drive arrangement (90) has a second rotary or drilling drive carriage (39) which is configured to be slidably mounted along the mast (20) of the drilling rig (10), wherein the second rotation gearbox (61) is mounted on the second rotary or respectively drilling drive carriage (39).

11. The multiple rotary drive arrangement (91) according to any one of claims 1 to 9, wherein
the multiple rotary drive arrangement (91) has a rotary or drilling drive carriage (93) which is configured to be slidably mounted along a mast (20) of a drilling rig (10) for civil engineering, wherein the first rotation gearbox (41) and the second rotation gearbox (61) are mounted on the rotary or drilling drive carriage (93).

12. A drilling or mixing apparatus (10) for civil engineering, comprising a carrier machine (12), which is preferably mobile and constructed with an undercarriage, a mast (20) being arranged on the carrier machine (12), and
a multiple rotary drive arrangement (90; 91) according to claim 10 or 11, which is arranged to be movable along the mast (20).

13. A method for operating a multiple rotary drive arrangement (90; 91) for civil engineering according to any one of claims 1 to 11,
wherein
the operation of the drive motor unit(s) (42, 43), and thus their respective contribution to the output torque of the respective rotation gearbox (41, 61), is variably controlled, preferably in dependance of a drilling or rotation torque requested at the respective gearbox output (49), and preferably so that the rotation gearboxes (41, 61) are driven in opposite directions of rotation.