

METHOD AND CONSTRUCTION APPARATUS FOR WORKING THE SOIL

The invention relates to a method for working the soil with a construction apparatus which has at least one rotary drive unit for driving a soil working tool in a rotating manner and at least one feed unit, with which the soil working tool is introduced into the soil, in accordance with the preamble of claim 1.

The invention further relates to a construction apparatus for working the soil with a rotary drive unit for driving a soil working tool in a rotating manner and a feed unit, with which the soil working tool can be introduced in a direction of advance into the soil, in accordance with the preamble of claim 12.

Construction apparatuses for working the soil are, for example, drilling apparatuses for pile drilling or diaphragm wall cutters for producing diaphragm walls in the soil. In a drilling apparatus a drilling tool is driven in a rotating manner via a drill drive and is in most cases introduced vertically into a soil by means of a feed unit. For an efficient production of a borehole it is of vital importance that the rotational speed and a feed speed are set such that they match each other.

In the case of simple drilling apparatuses the rotational speed and a feed speed are set manually by an operator of the drilling apparatus. Hence, the correct setting strongly depends on the experience of the drilling apparatus operator, the more so as the setting also depends on the type of the soil.

It is known that drilling apparatuses are provided with an electronic control, in which pre-selected programs are provided that can be selected by an operator of the drilling apparatus depending on the soil type present. In these programs e.g. a rotational speed of the drilling tool and a feed speed can be predetermined for a specific soil type. On the basis of these nominal values the control will then set and regulate torque and feed force on the drilling apparatus. The resultant actual values can be

measured and compared with the nominal values so that a conventional regulation is on hand.

However, even in the case of such pre-selection programs a corresponding experience of the drilling apparatus operator is still necessary. First of all, the correct program has to be selected. Even if a correct program is selected, for instance for sandy soil, it may be the case that in the course of the bore to be sunk different layers of the soil have to be penetrated that may be of different stability and cohesiveness. For instance a rotational speed and a feed speed that are efficient for a sandy soil can, in a rocky or clayey soil layer, lead to excessive tool wear, an increased consumption of energy or a reduced drilling progress.

From JP 09 089 563 A a diaphragm wall cutter with a control can be taken which detects several parameters during operation, such as the position of the axes of rotation, the depth and the direction of advance. The control is designed to control the cutter on the basis of the parameters determined in order to thereby produce a positionally precise trench in the soil.

The invention is based on the **o b j e c t** to provide a method and a construction apparatus for working the soil, with which an efficient soil working is rendered possible in a particularly reliable manner.

In accordance with the invention the object is achieved by a method having the features of claim 1 and by a construction apparatus having the features of claim 12. Preferred embodiments of the invention are stated in the respective dependent claims.

The method according to the invention is characterized in that a control and evaluation unit is provided, with which at least one input variable of the rotary drive unit and/or the feed unit is detected and saved during soil working, at least one resultant output variable is detected on the soil working tool and saved and the at least one input variable is placed in relation to the resultant output variable, wherein a soil working value is determined and saved.

A fundamental idea of the invention resides in the fact that during soil working at least one input variable and at least one output variable are detected and placed in relation to each other continuously or at regular intervals by a control and evaluation unit. For instance if a particular torque is applied as input variable on the rotary drive unit, the rotational speed on the soil working tool, e.g. a drilling tool or a cutting

wheel, that ensues therefrom under the influence of the soil allows conclusions as to the type of the soil, e.g. if this is of stable or loose nature. Hence, by comparing input variable and resultant output variable the control and evaluation unit can make an assessment on the workability of the soil, wherein a soil working value is determined. This soil working value can be displayed to an operator of the apparatus or taken directly into account in the control for the further operation of the drive units and the feed units. Especially when cutting through deeper soil layers that are not recognizable to an operator of the apparatus it is thus possible to make an assessment on the soil layer worked on in each case which proves to be useful for a more efficient setting of the input variables, i.e. the operating parameters, by the operator of the apparatus or by the control itself. In this way, a working operation with a most efficient or effective setting of the drive units, in particular the rotary drive unit and the feed unit, can take place.

A preferred further development of the method according to the invention resides in the fact that the at least one input variable and the at least one output variable are detected and saved via time and/or the advanced length. If, for example, at a construction site several bores or trenches are to be produced that are usually located close to each other or not too far away the saved input and output variables, which have been detected and saved via time or the advanced length during a working process, can be used to produce a repeat program. In particular, via an advanced length, i.e. a drilling depth or a trench depth, a profile with the respective soil working values can be created and to this a dataset with preferred operating parameters for the input variables can be assigned in each case.

Basically, a plurality of different input variables can be detected individually and in combination. The greater the number of input variables taken into account, the more meaningful the conclusions concerning the soil are and the more precise a soil working value is and thus the assessment on the workability of the soil. According to an embodiment of the invention it is especially preferred that as input variable a torque of the rotary drive unit, a feed force of the feed unit and/or a pressure or a volume in a hydraulic system for driving the rotary drive unit and/or the feed unit is selected. In doing so, the rotary drive unit can be a drill drive or a cutting wheel drive.

The torque can be detected in a direct manner. In a hydraulic drive system the torque and thus the power picked up can be detected indirectly via parameters in the hydraulic system, especially a pressure or a volume flow in the hydraulic system.

This applies correspondingly to a feed unit which can take place by way of a winch or positioning cylinders that can also be operated with a hydraulic drive system. However, in the case of a diaphragm wall cutter, for example, the feed unit can be a superimposed load or the weight of the diaphragm wall cutter that is suspended on a winch rope and reduces the superimposed load by a corresponding counterforce of the winch. The superimposed load can thus be determined via corresponding force sensors or through calculation by way of a winch torque in consideration of the weight of the diaphragm wall cutter and included in the ascertainment of the soil working value.

This applies correspondingly to the selection of the output variables. The output variables are in correlation with an assigned input variable. According to the invention it is particularly preferred that as output variable a rotational speed and/or a feed speed of the soil working tool are selected. For instance a torque on a rotary drive unit is related to the rotational speed of a soil working tool, such as a drilling tool or a cutting wheel. In a feed unit a feed force or a superimposed load is linked with a resulting feed speed. In softer soil, as compared to soil of greater stability, a higher feed speed is the natural consequence at a given feed force. The feed speed can also be referred to as penetration or advancement speed into the soil.

The stated input and output variables are solely preferred parameters. They can also be interchanged. For instance a rotational speed can also be predetermined as input variable by the control unit, in which case an ensuing torque or a power pick-up on the rotary drive unit is then detected as a resultant output variable.

Another preferred embodiment of the invention resides in the fact that the control and evaluation unit has a database, in which preferred input variables are stored for specific soil working values. The database can be preset already on delivery of a construction apparatus or installed during operation from a head office or provided

and maintained with new or supplementary values. Furthermore, according to a variant of the invention it is possible that on the part of the operator of the apparatus or by the control and evaluation unit itself preferred datasets, i.e. preferred input variables with output variables for specific soil working values where appropriate, are saved that have been created or determined for a respective construction site or for the respective apparatus. The database can thus represent an expert system, in which case an automatic improvement and change of the stored datasets can also be provided on the basis of a preferably self-learning logic of the control and evaluation unit.

According to an advantageous method variant of the invention provision is made in that by the control and evaluation unit a current soil working value is compared with soil working values stored in the database and in that depending on the comparison a current input variable is changed or a change is recommended to an operator of the apparatus. For example if the control and evaluation unit recognizes by a comparison of the input variable, e.g. the torque, with a resultant output variable, i.e. an ensuing rotational speed of the drilling tool or the cutting wheel, that a soil layer of altered stability and thus with a different soil working value is cut through, the control and evaluation unit can change the input variables according to the currently determined soil working value. If, in doing so, a dataset with an identical or a similar soil working value is determined in the database, the control and evaluation unit can change the input variable according to the ascertained dataset or display this to the operator of the apparatus on a monitor for example. In an automatic mode the previous input variable can be replaced by the more suitable input variable for the soil working value. In this case, an applied torque would therefore be changed depending on the ascertained soil working value after evaluation of the database.

Especially when cutting through soil with various soil layers it is of advantage in accordance with a method variant of the invention that on the basis of the soil working values determined during soil working via the advanced length a soil profile is determined and saved by the control and evaluation unit. According to data stored in the database a soil working value can have a specific type of soil, such as clay, sand, gravel, rock etc. assigned to it. Via a remote data connection that is preferably

provided these values and thus also a soil profile can be queried via the control and evaluation unit from a head office. In this way, a construction apparatus can not only be used for working the soil but can also be employed as a probing or analysis tool to explore a soil profile.

According to a further embodiment of the method according to the invention it is preferred that by the control and evaluation unit preferred input variables for the soil profile are determined via the advanced length and stored as a dataset in the database. For instance a sample dataset can be created for a bore at a construction site, in which case e.g. up to a first drilling depth a first torque and a first feed force are saved, subsequently up to a second drilling depth a second torque with a second feed force are saved and so on. Such a dataset for a bore or a trench can then be retrieved for a further bore at the same construction site. In this, it can be assumed that at a construction site a soil profile does not change or hardly changes, especially if bores or trenches are produced close to each other. This is frequently the case in the production of pile walls or diaphragm walls. Based on the data of the sample bore or the sample trench the further bores or trenches can thus also be produced effectively by less experienced apparatus operators.

According to a further development of the method pursuant to the invention provision is made in that the control and evaluation unit determines and saves different datasets for a soil profile which are preferably determined and differentiated with regard to a rapid advancement or a wear-reduced rotational speed. In this, the fact is taken into account that in soil working there exists no general optimum parameter setting for the input variables. In fact, the preferred input variables depend on specific aspects or objectives in soil working. For example a particularly rapid soil working, i.e. a rapid advancement, may be desired so that higher rotational speeds or higher feed forces are to be provided as compared to a soil working that is as low-wear or energy-saving as possible. Other objectives, such as a noise-reduced operation, can also be predetermined. Hence, for an ascertained soil working value different datasets can be saved for different objectives that are categorized, for instance, by an efficient advancement, being particularly low-wear, energy-saving or low in noise emission.

Basically, the method according to the invention can be used in the different soil working variants. A particularly preferred method variant resides in the fact that as soil working a drilling with a drilling tool is carried out. The drilling can be a continuous drilling, e.g. using a continuous flight auger, or a discontinuous drilling, e.g. using a drilling bucket or a simple auger. The method according to the invention can also be employed in double head drilling, in which at least two rotary drive units are provided. In this, a first rotary drive unit can be provided for an internally disposed drilling tool while a further rotary drive unit is arranged for an externally disposed drill pipe. Drilling into the soil also comprises rock drilling that can be carried out e.g. in anchor or HDI-drilling in an approximately vertical wall or even in the ceiling region in a tunnel.

Another preferred method variant can be seen in the fact that as soil working a cutting with a diaphragm wall cutter is carried out. A diaphragm wall cutter has at least one pair, by preference two pairs of cutting wheels driven in a rotating manner. The cutting of a cut trench can be carried out in a single-phase, two-phase or a CSM®- method, in which a soil mortar mixture is produced in-situ in the cut trench by the cutter. Provision can be made for one or several cutting wheel drives.

During drilling or cutting a supply of binding, flushing and/or stabilizing suspension can also be taken into account by the control and evaluation unit according to the invention. Especially in a CSM® cutting method an adjustment of the supply of stabilizing and binding suspension may be expedient when the rotational speed and the advancement speed are changed.

The construction apparatus for working the soil in accordance with the invention is characterized in that a control and evaluation unit is provided which is designed to detect and save at least one input variable of the rotary drive unit and/or the feed unit during soil working, to detect and save at least one resultant output variable on the soil working tool and to place the at least one input variable in relation to the resultant output variable, wherein a soil working value can be determined and saved.

By way of the construction apparatus according to the invention the previously described method for working the soil can be implemented in particular. The advantages described beforehand can be achieved thereby.

For soil working and in particular for soil removal use can be made of a great variety of construction apparatuses. According to the invention a particularly preferred construction apparatus resides in that this is a drilling apparatus, in which a drilling tool is driven in a rotating manner by means of the at least one rotary drive unit. The drilling tool in the process can be a drilling bucket or an auger that can preferably be displaced vertically along a mast or a leader. The drilling apparatus can also have a drill mount that is multi-axially adjustable in space, as used in anchor drilling or HDI-drilling for example. In principle, all drilling apparatuses can be employed, e.g. for double head drilling or drilling apparatuses with casing machine, in which drill pipes can be introduced into the soil.

According to another preferred embodiment of the invention provision is made in that this is a diaphragm wall cutter, in which cutting wheels are driven by means of the at least one rotary drive unit. The diaphragm wall cutter has one or several cutting wheel pairs at the lower end of a cutter frame. The cutter frame can be suspended on a rope and guided in the cut trench by way of suitable guide plates on the cutter frame. Alternatively, the diaphragm wall cutter is also guided and movable on a guide rod.

EN Translation of the Amendments under Article 34 PCT

NEW CLAIMS

1. Method for working the soil with a construction apparatus which has at least one rotary drive unit for driving a soil working tool in a rotating manner and at least one feed unit, with which the soil working tool is introduced into the soil,
c h a r a c t e r i z e d in that
a control and evaluation unit is provided, with which
 - at least one input variable of the rotary drive unit and/or the feed unit is detected and saved during soil working,
 - at least one resultant output variable is detected on the soil working tool and saved and
 - the at least one input variable is placed in relation to the resultant output variable, wherein a soil working value is determined and saved.
2. Method according to claim 1,
c h a r a c t e r i z e d in that
the at least one input variable and/or the at least one output variable are detected and saved via time and/or the advanced length.
3. Method according to claim 1 or 2,
c h a r a c t e r i z e d in that
as input variable a torque of the rotary drive unit, a feed force of the feed unit and/or a pressure or a volume in a hydraulic system for driving the rotary drive unit and/or the feed unit is selected.

4. Method according to any one of claims 1 to 3,
c h a r a c t e r i z e d in that
as output variable a rotational speed and/or a feed speed of the soil working tool
is selected.
5. Method according to any one of claims 1 to 4,
c h a r a c t e r i z e d in that
the control and evaluation unit has a database, in which preferred input variables
are stored for specific soil working values.
6. Method according to claim 5,
c h a r a c t e r i z e d in that
by the control and evaluation unit a current soil working value is compared with
soil working values stored in the database and
in that depending on the comparison a current input variable is changed or a
change is recommended to an operator of the apparatus.
7. Method according to any one of claims 1 to 6,
c h a r a c t e r i z e d in that
on the basis of the soil working values determined during soil working via the
advanced length a soil profile is determined and saved by the control and
evaluation unit.
8. Method according to claim 7,
c h a r a c t e r i z e d in that
by the control and evaluation unit preferred input variables for the soil profile are
determined via the advanced length and stored as a dataset in the database.
9. Method according to claim 7 or 8,
c h a r a c t e r i z e d in that
the control and evaluation unit determines and saves different datasets for the
soil profile which are preferably determined and differentiated with regard to a
rapid advancement or a wear-reduced rotational speed.

10. Method according to any one of claims 1 to 9,
c h a r a c t e r i z e d in that
as soil working drilling with a drilling tool is carried out.
11. Method according to any one of claims 1 to 9,
c h a r a c t e r i z e d in that
as soil working cutting with a diaphragm wall cutter is carried out.
12. Construction apparatus for working the soil pursuant to a method according to any one of claims 1 to 11, with a rotary drive unit for driving a soil working tool in a rotating manner and a feed unit, with which the soil working tool can be introduced in a direction of advance into the soil, and with a control and evaluation unit,
c h a r a c t e r i z e d in that
the control and evaluation unit is designed for determining a soil working value, wherein
- at least one input variable of the rotary drive unit and/or the feed unit is detected and saved during soil working,
 - at least one resultant output variable is detected on the soil working tool and saved, and
 - the at least one input variable is placed in relation to the resultant output variable, wherein the soil working value is determined and saved.
13. Construction apparatus according to claim 12,
c h a r a c t e r i z e d in that
this is a drilling apparatus, in which a drilling tool is driven in a rotating manner by means of the at least one rotary drive unit.
14. Construction apparatus according to claim 12,
c h a r a c t e r i z e d in that
this is a diaphragm wall cutter, in which cutting wheels are driven by means of the at least one rotary drive unit.