

METHOD FOR DETERMINING A LOAD, CONTROLLER FOR A HYDRAULIC
LIFTING DEVICE FOR CARRYING OUT A METHOD OF THIS TYPE

5

The invention concerns a method of determining a load which is lifted or which is to be lifted by a hydraulic lifting apparatus, having the features of the classifying portion of claim 1, a control means for a hydraulic lifting apparatus adapted for carrying out such a method and a
10 hydraulic lifting apparatus having such a control means.

A method of the general kind set forth for determining a load which is lifted or which is to be lifted by a hydraulic lifting apparatus is known from EP 1 477 452 B1. In the method described therein for a crane with manually actuated or hydraulic jib elements, for the purpose of weighing a
15 load which is to be mounted to a manual jib element of a crane, firstly the crane is moved into a predetermined position in a sampling phase. That predetermined position can be suitable for load pickup. Thereupon, in relation to the manually actuated jib element mounted to the crane, pressure measurements are carried out on the main cylinder for various,
20 specifically at least two, positions of the hydraulic jib elements between completely retracted and completely extended hydraulic jib elements and a sample diagram for that predetermined crane position is generated therefrom. That sampling phase takes place at the crane manufacturer.

In a further phase a load mounted to a manually actuated jib
25 element is determined. For that purpose the unloaded crane is moved into the predetermined position suitable for load pickup. Determining the pressure in the main cylinder and comparison with the sample diagram concerning that position provides the cantilever of the attachment point of the load to be fitted (length of the load arm). After attachment of the load
30 the load can be determined from the difference between the detected pressure in the unloaded and in the loaded state of the crane.

A disadvantage with that method known from the state of the art is that the operation of determining a load can in principle only be effected in

a predetermined position of the crane. Before a load is picked up the crane must be moved into a position for which a sample diagram was recorded by the crane manufacturer. After a load is picked up the crane must also be in the appropriate position for determining the load. The operation of
5 determining a load can moreover be effected only in the configuration (layout) of the crane in which implementation of the sampling phase, that is to say the recording of a sample diagram, was effected by the crane manufacturer. Upon a change in the crane configuration or layout it can therefore happen that the sample diagrams recorded by the crane
10 manufacturer can no longer be utilised for determining a load.

The object of the invention is to provide a method of determining a load which is lifted or is to be lifted by a hydraulic lifting apparatus, in which the above-mentioned disadvantages do not arise.

That object is attained by a method having the features of claim 1, a
15 control means adapted for carrying out such a method, and a hydraulic lifting apparatus having such a control means. Advantageous embodiments of the invention are defined in the appendant claims.

As in the method of the general kind set forth for determining a load which is lifted or is to be lifted by a hydraulic lifting apparatus, for example
20 in the form of a hydraulic loading crane, the lifting apparatus is firstly moved into a reference position in a reference phase. In that case the lifting apparatus can be in a first loading state.

In contrast to the method known in the state of the art however, the method according to the invention provides that a first detection of the
25 forces currently acting on the lifting apparatus and the current geometry of the lifting apparatus is now effected in the reference position of the reference phase. By virtue of the detection of the forces currently acting on the lifting apparatus and the current geometry of the lifting apparatus, the current crane configuration or crane layout the current geometry
30 (position) in which the lifting apparatus is disposed can be taken into account in determining a load which is lifted or is to be lifted. Accordingly, even the current (first) loading state of the lifting apparatus can also be taken into consideration. In other words an operation of determining a

load which is lifted or is to be lifted is now made possible, on the basis of the currently prevailing operating parameters of the lifting apparatus. Thus for example operating parameters of the lifting apparatus, which currently prevail in operation, can be detected as a starting point for determining a load which is lifted or is to be lifted.

In the method according to the invention there then follows a measurement phase in which the lifting apparatus is in a second loading state and the lifting apparatus is moved into a measurement position. In the measurement position a second detection of the forces currently acting on the lifting apparatus and the current geometry of the lifting apparatus is effected. Similarly to the first detection operation, an operation for determining a load which is lifted or is to be lifted can be effected, with the involvement of the currently prevailing operating parameters of the lifting apparatus.

In a comparison phase following the first and second operations for determining the forces acting on the lifting apparatus and the geometry of the lifting apparatus, the lifted load is characterised by a comparison of the respective detected forces currently acting on the lifting apparatus and the respective detected current geometry of the lifting apparatus. As the comparison of the detected forces and the detected geometries (positions) is based on the respective currently prevailing operating parameters, the load which is lifted or is to be lifted can be very precisely characterised. Thus for example the measurement phase can be carried out directly after the reference phase, whereby differences arising in the comparison phase in respect of the detected forces can be attributed directly to a change in the loading state of the lifting apparatus, in which case changes in the respectively detected or prevailing geometry can also be taken into account in characterising the load.

For determining a load which is lifted or is to be lifted by the lifting apparatus therefore there is no reliance on a sampling phase to be carried out by the crane manufacturer and sample diagrams which are linked thereto and which can be limitedly used, in the sense of the state of the art. For the crane manufacturer themselves a method according to the

invention makes it possible to dispense with the time-consuming implementation of a sampling phase. A method according to the invention also makes it possible for example to easily take account of ageing and wear phenomena of the lifting apparatus in determining a load which is
5 lifted or is to be lifted by the lifting apparatus.

The possibility of carrying out the measurement phase substantially as often as desired after carrying out the reference phase is not to be excluded.

It is advantageous in that respect that the reference position
10 corresponds to a freely selectable position of the lifting apparatus. Implementation of the method can thus be effected starting from substantially any position of the lifting apparatus. That can make it possible that the lifting apparatus does not have to be moved into a predetermined position specifically before carrying out the reference phase.

15 It can generally be advantageous if the measurement position corresponds to a position of the lifting apparatus after a load pickup or a load setdown. In that case the measurement position can correspond to a position of the lifting apparatus immediately after picking up or setting down a load. The measurement position can also correspond to a position
20 of the lifting apparatus which occurs by a (possibly slight) change in position directly after a load is picked up or set down.

It can be advantageous if the measurement position corresponds to a position of the lifting apparatus, approximated to the reference position of the lifting apparatus. By virtue thereof differences occurring in the
25 comparison phase in respect of the detected forces can be for a large part attributed to a change in the loading state of the lifting apparatus by virtue of the load which is lifted or is to be lifted. Changes in the detected forces by virtue of a change in the geometry, for example caused by a change in extension, can in that case provide a smaller proportion. An approach of
30 the measurement position to the reference position can occur for example by the lifting apparatus for picking up or setting down a load being moved out of the reference position and by the position of the lifting apparatus

then being moved back in the direction of the reference position for carrying out the measurement phase.

It can be advantageous for the measurement position of the lifting apparatus to substantially correspond to the reference position. By virtue thereof differences in the detected forces, that occur in the comparison phase, can be attributed substantially to a change in the loading state of the lifting apparatus by the load which is lifted or is to be lifted.

It can further be advantageous if the reference position corresponds to a position approximated to an intermediate position, wherein the intermediate position is a position of the lifting apparatus, that is suitable for load pickup or load setdown. That can be advantageous if for example the position of the lifting apparatus in which a lifted load is to be determined is not suitable for load pickup or set down. That can also make it possible for the reference position and also the measurement position to be away from the intermediate position suitable for load pickup or load set down.

In that respect it can be advantageous if transfer of the lifting apparatus out of the reference position into the intermediate position and transfer of the lifting apparatus out of the intermediate position into the measurement position is effected with a change in position of the lifting apparatus, that is within a tolerance range. Upon changes in position of the lifting apparatus within the tolerance range it can be possible that the forces detected in the reference phase and the detected geometry can still be used for determining the load which is lifted or is to be lifted in the measurement phase. Therefore after carrying out the reference phase substantially any changes in position of the lifting apparatus, that are within the tolerance range, can be carried out without renewed implementation of the reference phase being necessary before carrying out the measurement phase. In that case, when carrying out the measurement phase, the measurement position can also differ from the reference position within the tolerance range.

It can be advantageous that prior to each implementation of the measurement phase for detection of the forces currently acting on the

lifting apparatus in the second loading state and the current geometry of the lifting apparatus an implementation of the reference phase is effected for detecting the forces currently acting on the lifting apparatus in the first loading state and the current geometry of the lifting apparatus. In other words it is provided that, before any load pickup or load set down of the lifting apparatus, the reference phase is carried out. Implementation of the measurement phase can be effected substantially as often as desired after carrying out the reference phase. It should also not be excluded that implementation of the measurement phase can be effected as often as may be desired after a change in position of the lifting apparatus, that is within the tolerance range.

It can be provided that detection of the forces currently acting on the lifting apparatus and the current geometry of the lifting apparatus is effected with involvement of parameters characteristic of the respective position of the lifting apparatus and the respective loading state of the lifting apparatus, and a calculation model. The characteristic parameters in that case can correspond to the forces acting on the lifting apparatus and the geometry of the lifting apparatus. Information relating to the lifting apparatus, like for example its possible and also current configuration or layout, can be stored in the calculation model.

The lifting apparatus can have at least one crane column rotatable about a vertical axis of rotation and a main arm mounted to the crane column pivotably about a first horizontal pivot axis. In addition the lifting apparatus can have at least one hydraulic main cylinder for the pivotal movement of the main arm, wherein in the reference phase and the measurement phase the moment is detected in relation to the first horizontal pivot axis. In a simple case for example with incorporation of the pivotal angle and the length of the main arm and the pressure detected in the main cylinder, it is possible to determine the moment in relation to the first horizontal pivot axis.

In regard to the lifting apparatus it can further be provided that it has a rotary mechanism for rotation of the crane column and an articulated arm mounted to the main arm pivotably about a second

horizontal axis of rotation and with preferably at least one crane extension arm, wherein the lifting apparatus further has a first hydraulic articulation cylinder for the pivotal movement of the articulated arm and preferably at least one first hydraulic extension cylinder for actuation of the at least one
5 crane extension arm. Such a configuration can be involved for example when the lifting apparatus is in the form of an articulated arm crane.

In detection of the forces currently acting on the lifting apparatus and the current geometry of the lifting apparatus it can be provided that the characteristic parameters include at least the pressure in the at least
10 one main cylinder and/or the pressure in the articulation cylinder and/or the rotary angle of the rotary mechanism and/or the articulation angle of the main arm relative to the crane column and/or the articulation angle of the articulated arm relative to the main arm and/or the extension position of the at least one crane extension arm. The forces and the geometry can
15 be completely and precisely detected by a suitable selection of the characteristic parameters.

In that respect it can further be advantageous if the lifting apparatus further has an attachment articulated arm mounted to the articulated arm pivotably about a third horizontal pivot axis and having at least one crane
20 extension arm, wherein the lifting apparatus further has at least one second hydraulic articulation cylinder for the pivotal movement of the attachment articulated arm and a second hydraulic extension cylinder for actuation of the at least one crane extension arm and the characteristic parameters further include the pressure in the second articulation cylinder
25 and/or the articulation angle of the attachment articulated arm relative to the articulated arm and/or the extension position of the at least one crane extension arm of the attachment articulated arm. Such a configuration can occur for example when the lifting apparatus is in the form of an articulated arm crane with an attachment articulated arm. In that respect it can be
30 provided that in the reference phase and the measurement phase the moment is detected in relation to the first horizontal pivot axis and the moment is detected in relation to the third horizontal pivot axis. With corresponding detection of the geometry the load which is lifted or is to be

lifted can however also be determined by sole detection of the moment in relation to the first horizontal pivot axis. In the case of additional detection of the moment with respect to the third horizontal pivot axis however it can also be possible to more precisely characterise the load which is lifted or is
5 to be lifted.

In that respect it can further be advantageous if the lifting apparatus further has at least one fly jib and the additional displacement of the at least one fly jib is incorporated in the calculation model. Data relevant to the fly jib can be stored in the calculation model. Such a possibly manually
10 actuated fly jib can be used to increase the reach of a crane arm or crane extension arm of the lifting apparatus. The fly jib can be arranged at a predeterminable angle, for example by means of an adjusting device, on a crane arm or crane extension arm of the lifting apparatus.

It can further be advantageous in that respect if the lifting apparatus
15 further has a working device arranged on the lifting apparatus, in particular on a crane extension arm, and the additional loading due to the working device is incorporated in the calculation model. A working device like for example a cable winch can in that case be arranged at substantially any location on the lifting apparatus. A working device like for example a
20 gripping means can however also be arranged on a crane extension arm of the lifting apparatus. Data relevant to the working device can be stored in the calculation model, but that is not absolutely necessary. By virtue of detection of the forces currently acting on the lifting apparatus in the first loading state and the current geometry of the lifting apparatus it is also
25 possible for the working device and possibly also the position thereof on or in relation to the lifting apparatus to be taken into account in determining the load which is lifted or is to be lifted.

It can be advantageous if deformation of the lifting apparatus is incorporated in the calculation model. Deformation of the lifting apparatus
30 caused by the inherent weight and/or the load which is lifted or is to be lifted can influence the actual geometry of the lifting apparatus in a position or a loading state thereof. The load which is lifted or is to be lifted can be

more precisely determined by incorporation of the deformation of the lifting apparatus in the calculation model.

In that respect it can be advantageous that the deformation of the crane column and/or the main arm and/or the articulated arm and/or the at least one crane extension arm of the lifting apparatus are incorporated in the calculation model, whereby the actual geometry of the lifting apparatus can be better characterised in a position or a loading state of the lifting apparatus. Similarly thereto, incorporating the influence of seal frictions of the hydraulic cylinders can allow the load which is lifted or is to be lifted to be more accurately determined.

In that respect it can be advantageous if in the calculation model the deformation is applied in the form of a correction to detected articulation angles and/or in the form of a correction to detected extension positions, and/or the influence of the seal frictions is applied in the form of a correction to detected pressures. By virtue thereof for example the deformation occurring for a given position of the lifting apparatus and the hydraulic pressure which occurs for a given loading state or also for a given position can be taken into consideration in the calculation model.

In that respect it can further be advantageous if the correction is effected in dependence on the detected forces currently acting on the lifting apparatus and/or detected articulation angles and/or the detected extension positions. In that way it is possible not only to take account of a position-dependent or geometry-dependent deformation of the lifting apparatus, but that can also be effected (possibly also in combination) in dependence on the load which is lifted or is to be lifted. The deformation caused by the layout or configuration of the lifting apparatus can also be taken into account. In other words the extent of the corrections themselves can be in a given dependency on the detected parameters.

In that respect it can further be advantageous if the correction for the deformation is effected in linear dependency in respect of the detected pressure and/or in linear dependency in respect of the detected extension position and/or the correction for the seal frictions is effected inversely

proportionally to the detected pressure and in dependence on a direction of a change in position.

It can be provided that the first loading state corresponds to a loading state without a load lifted by the lifting apparatus and the second
5 loading state corresponds to a loading state with a lifted load. The reference phase would thus be carried out without the lifted load and the measurement phase would be carried out after a load has been lifted.

It should however not be excluded that the first loading state corresponds to a loading state with a first load lifted by the lifting
10 apparatus and the second loading state corresponds to a loading state with a second lifted load preferably differing from the first. The reference phase would thus for example be carried out with a load which has already been lifted and the measurement phase would be effected after a load has been partially set down or additionally picked up.

15 As already stated in the opening part of this specification protection is also sought for a control means for a hydraulic lifting apparatus which is adapted to carry out a method as described hereinbefore for determining a load which is lifted or is to be lifted.

Such a control means, in a first operating mode, can carry out the
20 reference phase in a first loading state in the reference position of the lifting apparatus for first detection of the forces currently acting on the lifting apparatus and the current geometry of the lifting apparatus.

In a second operating mode the control means can carry out the measurement phase in a second loading state in the measurement position
25 of the lifting apparatus for the second detection of the forces currently acting on the lifting apparatus and the current geometry of the lifting apparatus. The control means can for example be so adapted that after implementation of the reference phase in the first operating mode a switch into the second operating mode is automatically effected. It can also be
30 provided for example that the position of the lifting apparatus in the second operating mode can be altered only within the tolerance range or a suitable warning signal is output by the control means prior to leaving the tolerance range.

In a third operating mode the control means can carry out the comparison phase for characterising the lifted load by a comparison of the respective detected forces currently acting on the lifting apparatus and the respective detected current geometry of the lifting apparatus. In that
5 respect it can be provided for example that, after the measurement phase has been carried out, a switch into the third operating mode is automatically effected and the comparison phase is possibly also automatically carried out.

In that respect it can be advantageous if the load characterised in
10 the comparison phase can be displayed at a display means communicating with the control means in units corresponding to the load. In that way for example a user can be given information about the load determined by the method, in units which the user can understand.

As already stated protection is finally also claimed for a hydraulic
15 lifting apparatus having a control means as described hereinbefore. The hydraulic lifting apparatus can be in the form of a loading crane for a vehicle. Particularly advantageously the hydraulic lifting apparatus can be in the form of an articulated arm crane.

Further details and advantages of the present invention are
20 described more fully hereinafter by means of the specific description with reference to the embodiments by way of example illustrated in the drawings in which:

Figures 1a to 1c show side views of various embodiments of a lifting apparatus mounted on a vehicle,

25 Figures 2a to 2c show side views of various embodiments of a lifting apparatus,

Figures 3a and 3b show side views of different embodiments of a lifting apparatus and a respective diagrammatic representation of a control means with sensor arrangement,

30 Figures 4a to 4c show a diagrammatic view of an implementation of a lifting operation,

Figures 5a to 5c show a further diagrammatic view of an implementation of a lifting operation,

Figures 6a to 6c show a further diagrammatic view of an implementation of a lifting operation,

Figures 7a and 7b show diagrammatic views of various embodiments of a lifting apparatus and a respective representation of the tolerance
5 range,

Figures 8a and 8b show diagrammatic views of various embodiments of a lifting apparatus with fly jib,

Figures 9a and 9b show diagrammatic views of various embodiments of a lifting apparatus with a working device, and

10 Figures 10a and 10b show diagrammatic views of various embodiments of a lifting apparatus with a respective cable winch arranged at different positions.

Figure 1a shows a first embodiment of the lifting apparatus 2, wherein the lifting apparatus 2 is in the form of a loading crane or articulated arm crane and is arranged on a vehicle 19. As shown the lifting
15 apparatus has a crane column 3 rotatable about a first vertical axis v_1 by means of a rotary mechanism 18, a main arm 4 mounted to the crane column 3 pivotably about a first horizontal pivot axis h_1 and an articulated arm 5 mounted to the main arm 4 pivotably about a second horizontal
20 pivot axis h_2 , with at least one crane extension arm 6. A hydraulic main cylinder 15 is provided for the pivotal movement of the main arm 4 relative to the crane column 3 (articulation angle a_1). A hydraulic articulation cylinder 16 is provided for the pivotal movement of the articulated arm 5 relative to the main arm 4 (articulation angle a_2).

25 Figure 1b shows a second embodiment of the lifting apparatus 2, wherein the lifting apparatus 2 shown therein, in addition to the configuration of the embodiment shown in Figure 1a, has an attachment articulated arm 7 arranged on the crane extension arm 6 pivotably about a
third horizontal pivot axis h_3 , with a crane arm 10 and a further crane
30 extension arm 11. An articulation cylinder 17 is provided for pivotal movement of the attachment articulated arm 7 relative to the articulated arm 5 (articulation angle a_3).

Figure 1c shows a third embodiment of the lifting apparatus 2, wherein the lifting apparatus 2 shown therein, in addition to the configuration of the embodiment shown in Figure 1b, has a further attachment articulated arm 12 mounted to the articulated extension arm 11 of the attachment articulated arm 7 pivotably about a fourth horizontal pivot axis a4. An articulation cylinder 20 is provided for the pivotal movement of the further attachment articulated arm 12 relative to the attachment articulated arm 7 (articulation angle a4).

It will be appreciated that all illustrated embodiments can have a rotary mechanism 18.

Figures 2a to 2c respectively show a detail view of a lifting apparatus 2 of a configuration as shown in Figures 1a to 1c.

Figure 3a shows an embodiment of the lifting apparatus 2 as shown in Figure 1a and 2a respectively. In addition there is shown a diagrammatic representation of a control means 1 adapted for carrying out a method of determining a load 21 which is lifted or is to be lifted by the lifting apparatus 2 (this is not shown here, see in that respect for example Figures 4, 5 or 6). The control means 1 has a plurality of signal inputs to which signals of the sensor arrangement installed on the lifting apparatus 2 can be supplied. The control means 1 further has a storage means 9 in which for example program data relating to operating modes and calculation models of the control means 1 and incoming signals can be stored, and a computing unit 8 with which incoming signals and data stored in the storage means 9 can be processed. The control means 1 can also communicate with a display 22. The communication of the control means 1 with the display 22 can be wired and/or wireless. The sensor means for detecting the geometry of the lifting apparatus 2, in the structure shown in Figure 3a, includes a rotary angle sensor d1 for detecting the respective rotary angle d1a, an articulation angle sensor k1 for detecting the articulation angle a1 of the main arm 4 relative to the crane column 3, an articulation angle sensor k2 for detecting the articulation angle a2 of the articulated arm 5 relative to the main arm 4 and an extension position sensor s1 for detecting the extension position of the crane extension arm 6.

For detecting the forces acting on the lifting apparatus 2 there are provided a pressure sensor p1 for detecting the hydraulic pressure p1a in the main cylinder 15 and a pressure sensor p2 for detecting the hydraulic pressure p2a in the articulation cylinder 16.

5 Figure 3b, similarly to Figure 3a, shows an embodiment of the lifting apparatus 2 as shown in Figure 1b and Figure 2b respectively. As shown the configuration of the lifting apparatus 2 includes an attachment articulated arm 7 arranged on the crane extension arm 6 of the articulated arm 5. Provided as an additional sensor arrangement for detecting
10 parameters characteristic of the loading state of the lifting apparatus there are an articulation angle sensor k3 for detecting the articulation angle a3 of the attachment articulated arm 7 relative to the articulated arm 5, an extension position sensor s2 for detecting the extension position of the further crane extension arm 11 and a pressure sensor p3 for detecting the
15 hydraulic pressure p3b in the articulation cylinder 17.

A similar configuration in respect of the arrangement shown in Figures 3a and 3b comprising a lifting apparatus 2 as shown in Figure 1c or Figure 2c respectively and a control means 1 is also conceivable.

In a method as described hereinbefore for determining a load 21
20 which is lifted or is to be lifted by the lifting apparatus 2 that sensor arrangement which is additional in relation to Figure 3a, in a design configuration of the lifting apparatus 2 with an attachment articulated arm 7, is however not absolutely necessary as (possibly with a known extension of the attachment articulated arm 7) the load 21 which is lifted or is to be
25 lifted can in principle be determined by determining the moment with respect to the first horizontal pivot axis h1. The additional sensor arrangement and the fact of taking account of the measurement values or parameters supplied thereby, in particular additional determination, which is possible therewith, of the moment with respect to the third horizontal
30 pivot axis h3 can however contribute to enhanced accuracy of the determination result (measurement accuracy).

Figures 4a to 4c show an implementation of a load pickup (or in the reverse sequence the configuration of a load setdown) by the lifting

apparatus 2. The position shown in Figure 4a of the lifting apparatus 2 can in this case correspond to a reference position, wherein a substantially freely selectable position of the lifting apparatus 2 can serve as the reference position. Of the parameters characteristic of the loading state of the lifting apparatus 2, in the illustrated configuration of the load pickup operation only the extension position of the articulated arm 5, that is measured by the extension position sensor s1, and the hydraulic pressure in the main cylinder 15, that is measured by the pressure sensor p1, are considered. In the reference position the first extension position x1a of the crane extension arm 6 and the first hydraulic pressure p1a are measured and stored in the storage means 8 of the control means 1 (not shown). For that purpose the control means 1 has a first operating mode for the first detection of the forces currently acting on the lifting apparatus 2 and the current geometry of the lifting apparatus 2.

From the reference position, the lifting apparatus is now moved into the intermediate position by a change in geometry, here by extension of the crane extension arm 6 of the articulated arm 5 into the second extension positions x1b. The intermediate position is suitable as shown for picking up the load 21. In principle it will be appreciated that it is also possible for the position of the lifting apparatus 2 that is shown in Figure 4b (before lifting the load 21) to serve as the reference position. In the intermediate position the second extension position x1b of the crane extension arm 6 and the second hydraulic pressure p1b are measured and also stored in the storage means 8 of the control means 1 (not shown). That can be effected generally for all lifting operations in an intermediate phase in which the control means 1 is in an operating mode suitable for same. In the intermediate position the load 21 is now attached to the lifting apparatus 2 and possibly also lifted. In principle the lifted load 21 can now already be determined.

From the intermediate position the lifting apparatus 2 is moved into the measurement position by a change in geometry, here after lifting the load 21, by retraction of the crane extension arm 6 into the third extension positions x1c. As shown the measurement position is approached to the

reference position. In that respect it can be provided that a change in position or geometry of the lifting apparatus 2 must be within a tolerance range in order to be able to use the characteristic parameters detected in the reference phase for the forces currently acting on the lifting apparatus 2 and the current geometry of the lifting apparatus 2, for determining the lifted load 21. In that respect the tolerance range can apply for a maximum permissible change in extension position and/or a maximum permissible change in articulation angle (see for example Figures 7a and 7b).

In Figure 4c the lifting apparatus 2 is in the measurement position after lifting of the load 21. In the measurement position the third extension position x_{1c} of the crane extension arm 6 and the third hydraulic pressure p_{1c} are now measured and stored in the storage means 8 of the control means 1 (not shown). For that purpose the control means 1 has a second operating mode for the second detection of the forces currently acting on the lifting apparatus 2 and the current geometry of the lifting apparatus 2.

In a comparison phase in which the control means 1 is in a third operating mode, characterisation of the lifted load 21 is now effected by a comparison of the respective detected forces currently acting on the lifting apparatus 2 and the respective detected current geometry of the lifting apparatus 2. Detection of the forces currently acting on the lifting apparatus 2 and the current geometry of the lifting apparatus is generally advantageously effected in each case with involvement of parameters characteristic of the respective position of the lifting apparatus 2 and the respective loading state of the lifting apparatus 2 (for example pressures, extension positions, articulation angles and possible additional data relating to the configuration) and a calculation model stored in the storage means 8 of the control means 1.

Figures 5a to 5c show a further implementation of a load pickup (or in the reverse sequence the implementation of a load setdown) by the lifting apparatus 2. Load pickup of the load 21 by the lifting apparatus 2 is effected as shown by a pivotal movement of the articulated arm 5 relative

to the main arm 4. Of the parameters characteristic of the loading state of the lifting apparatus 2 only the articulation angle of the articulated arm 5, that is measured by the articulation angle sensor k2, and the hydraulic pressure in the main cylinder 15, that is measured by the pressure sensor p1, are considered in the illustrated performance of load pickup.

In the reference position shown in Figure 5a the first articulation angle position a21 of the articulated arm 5 and the first hydraulic pressure p1a are measured and stored in the storage means 8 of the control means 1 (not shown) (reference phase, control means 1 in the first operating mode). The lifting apparatus 2 is moved into the intermediate position shown in Figure 5b by a change in geometry, here a pivotal movement of the articulated arm 5. In the intermediate position the second articulation angle position a22 of the articulated arm 5 and the second hydraulic pressure p1b are measured and also stored in the storage means 8 of the control means 1 (not shown). As previously in this case too the position of the lifting apparatus 2 shown in Figure 5b can serve as the reference position. By a further change in geometry, here once again a pivotal movement of the articulated arm 5, the lifting apparatus 2 is moved into the measurement position shown in Figure 5c, whereby lifting of the load 21 is also effected. In the measurement position the third articulation angle position a23 of the articulated arm 5 and the third hydraulic pressure p1c are now measured and stored in the storage means 8 of the control means 1 (not shown) (measurement phase, control means 1 in the second operating mode). In the subsequent comparison phase (control means 1 in the third operating mode) the lifted load 21 can again be characterised by the control means 1.

Figures 6a and 6b show a further implementation of a load pick up (or in the reverse sequence the implementation of a load setdown) by the lifting apparatus 2, wherein the lifting apparatus 2 has an additional working device 14 arranged on the articulated arm 5, in the form of a cable winch. Pickup of the load 21 by the lifting apparatus 2 is effected by means of the working device 14 in the form of a cable winch. Of the parameters characteristic of the loading state of the lifting apparatus 2 only

the hydraulic pressure in the main cylinder 15, measured by the pressure sensor p1, and the hydraulic pressure in the articulation cylinder 17, that is measured by the pressure sensor p3, are considered in the illustrated implementation of load pickup. In Figure 6a the lifting apparatus 2 is in the reference position which is already suitable for load pickup. In Figure 6b the lifting apparatus 2, after the load has been picked up, is in the measurement position, that in the illustrated situation substantially corresponding to the reference position. By a comparison of the pressures p1a, p3a recorded in the reference phase and the pressures p1b, p3b recorded in the measurement phase it is possible (with an adequately determined geometry) to arrive at a conclusion about the change in loading of the lifting apparatus 2, and thus the lifted load 21 can be characterised.

In principle by means of the above-described method it is possible to determine a load which is lifted or is to be lifted by the lifting apparatus 2 in any combination of changes in geometry – in particular in any combination of the changes in geometry shown in the Figures described –.

In Figures 4, 5 and 6 it is respectively self-evident that, for the illustrated positions of the lifting apparatus 2, detection of the current geometry – therefore specifically detection of the characteristic parameters relevant to the current geometry (for example rotary angle, articulation angle and extension positions) is respectively effected. In the configurations of the lifting apparatus 2 having an attachment articulated arm 7 (frequently referred to as the jib) the characteristic parameters detected for that attachment articulated arm 7 can also be incorporated for determining the load 21 which is lifted or is to be lifted.

Figures 7a and 7b each show a diagrammatic configuration of a lifting apparatus 2 with manually actuatable, static fly jibs 13 arranged thereon.

In the structure shown in Figure 7a the fly jibs 13 are arranged on the articulated arm 5. In that case the fly jibs 13 can be arranged pivotably on the articulated arm 5, wherein the articulation angle of the fly jibs 13 can be detected by means of an articulation angle sensor k3. Information relating to the additional displacement of the fly jibs 13 can be

stored in the storage means 8 of the control means 1 and incorporated into the operation of determining a load 21 which is lifted or is to be lifted. In addition Figure 7a indicates in broken lines the respective tolerance range for the change in extension position of the articulated arm 5 and the
5 change in articulation angle of the fly jibs 13.

In the structure shown in Figure 7b the fly jibs 13 are arranged on an attachment articulated arm 7 disposed on the articulated arm 5. In that case the fly jibs 13 can be arranged pivotably on the attachment articulated arm 7, wherein the articulation angle of the fly jibs 13 can be detected by
10 means of an articulation angle sensor k4. Figure 7b also indicates in broken lines the respective tolerance range for the change in extension position of the articulated arm 5, the attachment articulated arm 7 and the change in articulation angle of the fly jibs 13.

In a particularly advantageous configuration of the lifting apparatus 2
15 the tolerance range can substantially embrace the entire range of movement of the lifting apparatus 2.

Figures 8a and 8b show an embodiment of the lifting apparatus 2 that is similar to Figures 7a and 7b, but therein the fly jibs 13 are mounted to the articulated arm 5 and the attachment articulated arm 7 respectively
20 at a predetermined, invariable articulation angle.

Figures 9a and 9b each shown an embodiment of the lifting apparatus 2 with a working device 14 arranged thereon, for example in the form of a gripping means or grab. In Figure 9a the working device 14 is arranged on the articulated arm 5 while in Figure 9b the working device 14
25 is arranged on the attachment articulated arm 7. Optionally an angular position of the working device 14 related to the crane arm carrying same can be detected and also taken into consideration when determining a lifted load 21. As, in the case of the above-described method, in the reference phase and in the measurement phase, the loading of the lifting apparatus 2
30 that is caused by the working device 14 is detected, that can be incorporated in the calculation model.

Figures 10a and 10b each shown an embodiment of the lifting apparatus 2 with a working device 14 arranged thereon, here in the form of

a cable winch, and a load 21 lifted by the lifting apparatus 2. In Figure 10a the working device 14 is arranged on the articulated arm 5 while in Figure 10b the working device 14 is arranged on the main arm 4. As in the above-described method in the reference phase and in the measurement
5 phase the loading of the lifting apparatus 2 caused by the working device 14 is detected, substantially independently of the position thereof on the lifting apparatus 2, that can be incorporated in the calculation.

The functionality of determining a load 21 which is lifted or is to be lifted by the lifting apparatus 2 is therefore not limited by the layout or
10 configuration of the lifting apparatus 2.

List of references:

	1	control means
	2	lifting apparatus
	3	crane column
5	4	main arm
	a1, a2, a3, a4	articulation angle
	5	articulated arm
	6	crane extension arm
	7	attachment articulated arm
10	s1, s2	extension position sensor
	x1a, x2b, x3c	extension positions
	p1, p2, p3	pressure sensors
	p1a, p1b, p1c	pressures
	p3a, p3b	pressures
15	8	storage means
	9	computing unit
	k1, k2, k3, k4	articulation angle sensor
	d1	rotary angle sensor
	a21, a22, a23	articulation angle
20	d1a	rotary angle
	10	crane arm
	11	crane extension arm
	12	attachment extension arm
	13	fly jib
25	14	working device
	15	main cylinder
	16, 17, 20	articulation cylinder
	18	rotary mechanism
	19	vehicle
30	22	display device
	h1, h2, h3	horizontal pivot axis
	v1	vertical pivot axis
	21	load

CLAIMS

1. A method of determining a load (21) which is lifted or is to be lifted by a hydraulic lifting apparatus (2), preferably a hydraulic loading crane, wherein the lifting apparatus (2) for determining the load (21) which is lifted or is to be lifted is moved into a reference position in a reference phase in a first loading state of the lifting apparatus (2), characterised in that
- in the reference position a first detection of the forces currently acting on the lifting apparatus (2) and the current geometry of the lifting apparatus (2) is effected, wherein the reference position corresponds to a freely selectable position of the lifting apparatus (2),
 - in a measurement phase the lifting apparatus (2) is moved into a measurement position in a second loading state and in the measurement position a second detection of the forces currently acting on the lifting apparatus (2) and the current geometry of the lifting apparatus (2) is effected, and
 - in a comparison phase the lifted load (21) is characterised by a comparison of the respective detected forces currently acting on the lifting apparatus (2) and the respective detected current geometry of the lifting apparatus.
2. A method according to claim 1 wherein the measurement position corresponds to a position of the lifting apparatus (2) after a load pickup or a load setdown.
3. A method according to at least one of the preceding claims wherein the measurement position corresponds to a position of the lifting apparatus (2), approximated to the reference position of the lifting apparatus (2).

4. A method according to at least one of the preceding claims wherein the measurement position of the lifting apparatus (2) substantially corresponds to the reference position.

5 5. A method according to at least one of the preceding claims wherein the reference position corresponds to a position approximated to an intermediate position, wherein the intermediate position is a position of the lifting apparatus (2), that is suitable for load pickup or load setdown.

10 6. A method according to the preceding claim wherein transfer of the lifting apparatus (2) out of the reference position into the intermediate position and transfer of the lifting apparatus (2) out of the intermediate position into the measurement position is effected with a change in position of the lifting apparatus (2), that is within a tolerance range.

15 7. A method according to at least one of the preceding claims wherein prior to each implementation of the measurement phase for detection of the forces currently acting on the lifting apparatus (2) in the second loading state and the current geometry of the lifting apparatus (2)
20 an implementation of the reference phase is effected for detecting the forces currently acting on the lifting apparatus (2) in the first loading state and the current geometry of the lifting apparatus (2).

25 8. A method according to at least one of the preceding claims wherein detection of the forces currently acting on the lifting apparatus (2) and the current geometry of the lifting apparatus (2) is effected with involvement of parameters characteristic of the respective position of the lifting apparatus (2) and the respective loading state of the lifting apparatus (2), and a calculation model.

30 9. A method according to at least one of the preceding claims wherein the lifting apparatus (2) has at least one crane column rotatable about a vertical axis of rotation (v1) and a main arm (4) mounted to the

crane column (3) pivotably about a first horizontal pivot axis (h1), wherein the lifting apparatus (2) further has at least one hydraulic main cylinder (15) for the pivotal movement of the main arm (4), wherein in the reference phase and the measurement phase the moment is detected in
5 relation to the first horizontal pivot axis (h1).

10. A method according to the preceding claim wherein the lifting apparatus (2) has a rotary mechanism (18) for rotation of the crane column (3) and an articulated arm (5) mounted to the main arm (4)
10 pivotably about a second horizontal axis of rotation (h2) and with preferably at least one crane extension arm (6), wherein the lifting apparatus (2) further has a first hydraulic articulation cylinder (16) for the pivotal movement of the articulated arm (5) and preferably at least one first hydraulic extension cylinder for actuation of the at least one crane
15 extension arm (6).

11. A method according to claim 8 and one of claims 9 and 10 wherein the characteristic parameters include at least the pressure in the at least one main cylinder (15) and/or the pressure in the articulation cylinder (16) and/or the rotary angle of the rotary mechanism (18) and/or the
20 articulation angle (a1) of the main arm (4) relative to the crane column (3) and/or the articulation angle (a2) of the articulated arm (5) relative to the main arm (4) and/or the extension position of the at least one crane extension arm (6).

25

12. A method according to at least one of claims 8 to 11 wherein the lifting apparatus (2) further has an attachment articulated arm (7) mounted to the articulated arm (5) pivotably about a third horizontal pivot axis (h3) and having at least one crane extension arm (11), wherein the
30 lifting apparatus (2) further has at least one second hydraulic articulation cylinder (17) for the pivotal movement of the attachment articulated arm (7) and the characteristic parameters further include the pressure in the second articulation cylinder (17) and/or the articulation angle (a3) of the

attachment articulated arm (7) relative to the articulated arm (5) and/or the extension position of the at least one crane extension arm (11) of the attachment articulated arm (7), wherein in the reference phase and the measurement phase the moment is detected in relation to the first
5 horizontal pivot axis (h3) and the moment is detected in relation to the third horizontal pivot axis (h3).

13. A method according to at least one of preceding claims 8 to 12 wherein the lifting apparatus (2) further has at least one fly jib (13)
10 arranged on a crane extension arm (6, 11) – preferably at a predeterminable angle – and the additional displacement of the at least one fly jib (13) is incorporated in the calculation model.

14. A method according to at least one of preceding claims 8 to 13
15 wherein the lifting apparatus (2) further has a working device (14) arranged on the lifting apparatus (2), in particular on a crane extension arm (6, 11), and the additional loading due to the working device (14) is incorporated in the calculation model.

20 15. A method according to at least one of preceding claims 8 to 14 wherein the deformation of the lifting apparatus (2) is incorporated in the calculation model.

16. A method according to the preceding claim and at least one of
25 claims 9 to 15 wherein the deformation of the crane column (3) and/or the main arm (4) and/or the articulated arm (5) and/or the attachment articulated arm (7) and/or the at least one crane extension arm (6, 11), of the lifting apparatus (2) and/or the at least one fly jib (13) and/or the influence of seal frictions of the hydraulic cylinders (15, 16, 17, 20) are
30 incorporated in the calculation model.

17. A method according to the preceding claim wherein in the calculation model the deformation in the form of a correction to detected

articulation angles and/or in the form of a correction to detected extension positions is applied, and/or the influence of the seal frictions is applied in the form of a correction to detected pressures.

5 18. A method according to the preceding claim wherein the correction is effected in dependence on the detected forces currently acting on the lifting apparatus (2) and/or detected articulation angles and/or the detected extension positions.

10 19. A method according to one of the two preceding claims wherein the correction for the deformation is effected in linear dependency in respect of the detected pressure and/or in linear dependency in respect of the detected extension position and/or the correction for the seal frictions is effected inversely proportionally to the detected pressure and in
15 dependence on a direction of a change in position.

 20. A method according to at least one of the preceding claims wherein the first loading state corresponds to a loading state without a load (21) lifted by the lifting apparatus (2) and the second loading state
20 corresponds to a loading state with a lifted load (21).

 21. A method according to at least one of claims 1 to 19 wherein the first loading state corresponds to a loading state with a first load (21) lifted by the lifting apparatus (2) and the second loading state corresponds to a
25 loading state with a second lifted load (21) preferably differing from the first.