

LIFTING DEVICE AND OPERATION METHOD THEREOF

Field of the Invention

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The present invention relates to the field of lifting technology, and in particular, to a lifting device and its operation method.

Background of the Invention

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At the construction site, it is necessary to use lifting and handling apparatus to pick and place hoppers filled with concrete or empty hoppers. Traditional lifting and handling apparatus for ground use include forklifts or the like, which, however, cannot meet the requirements for construction sites. There is an urgent need for a lifting and handling apparatus dedicated to construction sites to improve working efficiency and save labor.

Summary of the Invention

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The present invention aims to provide a lifting device and its operation method, by which the working efficiency can be improved while the labor cost can be reduced.

According to a first aspect, the present invention provides a lifting device, comprising a frame, a lifting drive mechanism, a lifting arm assembly and a sensing assembly. The lifting drive mechanism includes a chain, a sprocket, a lifting motor and an electric control box, wherein the sprocket, the lifting motor and the electric control box are all arranged at a top portion of the frame, the chain is connected to the sprocket, which is connected to the lifting motor, and the electric control box is used

to control and drive the lifting motor, which drives the chain to move up and down through the sprocket. The lifting arm assembly is connected to a first end of the chain, and used to pick and place a hopper, and drive the hopper to move up and down following the chain. The sensing assembly includes: a position sensing sheet, which is
5 arranged on a top of the frame, for being detected by a sensor of a transport vehicle for positioning; a descending position sensor and a descending limit sensor, which are located at respective lower positions of the frame, for detecting different descending positions of the lifting arm assembly; and an ascending position sensor and an ascending limit sensor, which are located at respective upper positions of the frame,
10 for detecting different ascending positions of the lifting arm assembly. The descending position sensor, the descending limit sensor, the ascending limit sensor and the ascending position sensor are all in signal communication with the electric control box, respectively.

15 In a possible implementing mode, the electric control box is configured to: control the lifting motor to stop when the descending position sensor senses the lifting arm assembly descends to a predetermine position, and then control the lifting arm assembly to put down the hopper on a handling apparatus or take away the hopper from the handling apparatus, the handling apparatus being a distribution machine or a
20 transfer station; and control the lifting motor to stop immediately when the descending limit sensor senses the lifting arm assembly further descends after reaching the predetermine position.

In a possible implementing mode, the electric control box is configured to:
25 control the lifting motor to stop when the ascending position sensor senses the lifting arm assembly ascends to a predetermine position, so that the transport vehicle puts down the hopper on the lifting arm assembly or takes away the hopper from the lifting arm assembly; and control the lifting motor to stop immediately when the ascending

limit sensor senses the lifting arm assembly further ascends after reaching the predetermine position.

5 In a possible implementing mode, the lifting drive mechanism includes two chains and two sprockets arranged side by side, said two sprockets being connected to and driving said two chains respectively, and the lifting arm assembly consists of two arms, which are connected to said two chains, respectively.

10 In a possible implementing mode, each arm of the lifting arm assembly is provided with a V-shaped element, which is configured to receive a V-shaped member on the hopper, and snugly fit with a baffle on the hopper to restrict the hopper in position.

15 In a possible implementing mode, the electric control box is provided therein with a frequency inverter for activating and deactivating the lifting motor, wherein the frequency inverter is in signal communication with an encoder arranged on a rear drive shaft of the lifting motor.

20 In a possible implementing mode, a buffer assembly is arranged in a lower position of the frame, and a counterweight assembly is connected to a second end of the chain.

25 In a possible implementing mode, the counterweight assembly includes a mounting bracket and a weighting block arranged on the mounting bracket. The buffer assembly includes four buffers, two of them being located at each side of the frame and under the lifting arm assembly and the counterweight assembly respectively. Each buffer is provided with a sensor in signal communication with the electric control box, for transmitting an alarm signal to the electric control box when the buffer descends to

a preset position.

According to a second aspect, the present invention provides an operation method for lifting devices, comprising steps of: driving a transport vehicle carrying a hopper full of concrete to a first lifting device; detecting, by a sensor of the transport vehicle, a position sensing sheet of the first lifting device, and stopping the transport vehicle at a position of the first lifting device; activating a lifting motor of the first lifting device, and lifting a lifting arm assembly thereof to take away the hopper full of concrete from the transport vehicle; carrying, through a handling apparatus, an empty hopper to a position of a second lifting device; lifting, by the second lifting device, the empty hopper to be taken away by the transport vehicle; moving a hopper placing device of the handling apparatus to a position under the hopper of the first lifting device, and placing, through the first lifting device, the hopper full of concrete in the hopper placing device of the handling apparatus; and driving the transport vehicle to the position of the second lifting device, and taking away the empty hopper lifted by the second lifting device. The first and second lifting devices are each a lifting device as mentioned above, and the handling apparatus is a distribution machine or a transfer station.

Further, the method may comprise steps of: returning, after the handling apparatus moves far from the first lifting device, the lifting arm assembly of the first lifting device to an origin position, which is in a middle of the frame; and returning, after the transport vehicle moves far from the second lifting device, the lifting arm assembly of the second lifting device to an origin position, which is in a lower portion of the frame.

It can be seen from the above technical solution that the present invention has the following advantages.

First, the lifting device according to the present invention, which comprises a frame, a lifting drive mechanism, a lifting arm assembly, a sensing assembly or the like, can move up and down rapidly in a safe range to pick and place the hopper, thus improving efficiency and saving time. The lifting device can be operated smoothly, and accurately reach corresponding heights according to actual needs. The structure of the lifting device is designed optimally in a simple, reliable and practical manner, and is convenient for maintenance and repair.

Moreover, the lifting device is provided with a counterweight assembly. Therefore, the operating efficiency of the lifting motor can be improved with the weight of the counterweight assembly, thereby achieving the purpose of energy saving and consumption reduction.

Further, a buffer assembly is provided under the lifting device. In case of extreme conditions such as broken chain or the like, the buffer assembly can reduce damages to other related components of the lifting device, thereby reducing maintenance and inspection costs.

Brief Description of the Drawings

In the following, the drawings that are necessary for illustrating the embodiments and the prior arts will be briefly introduced, in order to explain the technical solutions of embodiments of the present invention more clearly. Obviously, the drawings used in the following are only some examples of the present invention. One ordinarily skilled in the art can obtain other drawings based on these drawings without creative labor. In the drawings:

Figure 1 schematically shows the structure of a lifting device provided by an embodiment of the present invention.

Detailed Description of the Embodiments

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In order to enable those skilled in the art to better understand the technical solutions of the present invention, the technical solutions of the embodiments of the present invention will be described clearly and completely with reference to the accompanying drawings in the embodiments of the present invention. Obviously, the
10 embodiments as described are only part of, rather than all, the embodiments of the present invention. All other embodiments obtained by those ordinarily skilled in the art based on the embodiments of the present invention provided here but without creative labor shall fall within the scope of protection of the present invention.

15 The terms "first", "second", "third" or the like in the description and claims of the present invention and the above-mentioned drawings are used to distinguish different objects, rather than to define a specific sequence. In addition, the terms "including", "having" and any variations thereof are intended to cover non-exclusive inclusion. For example, a process, method, system, product, or device that includes a series of steps
20 or units are not limited to the steps or units as listed, but can optionally include other steps or units not being listed here, or optionally also includes other steps or units that are inherent in the process, method, product or device.

In the following, the present invention will be further illustrated with reference to
25 a specific embodiment.

Referring to Figure 1, an embodiment of the present invention provides a lifting device. The lifting device includes a frame 12, a lifting drive mechanism, a lifting arm

assembly 7, and a sensing assembly. The lifting device may further include a buffer assembly 8 and a counterweight assembly 3. The lifting drive mechanism includes a chain 4, a sprocket 9, a lifting motor 2, and an electric control box (not shown), and the sensing assembly includes a position sensing sheet 1, a descending position sensor 5, a descending limit sensor 6, an ascending limit sensor 10, and an ascending position sensor 11. The lifting motor is driven and controlled by the electric control box, and the descending position sensor 5, the descending limit sensor 6, the ascending limit sensor 10, and the ascending position sensor 11 are all in signal communication with the electric control box, respectively.

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In the lifting device, the lifting motor 2 drives the sprocket 9 in rotation, which drives the chain 4 to move up and down. The chain 4, in turn, drives the lifting arm assembly 7 to move up and down. The lifting arm assembly 7 is used to pick and place the hopper, and drive the hopper to move up and down as the chain 4 moves, so as to deliver the hopper to a designated position. During the whole operation, the electric control box of the lifting device can detect the position of the lifting arm assembly 7 through the descending position sensor 5, the descending limit sensor 6, the ascending limit sensor 10, and the ascending position sensor 11, and control the lifting motor 2 and the lifting arm assembly 7 according to the position detected.

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The control procedure may include the follows. When the descending position sensor 5 detects that the lifting arm assembly 7 descends to its destination position, the lifting motor 2 is controlled to stop, and then the lifting arm assembly 2 is controlled to place the hopper on a handling apparatus or pick the hopper from the handling apparatus. The handling apparatus can be a distribution machine or a transfer station. When the descending limit sensor 6 detects that the lifting arm assembly 7 continues to descend after it reaches to its destination position, the lifting motor 2 is controlled to stop immediately.

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In addition, when the ascending position sensor 11 detects that the lifting arm assembly 7 ascends to its destination position, the lifting motor 2 is controlled to stop so that a transport vehicle can pick the hopper from the lifting arm assembly 7 or place the hopper on the lifting arm assembly 7. When the ascending limit sensor 10 detects that the lifting arm assembly 7 continues to ascend after it reaches to its destination position, the lifting motor 2 is controlled to stop immediately.

In order to ensure reliability, the lifting drive mechanism may particularly include two chains 4 and two sprockets 9 that are arranged side by side respectively. Said two sprockets 9 are connected to and thus drive said two chains 4, respectively. The lifting arm assembly 7 consists of two arms, which are connected to said two chains 4, respectively.

In the following, each component of the lifting device will be described in detail.

(1) Position sensing sheet 1

The position sensing sheet 1 is arranged on a top end of the frame, for being detected by a sensor of external equipment, such as a transport vehicle or the like, for positioning. The transport vehicle can be braked and thus accurately stopped when reaching the position of the lifting device through detecting the position sensing sheet, so as to achieve the purpose of picking and placing the hopper. When the transport vehicle reaches the position of the lifting device and then stops, a corresponding sensor on the transport vehicle will transmit a signal to a control center, which will, according to the signal, issue a command to activate the lifting device.

(2) Lifting motor 2

The lifting motor 2 is arranged at a top portion of the frame, for driving the chain to move the hopper up and down. The lifting motor can be activated and deactivated by a corresponding frequency inverter arranged in the electric control box. An encoder
5 may be installed on a rear drive shaft of the lifting motor 2, and is mainly used to feed back signals to the frequency converter in the electric control box.

(3) Counterweight assembly 3

10 The counterweight assembly 3 is connected to the other end of the chain, and includes a mounting bracket connected to the chain and a weighting block arranged on the mounting bracket, such as a concrete weighting block. When the hopper is picked or placed, the operating efficiency of the lifting motor can be improved through the weight of the weighting block *per se* of the counterweight assembly 3.

15 (4) Chain 4

The chain 4 is used to be driven by the lifting motor through the sprocket, so as to achieve the purpose of driving the lifting arm assembly, which can, in turn, drive
20 the hopper to move up and down. Two chains can be arranged side by side on the lifting device. For example, a double-row roller chain can be used, which can increase the pulling force and improve the safety of the whole machine. One end of the chain is connected with the lifting arm assembly, and the other end thereof is connected with the mounting bracket of the counterweight assembly. When the lifting motor drives
25 the sprocket to rotate, the chain is driven by the sprocket to move up and down, so that the lifting arm assembly and the counterweight assembly respectively arranged at two ends of the chain can move up and down.

(5) Descending position sensor 5

The descending position sensor 5 is located at a lower portion of the frame, for checking whether the lifting arm assembly has descended to a predetermined position.

5 When the lifting arm assembly has descended to this position and thus the sensor 5 is detected, the lifting device can put down the hopper, or take away the hopper from the distribution machine or the transfer station. If a position value calculated by the encoder has been sent back to the frequency inverter, the frequency inverter will stop the lifting motor according to the value provided by the encoder. However, if the
10 corresponding position sensing sheet on the lifting device fails to detect the sensor after the lifting motor stops, the sensor cannot transmit a signal to the PLC (Programmable Logic Controller) of the electrical control box at this time. Then, the PLC will send an alarm signal to the control center. In this case, the operator at the control center will take corresponding measures according to the actual situation, such
15 as shutdown and maintenance, reset to origin, or the like.

(6) Descending limit sensor 6

The descending limit sensor 6 is located at a lower portion of the frame and
20 below the descending position sensor, for achieving emergency stop of the lifting motor. If the lifting motor descends to its destination position but does not stop as expected, the descending limit sensor 6 will be detected as the lifting motor continues to descend, and then a signal will be sent so that the electric control box can control the lifting motor to stop immediately.

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(7) Lifting arm assembly 7

The lifting arm assembly 7 is used to fix the hopper when picking and placing

the hopper, and drive the hopper to move up and down together. The lifting arm assembly can include two identical arms, each with two V-shaped elements. When the hopper is driven, a V-shaped member on the hopper will exactly sit on the V-shaped element of each arm, and one side face of said V-shaped element will be in snug fit
5 with a corresponding baffle on the hopper, so as to restrict the movements of the hopper along the forth-and-back direction and the right-to-left direction, thus fixing the hopper in position.

(8) Buffer assembly 8

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The buffer assembly 8 may include four buffers, two at each side of the frame on a lifting platform. Each buffer can be one consisting of a hydraulic cylinder assembly and a spring, and a sensor that can transmit an alarm signal is arranged on each buffer. The buffer assembly 8 is mainly provided for protection. In case of extreme
15 conditions, e.g., the chain breaks or the motor is out of control, the hopper and counterweight assembly will fall down due to their own weights. When they hit the buffer assembly, the spring and the hydraulic cylinder assembly can provide buffering effect. When the buffer ascends to a certain position, the sensor will be detected, thus an alarm signal will be sent to the control center.

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(9) Sprocket 9

The sprocket 9 may include two sprockets, which are arranged on a shaft directly connected to the lifting motor. The sprocket 9 can rotate following the operation of the
25 lifting motor, thereby driving the chain to move up and down.

(10) Ascending limit sensor 10

The ascending limit sensor 10 is located at an upper portion of the frame and above the ascending position sensor 11, for achieving emergency stop of the lifting motor. If the lifting motor ascends to its destination position but does not stop as expected, the ascending limit sensor 10 will be detected as the lifting motor continues
5 to ascend, and then the lifting motor will be stopped immediately.

(11) Ascending position sensor 11

The ascending position sensor 11 is located at an upper portion of the frame, for
10 checking whether the lifting arm assembly has ascended to a predetermined position. When the lifting arm assembly has ascended to this position and thus the sensor 11 is detected, the transport vehicle can, as normal, take away the hopper or put down the hopper on the lifting arm assembly of the lifting device. If a position value calculated by the encoder has been sent back to the frequency inverter, the frequency inverter
15 will stop the lifting motor according to the value provided by the encoder. However, if the corresponding position sensing sheet on the lifting device fails to detect the sensor after the lifting motor stops, the sensor cannot transmit a signal to the PLC of the electrical control box at this time. Then, the PLC will send an alarm signal to the control center. In this case, the operator at the control center will take corresponding
20 measures according to the actual situation, such as shutdown and maintenance, reset to origin, or the like.

(12) Frame 12

25 The frame 12 forms the main structure of the lifting device, and all the other components are arranged on the frame 12.

(13) Electric control box

The electric control box is a control device of the lifting device, and may include a PLC and a frequency converter connected to the PLC.

5 In the foregoing the specific structure of the lifting device according to an embodiment of the present invention has been described. In the following, the operation method of the lifting device will be introduced with reference to a specific application scenario.

10 In this scenario, a hopper is arranged on a distribution machine (i.e., a concrete distribution machine) and two lifting devices are provided to operate. A first lifting device is only responsible for discharging the hopper from the transport vehicle to the distribution machine, and the lifting arm assembly of the first lifting device stays, after each use, at a middle position of the lifting device, which is set as the origin
15 position of the lifting arm assembly of the first lifting device. A second lifting device is only responsible for taking the empty hopper from the distribution machine to the transport vehicle. After each use, the lifting arm assembly will, according to its setting, stay at a position which is at a lower portion of the lifting device and would not interfere with the path along which the distribution machine carrying the empty
20 hopper can reach said position. This position is set as the origin position of the lifting arm assembly of the second lifting device. The first lifting device can be located at the left side of the distribution machine, while the second lifting device can be located at the right side thereof. The procedure by which the lifting devices pick and place the hopper at the transfer station is basically the same as that at the distribution machine.
25 In the following the procedure will be described with the distribution machine as an example.

The operation method of the lifting device according to an embodiment of the

present invention in this scenario includes the following steps.

In step S1, the on-site operator, after the hopper on the distribution machine is empty with concrete, sends a signal to the control center, indicating that concrete is
5 needed again.

In step S2, the control center, after receiving the signal, issues a hopper changing command, by which the transport vehicle will carry a hopper full of concrete to the first lifting device. When approaching the first lifting device, the transport vehicle will
10 slow down, and finally stop at the position where the first lifting device is after the sensor of the transport vehicle detects the position sensing sheet on the lifting device.

In step S3, the control center issues a command, by which the distribution machine carries the empty hopper to automatically move to a designated position
15 under the rail. When the distribution machine moves to the rail, the empty hopper moves to the right to the position where the second lifting device is, so that the second lifting device can lift the empty hopper and wait for the transport vehicle to pick the hopper.

20 In step S4, the second lifting device lifts the empty hopper, and then a hopper placing device of the distribution machine will move to a position below the hopper of the first lifting device.

Step S5 is performed during the above steps S3 to S4 are carried out. In step S5,
25 the transport vehicle has stopped at the position of the first lifting device, carrying the hopper filled with concrete. At this time, the lifting motor of the first lifting device is activated, so that the lifting arm assembly thereof is raised to pick the hopper filled with concrete from the transport vehicle, and then place the hopper filled with

concrete into the hopper placing device of the distribution machine. In this manner, placement of the hopper is completed.

5 In step S6, the distribution machine carrying the hopper filled with concrete moves on the rail towards the formwork at the construction site. At this time, with a safety protection mechanism, the hopper cannot move to the left or right on the distribution machine. When the distribution machine reaches an area completely out of the lifting device, a corresponding sensor on the distribution machine will send a signal, whereby the lifting arm assembly of the first lifting device will return to its
10 origin position, which is in the middle of the frame.

In step S7, the distribution machine is operated by the operator to move back and forth or left and right in an area where concrete can be unloaded, and then start to distribute concrete to the formwork. At this time, the transport vehicle has arrived at
15 the position of the second lifting device to pick the empty hopper. After the transport vehicle is far away from the second lifting device, the lifting arm assembly of the second lifting device returns to its origin position, which is at a lower portion of the frame.

20 It should be understood that the above steps remain unchanged if the distribution machine in the above steps is replaced with the transfer station.

In the foregoing, the embodiment of the present invention discloses a lifting device and its operation method. It can be seen from the above technical solution that
25 the present invention has the following advantages.

First, the lifting device can move up and down rapidly in a safe range to pick and place the hopper, thus improving efficiency and saving time.

Second, the lifting device can be operated smoothly, and accurately reach corresponding heights according to actual needs. The structure of the lifting device is designed optimally in a simple, reliable and practical manner, and is convenient for
5 maintenance and repair.

Moreover, the lifting device is driven by a lifting motor, and provided with a counterweight assembly. Therefore, the operating efficiency of the lifting motor can be improved with the weight of the counterweight assembly, thereby achieving the
10 purpose of energy saving and consumption reduction.

Further, a buffer assembly is provided under the lifting device. In case of extreme conditions such as broken chain or the like, the buffer assembly can reduce damages to other related components of the lifting device, thereby reducing maintenance and
15 inspection costs.

In the above-mentioned embodiments, the description of each embodiment has its own emphasis. For parts that are not described in detail in an embodiment, reference may be made to related descriptions of other embodiments.
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The foregoing are only preferred embodiments of the present invention, and are not intended to limit the present invention. Any modification, equivalent replacement or improvement made within the spirit and principle of the present invention should be included in the protection scope of the present invention.

CLAIMS

1. A lifting device, comprising a frame, a lifting drive mechanism, a lifting arm assembly and a sensing assembly, wherein:

5 the lifting drive mechanism includes a chain, a sprocket, a lifting motor and an electric control box, wherein the sprocket, the lifting motor and the electric control box are all arranged at a top portion of the frame, the chain is connected to the sprocket, which is connected to the lifting motor, and the electric control box is used to control and drive the lifting motor, which drives the chain to move up and down
10 through the sprocket;

 the lifting arm assembly is connected to a first end of the chain, and used to pick and place a hopper, and drive the hopper to move up and down following the chain;
 and

 the sensing assembly includes:

15 a position sensing sheet, which is arranged on a top of the frame, for being detected by a sensor of a transport vehicle for positioning;

 a descending position sensor and a descending limit sensor, which are located at respective lower positions of the frame, for detecting different descending positions of the lifting arm assembly; and

20 an ascending position sensor and an ascending limit sensor, which are located at respective upper positions of the frame, for detecting different ascending positions of the lifting arm assembly,

 wherein the descending position sensor, the descending limit sensor, the ascending limit sensor and the ascending position sensor are all in signal
25 communication with the electric control box, respectively.

2. The lifting device according to claim 1, characterized in that the electric control box is configured to:

control the lifting motor to stop when the descending position sensor senses the lifting arm assembly descends to a predetermined position, and then control the lifting arm assembly to put down the hopper on a handling apparatus or take away the hopper from the handling apparatus, the handling apparatus being a distribution machine or a transfer station; and

control the lifting motor to stop immediately when the descending limit sensor senses the lifting arm assembly further descends after reaching the predetermined position.

3. The lifting device according to claim 1, characterized in that the electric control box is configured to:

control the lifting motor to stop when the ascending position sensor senses the lifting arm assembly ascends to a predetermined position, so that the transport vehicle puts down the hopper on the lifting arm assembly or takes away the hopper from the lifting arm assembly; and

control the lifting motor to stop immediately when the ascending limit sensor senses the lifting arm assembly further ascends after reaching the predetermined position.

4. The lifting device according to claim 1, characterized in that the lifting drive mechanism includes two chains and two sprockets arranged side by side, said two sprockets being connected to and driving said two chains respectively, and

the lifting arm assembly consists of two arms, which are connected to said two chains, respectively.

5. The lifting device according to claim 4, characterized in that each arm of the lifting arm assembly is provided with a V-shaped element, which is configured to receive a V-shaped member on the hopper, and snugly fit with a baffle on the hopper

to restrict the hopper in position.

6. The lifting device according to claim 1, characterized in that the electric control box is provided therein with a frequency inverter for activating and
5 deactivating the lifting motor, wherein the frequency inverter is in signal communication with an encoder arranged on a rear drive shaft of the lifting motor.

7. The lifting device according to claim 1, characterized in that a buffer assembly is arranged in a lower position of the frame, and a counterweight assembly is
10 connected to a second end of the chain.

8. The lifting device according to claim 7, characterized in that the counterweight assembly includes a mounting bracket and a weighting block arranged on the mounting bracket; and
15 the buffer assembly includes four buffers, two of them being located at each side of the frame and under the lifting arm assembly and the counterweight assembly respectively, wherein each buffer is provided with a sensor in signal communication with the electric control box, for transmitting an alarm signal to the electric control box when the buffer descends to a preset position.

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9. An operation method for lifting devices, comprising steps of:

driving a transport vehicle carrying a hopper full of concrete to a first lifting device;

detecting, by a sensor of the transport vehicle, a position sensing sheet of the first
25 lifting device, and stopping the transport vehicle at a position of the first lifting device;

activating a lifting motor of the first lifting device, and lifting a lifting arm assembly thereof to take away the hopper full of concrete from the transport vehicle;

carrying, through a handling apparatus, an empty hopper to a position of a second lifting device;

lifting, by the second lifting device, the empty hopper to be taken away by the transport vehicle;

5 moving a hopper placing device of the handling apparatus to a position under the hopper of the first lifting device, and placing, through the first lifting device, the hopper full of concrete in the hopper placing device of the handling apparatus; and

driving the transport vehicle to the position of the second lifting device, and taking away the empty hopper lifted by the second lifting device,

10 wherein the first and second lifting devices are each a lifting device according to claim 1, and the handling apparatus is a distribution machine or a transfer station.

10. The method according to claim 9, further comprising steps of:

15 returning, after the handling apparatus moves far from the first lifting device, the lifting arm assembly of the first lifting device to an origin position, which is in a middle of the frame; and

returning, after the transport vehicle moves far from the second lifting device, the lifting arm assembly of the second lifting device to an origin position, which is in a lower portion of the frame.