

SAFE LOCKING CONTROL APPARATUS AND CONTROL METHOD FOR TOWER CRANE

TECHNICAL FIELD

5 The present invention relates to the technical field of construction machinery, specifically to a safe locking control apparatus and a control method for a tower crane.

BACKGROUND

10 Due to the particularity of the tower crane industry, where some tower cranes in China are purchased in installments, on the purpose of big data collection and working status safety monitoring of tower cranes, the tower cranes in China are equipped with a GPS locking function. When the customer is overdue on payments, the tower crane suffers GPS or GPRS signal loss and the like. The tower crane control system can be in active locking or passive locking.

15 At present, the locking mode on the market is controlled by a programmable logic controller (PLC). After the host machine factory issues the locking instruction, the PLC controller immediately locks the lifting, luffing, and rotation movements of the three major mechanisms to make it unable to operate. This locking control mode is simple and can
20 achieve the purpose of locking, but the safety of the construction site and the tower crane cannot be guaranteed. If the tower crane is carrying out a lifting operation when the crane is locking, it is likely to suspend heavy objects in mid-air. If the lifting hook is not put in a safe position and a strong wind strikes, the lifting hook may hook or hang onto site objects, resulting in serious consequences, such as damage to the tower crane, falling of the tower
25 crane, or pulling down the building site. In summary, the prior art gives no early-warning and prompting before locking. When sudden locking occurs, customers have no response plans and measures in place, which affects the progress of the construction project. Additionally, the locking control logic in the prior art is defective in that when the three major mechanisms lock at the same time, the position of the lifting hook cannot be adjusted,

which may lead to the lifting hook being in an unsafe state for a long time and cause serious consequences, such as the arm of the tower crane being broken or causing the tower crane to fall, etc. Furthermore, the lack of safety monitoring of the locking cannot ensure that the lifting hook is in a safe state after being locked, and the lifting hook may hook or hang onto the building site after being locked, resulting in serious consequences, such as damage to the tower crane, falling of the tower crane, or pulling down the building site.

SUMMARY

The technical problem to be solved in the present invention is to overcome the shortcomings of the prior art and to provide a safe locking control apparatus and a control method for the tower crane, which is more convenient and effective.

The present invention is realized by the following technical solution: A safe locking control apparatus for the tower crane includes a programmable logic controller (PLC), a lifting encoder, a luffing encoder, a height limit sensor, a luffing limit sensor, a rotation limit sensor, a weight sensor, a safety monitoring display device, and a video monitoring device which are integrated based on a controller area network (CAN) bus.

The control method of the safe locking control apparatus for the tower crane includes an early-warning and prompting before locking, control steps of safe locking control logic, and safety state monitoring steps of the tower crane after being locked.

Early-warning and prompting before locking: Before issuing the locking command, the PLC controller first triggers the safety monitoring display device to automatically pop up the locking early-warning screen through the bus.

Safe locking control logic steps: If the driver has not yet taken measures to eliminate the locking conditions under the early-warning prompt of the system, the system enters the locking control stage and locks the luffing action, the rotation action, and the lifting action

through the controller in turn.

Safety state monitoring steps: After the locking process is completed, the system detects the position and lifting state of the lifting hook by using the safety monitoring system and video monitoring system.

During the early-warning and prompting before locking, the driver is reminded that the system is about to enter the locking state 1h later, and the locking time, the state of the device, and the risk after being locked, and other content will be displayed to the driver.

The specific steps of control steps of the safe locking control logic are as follows:

1 h after the early-warning and prompting before locking, the steps of locking the luffing action by the PLC controller occur, that is, shielding the run of the output port for the luffing outward, so that the luffing is allowed to run inward and is not allowed to run outward.

After another hour elapses, the step of locking the rotation action by the PLC controller occurs, that is, shielding the run of the output port for rotating right, so that the rotation is allowed to run left and is not allowed to run right.

After another hour elapses, the step of locking the lifting action by the PLC controller occurs, that is, shielding the run of the output port for lifting up, so that the lifting is allowed to run downward and is not allowed to run upward.

In the process of safe locking control logic, the weight sensor detects the status of the lifting hook in real-time. If a lifting weight is detected on the lifting hook, the system will remind the driver that the machine is locking and that the lifting hook should be put away safely (e.g., "the machine is locking; please place the weight on the ground immediately and put the lifting hook in a safe state") every minute.

In the control method of the safe locking control apparatus for the tower crane, the specific steps of the safety state monitoring steps are as follows:

The step of detecting the lifting weight of the lifting hook by the video monitoring device and a weight sensor to determine whether there is a lifting weight or a surplus. If there is a surplus, the step of sending alarm information to the display device occurs to prompt the driver to deal with it. The step of determining whether the lifting hook position is in a safe position by the lifting encoder, luffing encoder, and PLC controller occurs. If the lifting hook is empty and in a safe position, the locking control is completed.

If there is a surplus, such as a lifting weight, a strap and the like on the lifting hook, the step of triggering, by the PLC controller, a danger warning screen on a display through the bus occurs to remind the driver that "the system is locked and the lifting hook is in danger; please contact the supplier immediately."

If the lifting hook is empty, but not in a safe position, the step of automatically lifting, by the control system, the lifting hook to a safe position according to the preset logic occurs.

The safe position of the lifting hook is within 3 m away from the bottom of the arm upward and away from the base of the arm inward.

According to the preset logic of the control system, the height of the lifting hook is detected by the lifting encoder and the height limit sensor, and the luffing level of the lifting hook is detected by the luffing limit sensor and the luffing limit sensor.

The advantages of the present invention are as follows: A safe locking control apparatus and a control method for the tower crane of the present invention provide the early-warning and prompting before locking, the logic control of the locking process, and the safe state of the device after being locked through the PLC controller, the weight sensor, the lifting encoder, the display, and others which are integrated based on the CAN bus, which are comprehensively controlled to ensure the safety of the device before and after locking.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow chart of the safe locking control logic steps of the present invention.

FIG. 2 is a flow chart of the safety state monitoring steps of the present invention.

5 DETAILED DESCRIPTION OF THE EMBODIMENTS

As shown in FIGS. 1 and 2, a safe locking control apparatus for a tower crane includes a PLC controller, a lifting encoder, a luffing encoder, a height limit sensor, a luffing limit sensor, a rotation limit sensor, a weight sensor, a safety monitoring display device, and a video monitoring device which are integrated based on a CAN bus. In the safe locking control
10 apparatus for the tower crane of the present invention, the PLC controller is configured for receiving the locking control command and all sensor feedback signals while executing the locking control logic, which is the core of the control system. The safety monitoring display device is configured to provide the display of early-warning and alarm information on a man-machine interface. The lifting encoder, the height limit sensor, the luffing limit sensor, and
15 the rotation limit sensor are configured to provide the height, luffing level, and rotation angle information of the lifting hook, and the PLC controller is configured to calculate the position of the lifting hook. The weight sensor is configured to detect the actual lifting weight of the lifting hook, and the video monitoring system is configured to monitor whether there is a surplus on the lifting hook, such as a sling or a strap. Through the control and monitoring
20 system composed of the PLC controller, the weight sensor, the lifting encoder, and the like, the locking control is carried out with early-warning and prompting before locking, safety logic control of the locking process, and safety state monitoring after being locked.

The control method of the safe locking control apparatus for the tower crane includes
25 an early-warning and prompting before locking, control steps of safe locking control logic, and safety state monitoring steps of the tower crane after being locked. The driver is provided with a comprehensive warning prompt and sufficient safe operating time to put down the heavy objects and lift the lifting hook to a safe position before and during the locking process through the safe locking control logic. After being locked, the PLC controller monitors the

position and lifting state of the lifting hook to determine whether it is in a safe state. The real-time lifting weight of the lifting hook is measured by the weight sensor. If a lifting weight is detected, alarm information will be sent to the display device to prompt the driver to deal with it. The height of the lifting hook is detected by the lifting encoder and the height limit sensor. The height direction is safe if the lifting hook is within 3 m away from the bottom of the arm. The luffing level of the lifting hook is detected by the luffing limit sensor, and the luffing direction is safe if the lifting hook is less than 3 m from the base of the arm. Through the video monitoring system, the lifting hook images are compared to determine whether there is a surplus on the lifting hook, such as a strap, a sling, and the like. If there is a surplus, alarm information will be sent to the display device to prompt the driver to deal with it. After comprehensively judging the lifting state and lifting hook position, the PLC controller will process according to the preset logic. If there is a surplus, such as a lifting weight or sling on the lifting hook, the driver will be prompted to deal with it by the display device, and the system will not act. If there is no surplus, such as a lifting weight and sling on the lifting hook, the control system will judge the position of the lifting hook. If the lifting hook is not in a safe position, the lifting hook will be automatically lifted to a safe position and its luffing level will be changed inward to a safe position.

The specific control methods are as follows:

Early-warning and prompting before locking:

Before issuing the locking command, the PLC controller first triggers the safety monitoring display device to automatically pop up the locking early-warning screen through the bus. The driver is reminded that the system is about to enter the locking state; the locking time, the state of the device, the risk after being locked, and other content will be displayed to the driver.

Safe locking control logic steps:

If the driver has not yet taken measures to eliminate the locking conditions (such as inquiring the reason for the imminent lock, contacting the supplier to solve the problem, and the like) under the early-warning prompt of the system, the system will enter the locking

control stage and lock the luffing action, the rotation action, and the lifting action through the controller in turn. During the locking process, the system will first lock the luffing action so that it can only move inward (safe direction). After an interval of 1 h has elapsed, the system will lock the rotation action so that it can only move to the left. After another interval of 1 h has elapsed, the system will lock the lifting action so that it can only move downward (safe direction). In the process of locking, the driver still has the opportunity to place the heavy objects on the ground and lift the lifting hook to a safe position. In the process of locking, the weight sensor detects the status of the lifting hook in real-time. If a lifting weight is detected on the lifting hook, the system will remind the driver that "the machine is locking; please place the weight on the ground immediately and put the lifting hook to a safe state" every minute.

Safety state monitoring steps:

After the locking process is completed, the system uses the safety monitoring system and video monitoring system to detect the position and lifting state of the lifting hook. The specific steps of the safety state monitoring steps are as follows:

The lifting weight of the lifting hook is detected by the video monitoring device and weight sensor to determine whether there is a surplus, such as a lifting weight, a strap and the like on the lifting hook. If there is a surplus, alarm information will be sent to the display device to prompt the driver to deal with it. The lifting encoder, luffing encoder, and PLC controller are configured to determine whether the lifting hook position is in a safe position. If the lifting hook is empty and in a safe position (within 3 m away from the bottom of the arm upward and away from the base of the arm inward), the locking control is completed. If there is a surplus on the lifting hook, such as a lifting weight, a strap, and the like, the PLC controller triggers a danger warning screen on the display through the bus to remind the driver that "the system is locked and the lifting hook is in danger; please contact the supplier immediately." If the lifting hook is empty but not in a safe position, the control system automatically lifts the lifting hook upwards to 3 m from the bottom of the arm and then inwards to 3 m from the base of the arm according to the preset logic to ensure that the lifting

hook is in a safe position. According to the preset logic of the control system, the height of the lifting hook is detected by the lifting encoder and the height limit sensor, and the luffing level of the lifting hook is detected by the luffing limit sensor and the luffing encoder.

5 The advantages of this application are as follows:

- 1) This application is designed humanized to reduce customer complaints. Through the display device, the system provides customers with a locking early-warning, related solutions, and operation tips, and the reminders to customers are more intuitive and
10 clearer.
- 2) The locking control logic has a higher security. The locking control logic is improved from the traditional locking (three major mechanisms perform locking at the same time) to step-by-step locking, leaving sufficient safe operating time for the
15 driver, and ensuring the safety of the tower crane and construction site while realizing the locking purpose.
- 3) The state monitoring after being locked has a higher security. After being locked, the state and position of the lifting hook are further detected by the system, and the
20 driver is reminded by the display device to effectively ensure the safety of the tower crane after being locked.

CLAIMS

WHAT IS CLAIMED IS:

1. A safe locking control apparatus for a tower crane, comprising a programmable logic controller (PLC), a lifting encoder, a luffing encoder, a height limit sensor, a luffing limit
5 sensor, a rotation limit sensor, a weight sensor, a safety monitoring display device, and a video monitoring device which are integrated based on a controller area network (CAN) bus.
2. A control method of the safe locking control apparatus for the tower crane according to claim 1, comprising an early-warning and prompting before locking, control steps of safe
10 locking control logic, and safety state monitoring steps of the tower crane after being locked;
early-warning and prompting before locking: before issuing a locking command, the PLC controller first triggers the safety monitoring display device to automatically pop up a locking early-warning screen through the bus;
safe locking control logic steps: if a driver has not yet taken measures to eliminate
15 locking conditions under the early-warning prompt of the system, entering a locking control stage and locking a luffing action, a rotation action, and a lifting action through the controller in turn in the system; and
safety state monitoring steps: after a locking process is completed, detecting the position and lifting state of a lifting hook by using a safety monitoring system and a video monitoring
20 system in the system.
3. The control method of the safe locking control apparatus for the tower crane according to claim 2, wherein during the early-warning and prompting before locking, contents comprising a locking time, state of device, and risk after being locked and the like
25 are displayed to the driver to remind the driver that the system is about to enter a locking state.
4. The control method of the safe locking control apparatus for the tower crane according to claim 2, wherein the specific steps of control steps of the safe locking control

logic are as follows:

a: 1 h after the early-warning and prompting before locking later, locking the luffing action by the PLC controller, wherein locking the luffing action comprises shielding the run of an output port for luffing outward, so that the luffing is allowed to run inward and is not allowed to run outward;

b: another 1 h later, locking the rotation action by the PLC controller, wherein locking the rotation action comprises shielding the run of an output port for rotating right, so that the rotation is allowed to run left and is not allowed to run right; and

c: another 1 h later again, locking the lifting action by the PLC controller, wherein locking the lifting action comprises shielding the run of an output port for lifting up, so that the lifting is allowed to run downward and is not allowed to run upward.

5. The control method of the safe locking control apparatus for the tower crane according to claim 4, wherein in the process of safe locking control logic, the weight sensor detects the status of the lifting hook in real-time; if a lifting weight is detected on the lifting hook, the system will remind the driver that "the machine is locking; please place the weight on the ground immediately and put the lifting hook to a safe state" every minute.

6. The control method of the safe locking control apparatus for the tower crane according to claim 2, wherein the specific steps of the safety state monitoring steps are as follows:

d: detecting the lifting weight of the lifting hook by the video monitoring device and the weight sensor to determine whether there is a surplus, such as a lifting weight, a strap and the like on the lifting hook; if there is a surplus, sending an alarm information to the display device to prompt the driver to deal with it;

e: determining whether a lifting hook position is in a safe position by the lifting encoder, the luffing encoder, and the PLC controller;

f: if the lifting hook is empty and in a safe position, a locking control is completed;

g: if there is the surplus, such as the lifting weight, the strap and the like on the lifting hook, triggering, by the PLC controller, a danger warning screen on a display through the

bus to remind the driver that "the system is locked and the lifting hook is in danger; please contact the supplier immediately;" and

h: if the lifting hook is empty, but not in a safe position, automatically lifting, by a control system, the lifting hook to a safe position according to a preset logic.

5

7. The control method of the safe locking control apparatus for the tower crane according to claim 6, wherein the safe position of the lifting hook is within 3 m away from the bottom of an arm upward and away from the base of the arm inward.

10 8. The control method of the safe locking control apparatus for the tower crane according to claim 6, wherein according to the preset logic of the control system, the height of the lifting hook is detected by the lifting encoder and the height limit sensor, and the luffing level of the lifting hook is detected by the luffing limit sensor and the luffing limit sensor.