

# **AUTOMATIC CONTAINER LANDING AND LIFT PREVENTION METHODS OF AUTOMATED LOADING AND UNLOADING OPERATION**

## **Technology Field**

The invention is applicable to accurate positioning and anti-lifting of container truck and hoist in container loading and unloading operation, especially to automated loading and unloading of containers in ports.

## **Background of the Invention**

At present, there is no effective and accurate measurement method for automatic loading and unloading operation of container, the precise alignment of portal crane and hoist, and lift prevention. For example, the patent ZL 200820055788.6 site container portal crane rectification, laser alignment, and anti-lifting device, and patent ZL 201420312848.3 tire crane positioning rectification and anti-lifting system. The laser scanning range finder moves with the portal crane and it is limited to a certain height. Moreover, due to the different heights of the container trucks and lock holes, the chassis twist-locks of no-load container trucks cannot be accurately measured. Although there is a cloud deck for rotation, it is impossible to detect the position of all the locks. In automatic loading and unloading operation of containers, the automatically lifted container cannot be accurately aligned with locks, and if the locks are not fully unlocked, the container chassis would have different heights. Moreover, since the scanner is fixed at a certain height and cannot have anti-lifting detection on the lifted containers, it will lift the container chassis and the front of the container chassis, which will pose a safety hazard. At present, there is no effective detection method to solve precise positioning and anti-lifting of external container trucks in the automatic loading and unloading operation.

## **Description of the invention**

In the automated terminal container yard, there are a number of parking lanes for external container trucks, and an automatic lifting device and automatic tilt adjuster are installed beside the lanes. Moreover, a laser scanner is installed on the device. The laser scanner can detect the lifting and tilting of the lock holes in the no-load container chassis entering the lane. By measuring the

position of the nearest one or several lock holes, position all the lock holes on the container chassis can be deduced. Then accurate inspection can be carried out to find the exact position of all the locks to achieve precise positioning of container chassis. For the heavy-load container truck entering the lane, the laser scanner scans the container truck horizontally, and adjusts the automatic lifting device to the corresponding height according to the height information of the container landing signal and the hoist height signal to prevent that locks of the container are unlocked and lift the container truck. Through the above method, the precise positioning, automatic container landing and anti-lifting detection of external chassis twist-locks in the portal crane yard of the automation site can be realized. In addition, the system can be also installed on the side pillars of the portal crane, following the movement of the cart, and have precise positioning and anti-lift detection on locks of container trucks in single lanes.

The invention provides a container truck positioning, loading chassis lock positioning and container anti-lifting device for automatic loading and unloading operation.

Objectives of the invention are realized through the below technical proposals:

The automatic container loading and anti-lifting method for automatic loading and unloading operation is characterized in that it comprises: an automatic lifting device, an automatic tilt adjuster, a motor, a motor driver, a laser scanner, a chassis twist-lock, a container, a system processor, PLC, hoist height signal, trolley position signal, gantry position locating device, container landing signal and automatic portal crane.

The automatic lifting device and the automatic tilt adjuster are installed beside the external truck parking lane of the automatic dock yard; the laser scanner is installed on the automatic lifting device and the automatic tilt adjuster. Moreover, the motor driver is controlled by the system processor to adjust the automatic lifting device and the automatic tilt adjuster, thus adjusting the lifting height and the tilt angle of the laser scanner. The height and tilt angle data of the laser scanner is provided by an automatic lifting device encoder and an automatic tilt adjuster encoder. The laser scanner traces and detects locks of the container truck. It searches mutation status of the locks and the chassis through the data measures by the laser scanner and the system processor, determines the three-dimensional coordinate position of the X, Y and Z axes of the locks and sends it to the PLC to control the position of the hoist and the locks of the chassis, thus achieving precise positioning and realizing automatic container landing of container under the hoist. The system processor is connected to the PLC and participates in the position analysis and lifting control of the

site portal crane. In addition, the automated site portal crane includes a tire crane and a track crane.

In the three-dimensional coordinate mentioned above, the X axis represents the lateral movement direction of the trolley and the hoist; the Y axis represents the driving direction of the field portal crane, and the Z axis represents the vertical direction of hoist.

The lock of the container chassis provides a target point of the measurement position, and determines the three-dimensional coordinate position information of the measured X, Y, and Z axes of the lock. The horizontal scanning of the laser scanner sends the measured data to the system processor to control the motor driver and drive the motor to lift or rotate, finds out the three-dimensional coordinate position of the lock in the chassis, and provides it to the PLC to control the three-dimensional coordinate position. When landing container, the laser scanner scans and measures the edge position of the container, and calculates the distance between the container edge position and the lock position so as to realize accurate positioning of the container and the lock hole position in the chassis, as well as automatic landing of containers under the hoist.

When anti-lifting detection is performed, the laser scanner horizontally scans and adjusts the height of the gap between the container and the chassis through the automatic lifting device, and when no obstacles are found, the system allows the hoist to move up and lift the container.

When the laser scanner scans horizontally, it measures the front, lock, and container of the container truck, and displays position information of the current container through the display screen for the container truck driver.

The automatic lifting device and the automatic tilt adjuster comprise a limit control device, a mechanical arm, a lifting platform and a rotating module, and the scanner can be moved up and down, and can be rotated forward and backward. Moreover, position of the lock of the container chassis can be found through driving of the motor. The limit device control prevents the motor from moving up and down beyond the range.

There are several lanes on the container automation dock. The automatic lifting device and the automatic tilting adjuster are installed next to the lanes, which would not affect vehicle driving. It does not move with the automation site portal crane, and can be installed at any position in each lane. Moreover, a set of automatic lifting devices and automatic tilt adjuster can be shared by multiple lanes. The automatic lifting device and the automatic tilt adjuster can be installed on the

side of the portal crane of the artificial control site with a height from the ground of about 2 meters, and the height and inclination angle of the laser scanner can be adjusted to horizontally detect the gap between the lock of the container chassis and the container, and the flat plate as well, thus realizing automatic container landing and anti-lifting detection.

The trolley position signal provides location information of the field portal crane. The gantry position locating device provides location information of the portal crane. The container landing signal provides the height position when the container is hoisted. The hoist height signal provides hoist height information.

Combination of the automatic tilt adjuster and the laser scanner can realize functions of 3D laser scanner.

When the container truck enters the parking lane for external container trucks, the system processor controls the automatic lifting device and the automatic tilt adjuster to slowly lower the laser scanner from a height. Meanwhile, the laser scanner scans the lane horizontally, and if the truck head is scanned, the car is an empty container chassis, but if the edge is scanned, it is considered to be a heavy-load container truck.

For no-load container chassis entering the lane, the system processor controls the automatic lifting device and the automatic tilt adjuster to lower the laser scanner, and the laser scanner would measure the position of the nearest one or several lock holes. If the first lock is detected far away (greater than or equal to the length of one container), the front end of the vehicle is considered to be high; if the first lock is detected to be close, the rear end is considered to be high. According to the height, the approximate position of all the lock holes on the container chassis can be calculated, and then the tilt angle of the laser scanner can be adjusted through the automatic lifting device and the automatic tilt adjuster to accurately detect until all the locks are measured, and all the locks are determined in the X, Y and Z axes of the three-dimensional coordinate, thus realizing precise positioning of the container chassis.

After the system locates the lock of the container chassis, the position information of the lock will be sent to the PLC, and the laser scanner rises to a height of about 1.7m for horizontal scanning and traces and locates the position of the container chassis. If the container chassis moves, the moved position will be sent to the PLC in real time. When the hoist lands containers, and the laser scanner scans the side of the container, it will compare the three-dimensional coordinate position

information of the container edge on the X, Y, and Z axes with the three-dimensional coordinate position information of the lock on the X, Y, and Z axes to achieve precise landing.

For double 20-foot no-load container truck entering the lane, the laser scanner first detects the lock of the previous 20-foot container chassis and provides the position information to the PLC. The portal crane first lands the previous 20-foot container. Then, the scanner inspects the next 20-foot chassis twist-lock and provides the location information to the PLC, and then lands the next 20-foot container.

For heavy-load container trucks entering the lane, when the portal crane on the field lifts the container on the container truck, the laser scanner scans the container truck horizontally and automatically raises and lowers to the corresponding height according to the height information of the hoist's container signal and the hoist height signal. The laser scanner scans the distance between the container chassis and the bottom of the container. When the lock on the container flatbed is unlocked and still grapples the container lock hole, and the container chassis is taken up by the container, and when the laser scanner detects an object under the bottom of the container, the device would immediately emit an audible and visual alarm, and send a stop lifting signal to the portal crane PLC. However, if no obstacles are found, the system allows the hoist to move up and lift the container. For dual 20-foot heavy-load container trucks entering the lane, the laser scanner first performs an anti-lift test on the next 20-foot container; while the portal crane on the field first lifts the next 20-foot container and provides the location information to the PLC. Then, the laser scanner conducts an anti-lift test on the previous 20-foot container and then lifts the previous 20-foot container.

The method can realize precise alignment of lock head of container truck under the portal crane on the field of automatic loading and unloading operation and the hoist of portal crane, and prevent the hoisting of the container truck when the container is hoisted.

Due to the above technical solution, the beneficial effects of the invention are: solving the precise positioning and anti-lifting detection of locks of external container truck in automatic dock, reducing labor intensity of drivers, preventing lifting of container trucks, eliminating potential safety hazards, and improving production efficiency of container loading and unloading by portal crane in the automation dock.

## Brief Introduction of the Drawings

Figure 1 Schematic diagram of container automation terminal

Figure 2 Schematic diagram of the laser scanner's inspection of container trucks entering the lanes

Figure 3 Schematic diagram of the laser scanner's detection principle for locks of container chassis

Figure 4 Schematic diagram of precise positioning of containers and locks

Figure 5 Schematic diagram of laser scanner's position detection for double 20-foot and 40-foot container chassis locks

Figure 6 Schematic diagram of anti-lifting detection principles

Figure 7 Electrical connection diagram of components

In the figure, (1) automatic lifting device, automatic tilt adjuster, (2) laser scanner, (3) lane, (4) double 20-foot no-load container chassis, (5) double 20-foot heavy-load container truck, (6) lock head, (7) 40-foot no-load container chassis, (8) 40-foot heavy-load container truck, (9) 20-foot container, (10) 40-foot container, (11) site portal crane, (12) scanning surface, (13) hoist, (14) system processor, (15) PLC, (16) motor, (17) motor driver.

## Detailed Description of the Preferred Embodiments

The automatic lifting device and the automatic tilt adjuster (1) are installed beside the parking lane (3) for external container trucks in the automated dock yard; the laser scanner (2) is installed in the automatic lifting device and the automatic tilt adjuster (1). The motor driver (17) and the motor (16) control the automatic lifting device and the automatic tilt adjuster (1) to adjust the lifting and tilting angle of the laser scanner (2), and traces and detects the chassis twist-lock (6). Data measured by the laser scanner (2) and software program processing data are used to find the mutation status of the lock head (6) and the container chassis, determine the reference three-dimensional coordinate position of the lock head (6), and send it to the PLC (15) to control the position of the hoist (13) and the container chassis lock (6), thus achieving precise positioning and automatic container under the hoist. The system processor (14) is connected to the PLC (15) and participates in the position analysis and lifting control of the site portal crane.

In the three-dimensional coordinate position, the X axis represents the horizontal movement direction of the trolley and the hoist (13); the Y axis represents the driving direction of the field portal crane (11); and the Z axis represents the vertical direction the hoist (13).

When one container truck enters the lane (3) for external container trucks, the system processor (14) controls the automatic lifting device and the automatic tilt adjuster (1) to cause the laser scanner (2) to slowly descend from a height, at which time the laser scanner (2) horizontally scans the lane (3). If the truck head is scanned, the vehicle is a no-load container chassis; while if the edge is scanned, the vehicle is considered to be a heavy-load container truck.

By taking a 40-foot no-load container chassis (7) as an example, for a 40-foot no-load container chassis (7) entering the lane (3), the system processor (14) controls the automatic lifting device and the automatic tilt adjuster (1) to drive the laser scanner (2) to descend, and the position of the nearest one or several lock holes (6) is measured by the laser scanner (2), and the approximate position of all lock holes (6) of the 40-foot no-load container chassis (7) can be also derived. Then, adjust the inclination of the laser scanner (2) through the automatic lifting device and the automatic tilt adjuster (1) to accurately detect until all the locks (6) are measured, and find out position of all the locks (6) in the X, Y and Z axes of the three-dimensional coordinate to realize precise positioning of the 40-foot no-load container chassis (7).

After the system locates lock of the container chassis (6), it will send the position information of the lock (6) to the PLC (15), and the laser scanner (2) is raised to a height of 1.7 m for horizontal scanning and traces the position of the container chassis. If the container chassis moves, the moving position will be sent to the PLC (15) in real time. When the hoist (13) lands containers and the laser scanner (2) scans the side of the 40-foot container (10), it will compare the three-dimensional coordinate position information of the edge of the 400-foot container with the three-dimensional coordinate position information of the lock in the X, Y, and Z axes, thus achieving accurate landing.

For double 20-foot no-load container chassis (4) entering the lane, the laser scanner first detects the previous 20-foot no-load container chassis (4) lock (6) and provides position information to the PLC (15). However, the site portal crane (15) first lands the previous 20-foot container (9), and the laser scanner (2) detects the next 20-foot no-load container chassis (4) lock (6), sends the position information to the PLC (15), and then lands the next 20-foot container (9).

By taking a 40-foot heavy-load container truck (8) as an example, for a heavy-load container

truck entering into the lane, when the portal crane lifts the container on the container truck, the laser scanner (2) horizontally scans the container truck and according to the height information provided by container landing signal of the hoist (13) and the hoist height signal, it adjusts the automatic lifting device to the corresponding height. The laser scanner (2) scans the gap between the 40-foot heavy-load container truck (8) and the bottom of the 40-foot container (10). When the lock (6) on the 40-foot heavy-load container truck (8) is locked and still hooks the container lock hole, the 40-foot heavy-load container truck (8) will be taken up by the 40-foot container (10). When the laser scanner (2) detects an object under the bottom of the 40-foot container (10), the device immediately gives an audible and visual alarm, and sends a stop lifting signal to the site portal crane PLC (15). If no obstacles are found, the system allows the hoist to move up and lift the 40-foot container (10).

For a double 20-foot heavy-load container truck (5) entering the lane, the laser scanner first performs an anti-lift test on the next 20-foot container (9), while the site portal crane (11) first hangs the next 20-foot container (9) and provides the position information to the PLC (15). Then the laser scanner (2) performs an anti-lift test on the previous 20-foot container (9) and lifts the previous 20-foot container (9).

General technicians in the technology field should realize that the above implementation cases are just used to explain the invention instead of limiting the invention. Only if it is in the range of essence spirit of the invention, changes or transformation of the above implementations cases will be involved in the scope of the claims.

## **CLAIMS**

1. A kind of automated container landing and lift prevention method for automatic loading and unloading operation, characterized in that: automatic lifting device, automated tilt adjuster, motor, motor driver, laser scanner, chassis twist-lock, container, system processor, PLC, hoist height signal, trolley position signal, gantry positioning device, container landing signal and field portal crane;

the mentioned automatic lifting device and automated tilt adjuster are installed besides the parking lane outside the automated terminal; and the mentioned laser scanner is installed in the automatic lifting device and automated tilt adjuster; moreover, the system processor controls the motor driver, adjusts the automatic lifting device and automated tilt adjuster so as to realize adjustment of rising-lowering height and tilt angle of the laser scanner; besides, the height and tilt angle data of the laser scanner is provided by the automatic lifting device encoder and the automated tilt adjuster encoder; the laser scanner traces and checks the chassis twist-lock, finds out mutation status of the lock and the chassis through the data measured by the laser scanner and the system processor, determines the standard three-dimensional coordinate of the X, Y and Z axial of the lock, and sends it to PLC to control position of the hoist and the chassis lock and realize accurate positioning;

the mentioned horizontal sweep of the laser scanner sends the measured data to the system processor to control the motor driver and drive the motor to rise or rotate, finds out the lock of the chassis, determines the three-dimensional coordinate of the lock and provides it to PLC; when placing container, the laser scanner would scan and measure the border position of the container, and calculate distance between the border position and the lock hole so as to realize accurate positioning of the container and the lock hole in the chassis, and automated container landing as well;

when performing the anti-lifting detection, the laser scanner horizontally scans and adjusts the height through the automatic lifting device, and determines the gap between the container and the chassis; when no obstacles are found, the system allows the hoist to move up and lift the container;

when the laser scanner scans and measures, it measures the front, lock, and container of the container truck, and displays the current container position information through the display screen for the container truck driver;

the mentioned automatic lifting device and the automatic tilt adjuster can be installed on the side of the portal crane on the artificially controlled site; with a height from the ground of about 2 meters, it can adjust the height and tilt angle of the laser scanner, horizontally scan the gap between the container chassis and the container, and the flat plat so as realize automatic container landing and anti-lift detection.

2. The method according to claim 1, characterized in that: the automatic lifting device and the automatic tilt adjuster comprise a limit control device, a mechanical arm, a lifting platform and a rotating module, which make the scanner can be moved up and down, and can be rotated forward and backward, and seek for lock position of the chassis through motor drive; moreover, the limit device control can prevent the motor from moving up and down beyond the range.

3. The method according to claim 1, characterized in that: the mentioned automatic rising device and automated tilt adjuster are installed besides the lane and thus they would not affect vehicle driving.

4. The method according to claim 1, characterized in that: if it is detected that the first lock is far away (greater than or equal to the length of a container), the front end of the vehicle is considered to be high; if the first lock is detected to be close, the rear end is considered high; according to the height, the approximate position of all the keyholes in the container chassis can be worked out; and moreover, the automatic lifting device and the automatic tilting adjuster can adjust the tilt angle of the laser scanner for accurate detection until all the locks are measured, and the accurate three-dimensional coordinates of all the locks are determined, thus achieving precise positioning of the container chassis.

5. The method according to claim 1, characterized in that: for the double 20-foot no-load container truck entering the lane, the laser scanner first detects the lock of the previous 20-foot container chassis and provides the position information to the PLC; the portal crane on the field first lands the previous 20-foot container, and then the scanner inspects lock of the next 20-foot container truck and provides location information to the PLC; then the crane lands the next 20-foot container.
6. The method according to claim 1, characterized in that: for the double 20-foot heavy-load container truck entering the lane, the laser scanner first detects the lock of the later 20-foot container chassis, and the portal crane on the field first conveys the later 20-foot container and provides the position information to the PLC; then, the laser scanner detects the previous 20-foot container and then conveys the previous 20-foot container.
7. The method according to claim 1, characterized in that: the container landing signal mentioned above provide height position when the container is lifted; and the signal of hoist height provides height information of the hoist.
8. The method according to claim 1, characterized in that: the gantry position locating device provides location information of the portal crane on the site; the trolley position signal provides location information of the portal crane on the site.
9. The method according to claim 1, characterized in that: the container chassis lock provides a target point of the measurement position, and determines the three-dimensional coordinate position information of the measured lock; in the three-dimensional coordinate, the X-axis represents a lateral movement direction of the trolley and the hoist; the Y axis represents the direction of the portal crane; and the Z axis represents the vertical direction of the lifting device.
10. The method according to claim 1, characterized in that: combination of the automatic tilt adjuster and the laser scanner can realize functions of 3D laser scanner.