

Method and Apparatus for Correcting
Running Track of Railless Crane

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The present invention relates to a method and apparatus for correcting a running track of a railless crane, capable of generating a signal for correcting a direction when the railless crane runs in a direction offset from a predetermined running direction.

Since a container stacking field generally occupies a wide area in a container yard, a railless crane which can move to a necessary container location in accordance with an amount of cargos is often used at such a place. This crane is driven by rubber tires and can freely run in every direction like an automobile.

Loading/unloading works performed by such a railless crane, however, are similar to those performed by a conventional railway crane. Therefore, the size of the railless crane is as large as that of the conventional railway crane, i.e., its crane span is about 20 m. For this reason, if containers are stacked in the crane span, an unskilled operator may bring the crane into contact with the containers.

It is an object of the present invention to

provide a method and apparatus for correcting a running track of such a manned railless straddle crane having tyred wheels and being freely steerable to lift and move containers.

According to the present invention, there is provided apparatus for correcting a running track of a manned railless straddle crane having tyred wheels and being freely steerable to lift and move containers, said crane being drivable over an area including a running passage defined by a plurality of spaced passive reference points;

said apparatus being adapted for mounting on the crane and comprising:

a running reference point detecting unit adapted to generate a running reference point detection signal when said crane is driven so that said unit passes adjacent a said reference point, said signal being representative of any lateral offset of the unit from said running passage;

a running speed measuring unit responsive to a tyred wheel of the crane to generate a signal representative of the running speed of the crane;

a running direction angle detecting unit responsive to a first azimuth signal representative of the absolute azimuth of the crane and a second azimuth signal representative of the predetermined absolute azimuth of the running passage to generate a signal representative of the running direction angle of the crane; and

a track control unit responsive to the running reference point detection signal, the running speed signal and the running direction angle signal to generate a track correction signal adapted for supply to a crane drive control system to tend to correct the running track of said crane to follow the detected running passage.

The present invention also provides a method of correcting a running track of a manned railless straddle crane having tyred wheels and being freely steerable to lift and move containers, said crane being drivable over an area including a running passage defined by plurality of spaced passive reference points;

said method comprising:

generating a running reference point detection signal when said crane is driven adjacent a said reference point, said signal being representative of any lateral offset of the crane from said running passage;

generating a signal representative of the running speed of the crane in response to a tyred wheel of the crane;

generating a signal representative of the running direction angle of the crane in response to a first azimuth signal representative of the absolute azimuth of the crane and a second azimuth signal representative of the predetermined absolute azimuth of the running passage; and

generating a track correction signal in response to the running reference point detection signal, the running speed signal and the running direction angle signal, said track correction signal being for supply to a crane drive control system to tend to correct the running track of said crane to follow the detected running passage.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram showing an embodiment of the present invention;

Fig. 2 is a plan view showing a container yard;

Fig. 3 is a side view showing a railless straddle crane;

Fig. 4 is a schematic view showing a running reference point detecting unit shown in Fig. 1; and

Fig. 5 is a view showing a running direction of the railless straddle crane.

Fig. 2 is a plan view showing a container yard. This container yard has six lanes A to F and each lane includes two container locations 1a and 1b. A railless straddle crane 2 can run along running passages 3 formed in the longitudinal direction of the container locations 1a and 1b and move to another lane through shift passages 4. Running reference points 5 are formed along each running passage 3 every 12 meters at positions indicated by a to h.

Fig. 3 is a side view showing the railless crane. Referring to Fig. 3, reference numerals 6a and 6b denote running rubber tires whose running direction can be set at 0° or 90°. In Fig. 3, the running direction is set at 0°.

5 Reference numeral 7 denotes a running reference point detecting unit located at a lower position, i.e., a leg portion of a railless portal crane structure 8. Reference point position detection of the railless crane 2 and detection of the running reference points 5 located on the

10 ground are performed by the running reference point detecting unit 7. Reference numeral 9 denotes a running speed measuring unit driven by the rubber tire 6b. In Fig. 3, only a motor 17b for driving the tire 6b is shown. A motor 17a (not shown), however, drives a tire (not shown)

15 located at a leg portion on the deep side of Fig. 3. The motor 17b drives the tire 6b via a known mechanism 18 including a joint, a reduction unit, a chain and the like. Referring to Fig. 3, reference numeral 6d denotes a tire supported by a yoke shaft 21 which is pivotally connected

20 to a bogie 20. The tire 6d determines a running direction of the crane structure 8 within the range of 90° upon pivoting of the yoke shaft 21.

Fig. 1 is a block diagram showing an embodiment of a railless crane running system constituted by adopting

25 an apparatus according to the present invention. Referring to Fig. 1, reference numeral 10 denotes a running track correcting apparatus; 7, the running reference point

detecting unit; 9, the running speed measuring unit; 11, the running direction angle detecting unit; 12, a timer; 13, an adder; 14, an integrator; and 15, a track control unit.

5 In accordance with a control signal supplied from the track control unit 15, a rotational speed of one of the crane running motors 17a and 17b is reduced, thereby steering the crane to the right or left. When a DC motor is used, the rotational speed is reduced by field-enhancing control which is widely used as a DC running motor driving system. In this control method, a driver manually operates a lever to select a motor to be field-enhanced. For example, in order to turn the crane to the right, a motor at the right side of a running direction is field-enhanced to reduce the rotational speed of the motor, thereby turning the crane to the right. A field-enhancing operation is performed as follows:

20 (a) A field-enhancing amount is set in advance and ON/OFF voltage (digital) control is performed to obtain the set value only when ON control is executed.

 (b) A field-enhancing amount is variably controlled in an analog manner (a variable range is set beforehand). Alternatively, the rotational speed of a motor at one side may be reduced by field-enhancing while the field of the other motor is weakened to increase its rotational speed, thereby improving steering characteristics.

The above field-enhancing and field-weakening control of a DC motor is known to those skilled in the art.

Each time the railless crane 2 passes through the running reference point 5, the running reference point detecting unit 7 outputs a track offset amount $L(0)$ between the running reference point on the running passage and the crane. For example, as shown in Fig. 4, the running reference point detecting unit 7 comprises a controller 71, a detection head 72, and a plurality of magnetic sensors 54a aligned on the detection head 72. In an actual unit, the magnetic sensors 74a comprise magnetic limit switches. That is, 80 magnetic sensors 74a are aligned at 5-mm pitches. The controller 71 calculates an offset amount by detecting which sensor of those arranged in line is activated when the detection head 72 passes over the magnetic plate 5 and outputs an analog or digital track offset amount. For example, the controller 71 calculates a distance between the center of the detection head and the center of an ON sensor and outputs the calculation result as an offset amount. The running direction angle detecting unit 11 comprises, e.g., a gyrocompass, detects an azimuth of the railless crane 2, and generates a signal proportional to the detected angle. The timer 12 is reset immediately after the crane passes through the running reference point 5 and outputs a signal representing an elapsed time thereafter. The timer 12 determines a calculation time of a digital computer and gives time

intervals P_0 , P_1 and P_2 shown in Fig. 5 to be described later. The running speed detecting unit 9 and the running direction angle (angular speed) detecting unit 11 always output current values, while the integrator 14 fetches data representing a time designated by the timer 12. The timer 12 is essential in digital calculations. The adder 13 calculates a crane running offset angle on the basis of the crane running direction angle detected by the running direction angle detecting unit 11 and the azimuth of the running passage 3. The integrator 14 calculates the track offset amount on the basis of the crane running offset angle calculated by the running speed measuring unit 9 and the adder 13 and an initial track offset amount detected by the running reference point detecting unit 7. When the railless crane 2 is offset from the running passage 3, the track control unit 15 generates a signal for correcting the offset on the basis of a signal supplied from the integrator 14. Reference numeral 16 denotes a running motor control unit. When the track control unit 15 generates a track correction signal, the running motor control unit 16 performs correction control of the running motors 17a and 17b in accordance with the signal.

An operation of the apparatus having the above arrangement will be described below. Assume that the railless crane 2 runs from the running reference point 5 at the position a to the running reference point 5 at the position d in the lane A as shown in Fig. 2. Since the

running reference point detecting unit 7 generates a running reference point signal $i(0)$ each time the railless crane 2 passes through the running reference point 5, the timer 12 outputs an elapsed time signal i representing an elapsed time after the running reference point signal $i(0)$ is generated. As a result, the running speed measuring unit 9 and the running direction angle detecting unit 11 respectively generate a running speed signal and a running direction angle signal based on the elapsed time signal i . On the basis of these signals and the signal supplied from the running reference point detecting unit 7, the adder 13 outputs a signal represented by the following equation (1), and the integrator 14 outputs a signal represented by the following equation (2):

$$\theta(t) = \theta_c(t) - \theta_{tg} \quad \dots(1)$$

$$L(i) = \int_0^i v(t) \cdot \sin|\theta(t)| \cdot dt + L(0) \quad \dots(2)$$

where

- $\theta(t)$: a crane running offset angle after t seconds
- $\theta_c(t)$: an output signal from the running direction angle detecting unit 11
- θ_{tg} : a target direction which is preset
- $L(i)$: a track offset amount after i seconds
- $v(t)$: an output signal from the running speed measuring unit 9
- $L(0)$: an initial track offset amount upon passing of the running reference point

$\sin|\theta(t)|$: a sine value of $\theta(t)$ obtained by
equation (1)

Therefore, on the basis of the running reference point signal, the running speed and the running direction angle signal, the track control unit 15 generates and supplies a track correction signal for returning the railless crane 2 to the running passage 3 to the running motor control unit 16. As a result, the running motors 17a and 17b are so controlled as to return the railless crane 2 to the running passage 3. In this case, the running motors 17a and 17b are located at both legs of the railless crane 2. Each motor is controlled by controlling a magnetic field in accordance with the track correction signal to adjust the speed of the motor, thereby suppressing the track offset below a predetermined value.

Fig. 5 shows a relationship between a predetermined reference line 18 and a crane running track 19 in units of time intervals. Referring to Fig. 5, P_0 to P_5 denote positions of the railless crane 2 when $i = 0$ to 5, respectively; $v(0)$ to $v(5)$, crane running speeds at the respective time intervals by vectors; $\theta(0)$ to $\theta(5)$, crane running offset angles at the respective time intervals; and $L(0)$ to $L(5)$, track offset amounts at the respective time intervals. Note that $L(0)$ is a value measured by the running reference point detecting unit 7 when the railless crane 2 passes through a running reference point 20 (this passing is detected by the detecting unit on the crane in

accordance with a magnetic plate at the running reference point on the ground); $\theta(0)$, a running offset angle of the crane 2 at the position of the running reference point 20; and P_0 , a point located on a line perpendicular to the
5 reference line 18 at the position of the running reference point 20.

As has been described above, according to the method and apparatus of the present invention, the track offset amount is calculated on the basis of the running
10 reference point detection signal, the running speed and the running direction angle, thereby correcting the track offset. Therefore, even an unskilled operator can correctly drive the railless crane in a target direction.

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CLAIMS

1. Apparatus for correcting a running track of a manned railless straddle crane having tyred wheels and being freely steerable to lift and move containers, said crane being drivable over an area including a running passage defined by a plurality of spaced passive reference points;

said apparatus being adapted for mounting on the crane and comprising:

a running reference point detecting unit adapted to generate a running reference point detection signal when said crane is driven so that said unit passes adjacent a said reference point, said signal being representative of any lateral offset of the unit from said running passage;

a running speed measuring unit responsive to a tyred wheel of the crane to generate a signal representative of the running speed of the crane;

a running direction angle detecting unit responsive to a first azimuth signal representative of the absolute azimuth of the crane and a second azimuth signal representative of the predetermined absolute azimuth of the running passage to generate a signal representative of the running direction angle of the crane; and

a track control unit responsive to the running reference point detection signal, the running speed signal and the running direction angle signal to generate a track correction signal adapted for supply to a crane drive control system to tend to correct the running track of said crane to follow the detected running passage.

2. A method of correcting a running track of a manned railless straddle crane having tyred wheels and being freely steerable to lift and move containers, said crane being drivable over an area including a running passage defined by plurality of spaced passive reference points;

said method comprising:

generating a running reference point detection signal when

said crane is driven adjacent a said reference point, said signal being representative of any lateral offset of the crane from said running passage;

generating a signal representative of the running speed of the crane in response to a tyred wheel of the crane;

generating a signal representative of the running direction angle of the crane in response to a first azimuth signal representative of the absolute azimuth of the crane and a second azimuth signal representative of the predetermined absolute azimuth of the running passage; and

generating a track correction signal in response to the running reference point detection signal, the running speed signal and the running direction angle signal, said track correction signal being for supply to a crane drive control system to tend to correct the running track of said crane to follow the detected running passage.

3. Apparatus for correcting a running track of a manned railless straddle crane, substantially as described herein with reference to the accompanying drawings.

4. A method according to Claim 2 and substantially as described herein with reference to the accompanying drawings.

