

Description

Title of Invention

METHOD AND APPARATUS FOR MEASURING THIRD RAIL

Technical Field

[0001] The present invention relates to a method and an apparatus for measuring a third rail. Specifically, the present invention involves installing one or a plurality of laser range-scanning sensors and measuring the state of installation and degree of use (degree of wear) of a third rail on the basis of data acquired from the sensors.

Background Art

[0002] A “third rail” refers to a third power-supplying rail, separate from the running rails and lain parallel to the running rails, that is used as one of the current collection methods in electric railways. Collector shoes that are mounted on vehicles slide along this third rail to supply electricity to the vehicles.

In the present description, third rails of the type in which, relative to the rail, the collector shoes slide over the upper side are defined as top-contact third rails, and those of the type in which the collector shoes slide over the lower surface are defined as bottom-contact third rails.

[0003] In other words, as illustrated in Fig. 7, a top-contact third rail 1 is lain by being installed face-upwards on an insulator 2. A protective plate 3 is suspended thereabove by means of brackets 4, which are attachment fixtures. On the other hand, as illustrated in Fig. 8, a bottom-contact third rail 5 is suspended face-downwards from the upper ends of brackets 6, and the upper surface thereof is covered by a protective plate 7.

In this application, the brackets 4, 6 refer to fixtures that support the third rails 1, 5, and that are installed at regular intervals.

[0004] The top-contact type is the scheme that is primarily used in Japan, whereas the bottom-contact type is primarily used in other countries. The present invention is for use with the bottom-contact type, and where not particularly designated, “third rail” = “bottom-contact third rail”.

As with normal power lines, high-voltage electrical currents flow through third rails. Therefore, conventionally, when measuring third rails, there are methods in which the power is cut and a worker takes the measurement directly, or methods in which non-contact measurements are made while voltage is still being applied. Non-contact measurement methods include those using lasers, and the method in the below-mentioned Patent

Document 1 has been proposed.

- [0005] Patent Document 1 is a method for measuring top-contact third rails, which are widely used in Japan, wherein the upper portions of brackets are detected by using sensors from above the top-contact third rail, and values from a plurality of similarly installed sensors are recorded.

Citation List

Patent Literature

- [0006] Patent Document 1: JP 2012-173254 A

Summary of Invention

Technical Problem

- [0007] In the above-mentioned Patent Document 1, the values from sensors directed towards the upper surface of a top-contact third rail can be used to measure the amount of displacement thereof and to detect the upper portions of the brackets.

However, in bottom-contact third rails, there is a problem in that there are no portions of the brackets exposed to the upper surface as described above, so Patent Document 1 cannot be used to detect (measure) the brackets.

- [0008] In other words, with the conventional art, there was a problem in that bottom-contact third rails could not be measured.

The present invention was made in consideration of the above-mentioned conventional art, and has, as an objective thereof, to use one or a plurality of laser range-scanning sensors and to measure the state of installation and degree of use (degree of wear) of a bottom-contact third rail on the basis of data acquired from the sensors.

Solution to Problem

- [0009] The apparatus for measuring a third rail according to claim 1 of the present invention, which solves the above-mentioned problem, is characterized by comprising a laser range-scanning sensor that can simultaneously contain a bottom-contact third rail and a running rail within a measurement range thereof; and a data processing unit that computes a position of the third rail, relative to the running rail, based on position data acquired by the laser range-scanning sensor.

- [0010] The apparatus for measuring a third rail according to claim 2 of the present invention, which solves the above-mentioned problem, is characterized by comprising, in addition to the features in claim 1, a recording device that stores the position data acquired by the laser range-scanning sensor; and a data writing unit that writes the position data

acquired by the laser range-scanning sensor in the recording device.

[0011] The apparatus for measuring a third rail according to claim 3 of the present invention, which solves the above-mentioned problem, is characterized in that, in addition to the features in claim 1, there are a plurality of the laser range-scanning sensors, each mounted on a vehicle that runs on the running rail.

[0012] The apparatus for measuring a third rail according to claim 4 of the present invention, which solves the above-mentioned problem, is characterized by comprising, in addition to the features in claim 3, a vehicle roll correction unit that calculates an inclination of the running rail relative to the vehicle based on position data acquired by each of two laser range-scanning sensors mounted on the vehicle, and that, based on the inclination, corrects each piece of the position data that has been acquired regarding the running rail so as to be horizontal relative to the vehicle.

[0013] The method for measuring a third rail according to claim 5 of the present invention, which solves the above-mentioned problem, is characterized by making a bottom-contact third rail and a running rail be simultaneously contained within a measurement range of a laser range-scanning sensor, and computing a position of the third rail relative to the running rail based on the position data acquired by the laser range-scanning sensor.

The method for measuring a third rail according to claim 6 of the present invention, which solves the above-mentioned problem, is characterized in that, in addition to the features in claim 5, the position data acquired by the laser range-scanning sensor is written and stored.

[0014] The method for measuring a third rail according to claim 7 of the present invention, which solves the above-mentioned problem, is characterized in that, in addition to the features in claim 5, there are a plurality of the laser range-scanning sensors, each mounted on a vehicle that runs on the running rail.

[0015] The method for measuring a third rail according to claim 8 of the present invention, which solves the above-mentioned problem, is characterized by comprising, in addition to the features in claim 7, the features of calculating an inclination of the running rail relative to the vehicle based on position data acquired by each of two laser range-scanning sensors mounted on the vehicle; and based on the inclination, correcting each piece of the position data that has been acquired regarding the running rail so as to be horizontal relative to the vehicle.

Advantageous Effects of Invention

[0016] The present invention provides the advantageous effects of allowing a bottom-contact third rail to be measured, and also of allowing the position of the third rail relative to

a running rail (or the center of a vehicle running on the running rail) to be computed by using laser range-scanning sensors to measure the third rail while simultaneously measuring the running rail. Specifically, the present invention provides the advantageous effect of being able to measure the amount of wear of a third rail, displacement or loss of protective plates (covers), and the displacement or loss of brackets.

Brief Description of Drawings

- [0017] Fig. 1 is a schematic diagram of a third rail measurement apparatus according to Embodiment 1 of the present invention.
- Fig. 2 is a schematic diagram of a third rail measurement apparatus according to Embodiment 2 of the present invention.
- Fig. 3 is a diagram for explaining measurement items (inspection items).
- Fig. 4 is a diagram for explaining the rolling of a vehicle.
- Fig. 5 is a flow chart for the third rail measurement method according to Embodiment 1 of the present invention.
- Fig. 6 is a flow chart for the third rail measurement method according to Embodiment 2 of the present invention.
- Fig. 7 relates to a top-contact third rail, and Fig. 7(a) is a section view and Fig. 7(b) is a front view.
- Fig. 8 relates to a bottom-contact third rail, and Fig. 8(a) is a section view and Fig. 8(b) is a front view.

Description of Embodiments

- [0018] [Embodiment 1]
<Embodiment applying basic concepts>
- A third rail measurement apparatus according to Embodiment 1 of the present invention is illustrated in Fig. 1.
- [0019] As illustrated in Fig. 1, the third rail measurement apparatus of the present example comprises a laser range-scanning sensor 10 that simultaneously contains a third rail 5, a bracket 6, a protective plate 7 and a running rail 8 (these will hereinafter be referred to as structures) within the measurement range thereof; a recording device 20 for storing position data acquired by this laser range-scanning sensor 10; a data writing unit 30 for writing the position data acquired by this laser range-scanning sensor 10 in the recording device 20; and a data processing unit 40 for computing values corresponding to respective measurement items (inspection items) relating to the structures based on the position data acquired by this laser range-scanning sensor 10.

[0020] A laser range-scanning sensor 10 is a generic term for scanning-type laser range-finding sensors. As illustrated in Fig. 1, a fan-shaped measurement range forming the angle θ , delimited by the dashed lines in the drawing, is irradiated by an infrared laser from a laser generator in the sensor, and the light reflected by structures is received by a light-receiving sensor so as to consecutively acquire the distances to structures in the scanning plane of the infrared laser and angular values representing the directions of radiation of the infrared laser. The acquired position data is in polar coordinates, in the form of range data in each direction.

[0021] The laser range-scanning sensor 10 is installed so as to be parallel to the sleeper direction orthogonal to the direction in which the third rail 5, the protective plate 7 and the running rail 8 are lain, in order to have the structures simultaneously be within the measurement range. The fan-shaped measurement range is a vertical plane having a certain elevation angle and depression angle relative to the horizontal direction.

The laser range-scanning sensor 10 is not limited to being a single device as illustrated in Fig. 1. Providing a plurality of devices yields the advantage that the precision can be improved by averaging the acquired position data.

[0022] As illustrated in Fig. 3, the values corresponding to the various measurement items computed by the data processing unit 40 include, relative to a height reference V, which is the upper edge of the running rail 8, a third rail height A, which is the vertical distance from the height reference V to the third rail 5, and a protective plate vertical distance B, which is the vertical distance from the height reference V to the protective plate 7, and relative to a horizontal distance reference H, which is the side surface of the running rail 8, a bracket horizontal distance C, which is the horizontal distance from this horizontal distance reference H to the bracket 6, and a protective plate horizontal distance D, which is the horizontal distance from this horizontal distance reference H to the protective plate 7. The third rail height A corresponding to each measurement item is a value relative to the running rail 8.

[0023] The data processing unit 40 converts the polar coordinates comprised of the distances to the structures and the angular values representing the radiation directions, which constitute the position data acquired by the laser range-scanning sensor 10, into orthogonal coordinates in the horizontal direction and the vertical direction (hereinafter referred to as “division of data into the respective inspection items”), and computes, as values corresponding to the respective measurement items, the third rail height A, the protective plate vertical distance B, the bracket horizontal distance C and the protective plate horizontal distance D (hereinafter referred to as “calculation of distances relative to reference values”).

[0024] In the present embodiment, a recording device 20 and a data writing unit 30 are provided, so the data processing unit 40 is able to perform the above-mentioned

computations by using, as the position data acquired by the laser range-scanning sensor 10, position data that has already been recorded in the recording device 20 by the data writing unit 30.

[0025] The method for measuring a third rail performed by the third rail measurement apparatus having the above-described structure will be explained with reference to the flow chart shown in Fig. 5.

First, the third rail 5, the bracket 6, the protective plate 7 and the running rail 8, which are the structures, are made to be simultaneously contained within the measurement range of the laser range-scanning sensor 10, and the position data acquired by the laser range-scanning sensor 10 is written into the recording device 20 by means of the data writing unit 30, and stored (step S1).

[0026] Next, the position data acquired by the laser range-scanning sensor 10 is divided into the respective inspection items by the data processing unit 40 (step S2).

Subsequently, based on the data divided into the respective inspection items, the distances from the reference values are calculated by the data processing unit 40 (step S3).

[0027] As explained above, the present embodiment provides the advantageous effects of allowing the bottom-contact third rail 5 to be measured, and also allowing the values A, B, C and D corresponding to the respective measurement items to be computed relative to the running rail 8, as horizontal or vertical distances from the running rail 8, by measuring the third rail 5 while simultaneously measuring the running rail 8.

[0028] Specifically, as illustrated in Fig. 3, as values corresponding to the respective measurement items relative to the running rail 8, it is possible compute a third rail height A, a protective plate vertical distance B, a bracket horizontal distance C and a protective plate horizontal distance D. Stated differently, this means that the present embodiment has the advantage of being able to measure the height (amount of wear) of the third rail 5, the displacement or loss of the protective plate 7, and the displacement or loss of the bracket 6.

Additionally, since the structures can be consecutively measured, it is possible to determine whether a bracket 6, which is a support point of the third rail 5, is present or absent based on the presence or absence of the measurement value, "bracket horizontal distance C".

[0029] Furthermore, the present embodiment has the advantage that there are no restrictions on the positions of the running rail 8, the third rail 5 and the bracket 6 in the measurement range of the laser range-scanning sensor 10, and the installation position of the laser range-scanning sensor 10, as long as it is lower than the contact surface of the third rail 5.

Additionally, similar advantageous effects are obtained even when using the center

of a vehicle (not illustrated in the drawings) that runs on the running rail 8 as the reference instead of the running rail 8.

[0030] In other words, the present embodiment provides the advantageous effect that, when the laser range-scanning sensor 10 is mounted on a vehicle (not illustrated in the drawings) running on the running rail 8, it is possible to determine the installation conditions of the structures relative to the vehicle, without taking into consideration the rolling of the vehicle on which the laser range-scanning sensor 10 is mounted.

[0031] [Embodiment 2]

<Embodiment using two laser range-scanning sensors>

The third rail measurement apparatus according to Embodiment 2 of the present invention is illustrated in Fig. 2.

Whereas the structure in Embodiment 1 is for use with a third rail 5 on a single side, the present embodiment, as illustrated in Fig. 2, is for use with third rails 5a, 5b on both sides, and has one laser range-scanning sensor additionally installed coaxially in the sleeper direction.

[0032] In other words, the third rail measurement apparatus of the present embodiment, as illustrated in Fig. 2, has a laser range-scanning sensor 10a simultaneously containing the third rail 5a, a bracket 6a, a protective plate 7a and a running rail 8a (hereinafter referred to as structures) in the measurement range thereof, and a laser range-scanning sensor 10b simultaneously containing the third rail 5b, a bracket 6b, a protective plate 7b and a running rail 8b (hereinafter referred to as structures) in the measurement range thereof, respectively installed so as to face in opposite directions in the sleeper direction. That is to say, as illustrated in Fig. 4, with respect to the laser range-scanning sensor 10a, a laser range-scanning sensor 10b is additionally installed on the vehicle 9, on the other side, rotated by 180 degrees in the sleeper direction.

[0033] Additionally provided are a recording device 20 for storing position data acquired by each of the laser range-scanning sensors 10a, 10b, a data writing unit 30 for writing the position data acquired by each of the laser range-scanning sensors 10a, 10b in the recording device 20, and a data processing unit 40 for computing values corresponding to the respective measurement items relating to the third rails 5a, 5b, the running rails 8a, 8b and the brackets 6a, 6b based on the position data acquired by each of the laser range-scanning sensors 10a, 10b.

[0034] Furthermore, the present embodiment is characterized by having, in addition to the recording device 20, the data writing unit 30 and the data processing unit 40, a vehicle roll correction unit 50 for calculating vehicle roll from the position data of the running rails 8a, 8b acquired by the two laser range-scanning sensors 10a, 10b, and correcting for the roll.

Otherwise, the present embodiment is the same as Embodiment 1.

[0035] In other words, as illustrated in Fig. 4, when the rolling and the like of the vehicle 9 on which the two laser range-scanning sensors 10a, 10b are mounted causes them to be inclined, the position data for the running rails 8a, 8b acquired by each of the two laser range-scanning sensors 10a, 10b becomes data in which the running rails 8a, 8b are inclined with respect to the vehicle 9. However, this is only in appearance, and in actuality, the running rails 8a, 8b are not inclined, and it is the vehicle 9 that is inclined by rolling.

[0036] Therefore, the vehicle roll correction unit 50 calculates the inclination of the running rails 8a, 8b (hereinafter referred to as “rail inclination calculation”) with respect to the vehicle 9 based on the position data of the running rails 8a, 8b acquired by each of the two laser range-scanning sensors 10a, 10b, estimates the vehicle roll from this inclination, and makes corrections (hereinafter referred to as “vehicle roll correction”) so that the position data acquired for each of the running rails 8a, 8b is made horizontal relative to the vehicle 9. As a result thereof, the present embodiment has the advantage that it is possible to cancel out the influence of the rolling of the vehicle 9, which cannot be determined in Embodiment 1.

[0037] In this case, in comparison to situations in which the vehicle 9 is not rolling, when the vehicle 9 is rolling as illustrated in Fig. 4, the angular value representing the direction of the running rail 8a acquired by the laser range-scanning sensor 10a is larger by the amount of inclination of the running rails 8a, 8b relative to the vehicle 9, and conversely, the angular value representing the direction of the running rail 8b acquired by the laser range-scanning sensor 10b is smaller by the amount of inclination of the running rails 8a, 8b relative to the vehicle 9.

[0038] For this reason, as the vehicle roll correction, the vehicle roll correction unit 50, for example, subtracts the inclination of the running rails 8a, 8b relative to the vehicle 9 from the angular value representing the direction of the running rail 8a acquired by the laser range-scanning sensor 10a, and conversely, adds the inclination of the running rails 8a, 8b relative to the vehicle 9 to the angular value representing the direction of the running rail 8b acquired by the laser range-scanning sensor 10b.

[0039] The method for measuring third rails performed by the third rail measurement apparatus having the above-described structure will be explained with reference to the flow chart shown in Fig. 6.

First, the third rail 5a, the bracket 6a, the protective plate 7a and the running rail 8a, which are structures, are made to be simultaneously contained within the measurement range of the laser range-scanning sensor 10a, and the third rail 5b, the bracket 6b, the protective plate 7b and the running rail 8b, which are structures, are made to be simultaneously

contained within the measurement range of the laser range-scanning sensor 10b. Then, the position data acquired by each of the laser range-scanning sensors 10a, 10b is written into the recording device 20 by means of the data writing unit 30, and stored (step T1).

[0040] Next, the vehicle roll correction unit 50 calculates the rail inclination (step T2) and performs vehicle roll correction (step T3).

Subsequently, the data processing unit 40 divides the position data acquired by each of the laser range-scanning sensors 10a, 10b into the respective inspection items (step T4), and calculates the distances from the reference values based on the data divided into the respective inspection items (step T5).

[0041] As explained above, in addition to providing advantageous effects similar to those of Embodiment 1, the present embodiment calculates the inclination of the running rails 8a, 8b relative to the vehicle 9 based on position data acquired by each of the two laser range-scanning sensors 10a, 10b mounted on the vehicle 9 (rail inclination calculation), and based on this inclination, corrects the position data acquired for each of the running rails 8a, 8b so as to be horizontal relative to the vehicle 9 (vehicle roll correction). Thus, the present embodiment has the advantage of being able to cancel out the influence of rolling even when the vehicle 9 is inclined by rolling.

[0042] In the present embodiment, the laser range-scanning sensors 10a, 10b are each mounted on the vehicle 9 running on the running rails 8a, 8b, but the recording device 20, the data writing unit 30, the data processing unit 40 and the vehicle roll correction unit 50 do not always need to be mounted on the vehicle, and they may be installed on the ground and may be capable of communicating with the laser range-scanning sensors 10a, 10b via a network.

Industrial Applicability

[0043] The present invention is widely applicable to industry as a method and an apparatus for measuring third rails.

Reference Signs List

[0044]	1	Top-contact third rail
	2	Insulator
	3, 7, 7a, 7b	Protective plate
	4, 6, 6a, 6b	Bracket
	5, 5a, 5b	Bottom-contact third rail
	8, 8a, 8b	Running rail
	9	Vehicle

10, 10a, 10b	Laser range-scanning sensor
20	Recording device
30	Data writing unit
40	Data processing unit
50	Vehicle roll correction unit

Claims

- [Claim 1] An apparatus for measuring a third rail, comprising:
 a laser range-scanning sensor that can simultaneously contain a bottom-contact third rail and a running rail within a measurement range thereof; and
 a data processing unit that computes a position of the third rail, relative to the running rail, based on position data acquired by the laser range-scanning sensor.
- [Claim 2] The apparatus for measuring a third rail as in claim 1, comprising:
 a recording device that stores the position data acquired by the laser range-scanning sensor; and
 a data writing unit that writes the position data acquired by the laser range-scanning sensor in the recording device.
- [Claim 3] The apparatus for measuring a third rail as in claim 1, wherein there are a plurality of the laser range-scanning sensors, each mounted on a vehicle that runs on the running rail.
- [Claim 4] The apparatus for measuring a third rail as in claim 3, comprising a vehicle roll correction unit that calculates an inclination of the running rail relative to the vehicle based on position data acquired by each of two laser range-scanning sensors mounted on the vehicle, and that, based on the inclination, corrects each piece of the position data that has been acquired regarding the running rail so as to be horizontal relative to the vehicle.
- [Claim 5] A method for measuring a third rail, comprising steps of making a bottom-contact third rail and a running rail be simultaneously contained within a measurement range of a laser range-scanning sensor, and computing a position of the third rail relative to the running rail based on position data acquired by the laser range-scanning sensor.
- [Claim 6] The method for measuring a third rail as in claim 5, wherein the position data acquired by the laser range-scanning sensor is written and stored.
- [Claim 7] The method for measuring a third rail as in claim 5, wherein there are a plurality of the laser range-scanning sensors, each mounted on a vehicle that runs on the running rail.
- [Claim 8] The method for measuring a third rail as in claim 7, comprising:
 calculating an inclination of the running rail relative to the vehicle based on position

data acquired by each of two laser range-scanning sensors mounted on the vehicle; and
based on the inclination, correcting each piece of the position data that has been
acquired regarding the running rail so as to be horizontal relative to the vehicle.