position measurement device according to a first embodiment.

FIG. 2 is a diagram illustrating an exemplary case where measurement of a rail on which a railroad vehicle is running is performed using the measurement vehicle according to the first embodiment illustrated in FIG. 1.

FIG. 3 is a diagram illustrating another exemplary configuration of the measurement vehicle according to the first embodiment illustrated in FIG. 1.

FIG. 4 is a diagram illustrating an exemplary configuration in which the measurement vehicle illustrated in FIG. 3 is installed on a road-rail truck.

FIG. 5 is a diagram illustrating an exemplary configuration in which the rail position measurement device according to the first embodiment is installed on a railroad vehicle.

FIG. 6 is a diagram illustrating another exemplary configuration in which the rail position measurement device according to the first embodiment is installed on the railroad vehicle.

FIG. 7 is a block diagram illustrating a functional configuration of the rail position measurement device according to the first embodiment to which an automatic position adjustment function for a laser scanner is added.

FIG. 8 is a block diagram illustrating a functional configuration of the rail position measurement device according to the first embodiment in which the automatic position adjustment for the laser scanner is realized by a base adjustment device.

FIG. 9 is a diagram explaining the effect of a derailment prevention guard on the irradiation position of the laser scanner.

FIG. 10 is a diagram explaining a laser light source position that is preferable when the derailment prevention

regarded as a straight line part can be the entire length of the contour L1 of the rail web.

[0063] Over the entire length of the contour L2 of the rail bottom, if 50% or more of the measurement points are obtained from the uppermost point C of the rail bottom side surface, the contour L2 of the rail web can be estimated. If 70% or more of the measurement points are obtained from the uppermost point C of the rail bottom side surface, the contour L2 of the rail web can be estimated with a high degree of accuracy. With regard to the contour L2 of the rail bottom, in the same way as the rail web, a thick line part in the drawing that is regarded as a straight line part can be the entire length of the contour L2 of the rail bottom.

[0064] FIG. 14 is a diagram examining in further detail the laser irradiation position Vh illustrated in FIG. 13. In FIG. 14, the point Vh located on an extension of a straight line K7 means a laser irradiation position located on the vertical line P on the track center represented by a dashed-dotted line and located at the highest position on a laser optical path for enabling the measurement of the uppermost point C of the rail bottom side surface. In this regard, the distance in a rail width direction between the uppermost point C of the rail bottom side surface and the lowermost point A of the rail head side surface is denoted by d. The distance in a vertical direction between the lowermost point A of the rail head side surface and the rail plane M1 is denoted by a. The distance in the vertical direction between the uppermost point C of the rail bottom side surface and the rail plane M1 is denoted by c. The distance between the rails (hereinafter referred to as a "gauge distance") is denoted by G. The height of the laser irradiation position is denoted by Hh. In this

for scanning the rail web and the rail bottom are maximized whereby more measurement points can be obtained. Therefore, it is possible to obtain such an effect that the noise intensity increases and the measurement accuracy is improved owing to the large number of measurement points.

[0088] FIG. 33 is a diagram illustrating a computation result for the laser irradiation positions for enabling the measurement of two or more points on each of the rail web and the rail bottom. In order to obtain two or more measurement points on both the rail web and the rail bottom, each of the optical path angles φ1 and φ2 needs to be set at 0.144° or greater. Therefore, assuming that a laser scanner that measures, for example, 5000 points by making one round of 360° is used for, for example, the rails having the respective exemplary numerical values illustrated in FIGS. 18 to 21, then, as illustrated in FIG. 33, the laser irradiation position for the 60 kg rail with the standard gauge only needs to be set within a range of 1006 mm to 2339 mm, the laser irradiation position for the 50 kgN rail with the standard gauge only needs to be set within a range of 873 mm to 1955 mm, and the laser irradiation position for the 50 kgN rail with the narrow gauge only needs to be set within a range of 619 mm to 1509 mm.

[0089] FIG. 34 is a diagram illustrating another exemplary configuration of the rail position measurement device according to the third embodiment. The rail position measurement device illustrated in FIG. 34 is configured in such a manner that the laser position adjustment device 44 in the configuration in FIG. 7 includes an input display unit 50 and a storage unit 52. Components which are the same as or equivalent to those in FIG. 7 are denoted by the same reference signs, and

CLAIMS

1. A rail position measurement device that measures a three-dimensional position of a rail using a measurement vehicle, the rail position measurement device comprising:

a position posture measurement device installed on the measurement vehicle to measure a position and a posture of the measurement vehicle; and

a laser scanner that is a sensor installed on the measurement vehicle so as to be capable of irradiating at least a web and a bottom of a side surface of the rail with laser light and used for measuring the three-dimensional position of the rail.

2. The rail position measurement device according to claim 1, comprising a laser position adjustment device installed on the measurement vehicle and capable of moving a position of the laser scanner in an up-down direction.

3. The rail position measurement device according to claim 2, comprising a calculation unit installed on the measurement vehicle to calculate, on a basis of measurement information on any of the laser scanner and the position posture measurement device, a position of the laser scanner that enables at least the web and the bottom of the side surface of the rail to be irradiated with the laser light, wherein

the laser position adjustment device controls the position of the laser scanner on a basis of information from the calculation unit.

4. The rail position measurement device according to any one of claims 1 to 3, wherein the laser scanner is installed on the laser position adjustment device.

5. The rail position measurement device according to any one of claims 2 to 4, wherein the laser position adjustment device includes, in addition to a movable mechanism in the up-down direction, a movable mechanism in a horizontal direction orthogonal to both the up-down direction and a travelling direction of the measurement vehicle.

6. The rail position measurement device according to any one of claims 1 to 3, comprising a base unit equipped with the position posture measurement device and the laser scanner, wherein

the laser position adjustment device is an adjustment device configured to be capable of moving a position of the base unit in the up-down direction.

7. The rail position measurement device according to any one of claims 3 to 6, wherein the calculation unit calculates the position of the laser scanner on a basis of presence or absence of a derailment prevention guard.

8. The rail position measurement device according to any one of claims 3 to 6, wherein

the calculation unit further includes a derailment prevention guard detection unit to detect presence or absence of a derailment prevention guard from the measurement information obtained by the laser scanner, and

the calculation unit calculates the position of the laser scanner on a basis of a detection result from the derailment prevention guard detection unit.

9. The rail position measurement device according to any one of claims 3 to 6, comprising a track database to store

track data including gauge information at a track position and information on presence or absence of a derailment prevention guard along a running track, wherein

the calculation unit calculates the position of the laser scanner on a basis of the track data and the measurement information obtained by the position posture measurement device.

position measurement device according to a first embodiment.

FIG. 2 is a diagram illustrating an exemplary case where measurement of a rail on which a railroad vehicle is running is performed using the measurement vehicle according to the first embodiment illustrated in FIG. 1.

FIG. 3 is a diagram illustrating another exemplary configuration of the measurement vehicle according to the first embodiment illustrated in FIG. 1.

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FIG. 7 is a block diagram illustrating a functional configuration of the rail position measurement device according to the first embodiment to which an automatic position adjustment function for a laser scanner is added.

FIG. 8 is a block diagram illustrating a functional configuration of the rail position measurement device according to the first embodiment in which the automatic position adjustment for the laser scanner is realized by a base position adjustment device.

FIG. 9 is a diagram explaining the effect of a derailment prevention guard on the irradiation position of the laser scanner.

FIG. 10 is a diagram explaining a laser light source position that is preferable when the derailment prevention

regarded as a straight line part can be the entire length of the contour L1 of the rail web.

[0063] Over the entire length of the contour L2 of the rail bottom, if 50% or more of the measurement points are obtained from the uppermost point C of the rail bottom side surface, the contour L2 of the rail bottom can be estimated. If 70% or more of the measurement points are obtained from the uppermost point C of the rail bottom side surface, the contour L2 of the rail bottom can be estimated with a high degree of accuracy. With regard to the contour L2 of the rail bottom, in the same way as the rail web, a thick line part in the drawing that is regarded as a straight line part can be the entire length of the contour L2 of the rail bottom.

[0064] FIG. 14 is a diagram examining in further detail the laser irradiation position Vh illustrated in FIG. 13. In FIG. 14, the point Vh located on an extension of a straight line K7 means a laser irradiation position located on the vertical line P on the track center represented by a dashed-dotted line and located at the highest position on a laser optical path for enabling the measurement of the uppermost point C of the rail bottom side surface. In this regard, the distance in a rail width direction between the uppermost point C of the rail bottom side surface and the lowermost point A of the rail head side surface is denoted by d. The distance in a vertical direction between the lowermost point A of the rail head side surface and the rail plane M1 is denoted by a. The distance in the vertical direction between the uppermost point C of the rail bottom side surface and the rail plane M1 is denoted by c. The distance between the rails (hereinafter referred to as a "gauge distance") is denoted by G. The height of the laser irradiation position is denoted by Hh. In this

for scanning the rail web and the rail bottom are maximized, whereby more measurement points can be obtained. Therefore, it is possible to obtain such an effect that the noise tolerance increases and the measurement accuracy is improved owing to the large number of measurement points.

[0088] FIG. 33 is a diagram illustrating a computation result for the laser irradiation positions for enabling the measurement of two or more points on each of the rail web and the rail bottom. In order to obtain two or more measurement points on both the rail web and the rail bottom, each of the optical path angles φ1 and φ2 needs to be set at 0.144° or greater. Therefore, assuming that a laser scanner that measures, for example, 5000 points by making one round of 360° is used for, for example, the rails having the respective exemplary numerical values illustrated in FIGS. 18 to 21, then, as illustrated in FIG. 33, the laser irradiation position for the 60 kg rail with the standard gauge only needs to be set within a range of 1006 mm to 2339 mm, the laser irradiation position for the 50 kgN rail with the standard gauge only needs to be set within a range of 873 mm to 1955 mm, and the laser irradiation position for the 50 kgN rail with the narrow gauge only needs to be set within a range of 619 mm to 1509 mm.

[0089] FIG. 34 is a diagram illustrating another exemplary configuration of the rail position measurement device according to the third embodiment. The rail position measurement device illustrated in FIG. 34 is configured in such a manner that the laser position adjustment device 44 in the configuration in FIG. 7 includes an input display unit 50 and a storage unit 52. Components which are the same as or equivalent to those in FIG. 7 are denoted by the same reference signs, and

CLAIMS

1. A rail position measurement device that measures a three-dimensional position of a rail using a measurement vehicle, the rail position measurement device comprising:

a position posture measurement device installed on the measurement vehicle to measure a position and a posture of the measurement vehicle;

a laser scanner that is a sensor installed on the measurement vehicle so as to be capable of irradiating at least a web and a bottom of a side surface of the rail with laser light and used for measuring the three-dimensional position of the rail; and

a laser position adjustment device installed on the measurement vehicle and capable of moving a position of the laser scanner in an up-down direction.

2. The rail position measurement device according to claim 1, comprising a calculation unit installed on the measurement vehicle to calculate, on a basis of measurement information on any of the laser scanner and the position posture measurement device, a position of the laser scanner that enables at least the web and the bottom of the side surface of the rail to be irradiated with the laser light, wherein

the laser position adjustment device controls the position of the laser scanner on a basis of information from the calculation unit.

3. The rail position measurement device according to claim 1 or 2, wherein the laser scanner is installed on the laser position adjustment device.

4. The rail position measurement device according to any one of claims 1 to 3, wherein the laser position adjustment device includes, in addition to a movable mechanism in the up-down direction, a movable mechanism in a horizontal direction orthogonal to both the up-down direction and a travelling direction of the measurement vehicle.

5. The rail position measurement device according to any one of claim 1 or 2, comprising a base unit equipped with the position posture measurement device and the laser scanner, wherein

the laser position adjustment device is an adjustment device configured to be capable of moving a position of the base unit in the up-down direction.

6. The rail position measurement device according to any one of claims 2 to 5, wherein the calculation unit calculates the position of the laser scanner on a basis of presence or absence of a derailment prevention guard.

7. The rail position measurement device according to any one of claims 2 to 5, wherein

the calculation unit further includes a derailment prevention guard detection unit to detect presence or absence of a derailment prevention guard from the measurement information obtained by the laser scanner, and

the calculation unit calculates the position of the laser scanner on a basis of a detection result from the derailment prevention guard detection unit.

8. The rail position measurement device according to any one of claims 2 to 5, comprising a track database to store track data including gauge information at a track position

and information on presence or absence of a derailment prevention guard along a running track, wherein

the calculation unit calculates the position of the laser scanner on a basis of the track data and the measurement information obtained by the position posture measurement device.

9. The rail position measurement device according to any one of claims 1 to 8, wherein the laser scanner scans a plane orthogonal to the travelling direction of the measurement vehicle or a plane inclined at a preset angle in the travelling direction from the plane orthogonal to the travelling direction of the measurement vehicle.

10. A calculation unit that is used for a rail position measurement device that measures a three-dimensional position of a rail using a measurement vehicle, the calculation unit comprising:

a position calculation unit to calculate a scanner position with respect to the rail from measurement information obtained by a laser scanner that is a sensor installed on the measurement vehicle so as to be capable of irradiating at least a web and a bottom of a side surface of the rail with laser light and used for measuring the three-dimensional position of the rail; and

a laser position calculation unit to compute a movement amount or a scanner position of the laser scanner in an up-down direction on a basis of a calculation result from the position calculation unit and to transmit information on the movement amount or the scanner position to a laser position adjustment device capable of moving a position of the laser scanner in the up-down direction.

11. A calculation unit that is used for a rail position measurement device that measures a three-dimensional position of a rail using a measurement vehicle, the calculation unit comprising:

a position calculation unit to calculate a scanner position with respect to the rail from measurement information obtained by a laser scanner that is a sensor installed on the measurement vehicle so as to be capable of irradiating at least a web and a bottom of a side surface of the rail with laser light and used for measuring the three-dimensional position of the rail; and

a base position computation unit to compute a movement amount or a movement position of a base unit equipped with the laser scanner in an up-down direction on a basis of a calculation result from the position calculation unit and to transmit the movement amount or the movement position to a base position adjustment device capable of moving a position of the base unit in the up-down direction.