

DESCRIPTION

TITLE OF INVENTION: FLANGE-TO-FLANGE GAP MEASURING DEVICE,
PROGRAM, AND METHOD

5 Technical Field

[0001] The present invention relates to a technique for measuring a gap or a gap difference between flanges tightened by a bolt and a nut with a gasket interposed therebetween.

Background Art

10 [0002] Pipe conduits such as pipes and pumps are tightened with use of a plurality of bolts and nuts attached to peripheries of flanges formed at ends of the pipe conduits with a gasket interposed between the flanges.

In tightening the pipe conduits or the like, the pipe
15 conduits are required to be secured in a state in which the flanges are kept parallel by tightening the gasket between the flanges evenly. Therefore, it is essential to measure and manage a gap between the flanges.

In the measurement of the gap between the members, known
20 is a jig measuring a gap between members in which a gauge base straddling the members is provided, in which a wedge-shaped gauge member supported by a scale shaft is inserted into the gap between the members, and in which the insertion amount of the gauge member is converted into rotation of a dial (for
25 example, Patent Literature 1).

In contrast to such mechanical measurement, known is a technique for measuring a gap or a difference by capturing an irradiation image of slit light by means of an imaging device (for example, Patent Literature 2 and Patent Literature 3).

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Citation List

Patent Literature

[0003] Patent Literature 1: JP 2015-59755 A

Patent Literature 2: JP 2003-315020 A

Patent Literature 3: JP 2015-45571 A

Summary of Invention

Technical Problem

5 [0004] In tightening the pipe conduits or the like with use
of the flanges, it is essential to make center axes of the
flanges between which the gasket is interposed correspond to
each other, to evenly apply bolt tightening axial forces, and
to keep the flanges parallel to each other. In a case in which
10 the center axes of the flanges do not correspond, peripheral
surfaces of the flanges are misaligned, which causes a gap or
a difference. In a case in which there is a difference in the
axial force among the plurality of bolts, the gap between the
flanges changes due to the effect of elastic interaction
15 caused by the rigidity of the flanges and the gasket. The
state in which such a change in the gap occurs between the
flanges means a state in which so-called uneven tightening
occurs. These phenomena depend on the skill level and
carelessness of a person in charge of handling, and in a case
20 in which any of these phenomena is left untreated, a problem
occurs in which seal accuracy between the flanges is lowered.

However, in the gap measurement between the members, in
which the wedge-shaped gauge member is inserted (Patent
Literature 1), it is necessary to prepare a gauge member
25 corresponding to the flanges to be measured, which is inferior
to gap measurement using a feeler gauge.

A circular-type flange is often used as the flange for
use in tightening the pipe conduits or the like. In measuring
a gap or a gap difference on the circumferential surfaces,
30 there is a problem in which positioning is extremely difficult,
and in which positioning accuracy has a significant influence
on measurement accuracy.

In such seal handling between the flanges, a large number
of bolts must be tightened on each flange, and moreover, it is

necessary to perform the tightening a plurality of times. Therefore, time required to measure the gap between the flanges is desirably short, and in a case in which the plurality of measurement operations are time-consuming, there is a problem in which the handling time is extended. In a case in which the person in charge of handling neglects the gap measurement, there is a problem in which the case may cause the seal accuracy to be lowered.

[0005] Patent Literature 1 to Patent Literature 3 do not disclose or suggest such requirements and problems and do not disclose or suggest a configuration or the like that solves the requirements and problems.

[0006] Therefore, in view of the above problems, an object of the present invention is to facilitate positioning of a measurement position with respect to peripheral surfaces of flanges and measurement between the flanges, and to increase measurement accuracy.

Solution to Problem

[0007] To achieve the above object, as an aspect of a flange-to-flange gap measuring device according to the present invention, a flange-to-flange gap measuring device measuring a gap between flanges tightened by a plurality of bolts and nuts with a gasket interposed between the flanges includes a light irradiation unit that emits thin light to generate thin light images on the flanges, the gap between the flanges being interposed between the thin light images; an imaging unit that acquires an image including the thin light images; and a measurement unit that extracts thin light image data and flange edge data from the image and measures the gap or a gap difference between the flanges.

In this flange-to-flange gap measuring device, the light irradiation unit may cause the thin light images to be generated at a measurement position related to a position of

the bolt or a bolt tightening position.

This flange-to-flange gap measuring device may further include an information presenting unit that presents a measurement result of the gap or the gap difference in relation to identification information of the flange, the position of the bolt, or the bolt tightening position.

This flange-to-flange gap measuring device may further include a housing that inserts a positioning guide in the gap between the flanges and is positioned at a measurement position of the flanges. The positioning guide may include abutting units that abut on peripheral surfaces of the flanges with the measurement position interposed between the abutting units, and a guide projection formed at a part of the abutting units to be inserted in the gap. The housing may be positioned at the measurement position by the abutting units and the guide projection.

In this flange-to-flange gap measuring device, the housing may be provided with a grip unit and an imaging switch, and the imaging switch may be operable while the grip unit is gripped.

This flange-to-flange gap measuring device may further include a communication unit that transmits measurement data, and the measurement data may be provided to an information terminal connected to the communication unit by wire or wirelessly.

[0008] To achieve the above object, as an aspect of a program according to the present invention, a program causes a computer to fulfill a function of emitting thin light from a housing to generate thin light images on flanges, a gap between the flanges being interposed between the thin light images, a function of acquiring an image including the thin light images, and a function of extracting thin light image data and flange edge data from the image and measuring the gap or a gap difference between the flanges.

This program may cause the computer to fulfill a function of presenting a measurement result of the gap or the gap difference in relation to identification information of the flange, a position of a bolt, or a bolt tightening position.

5 [0009] To achieve the above object, as an aspect of a flange-to-flange gap measuring method according to the present invention, a flange-to-flange gap measuring method measuring a gap between flanges tightened by a plurality of bolts and nuts with a gasket interposed between the flanges includes
10 positioning a housing at a measurement position between the flanges, emitting thin light by means of a light irradiation unit to generate thin light images on the flanges, the gap between the flanges being interposed between the thin light images, acquiring an image including the thin light images by
15 means of an imaging unit, and extracting thin light image data and flange edge data from the image and measuring the gap or a gap difference between the flanges by means of a measurement unit.

This flange-to-flange gap measuring method may further
20 include presenting a measurement result of the gap or the gap difference in relation to identification information of the flange, a position of a bolt, or a bolt tightening position.

Advantageous Effects of Invention

25 [0010] According to the present invention, any of the following effects can be obtained.

(1) A housing of a measuring device can easily and accurately be positioned at a measurement position of a gap between flanges, and the gap or a gap difference at the
30 measurement position can be measured easily and quickly.

(2) In a seal operation for tightening a bolt of the flanges, the gap or the gap difference can be measured with high accuracy without taking time and labor for a measurement operation.

(3) Reliability of the seal operation can be improved.

[0011] Then, other objects, features, and advantages of the present invention will become more apparent by referring to the accompanying drawings and embodiments.

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Brief Description of Drawings

[0012] Fig. 1 illustrates a configuration example of a flange-to-flange gap measuring device according to a first embodiment.

10 Fig. 2 illustrates, in A, an example of gap measuring processing, and in B, an example of gap difference measuring processing.

Fig. 3 is a flowchart illustrating an example of flange-to-flange gap measuring processing.

15 Fig. 4 illustrates a configuration example of a flange-to-flange gap measuring device according to a second embodiment.

Fig. 5 is a perspective view illustrating the flange-to-flange gap measuring device.

20 Fig. 6 is a partial cross-sectional view illustrating an internal configuration example of the flange-to-flange gap measuring device.

Fig. 7 illustrates an example of a measurement operation for the flange-to-flange gap measuring device.

25 Fig. 8 illustrates an example of a state in which light is emitted to a measurement position.

Fig. 9 illustrates a configuration example of a control unit.

30 Fig. 10 illustrates an example of flange-to-flange gap measurement results.

Fig. 11 is a flowchart illustrating an example of flange-to-flange gap measuring processing.

Fig. 12 illustrates a configuration example of a flange-to-flange gap measuring system according to a third embodiment.

Fig. 13 illustrates an example of display of measurement results.

Fig. 14 is a flowchart illustrating an example of flange-to-flange gap measuring processing.

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Description of Embodiments

[0013] [First Embodiment]

<Flange-to-Flange Gap Measuring Device 2>

Fig. 1 illustrates a configuration example of a flange-to-flange gap measuring device according to a first embodiment. The configuration illustrated in Fig. 1 is illustrative, and the present invention is not limited to this configuration.

A flange-to-flange gap measuring device 2 is an example of a measuring means for use in managing a tightening state of a seal handling unit 4 that connects between a plurality of pipe conduits, between a pipe and a valve, between a pipe and a pump, and the like.

For example, as illustrated in A of Fig. 1, the seal handling unit 4 has a gasket 8 interposed between flanges 6-1 and 6-2, which are targets to be tightened, and is tightened by a bolt 10 and a nut 12 at tightening positions provided on flat portions of the flanges 6-1 and 6-2. That is, the gasket 8 is in a pressed state between the flat portions of the opposed flanges 6-1 and 6-2.

In the seal handling unit 4, the flange-to-flange gap measuring device 2 measures a width of a gap 14 between opposed surfaces of the flanges 6-1 and 6-2 between which the gasket 8 is interposed and a length of a gap difference representing displacement in a direction parallel to the opposed surfaces of the flanges 6-1 and 6-2.

[0014] The flange-to-flange gap measuring device 2 includes, for example, a housing 16 and a contact 18 which is formed in the housing 16 and at least a part of which is inserted into the gap 14 between the flanges 6-1 and 6-2. An entire portion

or a tip end portion of the contact 18 to be inserted into the gap 14 is formed to be thinner than the gap 14.

Also, the housing 16 includes, for example, a light irradiation unit 20 serving as a light source that irradiates the peripheral surfaces of the flanges 6-1 and 6-2 with light, an imaging unit 22 that captures an image at a measurement position C1, and a measurement unit 24 that measures a width of the gap 14 and a gap difference with use of the image captured by the imaging unit 22. The measurement position C1 is set in relation to an installation position of the bolt 10 and the nut 12 installed in the flanges 6-1 and 6-2 and a tightening position by means of the bolt 10 and the nut 12, for example. That is, the flange-to-flange gap measuring device 2 measures the dimension of the gap 14 and the amount of the gap difference between the flanges 6-1 and 6-2 at the tightening position by means of the bolt 10 and the nut 12 in the flanges 6-1 and 6-2 or at a position influenced by the tightening to manage a tightening state of the seal handling unit 4.

[0015] The contact 18 is an example of a positioning guide according to the present invention and causes the housing 16 to be arranged with respect to the measurement position C1. The contact 18 includes at least two contact arms 18-1 and 18-2 as illustrated in B of Fig. 1, for example. The contact arms 18-1 and 18-2 are, for example, equal in length La and project from the housing 16 toward a target to be measured in a parallel direction. Then, the two contact arms 18-1 and 18-2 are arranged along the peripheral surfaces of the flanges 6-1 and 6-2 in directions in which the contact arms 18-1 and 18-2 can be inserted into the gap 14.

[0016] The light irradiation unit 20 of the flange-to-flange gap measuring device 2 emits light, for example, in a range between the contact arms 18-1 and 18-2 and in parallel with projecting directions of the contact arms 18-1 and 18-2.

The light irradiation unit 20 is constituted by a light source of laser light, infrared light, or other light, for example, and directly emits light or emits slit light that has passed through a not-illustrated slit to the measurement position C1 to form thin light images (F1 and F2) (A of Fig. 1) having a predetermined length on the peripheral surfaces of the two flanges 6-1 and 6-2 with at least the gap 14 interposed therebetween.

The imaging unit 22 is arranged in a direction displaced by a predetermined arrangement angle θ from a light irradiation direction of the light irradiation unit 20, for example, and captures the thin light images (F1 and F2) emitted to the flanges 6-1 and 6-2 and the gap 14 at the measurement position C1.

In this manner, by inserting the contact arms 18-1 and 18-2 into the gap 14, the flange-to-flange gap measuring device 2 can maintain a fixed irradiation direction, such as a vertical direction or an angle close to the vertical direction, from the light irradiation unit 20 to the surfaces of the flanges 6-1 and 6-2 at the measurement position C1, and an irradiation distance Lb. This irradiation distance Lb is a distance to a light irradiation position on the flange surface and is determined in accordance with the curvature of the flanges 6-1 and 6-2, the widths of the contact arms 18-1 and 18-2, the contact position between the contact arms 18-1 and 18-2 and the flange surface, and the like. Also, as for the imaging unit 22, an imaging angle with respect to the irradiated thin light image and an imaging distance Lc are determined. The lengths of the contact arms 18-1 and 18-2 are set in accordance with a focal length of a camera constituting the imaging unit 22 with respect to the measurement position C1, for example.

[0017] The measurement unit 24 is an example of a functional unit that performs image processing of image data

captured by the imaging unit 22 and measuring/calculating processing of a gap and a gap difference, for example. In the flange-to-flange gap measuring device 2, a so-called light-section method is used as a means for measuring a gap and a gap difference by analyzing and processing an image obtained by capturing an image of light emitted to a target to be measured.

[0018] Fig. 2 illustrates an example of measuring processing of a gap and a gap difference.

The measurement unit 24 performs binarization processing, feature point extraction processing, and the like on the captured image as image processing, for example. The binarization processing is image processing for extracting a thin light image contained in the captured image, and light-dark comparison based on the light intensity in the image and image comparison processing before and after light irradiation may be performed, for example.

[0019] <Gap Measurement>

The measurement unit 24 performs feature point extraction processing from an image in which a thin light image is extracted, as illustrated in A of Fig. 2, for example. The measurement unit 24 extracts data of the thin light images F1 and F2 representing the thin light images on the peripheral surfaces of the flanges 6-1 and 6-2 and edge data Fx1 and Fx2 representing boundaries between the flanges 6-1 and 6-2 and the gap 14, for example.

The measurement unit 24 may perform processing for extracting feature points by means of analysis processing with use of binarized image data or may extract feature points by analyzing data of the thin light images F1 and F2 and the edge data Fx1 and Fx2 on the image captured by the imaging unit 22 by means of image analysis processing. The ends of the data pieces of the thin light images F1 and F2 may be extracted as the edge data Fx1 and Fx2, for example. Alternatively, parts

of the data pieces of the thin light images F1 and F2 may be regarded as ends, and the ends may be extracted as the edge data Fx1 and Fx2. Accordingly, in a case in which the tip end sides of the data pieces of the thin light images F1 and F2 are bent by light in the gap 14, the measurement unit 24 may extract straight line portions immediately before the bent portions as the edge data Fx1 and Fx2.

A space G exists between the edge data Fx1 and the edge data Fx2, for example. At the measurement position C1, the space G is in a state in which light emitted from the light irradiation unit 20 is not reflected or is reflected in a direction in which the imaging unit 22 cannot capture the light. That is, the space G represents existence of the gap 14 between the flanges 6-1 and 6-2, a position of the gap 14, and the like.

The measurement unit 24 then performs gap analysis processing on a width W between the edge data Fx1 and the edge data Fx2 as gap measuring processing to calculate a width of the gap 14, for example. In this gap analysis processing, the width W of the gap 14 is calculated with use of a calculation algorithm that takes into consideration the irradiation distance Lb, the imaging distance Lc, and a value for the arrangement angle θ between the light irradiation unit 20 and the imaging unit 22, for example.

[0020] <Gap Difference Measurement>

For example, as illustrated in B of Fig. 2, the measurement unit 24 determines whether or not the extracted data pieces of the thin light images F1 and F2 or the edge data pieces Fx1 and Fx2 representing boundaries between the flanges 6-1 and 6-2 and the gap 14 are displaced in a vertical direction and measures a displacement amount H thereof. This vertical displacement represents a state in which, at the measurement position C1, the flanges 6-1 and 6-2 are displaced in a front-rear direction with respect to an arrangement

direction of the flange-to-flange gap measuring device 2 and in which a gap difference is generated. The displacement amount captured in the image is a gap difference H between the flanges 6-1 and 6-2. This displacement amount is the sum of a displacement amount h1 in an upward direction and a displacement amount h2 in a downward direction with respect to a reference axis assumed at the time of imaging, for example. Since the flanges 6-1 and 6-2 have circular opposed surfaces, for example, detection values for the displacement amounts h1 and h2 change along the circumferential directions of the flanges 6-1 and 6-2, and the displacement amounts h1 and h2 have the directions reversed when the peripheral surfaces of the flanges 6-1 and 6-2 on the opposite side of a predetermined measurement position C1 are measured.

[0021] As gap difference measuring processing, the measurement unit 24 calculates a gap difference between the flanges 6-1 and 6-2 in the front-rear direction by deriving the displacement amounts h1 and h2 on a screen from lengths between the edge data Fx1 and the edge data Fx2 and values obtained by converting these lengths into coordinate values and by using a gap analysis algorithm that takes into consideration the irradiation distance Lb, the imaging distance Lc, and a value for the arrangement angle θ between the light irradiation unit 20 and the imaging unit 22.

[0022] <Flange-to-Flange Gap Measuring Processing>

Fig. 3 illustrates a processing example of flange-to-flange gap measurement. The processing content and processing procedure illustrated in Fig. 3 are examples of a flange-to-flange gap measuring method or a flange-to-flange gap measuring program according to the present invention, and the present invention is not limited to such content and procedure.

In flange-to-flange gap measuring processing, the contact arms 18-1 and 18-2 serving as the positioning guide are inserted into the gap 14 at the measurement position C1 of the

flanges 6-1 and 6-2 (S1). As a result, the arrangement position of the flange-to-flange gap measuring device 2, the light irradiation direction, the irradiation angle, and the imaging direction are stabilized in predetermined states.

5 The light irradiation unit 20 is turned on to emit light toward the measurement position C1 (S2), and thin light images are formed on the peripheral surfaces of the flanges 6-1 and 6-2 with the gap 14 interposed therebetween. Then, an image containing the thin light images formed at the measurement
10 position C1 is captured by the imaging unit 22 (S3).

 The measurement unit 24 performs, as the analysis processing by means of the light-section method, the binarization processing, the feature point extraction processing, the analysis processing that takes into
15 consideration the image capturing conditions based on the values on the image, and the like on the captured image, for example, to measure the gap and the gap difference between the flanges (S4).

[0023] [Effects of First Embodiment]

20 According to such a configuration, the following effects can be obtained.

 (1) By bringing the contact arms 18-1 and 18-2 into contact with the flanges 6-1 and 6-2, the housing 16 can easily and accurately be positioned at the measurement
25 position of the gap 14 between the flanges, and the gap or the gap difference at the measurement position can be measured easily and quickly.

 (2) In contrast to a measurement operation with use of a measuring instrument such as a ruler or calipers, the gap and
30 the gap difference between the flanges are calculated by analyzing the captured image. As a result, errors due to the skill level of an operator and recording errors of measurement results do not occur, and measurement accuracy can be improved.

 (3) Reliability of management of the gap between the

flanges is improved.

(4) The operation time for measuring processing of the gap and the gap difference can be shortened.

[0024] [Second Embodiment]

5 <Configuration of Flange-to-Flange Gap Measuring Device>

Figs. 4 and 5 illustrate a configuration example of a flange-to-flange gap measuring device according to a second embodiment. The configuration illustrated in Figs. 4 and 5 is illustrative.

10 For example, as illustrated in A of Fig. 4, a flange-to-flange gap measuring device 30 is provided on a front side of a housing 32 with two contact arms 34-1 and 34-2 in parallel. The contact arms 34-1 and 34-2 are provided with insertion
15 pieces 36 narrow in the width directions of tip end portions thereof, for example. The insertion piece 36 is an example of a guide projection according to the present invention. Then, the contact arms 34-1 and 34-2 and the insertion pieces 36 constitute a positioning guide according to the present
20 invention, and the insertion pieces 36 are inserted into the gap 14 between the flanges 6-1 and 6-2 to enable the housing 32 to be positioned at a measurement position. The contact arms 34-1 and 34-2 are detachably formed in the housing 32, for example.

In addition, an operation unit 38 is provided on the back
25 side of the housing 32. The operation unit 38 may be formed integrally with the housing 32 or may detachably be formed as an independent operation component and may be installed at the back surface portion of the housing 32, for example. The operation unit 38 includes a grip unit 40 gripped by the
30 measurement operator and enabling the housing 32 to be carried and a trigger switch 42 formed on the end side of the grip unit 40 and performing input operations such as measurement operations including power activation, light irradiation, image capturing, and the like, for example.

[0025] On the upper surface side of the flange-to-flange gap measuring device 30, as illustrated in B of Fig. 4, an information presenting unit 46 is formed on a part or an entirety of the ceiling surface of the housing 32, for example.

5 The information presenting unit 46 may include a display monitor 48 and a not-illustrated display lamp.

The display monitor 48 may display an operation instruction screen for the operator, a selection/operation screen related to measuring processing, and an image captured
10 by an imaging unit described below, for example.

In addition, the contact arms 34-1 and 34-2 are provided with abutting units 37 brought into contact with the peripheral surfaces of the flanges 6-1 and 6-2 when the insertion pieces 36 are inserted into the gap 14 between the
15 flanges 6-1 and 6-2, for example. The abutting unit 37 may be formed in a flat-plate shape in a direction perpendicular to the projecting direction of the contact arm 34-1 or 34-2 or may be formed in a curved shape to conform to the peripheral surface of the flange 6-1 or 6-2 on which the abutting unit 37
20 is to abut, for example. Each of the contact arms 34-1 and 34-2 may be opened at a center portion thereof and include contact arms 44A and 44B formed at both ends thereof with a predetermined width for weight reduction and improvement in visibility at the time of a measuring operation, for example.

25 [0026] As illustrated in C of Fig. 4, the front surface side of the housing 32 is provided between the contact arms 34-1 and 34-2 in parallel with each other in the up-down direction with a measuring region that lets light pass therebetween and captures an image of the flanges, for example.

30 For example, the housing 32 is provided with a light emitting means 50 that irradiates the flange peripheral surfaces with light passing through the measuring region. On the lower side of the light emitting means 50, the housing 32 is provided with an objective lens 52 in an imaging window for capturing

an image of the peripheral surfaces of the flanges 6-1 and 6-2 through the measuring region and a camera 54 that captures an image through the imaging window. The light emitting means 50 is an example of a light irradiation unit according to the present invention and emits light to a measurement position from a measuring window opened at a position near the upper contact arm 34, for example.

[0027] At least the objective lens 52 is arranged to be displaced upward at a predetermined angle with respect to the measuring region formed by the contact arms 34-1 and 34-2 contacting the measurement position, as illustrated in A of Fig. 5, for example. The arrangement angle of the objective lens 52 is set to an angle at which an image in the directions of the peripheral surfaces of the flanges 6-1 and 6-2 on which images of light emitted by the light emitting means 50 are formed can be captured.

In addition, a front surface 55 of the housing 32 may form an inclined surface in which a lower side than the contact arm 34-2 is inclined, for example. Inside the front surface 55 of the housing 32, the camera 54 installed in the housing 32 is mounted to correspond to the arrangement angle of the objective lens 52, for example. Also, the front surface 55 may be a grip unit that allows the operator who performs measuring processing to grip the housing 32.

[0028] In addition, the grip unit 40 on the back surface side of the housing may be arranged on the center side with respect to the right and left ends of the housing 32 as illustrated in B of Fig. 5 or may be formed at a position tilted in the right-left direction in accordance with the operator's dominant hand or either the right hand or the left hand gripping the grip unit 40, for example.

[0029] <Internal Configuration of Flange-to-Flange Gap Measuring Device>

Fig. 6 illustrates an internal configuration example of

the flange-to-flange gap measuring device.

For example, as illustrated in Fig. 6, the housing 32 includes therein the light emitting means 50 arranged toward the front surface side of the housing 32 and the objective lens 52 and the camera 54 inclined in accordance with a target to be imaged. Also, the housing 32 includes a control unit 56 that outputs an operation instruction to the light emitting means 50 and the camera 54 and that acquires and analyzes measured image data. Also, the control unit 56 is electrically or physically connected to the trigger switch 42 and is notified of whether or not the trigger switch 42 has been pressed.

[0030] <Measurement of Gap and Gap Difference>

Fig. 7 illustrates an example of a state in which a gap and a gap difference are measured with use of the flange-to-flange gap measuring device.

For example, as illustrated in A of Fig. 7, in the flange-to-flange gap measuring device 30, the operator grips the grip unit 40 and arranges the contact arms 34-1 and 34-2 to the seal handling unit 4 serving as a target to be measured. At this time, the operator arranges the respective insertion pieces 36 of the contact arms 34-1 and 34-2 in directions enabling both the insertion pieces 36 to be inserted into the gap 14 between the flanges 6-1 and 6-2. Also, in the gap and gap difference measuring processing, for example, one or a plurality of measurement positions C are set along the peripheral surfaces of the flanges 6-1 and 6-2, and the operator is required to arrange the flange-to-flange gap measuring device 30 to a predetermined measurement position C. For identification of the measurement position C and an instruction to the operator, a sign representing the measurement position may be provided at the flanges 6-1 and 6-2, the gasket 8 inside the gap 14, the bolt 10, or the nut 12, or the measurement position C may be set at the time of

measurement, for example. As for the measurement position, for example, a first measurement position determined by the operator may be set as a reference position, and a position displaced from that position by a predetermined angle with respect to the center axes of the flanges 6-1 and 6-2 may be set as the next measurement position.

In addition, the control unit 56 of the flange-to-flange gap measuring device 30 may read identification tag information provided at the bolt 10 or the nut 12 by means of the camera 54, a not-illustrated matching means, or the like and may determine whether or not the position is a set measurement position, for example.

[0031] For example, as illustrated in B of Fig. 7, when the trigger switch 42 is operated in a state in which the insertion pieces 36 are inserted into the gap 14, and in which both the contact arms 34-1 and 34-2 are brought in contact with the peripheral surfaces of the flanges, the flange-to-flange gap measuring device 30 performs light emission by means of the light emitting means 50 and imaging processing by means of the camera 54.

[0032] The light emitting means 50 emits light in a vertical direction with respect to the peripheral surfaces of the flanges 6-1 and 6-2 and the opening surface of the gap 14. As a result, on the surfaces of the flanges 6-1 and 6-2, for example, as illustrated in A of Fig. 8, the thin light images F1 and F2 (B in Fig. 8) are formed by the light emitted from the light emitting means 50 with the gap 14 interposed therebetween. Also, inside the gap 14, a thin light image is formed on a part of the opposed surfaces of the flanges 6-1 and 6-2, and as illustrated in B of Fig. 8, light is emitted to a peripheral surface of the gasket 8 inside the gap 14 as well to cause a thin light image F3 to be formed.

The camera 54 of the flange-to-flange gap measuring device 30 is arranged at a position displaced by a

predetermined angle with respect to the light emitting means 50, and a focal length thereof for imaging is adjusted to a length to the peripheral surfaces of the flanges 6-1 and 6-2. That is, since the two contact arms 34-1 and 34-2 are arranged along the gap, the camera 54 is displaced from the light emitting means 50 along a direction of the opening in the gap 14 of the seal handling unit 4 and captures the thin light images in a diagonal direction with respect to the measurement position C. As a result, the camera 54 at least captures the thin light images F1 and F2 formed on the surfaces of the flanges 6-1 and 6-2, and in some cases, the camera 54 captures an image formed by light emitted on the opposed surfaces of the flanges 6-1 and 6-2 and an image formed by light emitted on the gasket 8.

15 [0033] <Control Unit 56>

Fig. 9 illustrates a configuration example of the control unit of the flange-to-flange gap measuring device.

The control unit 56 is a control means of the flange-to-flange gap measuring device 30 and an example of a flange-to-flange gap measuring/managing means.

The control unit 56 is configured by a computer, for example, and includes a processor 60, a storage unit 62, an input/output unit (I/O) 64, a touch sensor 66, a communication unit 68, and the display monitor 48.

25 The processor 60 is an example of a processing means and performs arithmetic processing for an operating system (OS), a flange-to-flange gap measuring program, and the like stored in the storage unit 62. The arithmetic processing includes control of light emission executed by the light emitting means 50 in response to an operation of the trigger switch 42, processing for imaging performed by the camera 54, image processing for the thin light images F1 and F2 such as binarization, analysis processing for extracting data of the thin light images F1 and F2 and the edge data Fx1 and Fx2,

processing for calculating the width W and the gap difference H between the edge data Fx1 and the edge data Fx2 representing the gap 14 based on an analysis result, processing for displaying a measurement result on the monitor 48, and the like.

The storage unit 62 is used to store the OS, the flange-to-flange gap measuring program, a captured image, an analysis result, a calculation result, and the like and includes a read only memory (ROM) and a random access memory (RAM). As the storage unit 62, a storage element capable of holding the stored content may be used.

[0034] The I/O 64 is controlled by the processor 60 and is used for input/output of control information. The touch sensor 66, the display monitor 48, the camera 54, and the light emitting means 50 are connected to this I/O 64, for example. In addition, a barcode reader for use in identifying the flange, the gasket, the bolt, the nut, or the like, a detachable external memory, or the like may be connected to the flange-to-flange gap measuring device 30. The barcode reader is an example of an information acquisition unit. The external memory is a memory for taking out log information, and a universal serial bus (USB) memory may be used, for example.

The touch sensor 66 is an example of a means for forming the information presenting unit 46, and by detecting a contact operation of the operator corresponding to a display screen of the display monitor 48, the touch sensor 66 uses the contact operation as an input trigger of input information, as an output trigger of output information, for mode switching, or for other purposes.

The communication unit 68 is controlled by the processor 60 and is used for wireless connection to an external device or for Internet connection.

[0035] <About Measurement Results>

Fig. 10 illustrates an example of measurement results of gaps and gap differences.

Measurement data 70 calculated in the analysis processing is stored in the storage unit 62 as illustrated in Fig. 10, for example. The measurement data 70 contains results of analyzing the data of the thin light images F1 and F2 and the edge data Fx1 and Fx2 contained in the captured image by means of a predetermined calculation algorithm. For example, as illustrated in A of Fig. 10, the measurement data 70 contains the width W14 of the gap and the gap difference H for each measurement position C.

[0036] Also, the control unit 56 may generate a display screen that allows visual comparison of gaps or gap differences among measurement positions with use of the captured image data, for example. For example, as illustrated in B of Fig. 10, the display monitor 48 displays a measurement result screen obtained by extracting the data of the captured thin light images F1 and F2 and the edge data Fx1 and Fx2 thereof. On this measurement result screen, the data obtained by image capturing and analyses in measurement positions C1 to C3 may be displayed in combination with comparison lines (illustrated by dashed lines) to enable comparison. By displaying the measurement positions so that the measurement positions can be compared with each other in this manner, displacement in the width W of the gap 14 and the gap difference H among the measurement positions can be recognized.

[0037] <Flange-to-Flange Gap Measuring Processing>

Fig. 11 illustrates a processing example of flange-to-flange gap measurement. The processing content and processing procedure illustrated in Fig. 11 are examples of a flange-to-flange gap measuring method or a flange-to-flange measuring program according to the present invention, and the present invention is not limited to such content and procedure.

In flange-to-flange gap measuring processing, the

insertion pieces 36 of the contact arms 34-1 and 34-2 serving as the positioning guide are inserted into the gap 14 at the measurement position C set on the flanges (S11). As a result, the arrangement position of the flange-to-flange gap measuring device 2, the light irradiation direction, the irradiation angle, and the imaging direction are stabilized in predetermined states.

When the control unit 56 detects a pressing operation of the trigger switch 42 (S12), the control unit 56 turns on the light emitting means 50, emits light toward the measurement position C1 (S13), and captures an image containing thin light images formed at the measurement position C by means of the camera 54 (S14).

The control unit 56 performs measuring processing for a gap and a gap difference by means of an image analysis (S15). In this measuring processing, the processing described in S4 of Fig. 3 and the like may be performed, for example. Then, the control unit 56 then causes measurement results of the gap and the gap difference to be displayed on the display monitor 48 (S16).

[0038] [Effects of Second Embodiment]

According to such a configuration, the following effects can be obtained.

(1) In formation of the thin light images used to measure the gap and the gap difference, since the light irradiation direction, the distance, and the imaging angle are determined by the plurality of contact arms 34-1 and 34-2, it is possible to suppress occurrence of variation in the measurement results among operators and to perform highly accurate measuring processing.

(2) Since the number of processes that may cause a human error due to a visual recognition error or an operation skill level of the operator can be reduced, accuracy of measurement of the gap and the gap difference and management of seal

handling processing can be improved.

(3) It is possible to measure the gap and the gap difference by a simple operation of arranging the device at the measurement position and operating the trigger switch.

5 Hence, it is possible to shorten operation time for seal handling processing. In addition, since measurement time is short, tightening accuracy can be improved even in a case in which the number of times of the gap checking processes is increased without an increase of flange tightening operation
10 load.

(4) By displaying results of measurement at a plurality of positions on the flanges so that the results can be compared, it is possible to visually recognize a seal handling state and to easily identify a position in which the handling
15 is insufficient.

[0039] [Third Embodiment]

Fig. 12 illustrates a configuration example of a flange-to-flange gap measuring system according to a third embodiment. The configuration illustrated in Fig. 12 is illustrative, and
20 the present invention is not limited to this configuration. In Fig. 12, similar components to those in Figs. 1 and 4 are labeled with the same reference signs.

For example, as illustrated in Fig. 12, a flange-to-flange gap measuring system 80 includes a flange-to-flange gap
25 measuring device 30 measuring a gap in the seal handling unit 4 and an information terminal device 82.

The flange-to-flange gap measuring device 30 has a similar configuration to that described above, and thus description thereof will be omitted.

30 The information terminal device 82 is connected to the flange-to-flange gap measuring device 30 by wire or wirelessly.

This information terminal device 82 may have a function of capturing and managing the measurement results of the gaps and the gap differences measured by the flange-to-flange gap

measuring device 30 and a function of capturing the thin light image data captured by the flange-to-flange gap measuring device 30 for image processing and analysis processing, for example. In addition, the information terminal device 82 may
5 output a control instruction to the flange-to-flange gap measuring device 30, for example.

The information terminal device 82 is constituted by a controller terminal that operates in conjunction with the flange-to-flange gap measuring device 30, a personal computer
10 (PC), a server device, or the like, for example, and includes a processing unit 84, an input unit 86, and a display unit 88.

[0040] In addition, the information terminal device 82 is connected to a seal handling device that performs tightening processing for the bolt 10 and the nut 12 of the seal handling
15 unit 4 and stores an axial force detected in the seal handling processing, setting information such as a tightening torque value set in the seal handling device, tightening position information in the seal handling unit 4, and the like, for example.

[0041] The processing unit 84 of the information terminal device 82 generates a display screen displaying the tightening position information acquired in seal handling managing
20 processing and detection results such as a detected axial force, for example. Further, as illustrated in Fig. 13, for example, the processing unit 84 may generate a tightening result screen 90 in which the tightening position information of the bolts and the nuts acquired in the seal handling management and the gap and gap difference information acquired or calculated in the flange-to-flange gap measuring processing
25 are combined. On this tightening result screen 90, eight tightening positions [1] to [8] representing tightening positions of the bolts and the nuts are set, for example. In addition, on this screen, information about the measured gaps and information about the measurement positions C1 to C4 of
30

the four gaps are input. The processing unit 84 may combine the results of the gaps at the measurement positions C1 to C4 with the tightening positions [1] to [8] and may perform prediction processing for the gaps at positions other than the measurement positions, for example. In this prediction processing, a changing tendency of a gap state among a plurality of measurement positions may be calculated with use of previous gap measurement information, for example.

[0042] Due to such processing for combining the measurement results, it is possible to visually recognize a state in which the gap 14 varies among the tightening positions [1] to [8]. The difference in the gap 14 among the measurement positions or among the tightening positions is influenced by variation in the tightening axial force of the bolt and the nut among the tightening positions. Also, in the flanges 6-1 and 6-2, in a case in which a certain tightening position is tightened strongly, for example, an opposite position across the center axis, that is, a position at an angle of 180° or so around the center axes of the flanges, is tightened weakly and is in a so-called uneven tightening state, in which the width W of the gap 14 is longer. Hence, it is possible to recognize a bolt in the uneven tightening state from the variation in the gap.

[0043] <Flange-to-Flange Gap Measuring Processing>

Fig. 14 illustrates a measuring processing example in the flange-to-flange gap measuring system. The processing content and processing procedure illustrated in Fig. 14 are examples of a flange-to-flange gap measuring method or a flange-to-flange measuring program according to the present invention, and the present invention is not limited to such content and procedure.

The seal handling unit 4 is subjected to flange tightening processing in which the bolts and the nuts are tightened with use of a not-illustrated tightening tool, for example (S21).

As flange-to-flange gap measuring processing, the flange-to-flange gap measuring device 30 is installed at a set measurement position (S22), and when the trigger switch is pressed, light irradiation and processing for imaging the measurement position are performed (S23). Subsequently, the flange-to-flange gap measuring device 30 or the information terminal device 82 acquires the captured image information and calculates the gap and the gap difference, and a measurement result derived by the calculation is transmitted and received between the flange-to-flange gap measuring device 30 and the information processing device 82 (S24).

[0044] The information terminal device 82 performs gap management processing for the measurement result at the measurement position and performs image generation processing with use of axial force management information stored in seal handling management processing (S25). Subsequently, the information terminal device 82 causes a gap management image to be displayed on the display unit 88 (S26).

Meanwhile, the gap management image may be transmitted from the information terminal device 82 to the flange-to-flange gap measuring device 30 and displayed on the display monitor 48, for example.

[0045] [Effects of Third Embodiment]

According to such a configuration, the following effects can be obtained.

(1) Since the flange tightening state can be managed in association with the bolt and nut tightening processing, the convenience and reliability of seal handling management can be improved.

(2) It is possible to facilitate the measurement and management processing for the flange tightening state at the tightening position or the measurement position, which improves convenience.

(3) By facilitating the flange-to-flange gap measuring

processing, a check after a tightening operation, further tightening, and a re-tightening operation can be performed quickly, which enables operation efficiency to be improved and which enables operation time to be shortened.

5 (4) By facilitating the flange-to-flange gap measuring processing, looseness of screws due to a temporal change can be checked, and further tightening and a re-tightening operation can be performed quickly. Accordingly, operation efficiency can be improved, operation time can be shortened,
10 and reliability of the seal handling management can be improved over a long period of time.

[0046] [Other Embodiments]

 (1) The flange-to-flange gap measuring device 30 may perform processing for guiding a measuring processing
15 procedure or a measurement procedure with use of the monitor 48, for example.

 (2) A function of the monitor 48 of the flange-to-flange gap measuring device 30 is not limited to a function of displaying the measurement results, for example. The monitor
20 48 may function as a so-called finder that displays image information captured by the camera 50 in real time, for example. As a result, when the flange-to-flange gap measuring device 30 is arranged at the measurement position C1, the operator can arrange the device while actually checking an
25 image to be captured as well as visually recognizing the arrangement position from the outside of the device.

 Also, the monitor 48 may display an instruction screen for instructing the operator about the arrangement position, for example. As a result, the device can accurately be
30 arranged at the set position, and the accuracy of gap monitoring can be improved.

[0047] (3) In the above embodiments, although a case in which the arrangement angle θ of the imaging unit 22 with respect to the light irradiation unit 20 is fixed has been

described, the present invention is not limited to this. The arrangement angle θ may be adjustable according to the size of the diameter of the flange to be measured, for example.

(4) In the above embodiments, although processing for capturing the thin light images F1 and F2 formed on the peripheral surfaces of the flanges 6-1 and 6-2 and calculating the gap and the gap difference between the flanges has been described, the present invention is not limited to this. In the imaging unit 22 including the camera 54, the thin light image F3 formed inside the gap 14 may be captured together with the thin light images F1 and F2 formed on the peripheral surfaces of the flanges 6-1 and 6-2, and the thin light image data and the edge data of the thin light image F3 may be analyzed and used for measurement of the gap and the gap difference, for example. That is, as for the thin light image F3 formed inside the gap 14, the difference in the focal length of the imaging unit 22, the difference in the intensity of the reflected light, and the like may be analyzed, and the width inside the gap 14 may be measured with use of the length of the thin light image F3, for example.

Further, as a tightening state of the gasket in the gap 14, a state in which the gasket is wave-shaped, wrinkles on the gasket, or the degree of crushing of the gasket may be detected by means of an image analysis of the thin light image F3 and used for the seal handling management.

(5) Also, in the flange-to-flange gap measuring device 30, different switches may be provided for the light emission by the light emitting means 50 and the imaging processing by the camera 54.

[0048] (6) In the above embodiment, the case in which the abutting units 37 of the contact arms 34-1 and 34-2 serving as the contact 18 are brought into contact with the side surfaces of the flanges 6-1 and 6-2 at the measurement position, and the insertion pieces 36 provided at the tip end portions of

the contact 18 are inserted into the gap 14, to measure the gap and the gap difference has been described. However, the present invention is not limited to this case. In the flange-to-flange gap measuring processing, the flange-to-flange gap measuring processing may be performed without bringing the contact arms 34-1 and 34-2 into contact with the flanges 6-1 and 6-2, for example. In this case, in the flange-to-flange gap measuring device 2 or 30, the contact arms 34-1 and 34-2 may be removed from the housing 16 or 32, for example. Also, in the flange-to-flange gap measuring processing, the flange-to-flange gap measuring device 2 or 30 may be positioned into the gap 14 between the flanges 6-1 and 6-2 by the operator's visual inspection or with use of a not-illustrated positioning jig or the like to set the irradiation distance L_b , for example. Also, the flange measuring device 2 or 30 may have a function of determining whether the device is located at an appropriate measurement position and whether the device is arranged to have the irradiation distance L_b or the imaging distance L_c with use of the display monitor or the like, for example. Further, the camera 54 may use an auto focus (AF) function to adjust the imaging distance L_c in accordance with a distance from the camera 54 to the thin light images generated on the side surfaces of the flanges 6-1 and 6-2 to be measured or the gap 14, for example.

[0049] As described above, the most preferable embodiments of the present invention have been described. The present invention is not limited to the above description. Various modifications and changes can be made by those skilled in the art based on the summary of the invention described in the claims or disclosed in the description of embodiments. It is to be understood that such modifications and changes are included in the scope of the present invention.

Industrial Applicability

[0050] In the flange-to-flange gap measuring device, the program, and the method according to the present invention, at a set measurement position, conditions such as an irradiation distance and a distance for acquiring an image of generated thin light images are fixed to calculate a gap between flanges by means of an image analysis. Consequently, the flange-to-flange gap measuring device, the program, and the method according to the present invention are advantageous since a measurement operation is facilitated, measurement accuracy is improved, and a measurement result is stabilized.

Reference Signs List

[0051] 2, 30 Flange-to-flange gap measuring device

4 Seal handling unit

15 6-1, 6-2 Flange

8 Gasket

10 Bolt

12 Nut

14 Gap

20 16, 32 Housing

18 Contact

18-1, 18-2 Contact arm

20 Light irradiation unit

22 Imaging unit

25 24 Measurement unit

34-1, 34-2 Contact arm

36 Insertion piece

37 Abutting unit

38 Operation unit

30 40 Grip unit

42 Trigger switch

44A, 44B Contact arm

46 Information presenting unit

48 Display monitor

	50	Light emitting means
	52	Objective lens
	54	Camera
	55	Inclined unit
5	56	Control unit
	60	Processor
	62	Storage unit
	64	Input/output unit (I/O)
	66	Touch sensor
10	68	Communication unit
	70	Measurement data
	80	Flange-to-flange gap measuring system
	82	Information terminal device
	84	Processing unit
15	86	Input unit
	88	Display unit

CLAIMS

1. A flange-to-flange gap measuring device measuring a gap between flanges tightened by a plurality of bolts and nuts with a gasket interposed between the flanges, the flange-to-flange gap measuring device comprising:

a light irradiation unit that emits thin light to generate thin light images on the flanges, the gap between the flanges being interposed between the thin light images;

an imaging unit that acquires an image including the thin light images; and

a measurement unit that extracts thin light image data and flange edge data from the image and measures the gap or a gap difference between the flanges.

2. The flange-to-flange gap measuring device according to claim 1, wherein the light irradiation unit causes the thin light images to be generated at a measurement position related to a position of the bolt or a bolt tightening position.

3. The flange-to-flange gap measuring device according to claim 1, further comprising an information presenting unit that presents a measurement result of the gap or the gap difference in relation to identification information of the flange, a position of the bolt, or a bolt tightening position.

4. The flange-to-flange gap measuring device according to claim 1, further comprising:

a housing that inserts a positioning guide in the gap between the flanges and is positioned at a measurement position of the flanges,

wherein the positioning guide includes:

abutting units that abut on peripheral surfaces of the flanges with the measurement position interposed between the abutting units; and

a guide projection formed at a part of the abutting units to be inserted in the gap, and

wherein the housing is positioned at the measurement

position by the abutting units and the guide projection.

5 The flange-to-flange gap measuring device according to claim 1, wherein the housing is provided with a grip unit and an imaging switch, and the imaging switch is operable while the grip unit is gripped.

6. The flange-to-flange gap measuring device according to claim 1, further comprising a communication unit that transmits measurement data,
 wherein the measurement data is provided to an
10 information terminal connected to the communication unit by wire or wirelessly.

7. A program for causing a computer to fulfill:
 a function of emitting thin light from a housing to generate thin light images on flanges, a gap between the
15 flanges being interposed between the thin light images;
 a function of acquiring an image including the thin light images; and
 a function of extracting thin light image data and flange edge data from the image and measuring the gap or a gap
20 difference between the flanges.

8. The program according to claim 7, the program for further causing the computer to fulfill a function of presenting a measurement result of the gap or the gap difference in relation to identification information of the flange, a
25 position of a bolt, or a bolt tightening position.

9. A flange-to-flange gap measuring method measuring a gap between flanges tightened by a plurality of bolts and nuts with a gasket interposed between the flanges, the flange-to-flange gap measuring method comprising:

30 positioning a housing at a measurement position between the flanges;

 emitting thin light by means of a light irradiation unit to generate thin light images on the flanges, the gap between the flanges being interposed between the thin light images;

acquiring an image including the thin light images by means of an imaging unit; and

extracting thin light image data and flange edge data from the image and measuring the gap or a gap difference

5 between the flanges by means of a measurement unit.

10. The flange-to-flange gap measuring method according to claim 9, further comprising presenting a measurement result of the gap or the gap difference in relation to identification information of the flange, a position of a bolt, or a bolt

10 tightening position.