

DESCRIPTION

TITLE OF INVENTION:

DETERMINATION SYSTEM, PROGRAM, DETERMINATION METHOD, AND
LEARNING SYSTEM OF SEAL HANDLING

5

Technical Field

[0001] The present invention relates to a determination technology and learning of seal handling of piping flange joints or the like.

10 Background Art

[0002] Flange joints are used for connection of a fluid apparatus such as a piping and a pump unit. In handling of these flange joints, a gasket is interposed therebetween and tightening is made by a plurality of bolts and nuts which are
15 arranged in circumferences of the flanges.

As to work management of this seal handling, it has been known that a portable information terminal which is communicably connected to a management server is provided and tightening data associated with tool information and worker
20 information acquired by this portable information terminal is provided for the management server (for example, Patent Literature 1).

As to skill determination of flange tightening, it has been known that a measurement part, a calculation part, a
25 determination part, and an output part are provided, and the measurement part acquires transition of each output signal from each strain gauge which is provided for each of bolts; the calculation part acquires a calculation result indicating variation of the output signal of each of the strain gauges
30 under tightening work and a calculation result indicating variation of the output signal of each of the strain gauges upon completion of the tightening; the determination part collates skill determination items with determination references and determines any of three skill levels, which a

test subject has; and the output part outputs that determination result (for example, Patent Literature 2).

As to monitoring of the seal handling, it has been known that axial force distribution information is generated from axial force/position information of bolts for tightening flange joints and the monitoring is conducted by presenting this axial force distribution information (for example, Patent Literature 3).

10 Citation List

Patent Literature

[0003] Patent Literature 1: JP 5065851 B

Patent Literature 2: JP 6166222 B

Patent Literature 3: JP 2017-161388 A

15

Summary of Invention

Technical Problem

[0004] Incidentally, diverse abilities such as knowledge obtained by leaning, experiences of the seal handling, and skills based on the experiences are required of an engineer who works for the seal handling. For a flange joint, influences of uneven tightening and elastic interaction and the like which are exerted upon tightening flanges with a gasket interposed therebetween cannot be ignored.

20

25

As to the seal handling, detailed handling standards are specified in the Japanese Industrial Standards (JIS). Although as a matter-of-course, it is a presupposition that an engineer who engages in the seal handling specializes in this handling standards, just conforming to the handling standards is not necessarily sufficient, but cautious handling is required. An engineer is required of cultivating of a handling intuition, performing of handling without the influences of the uneven tightening and the elastic interaction, that is, handling having high reliability. Even if the engineer is proficient in

30

the seal handling, when an accuracy of a handling result is low, thereby leading to a problem in that a required sealing accuracy cannot be realized.

The present inventors have obtained the findings that in such seal handling, a surface-to-surface distance of flanges whose surfaces face each other is quantitatively perceived by measuring the surface-to-surface distance and a result of the measurement is confirmed, thereby allowing reliability of the seal handling to be enhanced.

Patent Literatures 1 to 3 neither disclose nor suggest any things as to the above-mentioned problem, and the above-mentioned problem cannot be solved by the configurations disclosed in these Patent Literatures 1 to 3.

[0005] Therefore, in view of the above-mentioned problem, an object of the present invention is to facilitation of determination of a state of seal handling and enhancement of reliability of the seal handling and handling skills based on findings required for the seal handling.

Solution to Problem

[0006] In order to achieve the above-mentioned object, according to one aspect of a seal handling determination system of the present invention, the seal handling determination system determines a handling result by a surface-to-surface distance between flanges which are tightened by bolts and nuts, with a gasket being interposed between the flanges, and the seal handling determination system includes: a seal handling part which includes the flanges being tightened by the bolts and the nuts, with the gasket being interposed between the flanges; a surface-to-surface distance measurement part which measures a surface-to-surface distance between the flanges; a processing part which takes in measured values of the surface-to-surface distance from the surface-to-surface distance measurement part in a

plurality of stages from start of tightening of the bolts up to completion of the tightening, calculates a difference between a maximum value and a minimum value of the measured values, and determines a skill level by comparing the difference and a determination reference; and an information presentation part which presents any or all of calculation information and a calculation result, the calculation information and the calculation result being processed by the processing part.

10 In this seal handling determination system, further, an axial force measurement part which measures axial forces being exerted from the bolts on the flanges is included,

the processing part may take in measured values of the axial forces of the bolts in the plurality of stages from the start of the tightening of the bolts up to the completion of the tightening, may calculate an average value of the measured values, and may determine a skill level by comparing the average value and a determination reference, and

15 the information presentation part may present any or all of calculation information and a calculation result, the calculation information and the calculation result being processed by the processing part.

In this seal handling determination system, further, a difference between a maximum value and a minimum value of the measured values may be calculated and a skill level may be determined by comparing the difference and a determination reference, and the information presentation part may present any or all of calculation information and a calculation result, the calculation information and the calculation result being processed by the processing part.

20 In this seal handling determination system, the processing part may calculate an amount of deviation of the difference with respect to a reference value and may determine a skill level by comparing the amount of deviation and a

determination reference.

In this seal handling determination system, the processing part may employ any or two or more of a measurement portion on the flanges where the surface-to-surface distance is measured and a tightening time as a piece or pieces of identification information and may perform information processing in a manner associated with the piece or the pieces of the identification information.

[0007] In order to achieve the above-mentioned object, according to one aspect of a program of the present invention, the program causes a computer to realize: a function to take in measured values of a surface-to-surface distance between flanges being tightened by bolts and nuts with a gasket being interposed between the flanges in a plurality of stages from start of tightening of the bolts of a seal handling part including the flanges up to completion of the tightening; a function to calculate a difference between a maximum value and a minimum value of the measured values and to determine a skill level by comparing the difference and a determination reference; and a function to generate any or all of calculation information and a calculation result as a piece or pieces of presentation information, the calculation information and the calculation result being processed by a processing part.

The program may further cause the computer to realize: a function to take in measured values of axial forces of the bolts in the plurality of stages from the start of the tightening of the bolts up to the completion of the tightening; a function to calculate an average value of the measured values and to determine a skill level by comparing the average value and a determination reference; and a function to generate any or all of calculation information and a calculation result as a piece or pieces of presentation information, the calculation information and the calculation

result being processed by the processing part.

This program may further cause the computer to realize: a function to take in measured values of axial forces of the bolts in the plurality of stages from the start of the
5 tightening of the bolts up to the completion of the tightening; a function to calculate a difference between a maximum value and a minimum value of the measured values and to determine a skill level by comparing the difference and a determination reference; and a function to generate any or all
10 of calculation information and a calculation result as a piece or pieces of presentation information, the calculation information and the calculation result being processed by the processing part.

The program may further cause the computer to realize: a
15 function to calculate an amount of deviation of the difference with respect to a reference value and to determine a skill level by comparing the amount of deviation and a determination reference.

[0008] In order to achieve the above-mentioned object,
20 according to one aspect of a seal handling determination method of the present invention, the seal handling determination method for determining a handling result by a surface-to-surface distance between flanges being tightened by bolts and nuts with a gasket being interposed between the
25 flanges includes: a step of measuring the surface-to-surface distance between the flanges in a seal handling part, the seal handling part including the flanges being tightened by the bolts and the nuts with the gasket being interposed between the flanges; and a step of, in a plurality of stages from
30 start of tightening of the bolts up to completion of the tightening, taking in measured values of the surface-to-surface distance, calculating an average value of the measured values, and determining a skill level by comparing the average value and a determination reference, or a step of calculating

a difference between a maximum value and a minimum value of the measured values, and determining a skill level by comparing the difference and a determination reference.

The seal handling determination method may further
5 include: a step of measuring axial forces being exerted from the bolts on the flanges; and a step of, in the plurality of stages from the start of the tightening of the bolts up to the completion of the tightening, taking in measured values of the axial forces from the bolts, calculating an average value of
10 the measured values, and determining a skill level by comparing the average value and a determination reference.

The seal handling determination method may further
include: a step of measuring axial forces being exerted from the bolts on the flanges; and a step of, in the plurality of
15 stages from the start of the tightening of the bolts up to the completion of the tightening, taking in measured values of the axial forces from the bolts, calculating a difference between a maximum value and a minimum value of the measured values, and determining a skill level by comparing the difference and
20 a determination reference.

The seal handling determination method may further
include: a step of calculating an amount of deviation of the difference with respect to a reference value and determining a skill level by comparing the amount of deviation and a
25 determination reference.

[0009] In order to achieve the above-mentioned object, according to one aspect of a seal handling learning system of the present invention, the seal handling learning system for learning seal handling by using a surface-to-surface distance
30 between flanges being tightened by bolts and nuts with a gasket being interposed between the flanges includes: a seal handling part which includes the flanges being tightened by the bolts and the nuts, with the gasket being interposed between the flanges; a surface-to-surface distance measurement

part which measures the surface-to-surface distance between the flanges; a processing part which takes in measured values of the surface-to-surface distance from the surface-to-surface distance measurement part in a plurality of stages from start
5 of tightening of the bolts up to completion of the tightening, calculates a difference between a maximum value and a minimum value of the measured values, and determines a skill level by comparing the difference and a determination reference; and an
10 information presentation part which presents any or all of calculation information and a calculation result, the calculation information and the calculation result being processed by the processing part.

The seal handling learning system may further include an axial force measurement part which measures axial forces being
15 exerted from the bolts on the flanges, the processing part may take in measured values from the axial force measurement part in the plurality of stages from the start of the tightening of the bolts up to the completion of the tightening, may calculate a difference average value of the measured values,
20 and may determine a skill level by comparing the average value and a determination reference, and the information presentation part may present any or all of calculation information and a calculation result, the calculation information and the calculation result being processed by the
25 processing part.

The seal handling learning system may further include an axial force measurement part which measures axial forces being
exerted from the bolts on the flanges, the processing part may take in measured values from the axial force measurement part
30 in the plurality of stages from the start of the tightening of the bolts up to the completion of the tightening, may calculate a difference between a maximum value and a minimum value of the measured values, and may determine a skill level by comparing the difference and a determination reference, and

the information presentation part may present any or all of calculation information and a calculation result, the calculation information and the calculation result being processed by the processing part.

5

Advantageous Effects of Invention

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

(1) A surface-to-surface distance between flanges which
10 exerts influence on an accuracy of seal handling is measured, variation of measured values can be comprehended, and a skill level of a seal handler can be determined from the variation.

(2) Since the surface-to-surface distance between the
flanges is measured and evaluated by deviation of the
15 tightening (uneven tightening state) and a difference of axial forces, the uneven tightening state and an elastic interaction state are quantified, and the quantified states can be evaluated as a skill level, thereby allowing contribution to enhancement of skills of the seal handler.

20 (3) It is made possible to contribute to enhancement of reliability of the seal handling.

(4) Utilization for validation is made possible since conformity with standard procedures such as JIS appear on a skill level, and determination that a skill level is low from
25 a handling result can be utilized for confirmation that the seal handling is not in conformity with the standard procedures such as JIS.

(5) A system which can be utilized for handling training and handling validation can be constructed and utilization for
30 a learning system of the seal handling using a training facility and a real machine is made possible.

[0011] Additionally, other objects, features, and advantages of the present invention will become further apparent by referring to the accompanying drawings and

embodiments.

Brief Description of Drawings

[0012] Fig. 1 illustrates a diagram of a seal handling
5 determination system according to a first embodiment.

Fig. 2A illustrates a diagram of a seal handling part and
Fig. 2B illustrates a diagram for explaining a position of
measuring a surface-to-surface distance of flanges and
measurement thereof.

10 Fig. 3 illustrates a seal handling determination file
according to the first embodiment.

Fig. 4 is a flowchart that illustrates a processing
sequence of the seal handling determination system.

Fig. 5 illustrates a seal handling determination system
15 according to a second embodiment.

Fig. 6 illustrates a seal handling determination file
according to the second embodiment.

Fig. 7 is a flowchart that illustrates a processing
sequence of the seal handling determination system.

20 Fig. 8 illustrates a seal handling determination file
according to a third embodiment.

Fig. 9 is a flowchart that illustrates a processing
sequence of the seal handling determination system.

Fig. 10 illustrates a seal handling determination system
25 according to one exemplary embodiment.

Fig. 11 illustrates hardware of the seal handling
determination system.

Fig. 12 illustrates hardware of a surface-to-surface
distance measurement part.

30 Fig. 13 illustrates a diagram for explaining measurement
of a surface-to-surface distance D.

Fig. 14 illustrates a diagram of each axial force sensor.

Fig. 15 is a flowchart that illustrates a processing
sequence of the seal handling determination system.

Fig. 16 illustrates a diagram of a distribution graphic of measured values of the surface-to-surface distance.

Fig. 17 illustrates a diagram of a distribution graphic of measured values of axial forces.

5

Description of Embodiments

[0013] [First Embodiment]

Fig. 1 illustrates a seal handling determination system according to a first embodiment. A configuration shown in Fig. 10 1 is one example and the present invention is not limited to the configuration shown therein.

This seal handling determination system 2 determines a skill level of a handler by measurement information of seal handling. This seal handling determination system 2 includes a 15 seal handling part 4, a surface-to-surface distance measurement part (hereinafter, simply referred to as a "measurement part") 6, a processing part 8, a storage part 10, and an information presentation part 12.

The seal handling part 4 is, for example, a fastening 20 part of pipings 14-1 and 14-2. In this seal handling part 4, a gasket 18 is interposed between a flange joint (hereinafter, simply referred to as a "flange") 16-1 on a side of the piping 14-1 and a flange 16-2 on a side of the piping 14-2, and the seal handling part 4 is fastened by a plurality of bolts 20-1, 20-2, ..., and 20-N and nuts 22. A tightening tool 24 is used 25 to tighten the bolts 20-1, 20-2, ..., 20-N and the nuts 22. In this seal handling part 4, a surface-to-surface distance D between the flanges 16-1 and 16-2 is a distance between surfaces of the flanges 16-1 and 16-2 which face each other 30 and indicates a distance of a measurement portion.

[0014] The measurement part 6 measures the surface-to-surface distance D in the measurement portion and outputs the measured values. As this measurement part 6, besides a flange-to-flange measurement device which uses laser light or the

like, a clearance gauge or the like may be used.

It is only required for the measurement of this surface-to-surface distance D, for example, to provide through-holes for attaching length measuring devices, each of the through
 5 holes being provided between each two bolts of the flange 16-1 on one side, the each two bolts having a pitch circle diameter, and to measure the distance by applying a leading end of each of the length measuring devices to between the surfaces of the flange 16-2 on another side facing thereto and the flange 16-1.
 10 It is desirable that at least a pair of these length measuring devices which are diagonally arranged or two or more pairs thereof which are diagonally arranged, the two or more pairs thereof being orthogonal to each other, are attached. The length measuring devices may be attached on an outer rim of
 15 the flange 16-1 on one side and an outer rim of the flange 16-2 on another side facing thereto may be provided with overhangs which receive the leading ends of the length measuring devices.

The processing part 8 is, for example, a computing
 20 apparatus such as a computer. Processing performed by this processing part 8 includes: a) a process of taking in the measured values of the surface-to-surface distance D; b) a process of writing the measured values to the storage part 10 together with pieces of identification information; c) a
 25 process of extracting a maximum value and a minimum value from the measured values; d) a process of calculating a difference between the maximum value and the minimum value of the measured values; e) a process of determining a calculation result; f) information presentation process, and the like.

30 [0015] In the storage part 10, the measured values of the surface-to-surface distance D associated with the pieces of the identification information and the like are stored. In this storage part 10, a first seal handling determination file 26-1 (Fig. 3), in which the measured values of the surface-to-

surface distance D and the like are stored, or the like is stored.

On the information presentation part 12, any one or both of calculation information and the calculation result
 5 processed by the processing part 8 are presented. This presentation information includes: the measured values of the surface-to-surface distance D; the calculation result of the measured values; information pertinent to transition of the difference between the maximum value and the minimum value of
 10 the measured values; a determination result; and the like.

[0016] <Measurement of Surface-to-Surface Distance D of Flanges 16-1 and 16-2>

Fig. 2A illustrates the seal handling part 4, viewed from a side of the flange 16-1. In this seal handling part 4, eight
 15 bolts 20-1, 20-2, ..., and 20-8 are used for the flanges 16-1 and 16-2, and P1, P2, ..., and P8 indicate bolt positions and bolt tightening positions.

For temporary tightening of the flanges 16-1 and 16-2, for example, diagonal tightening is employed. In tightening
 20 order of this diagonal tightening, supposing that the tightening is started at P1, the order is P1→P5→P3→P7→P2→P6→P4→P8, and the tightening is ended at P8.

[0017] Fig. 2B illustrates a measurement position of the surface-to-surface distance D of the flanges 16-1 and 16-2
 25 with P1 as a center. In this case, a measured value d1 of the surface-to-surface distance D at P1 is measured by the measurement part 6, and as to the measured value d1, P1 indicates identification information of the measurement position where the measured value d1 is measured. As this
 30 identification information, the bolt 20-1 may be the identification information, and measurement date and time, a global positioning system (GPS), or the like may be used as the identification information.

Similarly, as to the surface-to-surface distance D, as a

plurality of measurement positions, for example, by setting measurement positions P2, P3, ..., and P8, measured values d2 to d8 are obtained in the measurement part 6.

Note that it is preferable that measurement of the flange surface-to-surface distance is conducted between the bolt positions or bolts in flange outer rim portions, and further, it is preferable that the measurement positions are between the same positions or are between approximate positions.

[0018] <Processing Contents by Processing Part 8>

In this seal handling determination system 2, processing contents by the processing part 8 includes the following processes.

a) The process of taking in the measured values of the surface-to-surface distance D

The measurement part 6 measures continuously or intermittently the surface-to-surface distance D. These measured values are taken into the processing part 8 at predetermined timing.

b) The process of writing to the storage part 10

The processing part 8 executes the process of wiring the measured values to the storage part 10 together with pieces of the identification information. The pieces of the identification information are pieces of information for identifying the measured values and may be any one or two or more of "measurement portions of the surface-to-surface distances D", "members", "measurement timing", "tightening time of the bolts 20-1, 20-2, ..., and 20-8", and the like. Although as the "measurement portions of the surface-to-surface distances D", for example, position information of the bolts 20-1, 20-2, ..., and 20-8 or the like may be used as reference, angles indicating the measurement portions or the like may be used. The "members" are, for example, pieces of information pertinent to components such as the flanges 16-1 and 16-2. As the "measurement timing", measurement date and

time, round pattern information, or the like may be used. As the "tightening time of each of the bolts 20-1, 20-2,..., and 20-8", tightening date and time or the like may be used. As these pieces of identification information, in addition
 5 thereto, information which can identify the bolt tightening may be used, and two or more of these pieces of the information may be combined.

[0019] c) The process of extracting of the maximum value and the minimum value of the measured values

10 The processing part 8 extracts the maximum value and the minimum value from the taken-in plurality of measured values in order to identify variation and fluctuation of the measured values.

As the maximum value and the minimum value of the
 15 measured values of the surface-to-surface distance D , a value during tightening and a value upon completion of the tightening are used. Here, the "tightening time" indicates respective stages of the temporary tightening of the bolts 20-1, 20-2,..., and 20- N performed when alignment of the flanges
 20 16-1 and 16-2 is adjusted and the surfaces of the flanges 16-1 and 16-2 become parallel with each other, respective stages upon finishing the temporary tightening, and respective stages of the bolt tightening.

As to the plurality of measured values dk (temporary
 25 tightening) and dh (final tightening) of the surface-to-surface distance D , a maximum value dk_{max} (temporary tightening) and a maximum value dh_{max} (final tightening) thereof and a minimum value dk_{min} (temporary tightening) and a minimum value dh_{min} (final tightening) thereof are extracted.

30 [0020] d) The process of calculating the difference between the maximum value and the minimum value of the measured values

The processing part 8 calculates the difference between the maximum value and the minimum value of the measured values in order to identify variation and fluctuation of the measured

values.

As to the plurality of measured values dk (temporary tightening) and dh (final tightening) of the surface-to-surface distance D , when the difference between the maximum value dk_{max} and the minimum value dk_{min} of the temporary tightening is expressed as Δdk and the difference between the maximum value dh_{max} and the minimum value dh_{min} of the final tightening is expressed as Δdh , the differences Δdk and Δdh are as follows.

$$\Delta dk = dk_{max} - dk_{min} \quad \dots (1)$$

$$\Delta dh = dh_{max} - dh_{min} \quad \dots (2)$$

[0021] e) The process of determining the calculation result

The processing part 8 determines a skill level from a distribution level by utilizing distribution of the differences each between the maximum value and the minimum value, as a function of determining the calculation result.

When reference values of the surface-to-surface distance D of the temporary tightening and the final tightening are expressed as Δdk_{ref} and Δdh_{ref} , by comparing the reference value Δdk_{ref} and the difference Δdk and by comparing the reference value Δdh_{ref} and the difference Δdh , a skill level La is determined. The skill level La (handling skill) is determined in accordance with, for example, a magnitude of the difference Δdh with respect to the reference value Δdh_{ref} . For example,

when the difference Δdh with respect to the reference value Δdh_{ref} is a value which can be ignored or is extremely small ($\Delta dh_{ref} = (\text{or } \approx) \Delta dh$), the skill level La is excellent (= pass);

when the difference Δdh with respect to the reference value Δdh_{ref} is medium ($\Delta dh_{ref} < (\text{or } >) \Delta dh$), the skill level La is good (= pass); and

when the difference Δdh with respect to the reference value Δdh_{ref} is large, ($\Delta dh_{ref} \ll (\text{or } \gg) \Delta dh$), the skill

level La is fair (= handling failure), and

these are pieces of skill level information indicating the skill level of a handler.

f) The information presentation process

5 The processing part 8 generates and presentation information to be presented on the information presentation part 12 and provides the presentation information for the information presentation part 12. The presentation information includes: the measured values of the surface-to-surface
10 distance D; the calculation result of the measured values; transition information of the difference between the maximum value and the minimum value of the measured values; the determination result of the skill level La; and the like.

[0022] <Seal Handling Determination File 26-1>

15 Fig. 3 shows one example of a first seal handling determination file 26-1 stored in the storage part 10. In this seal handling determination file 26-1, a number part 28, an identification information part 30, a surface-to-surface distance part 32, and a skill level part 34 are stored.

20 In the number part 28, numbers for identifying storage information in the seal handling determination file 26-1 are stored.

 In the identification information part 30, pieces of identification information for identifying the surface-to-
25 surface distances D are stored. This identification information part 30 includes, for example, a measurement portion part 30-1 and a tightening time part 30-2. In the measurement portion part 30-1, information indicating measurement portions Sn is stored. In the tightening time part
30 30-2, information indicating tightening time Tn is stored.

 The surface-to-surface distance information part 32 includes a temporary tightening measured value part 32-1, a final tightening measured value part 32-2, a maximum value part 32-3, a minimum value part 32-4, a difference part 32-5,

and a reference value part 32-6. In the temporary tightening measured value part 32-1, the measured values dk of the surface-to-surface distance D upon the temporary tightening are stored and in the final tightening measured value part 32-2, the measured values dh of the surface-to-surface distance D upon the final tightening are stored.

In the maximum value part 32-3, the maximum values dk_{max} extracted from the measured values dk and the maximum values dh_{max} extracted from the measured values dh are stored.

10 In the minimum value part 32-4, the minimum values dk_{min} extracted from the measured values dk and the minimum values dh_{min} extracted from the measured values dh are stored.

In the difference part 32-5, the differences Δdk each between each of the maximum values dk_{max} and each of the minimum values dk_{min} and the differences Δdh each between each of the maximum values dh_{max} and each of the minimum values dh_{min} are stored.

In the reference value part 32-6, the reference values Δdk_{ref} and Δdh_{ref} of the differences Δdk and Δdh are stored.

20 In addition, in the skill level part 34, the above-described skill levels La as the determination results are stored.

[0023] <Processing Sequence by Seal Handling Determination System 2>

25 Fig. 4 shows a processing sequence by the seal handling determination system 2. This processing sequence includes a program in the seal handling determination system 2 of the present invention or a processing procedure which is one example of a handling determination method thereof. Upon starting this seal handling determination system 2, the measurement part 6, the processing part 8, and the information presentation part 12 are initialized and the processing shifts to linkage operation.

In processes from starting of the temporary tightening

and the final tightening to completing of the handling by the seal handling part 4, the measurement part 6 measures the surface-to-surface distances D in measurement positions which are previously set (S101). The processing part 8 executes
 5 taking-in of the measured values dk and dh of the surface-to-surface distances D (S102). The processing part 8 stores the taken-in measured values dk and dh together with the pieces of identification information in the storage part 10 (S103). The measured values dk and dh are stored together with the pieces
 10 of identification information in the seal handling determination file 26-1.

[0024] The processing part 8 extracts the maximum values dk_{max} and dh_{max} and the minimum values dk_{min} and dh_{min} from the measured values dk and dh (S104). These maximum values
 15 dk_{max} and dh_{max} and minimum values dk_{min} and dh_{min} are stored in the seal handling determination file 26-1.

The processing part 8 calculates the difference Δdk between the maximum value dk_{max} and the minimum value dk_{min} and the difference Δdh between the maximum value dh_{max} and the
 20 minimum value dh_{min} (S105).

The processing part 8 determines the skill level La by comparing the differences Δdk and Δdh and the reference values Δdk_{ref} and Δdh_{ref} using these (S106).

After this determination, the processing part 8 generates,
 25 for example, the seal handling determination file 26-1 as presentation information and performs output thereof to the information processing part 12 (S107). The information presentation part 12 which has received this presents the provided presentation information (S108).

30 [0025] <Effects of First Embodiment>

According to this first embodiment, the following effects can be obtained.

(1) Since elastic interaction and uneven tightening which occur between the flanges 16-1 and 16-2 appear on the surface-

to-surface distances D , measured values of the surface-to-surface distances D and the transition thereof are calculated, thereby allowing evaluation as the skill level La .

(2) A seal handler can efficiently enhance handling skills with the skill level La as an index.

(3) The seal handler can have recognition of the handling skills with the skill level La as the index and can avoid the elastic interaction and the uneven tightening, thereby allowing reliability of the seal handling to be enhanced.

10 [0026] [Second Embodiment]

In this second embodiment, as shown in Fig. 5, as in the first embodiment, a measurement part 6, a processing part 8, a storage part 10, and an information presentation part 12 are included, and in addition thereto, an axial force measurement part (hereinafter, simply referred to as a "measurement part") 36 is included. The measurement part 6, as in the first embodiment, measures surface-to-surface distances D in measurement portions. In contrast to this, the measurement part 36 measures axial forces F of bolts 20-1, 20-2, ..., and 20-N. This measurement part 36 may include a plurality of axial force sensors which individually measures the axial forces of the bolts 20-1, 20-2, ..., and 20-N. In other words, in the seal handling determination system 2 according to this embodiment, processing in which based on the measurement of the axial forces F , a skill level $Lb-1$ (a skill level of the axial forces F), that is, whether or not tightening surface pressures are within an appropriate range is determined or the like is included.

[0027] Processing performed by the processing part 8 includes the a) to f) processes as in the first embodiment and in addition thereto, includes g) a process of taking in measured values of the axial forces F , h) a process of writing the measured values to the storage part 10 together with pieces of identification information, i) a process of

calculating an average value of the measured values, j) a process of determining a calculation result, k) an information presentation process, and the like.

The storage part 10 is provided with a second seal
 5 handling determination file 26-2 (Fig. 6). In this seal handling determination file 26-2, the measured values of the axial forces F of the bolts 20-1, 20-2, ..., and 20- N are stored together with the pieces of identification information.

On the information presentation part 12, any one or both
 10 of calculation information and the calculation result processed by the processing part 8 are presented. This presentation information includes the measured values of the axial forces F , average value information, a determination result, and the like.

15 [0028] <Measurement of Axial Forces F of Bolts 20-1, 20-2, ..., 20- N >

As to, for example, eight bolts 20-1, 20-2, ..., and 20-8 in the flanges 16-1 and 16-2 in the seal handling part 4 (Fig. 2A), axial forces F from when temporary tightening is
 20 performed to when final tightening is completed. This measurement timing is the same as the measurement timing of the surface-to-surface distances D in the first embodiment. Regarding the identification information of the measured value of the axial force F , P1 to P8 representing the bolt position
 25 and bolts 20-1 to 20-8 may also be used as the identification information, and the measurement date and time, GPS, or the like may be used as the pieces of identification information.

[0029] <Processing Contents by Processing Part 8>

In this seal handling determination system 2, processing
 30 contents by the processing part 8 includes the following processes.

g) The process of taking in the measured values f of the axial forces F

The measurement part 36 continuously or intermittently

measures the axial forces F . These measured values are taken into the processing part 8 at predetermined timing.

h) The process of writing to the storage part 10

The processing part 8 executes the process of writing the
 5 measured values f of the axial forces F together with the
 pieces of identification information to the storage part 10.
 The pieces of the identification information are pieces of
 information for identifying the measured values and may be any
 one or two or more of "measurement portions of the axial
 10 forces F ", "members", "measurement timing", "tightening time
 of the bolts 20-1, 20-2, ..., and 20-N", and the like. As the
 "measurement portions of the axial forces F ", for example,
 position information of the bolts 20-1, 20-2, ..., and 20-N or
 the like may be used as reference. The "members" are, for
 15 example, pieces of information pertinent to components such as
 the flanges 16-1 and 16-2. As the "measurement timing",
 measurement date and time, round pattern information, or the
 like may be used. As the "tightening time of each of the bolts
 20-1, 20-2, ..., and 20-N", tightening date and time or the
 20 like may be used. As these pieces of identification
 information, in addition thereto, information which can
 identify the bolt tightening may be used, and two or more of
 these pieces of the information may be combined.

[0030] i) The process of calculating the average value of
 25 the measured values of the axial forces F

The process of calculating of the average value of the
 measured values of the axial forces F is executed by the
 processing part 8. The processing performed by this processing
 part 8 includes taking-in of the measured values of the axial
 30 forces F and a process of calculating average values f_{kave} and
 f_{have} of a plurality of measured values. In other words,
 taking-in of the measured values of the axial forces F of the
 bolts is premised, and for example, in the process of
 calculating of the average value f_{have} , the plurality of

measured values f of the axial forces F upon final tightening are acquired and the average value f_{have} thereof is calculated.

[0031] j) The process of determining the calculation result

The process of determining the average value f_{have} (final
5 tightening) of the axial forces F is executed by the
processing part 8. For this determination, a range f_{href} of
target axial forces (final tightening) is used as a reference
range, and the determination is made based on whether or not
the axial forces F upon final tightening are included within
10 this range. In other words, since when the average value of
the axial forces measured upon final tightening is included in
the range f_{href} of the target axial forces (final tightening),
a proper tightening surface pressure can be ensured, the seal
handling is determined as proper seal handling.

15 k) The information presentation process

The processing part 8 generates and presentation
information to be presented on the information presentation
part 12 and provides the presentation information for the
information presentation part 12. The presentation information
20 includes the measured values of the axial forces and the
calculation result of the average value, that is,
determination results on whether or not a proper surface
pressure is ensured and on whether or not the proper seal
handling has been conducted, and the like.

25 [0032] Fig. 6 shows one example of the second seal handling
determination file 26-2 stored in the storage part 10. In this
seal handling determination file 26-2, the same parts as those
in the seal handling determination file 26-1 (Fig. 3) are
denoted by the same reference signs and the description
30 therefor is omitted.

In this seal handling determination file 26-2, the seal
handling determination file 26-1 (Fig. 3), in addition thereto,
an axial force part 39, and a skill level part 35 are stored.

The axial force part 39 includes a temporary tightening

measured value part 39-1, a final tightening measured value part 39-2, an average value part 39-3, and a target axial force range part 39-4. In the temporary tightening measured value part 39-1, measured values f_k of axial forces F upon
 5 temporary tightening are stored, and in the final tightening measured value part 39-2, measured values f_h of axial forces F upon final tightening are stored.

In the average value part 39-3, an average value f_{kave} of a plurality of measured values f_k and an average value f_{have}
 10 of a plurality of measured values f_h are stored. In the target axial force range part 39-4, a range f_{kref} of target axial forces upon temporary tightening and a range f_{href} of target axial forces upon final tightening are stored. In addition, in the skill level part 35, the already-described skill level Lb -
 15 1 which is a determination result is stored.

[0033] Fig. 7 shows a processing sequence by the seal handling determination system 2 according to the second embodiment. This processing sequence is a program in the seal handling determination system 2 of the present invention or
 20 one example of a processing procedure according to a handling determination method thereof.

In processes from starting of the temporary tightening and the final tightening to completing of the handling by the seal handling part 4, the axial force measurement part 36
 25 measures the axial forces F in previously set measurement positions. (S121). The processing part 8 takes in measured values f_k and f_h of the axial forces F (S122). The processing part 8 stores the taken-in measured values f_k and f_h together with pieces of identification information in the storage part
 30 10 (S123). The measured values f_k and f_h are stored in the seal handling determination file 26-2 (Fig. 6) together with the pieces of identification information.

[0034] The processing part 8 calculates average values f_{kave} and f_{have} of a plurality of measured values f_k and f_h

(S124) and stores the average values fk_{ave} and fh_{ave} in the seal handling determination file 26-2 (Fig. 6). As to these average values fk_{ave} and fh_{ave} , based on whether the average value fk_{ave} is within the range fk_{ref} of the target axial forces and whether the average value fh_{ave} is within the range fh_{ref} of the target axial forces, the skill level $Lb-1$ (the skill level of axial forces F) is determined (S125).

After this determination, the processing part 8 generates, for example, the seal handling determination file 26-2 as presentation information and performs output thereof to the information processing part 12 (S126). The information presentation part 12 which has received this presents the provided presentation information (S127).

[0035] <Effects of Second Embodiment>

According to this second embodiment, the following effects can be obtained.

(1) Based on whether or not the seal handling is implemented at a proper tightening surface pressure and whether elastic interaction and uneven tightening occurring between the flanges 16-1 and 16-2 appear on the average value of the measured values of the axial forces F , the skill level $Lb-1$ of the seal handling can be evaluated.

(2) A seal handler can recognize handling skills with the skill level $Lb-1$ as an evaluation index and with reference to a level which is an evaluation result of the handling skills, can effectively enhance the handling skills.

(3) Since the seal handler can implement the seal handling at the proper seal surface pressure and can avoid the elastic interaction and the uneven tightening, reliability of the seal handling can be enhanced.

[0036] [Third Embodiment]

A seal handling determination system 2 according to a third embodiment, as in the second embodiment (Fig. 5), includes measurement parts 6 and 36, and from the measurement

part 6, measured values of surface-to-surface distances D are taken into a processing part 8 and from the measurement part 36, measured values of axial forces F are taken into the processing part 8. Accordingly, in the seal handling
5 determination system 2 according to this embodiment, by measuring both of the surface-to-surface distances D and the axial forces F and by using both of a skill level La (a skill level of the surface-to-surface distances D) and a skill level Lb-2 (a skill level of the axial forces F), it is determined
10 whether or not tightening surface pressures are within a proper range.

[0037] Processing performed by the processing part 8 includes the a) to f) processes as in the first embodiment and in addition thereto, includes 1) a process of taking in
15 measured values of the axial forces F, m) a process of writing the measured values to the storage part 10 together with pieces of identification information, n) a process of calculating an average value of the measured values, o) a process of calculating a difference between a maximum value
20 and a minimum value of the measured values of the axial forces F, p) a process of determining calculation results, q) an information presentation process, and the like.

The storage part 10 is provided with a third seal handling determination file 26-3 (Fig. 8). In this seal
25 handling determination file 26-3, the measured values of the axial forces F of the bolts 20-1, 20-2, ..., and 20-N and the measured values of the surface-to-surface distances D are stored together with pieces of identification information.

On the information presentation part 12, any one or both
30 of calculation information and the calculation result processed by the processing part 8 are presented. This presentation information includes measured values of the axial forces F and the surface-to-surface distances D, information pertinent to transition of the difference between the maximum

value and the minimum value thereof, determination results, and the like.

[0038] <Measurement of Axial Forces F of Bolts 20-1, 20-2,..., 20-N>

5 As to, for example, eight bolts 20-1, 20-2,..., and 20-8 in the flanges 16-1 and 16-2 in the seal handling part 4 (Fig. 2A), axial forces F from when temporary tightening is performed to when final tightening is completed. This measurement timing is the same as the measurement timing of
 10 the surface-to-surface distances D in the first embodiment. The pieces of identification information of the measured values of the axial forces may also be P1 to P8 indicating bolt positions or bolts 20-1 to 20-8, or measurement date and time, a GPS, or the like may be used as the pieces of
 15 identification information.

[0039] <Measurement of Surface-to-Surface Distance D between Flanges 16-1 and 16-2>

Since the measurement thereof is similar to that in the first embodiment (Fig. 2A), the description therefor is
 20 omitted.

[0040] <Processing Contents by Processing Part 8>

In this seal handling determination system 2, processing contents by the processing part 8 includes the following processes.

25 1) The process of taking in the measured values f of the axial forces F

The measurement part 36 continuously or intermittently measures the axial forces F. These measured values f are taken into the processing part 8 at predetermined timing.

30 m) The process of writing to the storage part 10

The processing part 8 executes the process of writing the measured values f of the axial forces F together with the pieces of identification information to the storage part 10. The pieces of the identification information are pieces of

information for identifying the measured values and may be any one or two or more of "measurement portions of the axial forces F", "members", "measurement timing", "tightening time of the bolts 20-1, 20-2,..., and 20-N", and the like. As the

5 "measurement portions of the axial forces F", for example, position information of the bolts 20-1, 20-2,..., and 20-N or the like may be used as reference. The "members" are, for example, pieces of information pertinent to components such as the flanges 16-1 and 16-2. As the "measurement timing",

10 measurement date and time, round pattern information, or the like may be used. As the "tightening time of each of the bolts 20-1, 20-2,..., and 20-N", tightening date and time or the like may be used. As these pieces of identification information, in addition thereto, information which can

15 identify the bolt tightening may be used, and two or more of these pieces of the information may be combined.

[0041] n) The process of extracting a maximum value and a minimum value of the measured values of the axial forces F

The processing part 8 extracts the maximum value and the

20 minimum value from the acquired plurality of measured values in order to identify variation and fluctuation of the measured values of the axial forces.

As the maximum values and the minimum values of the measured values, values upon tightening and values upon

25 completion of the tightening are used. Here, the "tightening time" indicates respective stages of the temporary tightening of the bolts 20-1, 20-2,..., and 20-N performed when alignment of the flanges 16-1 and 16-2 is adjusted and the surfaces of the flanges 16-1 and 16-2 become parallel with each other,

30 respective stages upon finishing the temporary tightening, and respective stages of the bolt tightening.

As to a plurality of measured values f_k (temporary tightening) and f_h (final tightening) of the axial forces F, a maximum value f_{kmax} (temporary tightening) and a maximum value

fhmax (final tightening) thereof and a minimum value fkmin (temporary tightening) and a minimum value fhmin (final tightening) thereof are extracted.

- [0042] o) The process of calculating a difference between
 5 the maximum value and the minimum value of the measured values of the axial forces F

The processing part 8 calculates the difference between the maximum value and the minimum value of the measured values in order to identify variation and fluctuation of the measured
 10 values.

As to the plurality of measured values fk (temporary tightening) and fh (final tightening) of the axial forces, when the difference between the maximum value fkmax and the minimum value fkmin of the temporary tightening is expressed
 15 as Δfk and the difference between the maximum value fhmax and the minimum value fhmin of the final tightening is expressed as Δfh , the differences Δfk and Δfh are as follows.

$$\Delta fk = fkmax - fkmin \quad \dots (3)$$

$$\Delta fh = fhmax - fhmin \quad \dots (4)$$

- 20 [0043] p) The process of determining the calculation result

The processing part 8 determines a skill level from a distribution level by utilizing distribution of the differences each between the maximum value and the minimum value, as a function of determining the calculation result.

25 When reference values of the axial forces of the temporary tightening and the final tightening are expressed as Δfk_{ref} and Δfh_{ref} , by comparing the reference value Δfk_{ref} and the difference Δfk and by comparing the reference value Δfh_{ref} and the difference Δfh , a skill level Lb-2 is determined. The
 30 skill level Lb-2 (handling skill) is determined in accordance with, for example, a magnitude of the difference Δfh with respect to the reference value Δfh_{ref} . For example,

when the difference Δfh with respect to the reference value Δfh_{ref} is a value which can be ignored or is extremely

small ($\Delta fh_{ref} = (\text{or } \approx) \Delta fh$), the skill level Lb-2 is excellent (= pass);

when the difference Δfh with respect to the reference value Δfh_{ref} is medium ($\Delta fh_{ref} < (\text{or } >) \Delta fh$), the skill level

5 Lb-2 is good (= pass); and

when the difference Δfh with respect to the reference value Δfh_{ref} is large, ($\Delta fh_{ref} \ll (\text{or } \gg) \Delta fh$), the skill level Lb-2 is fair (= handling failure), and

these are skill level information indicating the skill
10 level of a handler.

q) The information presentation process

The processing part 8 generates and presentation information to be presented on the information presentation part 12 and provides the presentation information for the
15 information presentation part 12. The presentation information includes the measured values of the axial forces, the calculation result of the measured value, information pertinent to transition of the difference of the maximum value and the minimum value of the measured values, the
20 determination result of the skill level Lb-2, and the like.

[0044] <Taking-in and Determination of Measured Values of Surface-to-Surface Distance D of Flanges 16-1 and 16-2>

Since the measurement thereof is similar to that in the first embodiment, the description therefor is omitted.

25 [0045] <Seal Handling Determination File 26-3>

Fig. 8 shows one example of the third seal handling determination file 26-3 stored in the storage part 10. In the seal handling determination file 26-3, a step part 38, an axial force part 40, a surface-to-surface distance part 42, a
30 pass/fail part 44, and an overall determination part 45 are stored.

In the step part 38, a temporary tightening part 38-1 and a final tightening part 38-2 are set, and in the temporary tightening part 38-1, position symbols 1, 2, ..., and P are set

and in the final tightening part 38-2, similarly, position symbols 1, 2, ..., and Q are set. The position symbols 1, 2, ..., P, and Q indicate tightening positions.

In the axial force part 40, as to the temporary
 5 tightening part 38-1 and the final tightening part 38-2, a measured value part 40-1, a maximum value part 40-2, a minimum value part 40-3, a difference value part 40-4, an average value part 40-5, and a reference value part 40-6 are set. In the measured value part 40-1, the measured values of the axial
 10 forces F are stored in tightening measurement order 1, 2, ..., and n. In the maximum value part 40-2, maximum values of the measured axial forces F are stored. In the minimum value part 40-3, minimum values of the measure axial forces F are stored. In the difference value part 40-4, each value obtained by
 15 subtracting each of the minimum values from each of the maximum values is stored. In the average value part 40-5, each average value of each of the maximum values and each of the minimum values of the axial forces F is stored. In the reference value part 40-6, reference values of the axial
 20 forces F are stored.

[0046] In the surface-to-surface distance part 42, as to the temporary tightening part 38-1 and the final tightening part 38-2, a measured value part 42-1, a maximum value part 42-2, a minimum value part 42-3, a difference value part 42-4,
 25 and a reference value part 42-5 are set. In the measured value part 42-1, the measured values of the surface-to-surface distances D are stored in the tightening measurement order 1, 2, ..., and n. In the maximum value part 42-2, the maximum values of the measured surface-to-surface distances D are
 30 stored. In the minimum value part 42-3, minimum values of the measured surface-to-surface distance D are stored. In the difference value part 42-4, each value obtained by subtracting each of the minimum values from each of the maximum values is stored. In the reference value part 42-5, reference values of

the surface-to-surface distances D are stored.

In the pass/fail part 44, as to the temporary tightening part 38-1 and the final tightening part 38-2, pass/fail results of the respective positions are stored. In the overall
5 determination part 45, overall determination results obtained from the pass/fail results are stored. These overall determination results indicate whether or not the axial forces F and the surface-to-surface distances D are within the reference values. In other words, in the overall determination
10 part 45, determination results on whether or not proper tightening handling has been implemented are stored.

Also in this embodiment, the already-described seal handling determination file 26-2 (Fig. 6) can be used. Since the seal handling determination file 26-2 has already been
15 described in detail, the details thereof are omitted.

[0047] <Processing Sequence by Seal Handling Determination System 2>

Fig. 9 shows a processing sequence by the seal handling determination system 2. This processing sequence includes a
20 program in the seal handling determination system 2 of the present invention or a processing procedure which is one example of a handling determination method thereof. In this processing procedure, based on the averages of the axial forces and the surface-to-surface distances in respective
25 steps and the differences each between each of the maximum values and each of the minimum values, skills of a worker are evaluated, and determination of pass/fail is made based on measurement in each of the steps or previously set steps after completion of the final tightening or the like. The reference
30 values for the determination are individually set in accordance with work levels required for each tightening work. Steps for the same-day determination are individually set in accordance with work levels required for each tightening work.

Therefore, this processing procedure includes the

following processes as to the axial forces F .

(a) A process of obtaining differences of average values of the target axial forces (whether the average axial forces are within a fixed range of the target axial forces)

5 (b) A process of obtaining each difference between each of the maximum values and each of the minimum values (variation of the axial forces)

(c) A process of determining each difference between each of the target axial forces and each of the maximum values
10 (whether each local axial force does not exceed fracture stress of a gasket)

(d) A process of determining each difference between each of the target axial forces and each of the minimum values (whether each local axial force does not fall below sealing
15 limit stress of the gasket)

Furthermore, this processing procedure includes the following process as to the surface-to-surface distances D .

(e) A process of obtaining each difference between each of the maximum values and each of the minimum values (surface-
20 to-surface inclination)

[0048] Note that although in the seal handling determination system 2 according to this embodiment, it is determined that the axial forces and the surface-to-surface distances after the completion of tightening are within the
25 reference and the pass/fail determination is not made in each of the steps, the present invention is not limited to this.

In the processes from starting of the temporary tightening and the final tightening of the seal handling part 4 to the completion of the handling, the measurement part 6
30 measures the surface-to-surface distances D in previously set measurement positions (S201), and the measurement part 36 measures the axial forces F in previously set measurement positions (S202). The processing part 8 executes taking-in of the measured values dk and dh of the surface-to-surface

distances D (S203). The processing part 8 executes taking-in of the measured values f_k and f_h of the axial forces F (S204). The processing part 8 stores the taken-in measured values d_k and d_h and f_k and f_h together with the pieces of

5 identification information in the storage part 10 (S205). The measured values d_k and d_h are stored together with the pieces of identification information in the seal handling determination file 26-1. The measured values f_k and f_h are stored together with the pieces of identification information

10 in the seal handling determination file 26-3.

[0049] The processing part 8 extracts the maximum values d_{kmax} and d_{hmax} and the minimum values d_{kmin} and d_{hmin} from the measured values d_k and d_h (S206). The processing part 8 extracts the maximum values f_{kmax} and f_{hmax} and the minimum

15 values f_{kmin} and f_{hmin} from the measured values f_k and f_h (S207). These maximum values d_{kmax} and d_{hmax} and minimum values d_{kmin} and d_{hmin} are stored in the seal handling determination file 26-1. In addition, these maximum values f_{kmax} and f_{hmax} and minimum values f_{kmin} and f_{hmin} are stored

20 in the seal handling determination file 26-3.

The processing part 8 calculates each difference Δd_k between each of the maximum values d_{kmax} and each of the minimum values d_{kmin} and each difference Δd_h between each of the maximum values d_{hmax} and each of the minimum values d_{hmin}

25 (S208). The processing part 8 calculates each difference Δf_k between each of the maximum values f_{kmax} and each of the minimum values f_{kmin} and each difference Δf_h between each of the maximum values f_{hmax} and each of the minimum values f_{hmin} (S209).

30 [0050] The processing part 8 determines the skill level L_a by comparing the differences Δd_k and Δd_h and the reference values Δd_{kref} and Δd_{href} using these (S210). The processing part 8 determines the skill level L_{b-2} by comparing the differences Δf_k and Δf_h and the reference values Δf_{kref} and

Δfhref using these (S211).

After this determination, the processing part 8 generates, for example, the seal handling determination files 26-1 and 26-3 as presentation information and outputs the seal handling determination files 26-1 and 26-3 to the information processing part 12 (S212). The information presentation part 12 which has received these presents the provided presentation information (S213).

Based on whether numbers of skill levels La and Lb-2 are large or small, the processing part 8 performs overall determination in consideration of the skill levels La and Lb-2, generates presentation information indicating this overall determination results, stores this presentation information in the overall determination part 45 of the seal handling determination file 26-3, and presents the presentation information to the information presentation part 12.

[0051] <Modified Example of Processing Sequence by Seal Handling Determination System 2>

In the processing sequence shown in Fig. 9, for example, an arithmetic mean of the skill levels La and Lb-2 may be taken and a skill level Lc-1 with both of the skill levels La and Lb-2 taken into consideration may be calculated and presented. In addition, instead of the simple arithmetic mean of the skill levels La and Lb-2, the skill levels La and Lb-2 may be weighted and a degree of evaluation may be thereby adjusted.

[0052] <Effects of Third Embodiment>

According to this third embodiment, the following effects can be obtained.

(1) Elastic interaction and uneven tightening which occur between the flanges 16-1 and 16-2 appear on the surface-to-surface distances D, and this can be recognized as the skill level La, a situation of the axial forces F at this time can be recognized as the skill level Lb-2, and the seal handling

can be evaluated as the skill levels La and Lb-2.

(2) A seal handler can efficiently enhance handling skills with the two skill levels La and Lb-2 as indices.

(3) Since the seal handler uses the skill levels La and Lb-2 as the indices, recognizes interrelation of these, enhances the handling skills, and can thereby avoid the elastic interaction and the uneven tightening, the seal handler can enhance reliability of the seal handling.

[0053] [Fourth Embodiment]

In the first to third embodiments, magnitude correlation of the measured values of the surface-to-surface distances D or the axial forces F is obtained and the skill level La or the skill levels Lb-1 and Lb-2 are determined from each difference between each of the measured values of the surface-to-surface distances D or each of the axial forces F and each of the reference values. The present invention is not limited to the above-described embodiments.

The processing part 8 may obtain a difference Δ in the magnitude correlation of the measured values of the surface-to-surface distances D or the axial forces F, may calculate an amount of deviation of this difference Δ with respect to a reference value Δ_{ref} , and may determine a skill level Lc-2 by comparing this amount of deviation and the determination reference.

[0054] According to this fourth embodiment, the amount of deviation with respect to the reference value Δ_{ref} can be evaluated from the difference Δ in the magnitude correlation of the measured values of the surface-to-surface distances D or the axial forces F as the skill level Lc-2, and it is made possible to contribute to acquiring of further high seal handling skills.

[Exemplary Embodiment]

[0055] Fig. 10 illustrates a seal handling determination system according to one exemplary embodiment. In Fig. 10, the

same components as those shown in Fig. 1 are denoted by the same reference signs.

The seal handling determination system 2 of this exemplary embodiment is installed in a seal handling training center or the like and is used for training and learning of seek handling, handling simulation, or the like.

In this seal handling determination system 2, a seal handling part 4 is fixed on a floor 46 inside a building. The seal handling part 4 is provided with a long piping 14-2, and a fixed flange 48 which is attached on a lower end of this piping 14-2 is firmly fixed on the floor 46. In this exemplary embodiment, the already-described piping 14-1 is omitted, and heights of flanges 16-1 and 16-2 are set in such a way that a seal handler can perform handling by the piping 14-2. In the flanges 16-1 and 16-2, the already-described bolts 20-1, 20-2, ..., and 20-8 are attached.

[0056] A measurement part 6 for measuring surface-to-surface distances D of the flanges 16-1 and 16-2 is configured to be movable. This measurement part 6 includes a measurement function part 50 and a communication part 52. The measurement function part 50 measures the surface-to-surface distances D and outputs the measured values d. Outputted measurements which indicate the measured values d obtained by the measurement function part 50 are transmitted by the communication part 52 to a side of a processing part 8. For this signal transmission, any of wireless transmission or wired transmission may be used.

Each of the bolts 20-1, 20-2, ..., and 20-8 in the flanges 16-1 and 16-2 is provided with a measurement part 36 which measures an axial force F of each of the bolts. The measurement part 36 is provided with axial force sensors 36-1, 36-2, ..., and 36-8 (Fig. 11) in such a way as to correspond to the bolts 20-1, 20-2, ..., and 20-8.

[0057] A management table 54 for managing seal handling

made by the seal handling part 4 is provided. This management table 54 is movable by casters 56. Under and on this management table 54, a personal computer (PC) 58, a data logger 60, and a monitor 62 are installed. The PC 58 is one example of the already-described processing part 8. The data logger 60 is means for collecting and storing measurement data obtained by the measurement part 36. Pieces of output by the axial force sensors 36-1, 36-2, ..., and 36-8 are transmitted from the seal handling part 4 via a cable 64 to this data logger 60.

The monitor 62 is one example of an information presentation part 12. A screen 66 of this monitor 62 is provided with a touch panel 68 as one example of input means.

[0058] <Hardware of Seal Handling Determination System 2>

Fig. 11 shows hardware of the seal handling determination system 2. In Fig. 11, the same components those shown in Fig. 10 are denoted by the same reference signs.

The PC 58 is provided with a processor 70, an input/output part (I/O) 72, a communication part 74, and a storage part 10. The processor 70 is one example of the already-described processing part 8.

The data logger 60 and the monitor 62 are connected to the I/O 72. Measured value data of axial forces F amassed in the data logger 60 is taken into the I/O 72 by control of the processor 70 and is stored in the storage part 10. Presentation information generated by the processor 70 is presented to the monitor 62, and on the monitor 62, images are displayed. The communication part 74 is used for communication with the measurement part 6.

In the storage part 10, a variety of programs such as an operating system (OS) and a seal handling determination program, seal handling determination files 26-1 (Fig. 3), 26-2 (Fig. 6), and 26-3 (Fig. 8), and the like are stored. All of these seal handling determination files 26-1, 26-2, and 26-3

may be stored or any one or two or more thereof may be stored. This storage part 10 is constituted of storage elements such as a read-only-memory (ROM) and a random-access-memory (RAM).

An operation input part 76 includes interface devices for
 5 inputting information, such as the already-described touch panel 68 (Fig. 10), besides a keyboard and a mouse.

[0059] <Hardware of Measurement Part 6>

Fig. 12 shows hardware of the measurement part 6. In Fig.
 12, the same components as those shown in Fig. 10 are denoted
 10 by the same reference signs.

In this exemplary embodiment, a flange-to-flange measurement device using laser light is used as a measurement part 6.

In this measurement part 6, the measurement function part
 15 50 is provided with a light irradiation part 78, an imaging part 80, and an image processing part 82. The light irradiation part 78 forms a fine light image by irradiating a clearance portion between the flanges 16-1 and 16-2 of the measurement portion with laser light. This fine light image is
 20 a strip-like light image which travels from a surface portion of the flange 16-1 of the measurement portion via the clearance portion to a surface portion of the flange 16-1 and is formed by the laser light.

The imaging part 80 images the fine light image and
 25 converts the fine light image to image information. Pieces of the image information are pixels whose brightness differences of the fine light image are different from one another. This image information is taken into the image processing part 82 as the measured values d of the surface-to-surface distances D .

30 In this image processing part 82, the measured values d are counted by numbers of pixels of the fine light image and image processing part 82 recognizes the counted values as the measured values d . In other words, the measured values d of the surface-to-surface distances D can be obtained by light

measurement by this image processing part 82.

The pieces of the information of the measured values d of the surface-to-surface distances D obtained as described above are transmitted from the communication part 52 to the communication part 74 of the PC 58 in a wireless or wired manner and are stored in the seal handling determination file 26-1 of the storage part 10 together with pieces of identification information.

[0060] <Measurement of Surface-to-Surface Distance D by Measurement Part 6>

Fig. 13 illustrates a measurement state by the measurement part 6 in which the flange-to-flange measurement device is used.

In this example, a grip 86 which is provided for a main body part 84 of the measurement part 6 is held by a seal handler, a positioning guide 88 on a leading end side is inserted into the clearance portion 90 between the flanges 16-1 and 16-2 in a measurement position, and the measurement position is thereby identified.

While this state is maintained, the measurement position of the flanges 16-1 and 16-2 is irradiated with light from the light irradiation part 78. Thus, the fine light image is obtained in the flanges 16-1 and 16-2. The imaging part 80 images this fine light image.

[0061] <Axial Force Sensors 36-1, 36-2, ..., and 36-8>

Fig. 14 illustrates the bolts 20-1, 20-2, ..., and 20-8 and the axial force sensors 36-1, 36-2, ..., and 36-8.

Each of the bolts 20-1, 20-2, ..., and 20-8 is provided with a cavity portion, and in each cavity portion, each of the axial force sensors 36-1, 36-2, ..., and 36-8 is installed. When the flanges 16-1 and 16-2 are tightened by nuts 22, the axial force sensors 36-1, 36-2, ..., and 36-8 measure loads (stress) exerted on the bolts 20-1, 20-2, ..., and 20-8 as measured values f_k and f_h of the axial forces F . These

measured values f_k and f_h are taken into the data logger 60 (Fig. 11) via the cable 64.

[0062] <Processing Sequence of Seal Handling Determination System 2>

5 Fig. 15 shows a processing sequence of the seal handling determination system 2. This processing sequence includes a program in the seal handling determination system 2 of the present invention or a processing procedure which is one example of a handling determination method thereof. In this
10 exemplary embodiment, the processing sequence includes processing of measured values by both of the measurement parts 6 and 36.

As to the bolts 20-1, 20-2, ..., and 20-8, in respective stages from start of temporary tightening and final tightening
15 to completion of handling, the measurement part 6 measures the surface-to-surface distances D in measurement positions which are previously set (S301). In addition, the axial force sensors 36-1, 36-2, ..., and 36-8 of the measurement part 36 measure the axial forces F of the bolts 20-1, 20-2, ..., and
20 20-8 (S302). Timing at which the measurement is made by the measurement part 6 and timing at which the measurement is made by the measurement part 36 may be the same as each other or may be different from each other. The measured values f_k and f_h of the axial forces F are amassed together with the pieces
25 of identification information in the data logger 60.

[0063] The processor 70 takes in measured values d_k and d_h of surface-to-surface distance D (S303), takes in the measured values f_k and f_h of the axial forces F (S304), and stores the measured values d_k and d_h and the f_k and f_h in the storage
30 part 10 (S305). The measured values d_k and d_h are stored together with the pieces of identification information in the already-described seal handling determination file 26-1, and the measured values d_k and d_h and f_k and f_h are stored together with the pieces of identification information in the

already-described seal handling determination file 26-3.

The processor 70 performs processing of calculating in respective stages (S306), and this processing of calculating include the already-described processing procedures S104 to S106 (Fig. 4) or the processing procedures S206 to S211 (Fig. 9).

This calculation determines any or two or more of skill levels La, Lb-1, Lb-2, Lc-1, and Lc-2 as already described.

In this exemplary embodiment, pieces of image information of the seal handling determination files 26-1 and 26-3 are generated as the presentation information, and a distribution graphic of the measured values d of the surface-to-surface distances D (Fig. 16) and a distribution graphic of the measured values f of the axial forces F (Fig. 17) are generated (S307).

These pieces of presentation information are provided for the monitor 62 and are presented as images by the monitor 62 (S308).

[0064] <Distribution Graphic of Measured Values d of Surface-to-Surface Distances D>

Fig. 16 shows the distribution graphic of the measured values d of the surface-to-surface distances D. In this distribution graphic, with a center O of the flanges 16-1 and 16-2 as a center, axes y1, y2, ..., and y8 which extend toward positions P1, P2, ..., and P8 of the bolts 20-1, 20-2, ..., and 20-8 are displayed. A distance from the center O shows a magnitude of each of the measured values d of the surface-to-surface distances D. In contrast to graphics of regular hexagons drawn by broken lines, a hexagon of the measured values d, which is drawn by a solid line, is shown. That with respect to the graphics drawn by the broken lines, the graphic of the measured values d is distorted indicates that values of the measured values d are different from one another depending on the measurement positions. In other words, it is indicated

that a gasket surface pressure is distorted due to uneven tightening or elastic interaction.

[0065] <Distribution Graphic of Measured Values f of Axial Forces F >

5 Fig. 17 shows the distribution graphic of the measured values f of the axial forces F . Similarly, in this distribution graphic, with the center O of the flanges 16-1 and 16-2 as a center, axes $y_1, y_2, \dots$, and y_8 which extend toward the positions $P_1, P_2, \dots$, and P_8 of the bolts 20-1, 20-
10 2, $\dots$, and 20-8 are displayed. A distance from the center O shows a magnitude of each of the measured values f of the axial forces F . In contrast to a graphic of a regular hexagon drawn by a broken line, a hexagon of the measured values f , which is drawn by a solid line, is shown. That with respect to
15 the graphic drawn by the broken line, the graphic of the measured values f is distorted indicates that values of the measured values f are different from one another depending on the measurement positions. In other words, it is indicated that the measured values f of the axial forces F are different
20 from one another due to the uneven tightening or the elastic interaction.

[0066] <Effects of Exemplary Embodiment>

According to this exemplary embodiment, the following effects can be obtained.

25 (1) According to this exemplary embodiment, upon tightening, when alignment of the flanges is adjusted and surfaces of the flanges become parallel with each other, or in respective stages of the temporary tightening of the bolts, or upon finishing of the tightening, or in respective stages of
30 the tightening of the bolts, the surface-to-surface distances D and the axial forces F can be measured, and a skill level of a seal handler can be determined.

(2) According to this exemplary embodiment, no variation of gasket surface pressures is present, even gasket surface

pressures can be obtained by even tightening having no uneven tightening.

(3) According to this exemplary embodiment, skills which allow tightening having no uneven tightening and enable even
 5 and proper gasket surface pressures to be ensured, that is, a skill level can be quantitatively confirmed and evaluated by any one or both of the measurement of the surface-to-surface distances D and the measurement of the bolts axial forces F. Thus, training in conformity with an actual tightening method
 10 (JIS, ASME, or the like) can be conducted, this training can be implemented by the measurement of the surface-to-surface distances D or the measurement of the axial forces F, and training which simulates tightening on a real machine can be realized in a multitude of tightening stages.

15 (4) In a case where as evaluation of a handling result of a handler, the skill levels La, Lb-1, Lb-2, Lc-1, and Lc-2 which are the determination results are low or the like, not only the skill level is simply evaluated, but also handling, which is not in conformity with handling procedures of JIS and
 20 ASME, or the like can be determined.

[0067] <Flange Joint Tightening in Conformity with Standards>

In the above-described exemplary embodiment, in order to conform with JISB2251, it is required to implement tightening
 25 in conformity with temporary tightening stipulated therein. In a flange joint tightening procedure, in accordance with general matters and tightening order stipulated in the JISB2251 temporary tightening, temporary tightening of the bolts is conducted. A torque wrench is used for the temporary
 30 tightening (installing), and when the number of the bolts of the flanges is eight or less, all of the bolts are targeted for the temporary tightening. The diagonal tightening is as already described.

In the above-described exemplary embodiment, it is

required to implement final tightening in conformity with JISB2251 final tightening. All of the bolts are targeted for the final tightening, and the tightening is conducted by a target tightening torque. For management of the tightening torque, a torque wrench is used.

Note that in ASMEPCC-1, basically, all of the bolts are diagonally and alternately tightened and thereafter, a round pattern tightening is conducted, and a JISB2251 procedure is also stipulated.

10 [0068] [Other Embodiments]

The already-described embodiments embrace the following variations.

(1) For the measurement of each of the surface-to-surface distances D, a through-hole for attaching each length measuring device may be provided between the bolts between which a bolt pitch circle diameter of the flange 16-1 on one side extends, a leading end of each length measuring device may be applied to a surface of the flange 16-2 facing thereto, and a distance between surfaces thereof may be measured.

20 (2) As the number of the length measuring devices, at least one diagonal pair may be attached, and two or more diagonal pairs which are orthogonal thereto may be attached. The length measuring devices may be provided in a flange outer rim on one side and overhangs which receive leading ends of the length measuring devices may be provided in another flange outer rim of a surface facing thereto.

(3) Although in the exemplary embodiment, the flange-to-flange measurement device by optical measurement made by the measurement part 6 is illustrated, a variety of measurement devices such as a clearance gauge may be used as the measurement part 6.

(4) It may be determined whether by comparing the maximum value f_{hmax} (final tightening) measured by the axial force measurement part 36 and the reference value f_{href} of each of

the axial forces in the final tightening, a local axial force does not exceed fracture stress of a gasket.

(5) It may be determined whether by comparing the minimum value f_{hmin} (final tightening) measured by the axial force measurement part 36 and the reference value f_{href} of each of the axial forces in the final tightening, a local axial force does not fall below sealing limit stress of the gasket.

[0069] Hereinbefore, the most preferred embodiments and the like of the present invention are described. The present invention is not limited to the description given above. Based on the gist of the invention described in the scope of claims or disclosed in the description of embodiments, those skilled in the art can make a variety of deformations and modifications. Needless to say, these deformations and modifications are embraced in the scope of the present invention.

Industrial Applicability

[0070] According to the present invention, a skill level can be determined by measuring surface-to-surface distances D of flanges, and in addition to these surface-to-surface distances D , a skill level can be determined by measuring axial forces F , thus allowing contribution to promotion of skills of seal handling and enhancement of reliability of a seal handling result.

Reference Signs List

[0071] 2 Seal handling determination system
 4 Seal handling part
 6 Surface-to-surface distance measurement part
 8 Processing part
 10 Storage part
 12 Information presentation part
 14-1, 14-2 Piping

	16-1, 16-2	Flange joint
	18	Gasket
	20-1, 20-2, ..., 20-N	Bolts
	22	Nuts
5	24	Tightening tool
	26-1	First seal handling determination file
	26-2	Second seal handling determination file
	28, 38	Number information part
	30, 40	Identification information part
10	30-1	Measurement portion part
	30-2	Tightening time part
	32	Surface-to-surface distance part
	32-1, 42-1	Measurement value part
	32-2, 42-2	Final tightening measured value part
15	32-3, 42-3	Maximum value part
	32-4, 42-4	Minimum value part
	32-5, 42-5	Difference part
	32-6	Reference value part
	34, 44	Skill level part
20	36	Axial force measurement part
	36-1, 36-2, ..., 36-8	Axial force sensors
	42	Axial force part
	46	Floor
	48	Fixed flange
25	50	Measurement function part
	52	Communication part
	54	Management table
	56	Casters
	58	PC
30	60	Data logger
	62	Monitor
	64	Cable
	66	Screen
	68	Touch panel

	70	Processor
	72	I/O
	74	Communication part
	76	Operation input part
5	78	Light irradiation part
	80	Imaging part
	82	Image processing part
	84	Main body part
	86	Grip
10	88	Guide
	90	Clearance portion

CLAIMS

1. A seal handling determination system which determines a handling result by a surface-to-surface distance between flanges which are tightened by bolts and nuts, with a gasket being interposed between the flanges, the seal handling determination system comprising:

a seal handling part which includes the flanges being tightened by the bolts and the nuts, with the gasket being interposed between the flanges;

a surface-to-surface distance measurement part which measures a surface-to-surface distance between the flanges;

a processing part which takes in measured values of the surface-to-surface distance from the surface-to-surface distance measurement part in a plurality of stages from start of tightening of the bolts up to completion of the tightening, calculates a difference between a maximum value and a minimum value of the measured values, and determines a skill level by comparing the difference and a determination reference; and

an information presentation part which presents any or all of calculation information and a calculation result, the calculation information and the calculation result being processed by the processing part.

2. The seal handling determination system according to claim 1, further comprising an axial force measurement part which measures axial forces being exerted from the bolts on the flanges, wherein

the processing part takes in measured values of the axial forces of the bolts in the plurality of stages from the start of the tightening of the bolts up to the completion of the tightening, calculates an average value of the measured values, and determines a skill level by comparing the average value and a determination reference, and

the information presentation part presents any or all of calculation information and a calculation result, the

calculation information and the calculation result being processed by the processing part.

3. The seal handling determination system according to claim 1, further comprising an axial force measurement part which
5 measures axial forces being exerted from the bolts on the flanges, wherein

the processing part takes in measured values of the axial forces of the bolts in the plurality of stages from the start of the tightening of the bolts up to the completion of the
10 tightening, calculates a difference between a maximum value and a minimum value of the measured values, and determines a skill level by comparing the difference and a determination reference, and

the information presentation part presents any or all of
15 calculation information and a calculation result, the calculation information and the calculation result being processed by the processing part.

4. The seal handling determination system according to claim 1 or 3, wherein the processing part calculates an amount of
20 deviation of the difference with respect to a reference value and determines a skill level by comparing the amount of deviation and a determination reference.

5. The seal handling determination system according to claim 1, wherein the processing part employs any or two or more of a
25 measurement portion on the flanges where the surface-to-surface distance is measured and a tightening time as a piece or pieces of identification information and performs information processing in a manner associated with the piece or the pieces of the identification information.

30 6. A program which causes a computer to realize:

a function to take in measured values of a surface-to-surface distance between flanges being tightened by bolts and nuts with a gasket being interposed between the flanges, in a plurality of stages from start of tightening of the bolts of a

seal handling part including the flanges up to completion of the tightening;

a function to calculate a difference between a maximum value and a minimum value of the measured values and to

5 determine a skill level by comparing the difference and a determination reference; and

a function to generate any or all of calculation information and a calculation result as a piece or pieces of presentation information, the calculation information and the
10 calculation result being processed by a processing part.

7. The program according to claim 6, the program further causing the computer to realize:

a function to take in measured values of axial forces of the bolts in the plurality of stages from the start of the
15 tightening of the bolts up to the completion of the tightening;

a function to calculate an average value of the measured values and to determine a skill level by comparing the average value and a determination reference; and

20 a function to generate any or all of calculation information and a calculation result as a piece or pieces of presentation information, the calculation information and the calculation result being processed by the processing part.

8. The program according to claim 6, the program further
25 causing the computer to realize:

a function to take in measured values of axial forces of the bolts in the plurality of stages from the start of the tightening of the bolts up to the completion of the
tightening;

30 a function to calculate a difference between a maximum value and a minimum value of the measured values and to determine a skill level by comparing the difference and a determination reference; and

a function to generate any or all of calculation

information and a calculation result as a piece or pieces of presentation information, the calculation information and the calculation result being processed by the processing part.

9. The program according to claim 6 or 8, the program

5 further causing the computer to realize:

a function to calculate an amount of deviation of the difference with respect to a reference value and to determine a skill level by comparing the amount of deviation and a determination reference.

10 10. A seal handling determination method for determining a handling result by a surface-to-surface distance between flanges being tightened by bolts and nuts with a gasket being interposed between the flanges, the method comprising:

a step of measuring the surface-to-surface distance
15 between the flanges in a seal handling part, the seal handling part including the flanges being tightened by the bolts and the nuts with the gasket being interposed between the flanges; and

a step of, in a plurality of stages from start of
20 tightening of the bolts up to completion of the tightening, taking in measured values of the surface-to-surface distance, calculating a difference between a maximum value and a minimum value of the measured values, and determining a skill level by comparing the difference and a determination reference.

25 11. The seal handling determination method according to claim 10, the method further comprising:

a step of measuring axial forces being exerted from the bolts on the flanges; and

a step of, in the plurality of stages from the start of
30 the tightening of the bolts up to the completion of the tightening, taking in measured values of the axial forces from the bolts, calculating an average value of the measured values, and determining a skill level by comparing the average value and a determination reference.

12. The seal handling determination method according to claim 10, the method further comprising:

a step of measuring axial forces being exerted from the bolts on the flanges; and

5 a step of, in the plurality of stages from the start of the tightening of the bolts up to the completion of the tightening, taking in measured values of the axial forces from the bolts, calculating a difference between a maximum value and a minimum value of the measured values, and determining a
10 skill level by comparing the difference and a determination reference.

13. The seal handling determination method according to claim 10 or 12, the method further comprising: a step of calculating an amount of deviation of the difference with respect to a
15 reference value and determining a skill level by comparing the amount of deviation and a determination reference.

14. A seal handling learning system for learning seal handling by using a surface-to-surface distance between flanges being tightened by bolts and nuts with a gasket being
20 interposed between the flanges, the system comprising:

a seal handling part which includes the flanges being tightened by the bolts and the nuts, with the gasket being interposed between the flanges;

a surface-to-surface distance measurement part which
25 measures the surface-to-surface distance between the flanges;

a processing part which takes in measured values of the surface-to-surface distance from the surface-to-surface distance measurement part in a plurality of stages from start of tightening of the bolts up to completion of the tightening,
30 calculates a difference between a maximum value and a minimum value of the measured values, and determines a skill level by comparing the difference and a determination reference; and

an information presentation part which presents any or all of calculation information and a calculation result, the

calculation information and the calculation result being processed by the processing part.

15. The seal handling learning system according to claim 14, the system further comprising

5 an axial force measurement part which measures axial forces being exerted from the bolts on the flanges, wherein
the processing part takes in measured values from the axial force measurement part in the plurality of stages from the start of the tightening of the bolts up to the completion
10 of the tightening, calculates an average value of the measured values, and determines a skill level by comparing the average value and a determination reference, and

the information presentation part presents any or all of calculation information and a calculation result, the
15 calculation information and the calculation result being processed by the processing part.

16. The seal handling learning system according to claim 14, the system further comprising an axial force measurement part which measures axial forces being exerted from the bolts on
20 the flanges, wherein

the processing part takes in measured values from the axial force measurement part in the plurality of stages from the start of the tightening of the bolts up to the completion of the tightening, calculates a difference between a maximum
25 value and a minimum value of the measured values, and determines a skill level by comparing the difference and a determination reference, and

the information presentation part presents any or all of calculation information and a calculation result, the
30 calculation information and the calculation result being processed by the processing part.