

DESCRIPTION

TITLE OF INVENTION:

METHOD FOR MANAGING SEAL HANDLING, DEVICE FOR MANAGING SEAL
HANDLING, PROGRAM FOR MANAGING SEAL HANDLING, AND SYSTEM FOR
MANAGING SEAL HANDLING

Technical Field

[0001] The present invention relates to a management
technique of seal handling used for tightening flanges that
couple pipes, valves, pumps, and the like.

Background Art

[0002] Flanges sandwiching a gasket are used for coupling
pipes and connecting pumps to pipes. The flanges are fastened
by tightening bolts and nuts at tightening points set at a
plurality of points on the peripheral side. For tightening the
bolts and nuts, a manual tightening tool such as a torque
wrench, or an electric screw tightening tool is used.

In tightening the bolts and nuts on such flanges, it is
necessary to perform tightening processing at a predetermined
torque value at all the tightening points and to perform
tightening without causing variation in axial force acting on
the bolts. Therefore, it is important to manage tightened
states of the bolts and nuts with a tightening tool.

[0003] Examples of tightening management methods include
methods such as a torque method to manage tightening torque
applied to the bolts, a method to manage the axial force by
measuring elongation of the bolts with an ultrasonic axial
force meter, and a bolt tensioner (pulling method) that pulls
the bolts to target axial force, seats the nuts, and performs
tightening to tighten the bolts while the axial force is
managed.

[0004] With regard to such flange tightening management, a
method is known that approximates output shaft power for each
minute time to an output torque by electrically detecting, by

a detector, rotation speed and torque of output shafts of bolts and decomposing a detected value into rotation speed and a torque value for each moment of tightening elapsed time to calculate a power value for each minute time, and by

5 momentarily controlling increase/decrease of a rotation speed equivalent amount of a power wrench in accordance with a state of a tightening variable load (for example, Patent Literature 1). Furthermore, a method is known that calculates predicted axial force by using a relational expression that represents,
10 as a function of time required for tightening, a ratio of axial force at the time of completion of tightening of a screwing member and axial force after a lapse of a predetermined time from the time of completion (for example, Patent Literature 2). A device is known that includes an axial
15 force detection sensor for bolts that tightens flanges and executes a tightening operation when axial force on the bolts is smaller than a set value (for example, Patent Literature 3).

20 Citation List

Patent Literature

[0005] Patent Literature 1: JP S53-047959 B

Patent Literature 2: JP 5724595 B2

Patent Literature 3: JP 61-142082 A

25 Summary of Invention

Technical Problem

[0006] Incidentally, in the flange connection in which the gasket is sandwiched, it is necessary to keep the flanges

30 parallel by equalizing tightening the axial force of all the bolts and nuts. In the flange connection for tightening a plurality of bolts and nuts, when the axial force acting on the bolts varies, the flanges are not parallel. This is a so-called one-sided tightening state. In such a one-sided

tightening state, there is a problem that a gap is generated in pipelines coupled by the flanges, a sealing function by the gasket between the flanges is deteriorated, for example.

The tightening management by the torque method manages
5 tightening torque applied by tightening the bolts and the nuts. A torque coefficient, which is a proportional coefficient between the tightening torque and the axial force acting on the bolts, is affected by friction with the flanges, the nuts, and the like, and thus the axial force varies from
10 bolt to bolt. Therefore, there is a problem that, even if tightening is performed at the tightening torque calculated based on tightening force required for the tightening, the axial force acting on the bolts varies depending on a tightening position of the flanges due to differences in the
15 torque coefficient.

[0007] The tightening management using the ultrasonic axial force meter has a problem that an increase in work man-hours and work time is caused because the axial force is measured after the bolts are tightened and then additional tightening
20 or retightening is performed to make the axial force uniform. In tightening work of the bolts to the flanges, since tightening is performed multiple times while a value of the tightening torque is changed for one bolt, adjusting the tightening torque value each time so that target axial force
25 is achieved requires a large number of work man-hours. Furthermore, the additional tightening or retightening of the bolts is affected by an elastic interaction, so that tightening of other bolts is loosened, for example, and thus the axial force adjustment after tightening causes an increase
30 in a work load.

The tightening management by the bolt tensioner has a problem that a special tool is required and thus costs and working time are required, and extra lengths of the bolts are required to pull the bolts. Furthermore, although the axial

force is applied to the bolts by hydraulic pressure so that the nuts are seated on objects to be fastened such as the bolts, and the hydraulic pressure is removed to complete tightening, nut seat surfaces are deformed so as to sink into surfaces of the objects to be fastened when the hydraulic pressure is removed, so that the resultant axial force is lower than the axial force applied by the hydraulic pressure. To compensate for this, initial axial force is set high, but there is a problem that, if the strength of a fastening object is insufficient, there is a risk of damage and it is difficult to estimate axial force that decreases.

[0008] In seal handling with flanges sandwiching a gasket, one of these tightening management methods is adopted to perform tightening with a torque value set to a tightening tool or adjustment after tightening, but it takes a lot of time, labor, or costs to make axial force of tightened bolts uniform. The inventor of the present application has regarded, as a problem of the invention, performing tightening management by adjusting a torque coefficient used for calculating a tightening torque value, based on knowledge that the variation of the axial force due to these tightening management methods is affected by a difference in a state of each bolt.

Patent Literatures 1 to 3 do not disclose or suggest such a problem, and the configurations disclosed in these documents cannot solve such a problem.

[0009] Therefore, in view of the above problem, an object of the present invention is to enable tightening of bolts and nuts with less work man-hours and working time, and to achieve flange connection with high tightening accuracy.

In addition, another object of the present invention is to stabilize a tightened state with respect to the flanges and achieve tightening with required axial force by applying tightening torque according to a state of each bolt and nut.

There is no disclosure or suggestion of such a problem, and such a problem cannot be solved by the configurations disclosed in Patent Literatures 1 to 3.

5 Solution to Problem

[0010] In order to achieve the above objects, one aspect of a method for managing seal handling of the present invention is a method for managing seal handling wherein a plurality of tightening points is set on flanges sandwiching a gasket and
10 each of the tightening points is provided with a bolt and a nut to perform tightening, and the method includes steps of tightening the bolt and the nut with a tightening tool to which a first tightening torque value is set, detecting axial force of the bolt, calculating or selecting a torque
15 coefficient of the bolt by use of the detected axial force, and setting, for each of the tightening points on the bolt, a second tightening torque value calculated or selected by use of the torque coefficient to the tightening tool.

[0011] The above method for managing seal handling may
20 further include a step of comparing the detected axial force of the bolt with target axial force, set axial force, or a predetermined threshold value to calculate or select the torque coefficient based on a comparison result.

[0012] The above method for managing seal handling may
25 further include steps of detecting one or both of the number of rounds of the tightening tool and the tightening points, and changing set axial force or a tightening torque value set to the tightening tool stepwise or continuously in accordance with the number of rounds or the tightening points.

30 [0013] The above method for managing seal handling may further include a step of calculating or selecting the first tightening torque value by use of set axial force set for each tightening step and a torque coefficient selected in advance.

[0014] In order to achieve the above objects, one aspect of

a seal handling management device of the present invention is a seal handling management device wherein a plurality of tightening points is set on flanges sandwiching a gasket and each of the tightening points is provided with a bolt and a nut to perform tightening, and the seal handling management device includes a setting means that sets, the tightening points, the number of rounds of tightening, and a tightening torque value to a tightening tool, an acquisition means that acquires axial force of the bolt, and a control means that acquires the axial force of the bolt tightened by the tightening tool to which a first tightening torque value is set, calculates or selects a torque coefficient of the bolt by use of the axial force, and sets, for each of the tightening points on the bolt, a second tightening torque value calculated or selected by use of the torque coefficient to the tightening tool.

[0015] In the above seal handling management device, the control means may compare the detected axial force of the bolt with target axial force, set axial force, or a predetermined threshold value, and calculate or select the torque coefficient based on a comparison result.

[0016] The above seal handling management device may further include a detection means that detects one or both of the number of rounds of the tightening tool and the tightening points, and in the above method, the control means may change set axial force or a tightening torque value set to the tightening tool stepwise or continuously in accordance with the number of rounds or the tightening points.

[0017] In order to achieve the above objects, one aspect of a program for managing seal handling is a program for managing seal handling to be implemented by a computer, the program causing the computer to implement functions of setting a first tightening torque value to a tightening tool that tightens a bolt and a nut mounted on each of tightening points of flanges

sandwiching a gasket, acquiring a detection result of axial force of the bolt tightened by the tightening tool, calculating or selecting a torque coefficient of the bolt by use of the detected axial force, and setting, for each of the tightening points on the bolt, a second tightening torque value calculated or selected by use of the torque coefficient to the tightening tool.

[0018] In order to achieve the above objects, one aspect of a seal handling management system is a seal handling

management system wherein a plurality of tightening points is set on flanges sandwiching a gasket and each of the tightening points is provided with a bolt and a nut to perform tightening, and the seal handling management system includes a tightening tool that is capable of controlling a torque value applied to the bolt or the nut, a sensor that detects axial force of the bolt, and a controller that sets a first tightening torque value to the tightening tool, calculates or selects a torque coefficient of the bolt by use of the axial force detected by the sensor, and sets, for each of the tightening points on the bolt, a second tightening torque value calculated or selected by use of the torque coefficient to the tightening tool.

Advantageous Effects of Invention

[0019] According to the present invention, any of the following effects can be obtained.

[0020] (1) By calculating a torque coefficient for each bolt in a tightening step and performing tightening with corrected tightening torque, it is possible to eliminate or reduce a work load due to axial force adjustment such as retightening after tightening.

(2) By tightening nuts while correcting the torque coefficient for each bolt, it is possible to reduce influence on other bolts by a bolt with insufficient or excessive

tightening force in stepwise tightening processing.

(3) By calculating the torque coefficient for each bolt and tightening with a tightening torque value according to a state of a tightening point, it is possible to reduce

5 variation in axial force among the bolts.

[0021] In addition, other objects, features, and advantages of the present invention will be more apparent with reference to the accompanying drawings and embodiments.

10 Brief Description of Drawings

[0022] Fig. 1 is a diagram illustrating a configuration example of a seal handling management device according to a first embodiment.

Fig. 2 is a diagram illustrating a state example of force
15 acting on a bolt when flanges are tightened.

A of Fig. 3 is a diagram illustrating examples of detected axial force during a tightening step before torque coefficient correction, and B of Fig. 3 is a diagram illustrating examples of detected axial force during a
20 tightening step after the torque coefficient correction.

Fig. 4 is a flowchart illustrating an example of seal handling management processing.

Fig. 5 is a diagram illustrating a configuration example of a seal handling management device according to a second
25 embodiment.

Fig. 6 is a diagram illustrating examples of a tightening procedure.

Fig. 7 is a diagram illustrating an example of a tightening instruction information table.

30 Fig. 8 is a diagram illustrating an example of axial force detection results.

Fig. 9 is a diagram illustrating an example of calculation results of a torque coefficient.

Fig. 10 is a flowchart illustrating an example of seal

handling management processing.

Fig. 11 is a diagram illustrating a configuration example of a seal handling management system according to a third embodiment.

5 A of Fig. 12 is a diagram illustrating a configuration example of a tightening tool, and B of Fig. 12 is a diagram illustrating an example of an axial force sensor.

10 A of Fig. 13 is a diagram illustrating a configuration example of a controller, and B of Fig. 13 is a diagram illustrating a configuration example of a storage unit.

Fig. 14 is a diagram illustrating an internal configuration example of a server.

Fig. 15 is a diagram illustrating display examples of tightening results.

15 Fig. 16 is a sequence diagram illustrating an example of seal handling management.

Fig. 17 is a diagram illustrating a configuration example of a seal handling management device according to a fourth embodiment.

20 Fig. 18 is a diagram illustrating a comparative example.

Description of Embodiments

[0023] [First Embodiment]

25 Fig. 1 illustrates a configuration example of a seal handling management device according to a first embodiment. The configuration illustrated in Fig. 1 is an example, and the present invention is not limited to such a configuration.

<Seal Handling Management Device 2>

30 The seal handling management device 2 performs tightening processing and tightening management of a plurality of bolts 6 and nuts 8 of a seal handling unit 4 that couples a plurality of pipelines, pipes and valves, pipes and pumps, and the like. As illustrated in Fig. 1, for example, the seal handling unit 4 as an example of an object to be tightened includes a gasket

12 sandwiched between flanges 10-1 and 10-2, which are coupling means, and the bolts 6 and nuts 8 are arranged at a plurality of tightening points set on peripheral sides of the flanges 10-1 and 10-2. For example, eight tightening points
5 are set on the flanges 10-1 and 10-2. That is, eight bolts 6 and nuts 8 are tightened on the flanges 10-1 and 10-2, for example, at equal intervals at an angle $\theta = 45 [^\circ]$. The gasket 12 is made of a rigid resin material, contacts at least facing surfaces of the flanges 10-1 and 10-2, and is formed in such a
10 shape to avoid overlapping a flow path formed in a coupled object other than the flanges, such as a pipe. In addition, the gasket 12 is an example of a sealing means that prevents outflow of fluid or the like from the periphery of a coupled portion of the coupled object by being pressed to the flanges
15 10-1 and 10-2 when the bolts 6 and the nuts 8 are tightened.

As seal handling management, the seal handling management device 2 manages the tightening of the bolts 6 and the nuts 8, so that the gasket 12 between the flanges 10-1 and 10-2 is pressed in a uniform or almost uniform state.

20 [0024] The seal handling management device 2 includes, for example, a tightening tool 14 and a control means 16. The tightening tool 14 is an example of a means for applying an output torque T applied to the bolts 6 or the nuts 8, and examples of the tightening tool 14 include a nut runner and an
25 electric tool having a function capable of setting and adjusting the output torque (tightening torque T). The tightening tool 14 is carried, for example, by an operation of a worker who performs the tightening processing, and there are one that is capable of an on/off operation or the like at the
30 time of tightening and one that is installed on or gripped by an arm or the like of a product assembling device (not illustrated).

The tightening tool 14 includes, for example, a grip 22 that allows a device body 20 to be held and moved to a

predetermined position, a socket 24 that is fitted to the nuts 8, which are objects to be tightened, to apply the tightening torque, and a trigger switch 26 that turns on/off the tightening torque T through the socket 24 in a tightening step. In the tightening step of the bolts 6 and the nuts 8, an on/off state of the trigger switch 26 is switched by use of a finger of the worker, a manipulator (not illustrated), a switch circuit, or the like.

Furthermore, in the tightening step, for example, the worker or the assembling device arranges the tightening tool 14 in a set order at the tightening points set in the seal handling unit 4, that is, positions where the bolts 6 and the nuts 8 are installed, and performs the on/off operation of the trigger switch 26.

[0025] The control means 16 is an example of means for outputting an operation instruction for the tightening tool 14 and performing adjustment processing of a tightening torque value T1 set in the tightening tool 14 based on tightened states of the bolts 6 and the nuts 8. The control means 16 is configured by a computer, for example, and may be configured integrally with the tightening tool 14, or may be an independent device and connected to the tightening tool 14 by wire or wirelessly. Furthermore, the control means 16 is connected to axial force sensors 18-1, 18-2, ..., and 18-n (n is a natural number), and acquires an axial force value by tightening, an axial force change by tightening, or the like.

[0026] The axial force sensors 18-1, 18-2, 18-3, ..., and 18-n are examples of means for detecting axial force acting on the bolts 6 or the nuts 8, and are installed on either the bolts 6 or the nuts 8 installed at all the tightening points. Furthermore, the axial force sensors 18-1, 18-2, 18-3, ..., and 18-n may be installed, for example, at the time of measuring the axial force.

[0027] <Function of Control Means 16>

The control means 16 of the seal handling management device 2 having such a configuration has the following functions, for example.

a. A function of calculating or selecting the tightening torque value T1 to be applied to the bolts 6 or the nuts 8 in accordance with a set torque coefficient k1 and the number of rounds S of the tightening points.

b. A function of setting the tightening torque value T1 to the tightening tool 14.

c. A function of changing the tightening torque value T1 of the tightening tool 14 stepwise or continuously in accordance with the number of rounds S (STEP). The number of rounds S is a unit number of rounds of positions P1, P2, ..., and Pn that are the tightening points of the bolts 6 and the nuts 8.

d. A function of acquiring detection results of the axial force acting on the bolts 6 or the nuts 8 by tightening, to calculate a corrected torque coefficient k2 according to each of the tightening points P.

e. A function of calculating or selecting a corrected tightening torque value T2 using the calculated corrected torque coefficient k2.

[0028] The tightening torque value T1 of the function a is, for example, a tightening torque value calculated by use of value of a target axial force. The tightening torque value T1 is calculated as a level value required to reach target axial force F under tightening conditions including the gasket 12. The following formula is used to calculate a tightening torque value T.

$$T = kFd/n \dots (1)$$

Here, d is an outer diameter of each of the bolts 6 to be tightened, and n is the number of the bolts 6 or the nuts 8 installed in the seal handling unit 4. In addition, k is a torque coefficient representing a proportional coefficient

between the tightening torque T and tightening force (axial force F).

As illustrated in Fig. 2, for example, the axial force F of the bolts 6 and the nuts 8 is affected by a frictional force $N1$ between the flanges 10-1 and 10-2 and seat surfaces of the bolts 6 or the nuts 8 and a frictional force $N2$ of a screw surface, to the tightening torque T applied from the tightening tool 14. Furthermore, the axial force F of tightening is affected by surface roughness of a screw and the like. That is, the axial force F acting on the bolts 6 and the nuts 8 differs depending on the tightening points even if tightening is performed with the same tightening torque value $T1$. The torque coefficient k set in consideration of such influence has a different value depending on the tightening points P for the bolts 6 and the nuts 8. In the calculation of the tightening torque value $T1$ at the start of the seal handling, for example, the torque coefficient $k1$ for all the tightening points P is set to 0.2 as a constant value.

[0029] In the function b, the calculated torque value $T1$ is set to the tightening tool 14 as control information for the tightening tool 14 from the control means 16.

[0030] In the function c, the control means 16 changes the tightening torque value $T1$ by the tightening tool 14 stepwise or continuously in accordance with the number of rounds S of tightening to performs tightening. As a result, the axial force of the bolts 6 or the nuts 8 at the tightening points P reaches the target axial force F .

[0031] In the function d, the control means 16 acquires axial force F detected from the axial force sensors 18-1, 18-2, ..., and 18- n corresponding to the tightening points P , for example. The detected axial force F may be acquired every time when tightening is performed, or may be acquired when tightening is performed for a predetermined number of rounds S . The control means 16 then calculates the corrected torque

coefficient k_2 for each of the bolts 6 or the nuts 8 by using the formula (1), for example. In the calculation of the corrected torque coefficient k_2 , the set torque value T_1 and the detected axial force F are used.

5 [0032] In the function e, the control means 16 uses the corrected torque coefficient k_2 and the target axial force to calculate the tightening torque value T_2 corrected based on the formula (1) and sets the tightening torque value T_2 to the tightening tool 14.

10 [0033] <Results of Seal Handling Management>

Fig. 3 illustrates an example of the detected axial force during the tightening step.

The control means 16 manages the axial force detected at the tightening points P, for example, and notifies a worker or
15 a work manager who performs tightening of management results by a display means (not illustrated).

A of Fig. 3 is an example of the detection results of the axial force when tightening is performed with the torque coefficient set to a constant value $k_1 = 0.2$, for example. In
20 this tightening result $F\alpha$, for example, values of the detected axial force at tightening points [1] to [5] and [8] are equivalent, but a value of a tightening result $F\alpha_1$ at tightening point [7] is smaller, and a value of a tightening result $F\alpha_2$ at the tightening point [6] is larger than values
25 of other tightening points. That is, it is clear that, even if tightening is performed with the same tightening torque value T_1 , the torque coefficient k_1 is not an appropriate value for states of the tightening points [7] and [6].

In addition, B of Fig. 3 is an example of the detection
30 results of the axial force when the corrected torque coefficient k_2 corresponding to each of the tightening points is set to perform tightening. In this tightening result $F\beta$, values of tightening results $F\beta_1$ and $F\beta_2$ at the tightening points [7] and [6] are equivalent to values of the detected

axial force at the other tightening points. As a result, variation in the axial force that acts on the entire flanges 10-1 and 10-2 can be reduced.

[0034] <Seal Handling Management Processing>

5 Fig. 4 illustrates an example of seal handling management processing. A processing procedure and processing contents illustrated in Fig. 4 are examples of a method for managing seal handling or a program for managing seal handling of the present invention, and the present invention is not limited to
10 such contents.

[0035] As the seal handling management processing, the control means 16 uses the target axial force or set axial force and the first torque coefficient k_1 to calculate or select the first tightening torque value T_1 (S1), and sets the
15 first tightening torque value T_1 to the tightening tool 14 (S2). The target axial force is a target value of the axial force F that acts on the bolts 6 or the nuts 8 when tightening is completed. The set axial force is a value of the axial force F that is set at the time of calculating the tightening
20 torque value T_1 in a case where the tightening torque value T_1 for the bolts 6 and the nuts 8 is changed stepwise in accordance with the number of rounds S , and for example, x [%] of the target axial force is set in accordance with the number of rounds S . Furthermore, as the tightening torque value T_1 ,
25 for example, a value stored in advance in a database or the like may be selected and set.

The control means 16 acquires detection results of the axial force from the axial force sensors 18-1, 18-2, ..., and 18- n (S3), and compares the detection results with the target axial force or the set axial force (S4). This comparison of
30 the axial force is performed for each of the tightening points. Then, if there is a difference between the detection results and the target axial force or the set axial force (YES in S5), a corrected torque value k_2 that is a second torque

coefficient is calculated by use of a value of the detected axial force F (S6). In addition, if there is no difference between the detection results and the target axial force or the set axial force (NO in S5), it is determined that the torque coefficient k_1 corresponding to a state of the tightening point is set, and the first torque coefficient k_1 is maintained (S7).

The control means 16 calculates the tightening torque values T_1 and T_2 using respective torque coefficients for the tightening points, sets the tightening torque values T_1 and T_2 to the tightening tool 14 (S8), and shifts to the next tightening order.

[0036] Note that, in the seal handling management processing, the detected axial force is compared with the target axial force or the set axial force and the torque coefficient is corrected when there is a difference in the values, but the seal handling management processing is not limited to this. The second torque coefficient k_2 may be calculated based on the axial force detected at all the tightening points.

Furthermore, in the comparison processing of the detected axial force, the compared value is not limited to the target axial force or the set axial force, and the detected axial force may be compared with a predetermined threshold value set in advance, for example.

[0037] <Effects of First Embodiment>

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

(1) It is possible to easily perform correction processing of the tightening torque value during seal handling by calculating the torque coefficient according to a state of each of the tightening points from a relationship between the detection results of tightening the bolts 6 and the nuts 8 and the tightening torque value set to the tightening tool 14.

(2) By correction of the tightening torque value by calculating the torque coefficient, it is possible to reduce deviation of the axial force F acting on the bolts 6 or the nuts 8 from the target axial force or the set axial force, and thus it is possible to reduce a work load such as retightening and to shorten work time.

[0038] (3) By calculation of the torque coefficient during the tightening step and correction of the tightening torque value, there is no variation in the axial force acting on contact surfaces of the flanges 10-1 and 10-2 and the gasket 12, the possibility that wrinkles, distortions, and the like occur on a part of these contact surfaces is reduced, and thus it is possible to improve adhesion of the gasket and hermeticity of pipes to be connected.

(4) By reducing the variation in the tightening axial force among the plurality of bolts 6 and nuts 8 that fixedly support the flanges 10-1 and 10-2, it is possible to reduce the possibility of loose tightening occurs, and to enhance reliability of connectivity of the flanges 10-1 and 10-2 and sealability of the gasket 12.

(5) By automatically determining the states of the tightening points based on the tightening results and calculating the tightening torque value according to each of the states, it is possible to perform seal handling management according to states of the flanges 10-1 and 10-2, the gasket 12, the bolts 6 and the nuts 8 without depending on experience and intuition of a worker.

[0039] [Second Embodiment]

[0040] Fig. 5 illustrates a configuration example of a seal handling management device according to a second embodiment. The configuration illustrated in Fig. 5 is an example, and the present invention is not limited to such a configuration.

<Seal Handling Management Device 30>

The seal handling management device 30 includes, for

example, a tightening tool 14, a control means 16, and a tightening condition setting unit 32, as illustrated in Fig. 5. The control means 16 includes an acquisition means 34 that takes in detection results of axial force sensors 18-1, 18-2, ..., and 18-n installed on one or both of bolts 6 and nuts 8, for example. The acquisition means 34 may include, for example, a communication means that wirelessly connects to the axial force sensors 18-1, 18-2, ..., and 18-n and a connection interface that connects to the axial force sensors 18-1, 18-2, ..., and 18-n by wire. The acquisition means 34 may have a processing function that enables calculation processing and display processing of the detection results.

The tightening condition setting unit 32 has, for example, in addition to a function of setting, to the tightening tool 14, tightening torque values T1 and T2 set by the control means 16, a seal handling management function of grasping tightening points and the number of rounds in tightening work and performing instruction display and notification for a worker, for example.

The tightening condition setting unit 32 may be configured, for example, integrally with the control means 16 or may be a separate unit connected by wire or wirelessly.

Furthermore, the tightening condition setting unit 32 may have a calculation processing function of the tightening torque values T1 and T2, for example.

It is sufficient that the tightening tool 14 and a seal handling unit 4 have configurations similar to those in the first embodiment, and the description thereof will be omitted.

[0041] <Tightening Procedure and Number of Rounds>

Fig. 6 illustrates examples of a tightening procedure of the bolts and the nuts.

In the tightening work of the bolts 6 and the nuts 8, for example, as illustrated by an arrow a in A of Fig. 6, positions P1, P2, ..., and Pn may be sequentially rounded, or,

as illustrated by an arrow b in B of Fig. 6, the positions P1, P2, ..., and Pn may be rounded by a tightening procedure of so-called "diagonal tightening", in which the tightening points are changed in a diametrical direction of flanges 10-1 and 10-2, to perform tightening. That is, the positions P1, P2, ..., and Pn may be continuously tightened in the order of numbers, or a predetermined number of the tightening points may be regularly skipped and rounded. Therefore, the number of rounds S is not limited to a count value of rounds in which the positions P1, P2, ..., and Pn are consecutive in order, and may be a count value obtained by counting with a round skipping a predetermined position set as a unit.

In the seal handling management of this embodiment, for example, a tightening procedure based on the bolt tightening procedure for pressure boundary flanged joint assembly (JIS B 2251) of the Japanese Industrial Standard (JIS) is adopted. Furthermore, in this embodiment, for example, a case is shown where the number of the bolts 6 installed on the flanges 10-1 and 10-2 is $n = 8$. Therefore, in this tightening processing, from the beginning of tightening to a predetermined number of rounds (S), that is, at a so-called "temporary tightening" stage, the positions P1, P2, ..., and Pn are tightened by the so-called "diagonal tightening" (B of Fig. 6), in which the tightening points are changed in the diametrical direction of the flanges 10-1 and 10-2. Furthermore, in the tightening processing, after the number of rounds (S) in the "temporary tightening" is completed, as a so-called "main tightening" stage, P2 to Pn are sequentially rounded (A of Fig. 6) to perform tightening.

Note that, in the number of rounds (STEP) and the tightening procedure of the "temporary tightening" and the "main tightening", a different value may be set in accordance with the number of the bolts 6 installed on the flanges 10-1 and 10-2.

[0042] <Tightening Instruction Information Table 40>

Fig. 7 illustrates an example of a tightening instruction information table.

The tightening instruction information table 40 is an example of a table in which processing contents of the seal handling management are stored, and is stored in the control means 16, for example. The tightening instruction information table 40 stores, for example, information on "implementation contents" for each "STEP" representing the number of rounds and information on a "procedure" of tightening. The "STEP" of the tightening instruction information table 40 illustrated in Fig. 7 is determined by the number of the bolts 6 to be tightened and, for example, the number of rounds $S = 10$, that is, eight bolts 6 and nuts 8 are tightened in 10 times by a predetermined procedure. In this tightening instruction, for example, a torque coefficient is calculated in STEP3 and STEP7, and the torque coefficient is corrected in accordance with each state of the tightening points.

The information on the "implementation contents" stores, for example, a tightening torque value and a torque coefficient value, and also includes an instruction to take in detected axial force and an instruction to calculate the torque coefficient.

The information on the "procedure" stores a method for tightening the bolts 6 and the nuts 8.

[0043] <Detection Results of Axial Force>

Fig. 8 illustrates an example of the detection results of the axial force.

The control means 16 is provided with an information table including values of axial force F at the tightening points acquired from the axial force sensors 18-1, 18-2, ..., and 18-n. The information table illustrated in Fig. 8 is, for example, detection results of the axial force and calculation results of the tightening torque value and the torque

coefficient at the number of rounds (S) for calculating a corrected value of the torque coefficient k , and stores the tightening torque value T_1 set to the tightening tool 14, set axial force F_x acting on the bolts 6 or the nuts 8, the
 5 detected axial force F , an uncorrected torque coefficient k_1 , a corrected torque coefficient k_2 , a corrected torque value T' , and the like.

The tightening torque value T_1 is a value calculated based on the above-described formula (1) by use of the set
 10 axial force F_x set at this number of rounds and the torque coefficient k_1 . As seal handling management processing, the control means 16 compares, for example, the set axial force F_x and the axial force F when tightening is performed with the tightening torque value T_1 , and when these values do not match
 15 or the axial force F is not within a predetermined range with respect to the set axial force F_x , the control means 16 calculates the corrected torque coefficient k_2 .

The control means 16 then sets the corrected torque value T' to be set to the tightening tool 14 in the next number of
 20 rounds based on the comparison result of the axial force.

Note that the information table may be created, for example, for each number of rounds of tightening, or may be created only for the number of rounds (S) in which the torque coefficient is corrected.

25 [0044] <Calculation Results of Torque Coefficient>

Fig. 9 illustrates an example of calculation results of the torque coefficient.

For example, as illustrated in Fig. 9, the control means 16 generates a torque coefficient display screen associated
 30 with the tightening points, triggered by the calculation processing of the torque coefficient. This torque coefficient display screen may be displayed, for example, on a display unit (not illustrated) of the control means 16, or may be displayed on a terminal device for a manager by use of

communication or an external memory.

By generating such a torque coefficient display screen, it is possible for a worker or a work manager to easily grasp a variation state of the torque coefficients for the

5 tightening points.

[0045] <Seal Handling Management Processing>

Fig. 10 illustrates an example of seal handling management processing. A processing procedure and processing contents illustrated in Fig. 10 are examples of a method for
10 managing seal handling or a program for managing seal handling of the present invention, and the present invention is not limited to such contents.

In the seal handling management processing, the control means 16 is initialized (S11) and the tightening tool 14 is
15 set (S12). These setting steps include calculation of the tightening torque value T1 for each number of rounds based on the set torque coefficient k1 and the set axial force Fx, and input processing to the tightening tool 14 through the tightening condition setting unit 32.

20 The control means 16 acquires detection results F of axial force detected by axial force sensors 18-1, 18-2, ..., and 18-n (S13), and confirms the tightening points P and the number of rounds (S) (S14). In the confirmation processing, for example, the tightening points P are identified by numbers
25 of the eight bolts 6 at the eight tightening points P1 to P8 and change in the detected axial force. The number of rounds (S) is identified, for example, when tightening the bolts 6 at eight points is set as a unit, by the number of rounds that the same bolts 6 are tightened once.

30 [0046] The control means 16 determines whether the number of rounds (S) has reached a calculation step of the torque coefficient (S15), and in the case of the calculation step (YES in S15), compares the detected axial force F and the set axial force Fx, and calculates the corrected torque

coefficient k_2 for each of the bolts 6 (S16). Furthermore, the control means 16 associates the calculated corrected torque coefficient k_2 with corresponding one of the bolts 6 (S17), and uses the associated bolt coefficient k_2 in the next calculation of the tightening torque value T .

When the control means 16 determines that the number of rounds (S) is not the calculation step of the torque coefficient (NO in S15), returning to S12, the control means 16 counts up the number of rounds (S), and sets the axial force F or the tightening torque value according to the number of rounds (S), to perform the tightening processing.

[0047] <Effects of Second Embodiment>

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

(1) By setting the tightening torque value according to the number of rounds (S), monitoring tightened states by the detected axial force F , and correcting the tightening torque value, it is possible to prevent the variation in the tightened states among the tightening points.

(2) It is possible to match the axial force F of the bolts 6 with the target axial force F_x by correcting the torque coefficient k for the tightening torque that changes continuously or stepwise in accordance with the number of rounds (S) and the tightening points, and thus it is possible to achieve reliable seal handling.

(3) With regard to the round of the tightening points, it is possible to perform tightening not only in order of a bolt number but in various forms in which the bolt number is skipped, and to quickly perform appropriate seal handling regardless of which round of tightening is used.

[0048] [Third Embodiment]

[0049] Fig. 11 illustrates a configuration example of a seal handling management system according to a third embodiment. The configuration illustrated in Fig. 11 is an

example, and the present invention is not limited to such a configuration. In Fig. 11, the same components as those in Figs. 1 and 5 are designated by the same reference numerals.

The seal handling management system 50 includes a tightening tool 14, a controller 52, and a server 54. The tightening tool 14 has a configuration similar to that described above, and thus the description thereof will be omitted.

The controller 52 is connected to the tightening tool 14 with a cable 55. Furthermore, the controller 52 and the tightening tool 14 may be connected by Wi-Fi or infrared communication, for example. The controller 52 is, for example, a computer that sets a tightening torque value T and the like to the tightening tool 14, and also having functions of a control means for managing a tightened state and a tightening condition setting unit. The controller 52 operates independently or in cooperation with the server 54. The controller 52 includes a plurality of input operation units 58 and a display unit 60 on a front panel unit 56, for example.

[0050] The controller 52 achieves the following functions and effects by computer processing.

a. Calculating or selecting the torque value T to be applied to bolts 6 or nuts 8 in accordance with the number of rounds (S) of the tightening points or the tightening points P

b. Setting the torque value T to the tightening tool 14

c. Changing the output torque T of the tightening tool 14 stepwise or continuously in accordance with the number of rounds (S) or the tightening points P

d. Acquiring tightening management information from the server 54

e. Acquiring flange information on flanges 10-1 and 10-2

f. Acquiring gasket information on a gasket 12

g. Verifying the gasket information

h. Selecting tightening conditions from tightening

condition information and inputting the tightening conditions to the tightening tool 14

i. Acquiring tightening results from axial force sensors 18-1, 18-2, ..., and 18-n

5 j. Presenting tightening result information

k. Correcting the torque coefficient and the tightening torque value based on the tightening result

l. Presenting evaluation information on the tightening result

10 [0051] The controller 52 is linked with the server 54 by wire or wirelessly as a communication medium 62 indicated by a broken line. The server 54 is a computer that supports information processing of the controller 52 or manages the information processing, and for example, a personal computer
15 may be used. The server 54 includes, for example, a processing unit 64, an input operation unit 66, and a monitor 68.

[0052] <Tightening Tool 14>

A of Fig. 12 illustrates a configuration example of the tightening tool 14.

20 The tightening tool 14 includes, for example, a control unit 70, a motor 72, and a torque sensor 74.

The control unit 70 includes a computer and a motor drive unit, and the controller 52 provides control information such as tightening torque values T1 and T2. The motor 72 is driven
25 in accordance with the control information such as the tightening torque values T1 and T2, and when a trigger switch 26 is conductive, a drive current is supplied to the motor 72. Rotation of the motor 72 is transmitted to a socket 24 mounted on a rotary shaft 76, and the tightening torque value T is
30 applied to the nuts 8 fitted in the socket 24. The rotary shaft 76 may be provided with a gear mechanism to transmit rotational force of the motor 72 to the socket 24 at a desired gear ratio.

The torque sensor 74 detects the tightening torque value

T from the motor 72 or the rotary shaft 76, and the detected torque value is taken into the control unit 70. The torque sensor 74 is only required to detect the tightening torque of the bolts 6 and the nuts 8, and may be provided outside the tightening tool 14.

[0053] B of Fig. 12 illustrates an example of one of the bolts 6 provided with an axial force sensor 18. If each of the bolts 6 is provided with the axial force sensor 18 and axial force F applied to each of the bolts 6 is detected, the tightening torque value of the tightening tool 14 and its increase or decrease can be measured. As the axial force sensor 18, for example, a strain sensor may be used.

[0054] <Controller 52>

A of Fig. 13 illustrates a configuration example of the controller 52.

The controller 52 is a control means for the tightening tool 14 and is an example of a seal handling management device for seal tightening.

The controller 52 is configured by a computer, for example, and includes a processor 80, a storage unit 82, an input/output unit (I/O) 84, the input operation units 58, a communication unit 86, and the display unit 60.

The processor 80 is an example of a processing means and performs information processing such as an operating system (OS) and a program for managing seal handling stored in the storage unit 82. This information processing includes control of acquiring tightening condition information from the server 54, inputting tightening conditions including the tightening torque value T to the tightening tool 14, acquiring detection results of the tightening torque value from the tightening tool 14, monitoring and evaluating the tightened state, displaying evaluation results, outputting tightening result information, and the like.

The storage unit 82 is used to store the OS, the program

for managing seal handling, the tightening condition information, detection information, and the like, and includes a read only memory (ROM) and a random access memory (RAM). As the storage unit 82, a storage element capable of holding the stored contents may be used.

[0055] The I/O 84 is controlled by the processor 80 and is used for inputting and outputting control information. An external device such as a barcode reader 88 or a removable external memory 90 may be connected to the I/O 84. The barcode reader 88 is an example of an information acquisition unit. The external memory 90 is a memory for extracting log information, and for example, a universal serial bus (USB) memory may be used.

The input operation units 58 includes a key switch, a touch sensor, and the like, and is used for an input trigger of input information, an extraction trigger of output information, mode switching, and the like.

The communication unit 86 is controlled by the processor 80, and is used for wireless connection and internet connection with an external device such as the server 54.

The display unit 60 is controlled by the processor 80, and is an example of a means for presenting the input information and the output information. The display unit 60 may be provided with, for example, a green lamp 92-1 and a red lamp 92-2 as means for displaying status information, and the display unit 60 may turn on the green lamp 92-1 during normal operation and turn on the red lamp 92-2 during abnormal operation.

[0056] B of Fig. 13 illustrates an example of the storage contents of the storage unit 82.

The storage unit 82 includes a temporary storage area 94-1 and a storage area 94-2. The temporary storage area 94-1 temporarily stores, for example, flange information 100, which is a handling target, gasket information 102, worker

information 104, and tightening result information 106 acquired from the tightening tool 14.

In the storage area 94-2, a database such as a tightening instruction information table 40 is constructed.

5 [0057] <Server 54>

Fig. 14 illustrates a configuration example of the server 54.

The server 54 is a support device for the controller 52 and is also an example of a means for presenting the log
10 information. The server 54 includes, as a processing unit 110, for example, a processor 112, a storage unit 114, an input/output unit (I/O) 116, and a communication unit 118, and the input operation unit 66 and the monitor 68 described above are connected thereto.

15 The processor 112 performs information processing such as an OS and a program for managing seal handling stored in the storage unit 114. This information processing includes processing such as providing the tightening condition information to the controller 52, acquiring information
20 indicating tightening results from the controller 52, and presenting the tightening result information.

[0058] The storage unit 114 is used to store the OS, the program for managing seal handling, the tightening condition information, the log information, and the like, and includes a
25 ROM and a RAM. As the storage unit 114, a storage device such as a hard disk or a semiconductor memory capable of holding the stored contents may be used.

The I/O 116 is controlled by the processor 112 and is used for inputting and outputting the control information. For
30 example, an external memory 122 is connected to the I/O 116 as an external device. The communication unit 118 is used, for example, for wireless connection with the controller 52 or the like.

The communication unit 118 is controlled by the processor

112, and is used for wireless connection and internet connection between the server 54 and external devices such as the tightening tool 14 and the controller 52.

The input operation unit 66 is used for an input operation of the input information, and also used, by input operation, for an extraction trigger of the output information, mode switching operation, and the like.

The monitor 68 is an example of an information presenting unit and a display unit, and is used, for example, for displaying the tightening instruction information table 40 and the tightening results. A screen display unit of the monitor 68 may be provided with a touch panel 120, with which input information corresponding to display information may be performed, instead of the input operation unit 66.

[0059] <Tightening Results>

Fig. 15 illustrates an example of the tightening results.

For example, as illustrated in A of Fig. 15, a tightening result screen imitating the tightening points P1, P2, ..., and Pn of a seal handling unit 4 is displayed on the display unit 60 of the controller 52 or the monitor 68 of the server 54.

This tightening result screen is generated in combination of information on the detection results (B of Fig. 15) acquired from the axial force sensors 18-1, 18-2, ..., and 18-n by one or both of the controller 52 and the server 54, information on the tightening points and the number of rounds (S) by the tightening tool 14, and the like.

On the tightening result screen, for example, tightening target axial force and tightening force for each number of rounds (S) are displayed for each of the tightening point.

That is, on the tightening result screen, variation of the axial force among the tightening points and transition of the tightening force for each number of rounds (S) are displayed.

Furthermore, for example, as illustrated in B of Fig. 15, detection data including the axial force F of the bolts 6 for

each STEP, that is, for each number of rounds (S) is stored as the detection results in the temporary storage unit 94-1 of the controller 52 or the storage unit 114 of the server 54.

The detection results show, for example, the tightening results up to STEPs 1 to 6, and the detection data increases as a tightening step further progresses. Furthermore, in this seal handling management, correction processing of the torque coefficient is executed based on the detection results in STEP 3, as in the second embodiment, for example. Then, when the number of rounds (S) of tightening progresses after the correction of the torque coefficient, the detection results of the axial force of the bolts at a stage of STEP 6 become substantially equivalent values. As a result, it is shown that the seal handling is performed on surfaces of the flanges 10-1 and 10-2 by the axial force without variation.

[0060] <Processing Sequence for Seal Handling Management>

Fig. 16 illustrates a processing sequence for seal handling management by the seal handling management system 50.

In seal handling processing, the tightening tool 14 performs initialization (S31), and the controller 52 performs initialization (S32). After the initial setting, the controller 52 and the server 54 are linked, and the controller 52 takes in tightening condition information including the torque coefficient k_1 and the like provided from the server 54 (S33). The controller 52 takes in the tightening condition information by acquiring the tightening instruction information table 40.

The controller 52 that has acquired the tightening condition information selects tightening conditions corresponding to the flanges 10-1 and 10-2 and the gasket 12 that are selected in advance (S34). Furthermore, the controller 52 sets the number of rounds S and the tightening positions P (S35), and calculates the tightening torque value T_1 using the torque coefficient k_1 and set axial force F_x

(S36). When candidates for the tightening torque value T_1 are stored in advance, it is sufficient that one of the stored tightening torque values T_1 is selected.

After tightening preparation processing, the controller 52 sets the tightening torque value T_1 to the tightening tool 14 (S37).

[0061] A handler applies tightening torque to the bolts 6 or the nuts 8 at the tightening points with the tightening tool 14 to perform tightening (S38). The axial force sensors 18-1, 18-2, ..., and 18-n detect the axial force of the bolts 6 at the tightening points P (S39), and the detected axial force F is taken into the controller 52 (S40).

[0062] The controller 52 determines whether tightening work has been completed based on the number of rounds S of the tightening points P or the information on the tightening points P using the detected axial force (S41). That is, for example, in a case of the tightening points $P = 8$, the controller 52 identifies the tightening points P1 to P8 from the number of eight bolts 6 and change in the axial force. The controller 52 sets, as a unit, tightening of a plurality of bolts 6 selected from the tightening points P1 to P8, and sets the number of rounds of the selected bolts as the number of rounds $S = 1$. In addition, as described above, with regard to the number of rounds S , it is possible to specify $S = 0$ to n .

[0063] If the controller 52 determines that the tightening work has not been completed (NO in S41), the controller 52 determines whether it is a calculation step (number of rounds) of the torque coefficient k (S42). If it is the calculation step (YES in S42), the controller 52 determines whether the detected axial force and the set axial force are different (S43).

If it is not the calculation step of the torque coefficient k (NO in S42) and if there is no difference between the detected axial force and the set axial force (NO

in S43), the processing returns to S35 to continue the tightening work.

At this time, the controller 52 counts up the number of rounds (S), for example, and calculates the tightening torque value T corresponding to the next number of rounds. As a result, the output torque T is changed or set stepwise or continuously in accordance with the tightening points P and the number of rounds S.

[0064] If the controller 52 determines that the detected axial force and the set axial force are different (YES in S43), the controller 52 calculates the corrected torque coefficient k2 using the detection results of the axial force as the correction processing of the tightening torque value (S44). The controller 52 then sets new tightening conditions including the corrected torque coefficient k2 (S45) and returns to S35 to continue the tightening processing.

[0065] If the controller 52 determines that the tightening has been completed based on a count value of the number of rounds S (YES in S41), the tightening is completed (S46), and the controller 52 inputs a tightening completion instruction to the tightening tool 14 to complete the tightening. The completion of tightening may be presented by use of the monitor 68, for example. The controller 52 notifies the server 54 of the tightening result information. The tightening result information is then displayed on the server 54 (S47).

[0066] Note that the controller 52 determines a count number of the number of rounds (S) as determination as to whether the tightening has been completed, but the determination is not limited to this. If the controller 52 determines that the detection results acquired from the axial force sensors 18-1, 18-2, ..., and 18-n do not reach the variation of the axial force or the target axial force, or are not within a predetermined range, for example, the controller 52 may repeat additional tightening processing.

[0067] <Effects of Third Embodiment>

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

5 (1) Since the tightening conditions such as the torque coefficient k and the tightening torque value T are automatically selected, it is not necessary to force a worker to manage the tightening conditions, and it is possible to reduce a burden on the worker for setting the tightening conditions. It is possible to prevent setting mistakes and
10 tightening mistakes by avoiding setting the tightening conditions depending on experience and intuition of the worker.

(2) Since the tightening conditions can be individually and specifically provided from the server 54 to the controller
15 52, it is possible to achieve precise tightening results. It is possible to perform seal handling management in which correction of the torque coefficient k , setting of the tightening torque value, and the like are highly accurate, based on the detection results of the axial force.

20 (3) The tightening tool capable of tightening management and information processing using a computer can achieve automation, high precision, simplification, and high efficiency of the seal handling, and it is possible to perform highly reliable seal handling that does not depend on the
25 experience and the intuition of the worker.

[0068] [Fourth Embodiment]

[0069] Fig. 17 illustrates an example of a seal handling management device according to a fourth embodiment.

The seal handling management device 130 includes a
30 tightening tool 132 and a control means 134. The tightening tool 132 is, for example, a torque wrench or a hand nut runner, and includes a gear unit 136 that generates a set tightening torque value.

For example, a socket 138 coupled to nuts 8 is installed

to the gear unit 136. Furthermore, the gear unit 136 includes an information acquisition unit 140 that acquires identification information of bolts 6 and the nuts 8 and tightening point information. The information acquisition unit 140 includes, for example, a reception antenna, a reception unit, a signal conversion unit, a transmission unit, and a transmission antenna. Then, the information acquisition unit 140 receives tag information (not illustrated) installed on the bolts 6 and the nuts 8 and acquires the identification information such as identification (ID) from this tag information. This identification information is then converted into a transmission signal by the signal conversion unit and transmitted to the control means 134 side through the transmission unit. For the transmission of this transmission signal, for example, short-range wireless communication is used.

[0070] The control means 134 includes, for example, a communication unit 142, a processing unit 144, a storage unit 146, and an information presenting unit 148.

The communication unit 142 communicates with the information acquisition unit 140 installed in the tightening tool 132, and receives the identification information of the bolts 6 and the nuts 8.

The processing unit 144 transmits/receives the identification information and the like to/from the information acquisition unit 140 through the communication unit 142, and also performs setting processing of the tightening torque value, calculation processing of a torque coefficient, and the like.

The storage unit 146 stores, for example, the identification information of the bolts 6 and the nuts 8 and tightening position information, and also stores, in addition to a tightening procedure, calculation information of the tightening torque value, and calculation information of the

torque coefficient, axial force information and the like received from axial force sensors 18-1, 18-2,... and 18-n (Fig. 1) installed at tightening points (not illustrated).

The information presenting unit 148 is an example of means for displaying tightening torque value information set to the tightening tool 132, torque coefficient information, corrected torque coefficient information, detected axial force information, and the like, and also for displaying tightening position instruction information and the like in a tightening step.

[0071] Detection processing of the axial force, the calculation processing of the torque coefficient, and correction processing of the tightening torque value in the tightening step are as described in the above-described embodiments, and the description thereof will be omitted.

[0072] <Effects of Fourth Embodiment>

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

(1) It is possible to perform tightening with the tightening torque value corresponding to each of the tightening points, and to easily manage the tightening points by using the identification information of the bolts 6 and the nuts 8.

(2) By managing the tightening points based on the identification information of the bolts 6 and the nuts 8, even if an error of a work procedure occurs, guide display is performed by the information presenting unit 148 to guide a worker to an appropriate work, and thus, it is possible to improve reliability of seal handling management.

[Comparative Example]

[0073] Fig. 18 illustrates a comparative example of seal handling processing of flanges.

In the seal handling management processing illustrated in Fig. 18, for example, similarly to the second and third

embodiments described above, processing of tightening eight bolts 6 and nuts 8 on flanges 10-1 and 10-2 is performed. This tightening processing is a case where a value of 0.2 is maintained as a preset torque coefficient k in calculation processing of a tightening torque value T to be set to a tightening tool 14. Furthermore, the tightening torque value T is increased stepwise in accordance with the number of rounds.

As a result of this tightening processing, as illustrated in A of Fig. 18, it can be seen that axial force F acts in which axial force of a tightening position P6 is always larger than that of the other tightening positions. In STEP6, which is the number of rounds, only the tightening position P6 has reached target axial force while the other tightening points have not reached the target axial force.

The axial force detected by the axial force sensors 18-1, 18-2, ... and 18-8 has resulted in large variation among the bolts 6 at a stage of STEP 6, as illustrated in B of Fig. 18. When these axial force values are compared, the maximum value of variation is about 28 [%], and an average value of variation was 14 [%]. When such variation occurs, since the force does not act evenly between the flanges 10-1 and 10-2, a so-called one-sided tightening may occur, in which only some tightening positions act, and other bolts 6 and nuts 8 may become loose. Therefore, in the tightening processing, for example, retightening and additional tightening are performed while the axial force of all the bolts 6 is monitored. As described in the technical problem, in the tightening of the bolts 6 and the nuts 8 on the flanges 10-1 and 10-2, since the tightening of other bolts is loosened by being affected by an elastic interaction, for example, the axial force adjustment after tightening causes an increase in a work load.

[0074] Meanwhile, as in the present invention, by performing correction processing of the torque coefficient corresponding to each of the tightening points during the

tightening step, influence due to the variation in tightened states among the bolts 6 does not occur, or the influence is reduced. Therefore, it is possible to efficiently perform the seal handling management in which the tightened states are stabilized while a work load is reduced.

[0075] [Other Embodiments]

[0076] (1) In the above embodiments, the case has been shown where a hand nut runner provided with a processor or the like is used as the tightening tool 14, but the present invention is not limited to this. As the tightening tool 14, for example, a torque wrench capable of manually setting the tightening torque may be used. Furthermore, the tightening tool 14 may be a large-sized assembling device including a tightening arm that tightens the bolts and capable of grasping the tightening points of a product and detecting the axial force by tightening.

[0077] (2) In the above embodiments, the case has been shown where the axial force sensors are installed on the bolts themselves, as the means for detecting the axial force acting on the tightening points, but the present invention is not limited to this. In the seal handling management processing, for example, a detecting device such as an ultrasonic sensor may be used to detect the axial force on the tightened bolts 6, and the torque coefficient may be calculated by use of detection results.

[0078] (3) As the controller 52, a mobile information terminal such as a smartphone may be used.

[0079] (4) In the above embodiments, the example has been shown where the controller 52 and the server 54 are linked with one tightening tool 14, but the present invention is not limited to this. The controller 52 and the server 54 may be linked with a plurality of tightening tools 14, and a plurality of controllers 52 and a single server 54 may be provided.

[0080] As described above, the most preferable embodiments and examples of the present invention have been described. The present invention is not limited to the above description. Various modifications and changes can be made by those skilled in the art based on the gist of the invention described in the claims or disclosed in the description of embodiments or the examples. It goes without saying that these modifications and changes are included in the scope of the present invention.

10 Industrial Applicability

[0081] The method for managing seal handling, the seal handling management device, the program for managing seal handling, and the seal handling management system of the present invention are beneficial because correction processing of the torque coefficient is performed using the axial force detected in the tightening step, by information processing using a computer with the tightening tool capable of tightening management, and thus it is possible to set the tightening torque value according to the states of the tightening points, and it is possible to stabilize the tightened states for the flanges and perform the tightening processing with required axial force.

Reference Signs List

25 [0082] 2, 30, 130 Seal handling management device
 4 Seal handling unit
 6 Bolt
 8 Nut
 10-1, 10-2 Flange
 30 12 Gasket
 14, 132 Tightening tool
 16, 134 Control means
 18, 18-1, 18-2, ..., 18-n Axial force sensor
 20 Device body

	22	Grip
	24	Socket
	26	Trigger switch
	32	Tightening condition setting unit
5	34	Acquisition means
	40	Tightening instruction information table
	50	Seal handling management system
	52	Controller
	54	Server
10	55	Cable
	56	Front panel unit
	58	Input operation unit
	60	Display unit
	62	Communication medium
15	64, 110	Processing unit
	66	Input operation unit
	68	Monitor
	70	Control unit
	72	Motor
20	74	Torque sensor
	76	Rotary shaft
	80, 112	Processor
	82, 114	Storage unit
	84, 116	Input/output unit (I/O)
25	86, 118	Communication unit
	88	Barcode reader
	90	External memory
	92-1	Green lamp
	92-2	Red lamp
30	94-1	Temporary storage area
	94-2	Storage area
	100	Flange information
	102	Gasket information
	104	Worker information

	106	Tightening result information
	120	Touch panel
	122	External memory
	136	Gear unit
5	138	Socket
	140	Information acquisition unit
	142	Communication unit
	144	Processing unit
	146	Storage unit
10	148	Information presenting unit

CLAIMS

1. A method for managing seal handling wherein a plurality of tightening points is set on flanges sandwiching a gasket and each of the tightening points is provided with a bolt and a nut to perform tightening, and the method comprises steps of:
- 5 tightening the bolt and the nut with a tightening tool to which a first tightening torque value is set;
detecting axial force of the bolt;
10 calculating or selecting a torque coefficient of the bolt by use of the detected axial force; and
setting, for each of the tightening points on the bolt, a second tightening torque value calculated or selected by use of the torque coefficient to the tightening tool.
- 15 2. The method for managing seal handling according to claim 1, further comprising a step of comparing the detected axial force of the bolt with target axial force, set axial force, or a predetermined threshold value to calculate or select the torque coefficient based on a comparison result.
- 20 3. The method for managing seal handling according to claim 1 or 2, further comprising steps of:
detecting one or both of the number of rounds of the tightening tool and the tightening points; and
changing set axial force or a tightening torque value set
25 to the tightening tool stepwise or continuously in accordance with the number of rounds or the tightening points.
4. The method for managing seal handling according to any of claims 1 to 3, further comprising a step of calculating or selecting the first tightening torque value by use of set
30 axial force set for each tightening step and a torque coefficient selected in advance.
5. A seal handling management device wherein a plurality of tightening points is set on flanges sandwiching a gasket and each of the tightening points is provided with a bolt and a

nut to perform tightening, and the seal handling management device comprises:

a setting means that sets, the tightening points, the number of rounds of tightening, and a tightening torque value to a tightening tool;

an acquisition means that acquires axial force of the bolt; and

a control means that acquires the axial force of the bolt tightened by the tightening tool to which a first tightening torque value is set, calculates or selects a torque coefficient of the bolt by use of the axial force, and sets, for each of the tightening points on the bolt, a second tightening torque value calculated or selected by use of the torque coefficient to the tightening tool.

6. The seal handling management device according to claim 5, wherein the control means compares the detected axial force of the bolt with target axial force, set axial force, or a predetermined threshold value, and calculates or selects the torque coefficient based on a comparison result.

7. The seal handling management device according to claim 5 or 6, further comprising a detection means that detects one or both of the number of rounds of the tightening tool and the tightening points, wherein

the control means changes set axial force or a tightening torque value set to the tightening tool stepwise or continuously in accordance with the number of rounds or the tightening points.

8. A program for managing seal handling to be implemented by a computer, the program causing the computer to implement functions of:

setting a first tightening torque value to a tightening tool that tightens a bolt and a nut mounted on each of tightening points of flanges sandwiching a gasket;

acquiring a detection result of axial force of the bolt

tightened by the tightening tool;

calculating or selecting a torque coefficient of the bolt by use of the detected axial force; and

setting, for each of the tightening points of the bolt, a second tightening torque value calculated or selected by use of the torque coefficient to the tightening tool.

9. A seal handling management system wherein a plurality of tightening points is set on flanges sandwiching a gasket and each of the tightening points is provided with a bolt and a nut to perform tightening, and the seal handling management system comprises:

a tightening tool that is capable of controlling a torque value applied to the bolt or the nut;

a sensor that detects axial force of the bolt; and

a controller that sets a first tightening torque value to the tightening tool, calculates or selects a torque coefficient of the bolt by use of the axial force detected by the sensor, and sets, for each of the tightening points on the bolt, a second tightening torque value calculated or selected by use of the torque coefficient to the tightening tool.