

DESCRIPTION

Title of Invention:

SEAL HANDLING MANAGEMENT METHOD, SEAL HANDLING MANAGEMENT
5 DEVICE, SEAL HANDLING MANAGEMENT PROGRAM, AND SEAL HANDLING
MANAGEMENT SYSTEM

Technical Field

[0001] The present invention relates to a seal handling
10 management technology that is used for tightening a flange
connecting piping, valves, pumps, and the like.

Background Art

[0002] A flange coupling is used for piping connections
and to connect a pump or the like to piping. A gasket is held
15 between the flanges of the flange coupling, and tightening is
performed by means of bolts and nuts which are arranged in a
plurality of locations on the flanges. A tightening tool such
as a torque wrench is used for the tightening.

[0003] Regarding this tightening tool, in a tool which
20 uses an electric motor as its rotary drive source, applying a
current pulse intermittently to the motor, controlling a
current value according to a detected torque, and stopping the
current pulse upon attaining a target torque are known (Patent
Literature 1, for example).

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Citation List

Patent Literature

[0004] Patent Literature 1: Japanese unexamined patent
application publication No. 2002-1676

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Summary of Invention

Technical Problem

[0005] Incidentally, in the tightening of the flange
coupling, a tightening torque is exerted by the tightening

tool on the bolts and nuts which are arranged in a plurality of locations. If a tool capable of torque management is used in this tightening, a desired tightening torque may be exerted on the bolts and nuts, and even and uniform tightening is possible.

[0006] However, there is a wide variety of flanges and gaskets, and considerable experience is required to select a suitable gasket. Moreover, a procedure for tightening a plurality of bolts arranged on a flange is not uniform, and even when a tightening tool capable of torque management is used, such a tool is not enough to alleviate handling management. An increase in handling reliability by means of proficient workers remains desirable, and practice and experience are required to attain proficiency. The burden on workers is excessive, and seal handling management is therefore of great importance.

[0007] In seal handling of this kind, in addition to the selection and combination of tightening methods such as angular tightening and circular tightening to avoid uneven tightening and crushing and the like, the workmanship, capability and experience and so forth of the technician affect the handling accuracy, and handling inconsistencies arise.

[0008] Therefore, in view of such problems, an object of the present invention is to automate setting of an output torque according to a pass count of a tightening location, and the tightening location, to facilitate seal handling management, and improve handling accuracy.

In addition, in view of such problems, a further object of the present invention is to use a tightening tool which is capable of automatic setting of the output torque, facilitate seal handling management, and improve handling accuracy.

Solution to Problem

[0009] To achieve the foregoing object, an aspect of a seal handling management method of the present invention is a seal handling management method in which a plurality of tightening locations are set for flanges holding a gasket therebetween and tightening is performed by providing a bolt and a nut in each of the tightening locations, the seal handling management method including calculating or selecting a torque value that is exerted on the bolt or the nut according to a pass count of the tightening location, or the tightening location, setting the torque value for the tightening tool, and gradually or continuously modifying an output torque of the tightening tool according to the pass count or the tightening location.

[0010] The foregoing seal handling management method may further include detecting the pass count, or the tightening location, of the tightening tool.

[0011] The foregoing seal handling management method may further include setting, for the tightening tool, the pass count of the tightening location, or the tightening location.

The foregoing seal handling management method may include detecting the axial force on the bolt, and detecting the pass count, or the tightening location, of the tightening tool, by using information on variations in the detected axial force, and information identifying the bolt.

[0012] To achieve the foregoing object, an aspect of a seal handling management device of the present invention is a seal handling management device in which a plurality of tightening locations are set for flanges holding a gasket therebetween and tightening is performed by providing a bolt and a nut in each of the tightening locations, the seal handling management device including control means which calculates or selects a torque value that is exerted on the bolt or the nut according to a pass count of the tightening location, or the tightening location, which sets the torque

value for a tightening tool, and which gradually or continuously modifies an output torque of the tightening tool according to the pass count or the tightening location.

[0013] The foregoing seal handling management device may include detection means which detects the pass count of the tightening location, or the tightening location, of the tightening tool.

[0014] The foregoing seal handling management device may include setting means which sets the pass count of the tightening location, or the tightening location, for the tightening tool.

[0015] In the foregoing seal handling management device, the control means may be disposed in the tightening tool or may be disposed separately from the tightening tool and connected by a wired or wireless connection.

In the foregoing seal handling management device, the detection means may include an axial force sensor which detects an axial force on the bolt, and the detection means may detect the pass count, or the tightening location, of the tightening tool, by using information on a variation in the axial force detected by the axial force sensor, and information identifying the bolt.

[0016] To achieve the foregoing object, according to an aspect of a seal handling management program of the present invention, a function which calculates or selects a torque value that is exerted on a bolt or nut according to a pass count of a plurality of tightening locations that have been set for flanges holding a gasket therebetween, or to the tightening location, a function which sets the torque value for a tightening tool, and a function which gradually or continuously modifies an output torque of the tightening tool according to the pass count or the tightening location are realized by the computer.

[0017] To achieve the foregoing object, an aspect of a

seal handling management system of the present invention is a seal handling management system in which a plurality of tightening locations are set for flanges holding a gasket therebetween and tightening is performed by providing a bolt and a nut in each of the tightening locations, the seal handling management system including a tightening tool capable of gradually or continuously controlling an output torque that is applied to the bolt or the nut, and a controller which is connected by a wired or wireless connection to the tightening tool, calculates or selects a torque value that is exerted on the bolt or the nut according to a pass count of the tightening location, or the tightening location, sets the torque value for the tightening tool, and gradually or continuously modifies the output torque of the tightening tool according to the pass count or the tightening location.

Advantageous Effects of Invention

[0018] According to the present invention, any of the following effects is obtained.

- (1) By gradually or continuously modifying an output torque, which is exerted by a tightening tool on a bolt or nut at a flange tightening location, according to the pass count of the tightening location, or the tightening location, an axial force on each bolt can be made to attain a target axial force.
- (2) Because the output torque that is exerted by the tightening tool on a bolt or nut at a flange tightening location can be automatically modified to an optimal value gradually or continuously according to the pass count of the tightening location, or the tightening location, highly accurate seal handling can be realized without being affected by the workmanship or intuition of a technician.
- (3) Because it is possible to set the pass count with which the axial force of each bolt at a plurality of tightening locations is made to attain a target axial force, expedited

and uniform seal handling can be achieved.

(4) Blunders by technicians can be reduced, and the reliability of seal handling can be increased.

[0019] Moreover, further objects, characteristics and

5 advantages of the present invention will become more apparent upon referring to the attached drawings and each of the embodiments.

Brief Description of Drawings

10 [0020] Fig. 1 is a diagram illustrating a seal handling management device according to a first embodiment.

Fig. 2 is a diagram illustrating tightening location pass modes.

15 Fig. 3 is a flow chart illustrating a process order of seal handling management.

Fig. 4A is a diagram illustrating a seal handling management system according to a second embodiment, and Fig. 4B is a diagram illustrating functions of a control unit.

20 Fig. 5 is a diagram illustrating a processing sequence of seal handling management.

Fig. 6 is a diagram illustrating a seal handling management device according to a third embodiment.

Fig. 7 is a diagram illustrating a seal handling management system according to an example.

25 Fig. 8A is a diagram illustrating an example of a tightening tool, and Fig. 8B is a diagram illustrating an example of an axial force sensor.

30 Fig. 9A is a diagram illustrating hardware of a controller, and Fig. 9B is a diagram illustrating a storage unit.

Fig. 10 is a diagram illustrating a server.

Fig. 11 is a diagram illustrating a tightening condition table.

Fig. 12 is a diagram illustrating a torque value table.

Fig. 13 is a diagram illustrating a modified example of a torque value table.

Fig. 14 is a diagram illustrating a processing sequence of a seal handling management system.

5 Fig. 15 is a diagram illustrating transitions of detected axial forces using tightening management.

Description of Embodiments

[0021] (First embodiment)

10 Fig. 1 illustrates 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.

[0022] The seal handling management device 2-1 is used in
15 tightening and management of a plurality of bolts 6 and nuts 8 of a seal handling unit 4 which connects piping, valves, and pumps, and the like. The seal handling unit 4 is an example of a tightening target in which a gasket 12 is held between flanges 10-1, 10-2 and the bolts 6 and nuts 8 are arranged in
20 a plurality of tightening locations. In this example, the tightening locations of the flanges 10-1, 10-2 are set in eight locations on the periphery, that is, at intervals with an angle θ of 45° , where eight of each of the bolts 6 and nuts 8 are arranged.

25 [0023] The seal handling management device 2-1 includes a tightening tool 14 and a control unit 16-1 thereof. The tightening tool 14 is generation means which generates an output torque T which is exerted on the bolts 6 and nuts 8, and may be a tool that is capable of managing modifications to
30 increase or reduce the output torque. That is, a general electric tool such as a nut runner can be used as the tightening tool 14.

[0024] For the tightening tool 14, the worker grasps a grip 18 to hold a device body 20, and if a trigger switch 24

is pressed after a socket 22 has been made to mate with the nut 8 of the tightening location, the output torque T can be exerted on the nut 8 of the tightening location.

[0025] The control unit 16-1 is an example of control

5 means which controls the tightening tool 14, and is configured from a computer, for example. Functions of the control unit 16-1 include:

- a. A function which calculates or selects a torque value τ that is exerted on the bolt 6 or nut 8 according to a pass count N of a tightening location, or the tightening location P .
- 10 b. A function which sets the torque value τ in the tightening tool 14.
- c. A function which gradually or continuously modifies the output torque T of the tightening tool 14 according to the
- 15 pass count N or the tightening location P .

[0026] In the case of functions a, b, and c, the tightening locations are points where a tightening force is exerted between the flanges 10-1, 10-2, and in the aforementioned example, the tightening locations are the

20 positions where the bolts 6 or nuts 8 are arranged. The pass count N of the tightening location P is the unit number of passes in positions $P_1, P_2, \dots, P_n$ of the bolts 6 and nuts 8.

[0027] The torque value τ is a torque that is set to attain a target axial force F_e of a tightening location and is

25 a value that is to be exerted on the bolt 6 or nut 8 according to a pass count N of a tightening location, or the tightening location P . The torque value τ is calculated as a level value that is required to attain the target axial force F_e according to tightening conditions which include the gasket 12. Instead

30 of calculating the torque value τ , selection may also be performed, according to the pass count N of a tightening location, or the tightening location P , from a database of precalculated torque values τ .

[0028] In the case of b, the torque value τ is control

information which the control unit 16-1 outputs to the tightening tool 14, and the torque value τ is set for the tightening tool 14 by means of the control information.

[0029] In the case of c, the output torque T of the tightening tool 14 is gradually or continuously modified by the control unit 16-1 according to the pass count N or the tightening location P. As a result, the axial force of the bolt 6 or nut 8 of each tightening location is made to attain the target axial force F_e .

[0030] Regarding the passes of the tightening location, passes may be made in the positions P1, P2, ... Pn in that order, as illustrated by arrow a in Fig. 2A, or passes may be made in the positions P1, P2, ... Pn by changing the tightening location in the diametrical direction of the flanges 10-1, 10-2, as illustrated by arrow b in Fig. 2B. That is, the tightening location may be changed continuously in the number order of the positions P1, P2, ... Pn, or passes may be performed by regularly skipping a predetermined number of tightening locations. Therefore, the pass count N is not limited to an enumerated value for continuous passes in the order of the positions P1, P2, ... Pn, and may also be an enumerated value that is enumerated by taking passes, obtained by skipping predetermined positions, as units.

[0031] Fig. 3 illustrates a seal handling management step which uses the control unit 16-1.

This handling management is an example of a seal handling management method which includes a tightening step in which a plurality of tightening locations are set in the flanges 10-1, 10-2 which hold the gasket 12 therebetween and the bolts 6 and nuts 8 are provided in each of the tightening locations (S101, S102, S103, S104, S105, and S106).

[0032] In this seal handling management, the torque value τ , which is exerted on the bolts 6 or nuts 8 according to the pass count N of a tightening location, or the tightening

location P, is calculated or selected at the time of seal handling (before or during seal handling) (S101).

The calculated or selected torque value τ is set for the tightening tool 14 by the control unit 16-1 (S102).

5 [0033] In handling the tightening in the tightening locations, it is determined whether or not there is to be a modification to the pass count N of a tightening location, or the tightening location P (S103). If there is to be a modification to the pass count N of a tightening location, or
10 the tightening location P (YES in S103), the output torque T of the tightening tool 14 is gradually or continuously modified according to the tightening location pass count N or the tightening location P (S104). If there is to be no modification to the tightening location pass count N or
15 tightening location P (NO in S103), the current output torque T is maintained (S105).

[0034] Further, it is determined whether or not an axial force F of each tightening location has attained the target axial force F_e (S106). If the axial force F of each tightening
20 location has not attained the target axial force F_e (NO in S106), the steps S103 to S106 are each repeated, the configuration of the torque value τ according to the tightening location pass count N or the tightening location P is repeated, and the output torque T is modified.

25 [0035] If the axial force F of each tightening location has attained the target axial force F_e (YES in S106), the seal handling is complete.

[0036] The axial force F of each tightening location may be detected from each bolt 6 by means of an axial force sensor
30 or may be calculated by using a detection value of a torque sensor in the tightening tool 14.

[0037] <Effect of first embodiment>

(1) Reliable, highly accurate seal handling can be realized without relying upon the workmanship or intuition of a

technician.

(2) The calculation and configuration of the torque value τ , and the detection of the output torque T can be performed consistently, and highly reliable seal handling can be

5 expedited.

(3) Seal handling blunders by technicians can be reduced and technician safety can be increased.

[0038] (Second embodiment)

Fig. 4A illustrates a seal handling management system according to a second embodiment. In Fig. 4A, the same reference signs are assigned to the same parts as Fig. 1A. The configuration illustrated in Fig. 4A is an example, and the present invention is not limited to such a configuration.

[0039] The seal handling management system 2-2 includes a tightening tool 14, a control unit 16-2, and axial force sensors 26-1, 26-2, ... 26-n. The tightening tool 14 is the same as in the foregoing configuration, and therefore a description thereof is omitted.

[0040] The control unit 16-2 is an example of control means which controls the tightening tool 14, and is configured from a computer, for example. The control unit 16-2 controls the tightening tool 14 similarly to the control unit 16-1 (Fig. 1A) but differs from the control unit 16-1 in using, for the control, detected axial forces of the axial force sensors 26-1, 26-2, ... 26-n. The axial force sensors 26-1, 26-2, ... 26-n are an example of axial force detection means which detects the axial force on each bolt 6 in the seal handling unit 4. In this example, the axial force sensors 26-1, 26-2, ... 26-8 are provided individually for eight bolts 6, and the detected axial forces are each fed to the control unit 16-2. In the control unit 16-2, the detected axial forces F are each used in comparison information indicating whether or not the detected axial forces F have attained a target axial force F_e , information specifying tightening locations, and tightening

location pass information, and the like.

[0041] The control unit 16-2 realizes first, second, and third functions 28, 30, and 32, as illustrated in Fig. 4B. The function 28 calculates or selects a torque value τ that is exerted on the bolts 6 or nuts 8 according to a pass count N of a tightening location, or the tightening location P. The function 30 sets the torque value τ in the tightening tool 14. Further, the function 32 gradually or continuously modifies or maintains the output torque T of the tightening tool 14 according to the pass count N or the tightening location P.

[0042] Fig. 5 illustrates a seal handling management processing sequence of a seal handling management system 2-2.

[0043] At the time of seal handling, an initial configuration of the tightening tool 14 is performed (S201) and an initial configuration of the control unit 16-2 is performed (S202). The axial force sensors 26-1, 26-2, ... 26-n each detect the axial force on each bolt 6 (S203), and the control unit 16-2 performs feeding of each detected axial force (S204). The control unit 16-2 performs a determination of the pass count N of the tightening location P, or the tightening location P (S205). In this case, each tightening location P can be specified from the numbers of the eight bolts 6 in the eight tightening locations P1 to P8 and from a variation in the detected axial force, and, by taking the tightening of the bolts 6 in the eight locations as the units, for example, the pass count N is specified from the number of tightening passes the same bolt 6 undergoes.

[0044] The control unit 16-2 calculates the torque value τ that is exerted on the bolts 6 or nuts 8 according to the pass count N of a tightening location P, or the tightening location P (S206). In this calculation, the control unit 16-2 refers to a selected tightening condition of the gasket 12, or the like, and calculates a torque value τ_0 for a pass count N=0, a torque value τ_1 for a pass count N=1, and a torque value τ_2

for a pass count $N=2$, and so forth. In this case, the torque value τ according to the pass count N may also be selected from precalculated torque values τ_0 , τ_1 , τ_2 , and so forth.

[0045] The torque value τ is provided and set for the tightening tool 14 by the control unit 16-2 (S207). The tightening tool 14 generates an output torque T_τ according to the torque value τ . As a result, the output torque T_τ is gradually or continuously modified or maintained according to the tightening pass count N or the tightening location P (S208).

[0046] Furthermore, by means of the tightening tool 14, the technician exerts an output torque T on the bolts 6 or nuts 8 of the tightening locations P_1 to P_8 and performs tightening (S209). The axial force sensors 26-1, 26-2, ... 26-8 perform detection of the axial forces on the bolts 6 in each of the tightening locations P_1 to P_8 (S210), and the detected axial forces are each fed to the control unit 16-2 (S211).

[0047] The control unit 16-2 determines whether or not each of the detected axial forces has attained a target axial force (S212). If each detected axial force F has not attained the target axial force F_e (NO in S212), the control unit 16-2 returns to S205 and repeats the processing of S205 to S212.

[0048] If the detected axial force F has attained the target axial force F_e (YES in S212), the tightening is then complete (S213), and the control unit 16-2 reports the completion to the tightening tool 14 and ends the tightening. The completion of tightening may also be reported by using a display device.

[0049] <Effect of second embodiment>

(1) The torque value τ can be calculated according to the pass count N of a tightening location, or the tightening location P . The torque value τ which corresponds to the tightening location pass count or the tightening location can

be set, and the output torque T can be gradually or continuously modified according to the tightening location pass count or the tightening location so that the axial force F of the bolts 6 can be made to rapidly attain the target

5 axial force F_e .

(2) Because the output torque T that is applied to the bolts 6 by the tightening tool 14 can be captured and monitored by means of the detected axial force F from each bolt 6, reliable seal handling can be realized.

10 (3) A suitable axial force can be obtained as the target axial force without generating an axial force insufficiency or an excessive axial force.

(4) Tightening location passes enable tightening to be performed, not only in bolt number order, but also in various
15 modes obtained by skipping bolt numbers, and suitable seal handling can be carried out rapidly regardless of which tightening passes are used.

[0050] (Third embodiment)

Fig. 6 illustrates a seal handling management device
20 according to a third embodiment. In Fig. 6, the same reference signs are assigned to the same parts as Fig. 1A. The configuration illustrated in Fig. 6 is an example, and the present invention is not limited to such a configuration.

[0051] The seal handling management device 2-3 includes a
25 tightening tool 14, a control unit 16-3, and a tightening condition setting unit 34. The tightening tool 14 has the same configuration as the seal handling management device 2-1, and therefore a description thereof is omitted.

[0052] The tightening condition setting unit 34 sets the
30 pass count N of a tightening location P , or the tightening location P , which is an example of a tightening condition. The control unit 16-3 calculates or selects the torque value τ from the pass count N of the tightening location P , or the tightening location P , which is set by the tightening

condition setting unit 34, and controls the output torque T of the tightening tool 14. Thus, the functions of the control unit 16-1 according to the first embodiment may also be realized by the control unit 16-3 and the tightening condition setting unit 34.

[0053] As per the third embodiment, effects similar to those of the foregoing embodiments are also obtained in the case of a configuration in which the pass count N of a tightening location P, or the tightening location P, is set by using the tightening condition setting unit 34.

Examples

[0054] Fig. 7 illustrates a seal handling management system according to an example. The configuration illustrated in Fig. 7 is an example, and the present invention is not limited to such a configuration.

The seal handling management system 2-4 includes a tightening tool 14, a controller 16-4, and a server computer (hereinafter simply called a "server") 16-5. The tightening tool 14 is the same as in the foregoing configuration, and therefore a description thereof is omitted.

[0055] The controller 16-4 is connected by a wired or wireless connection to the tightening tool 14 and, in this example, is connected using a cable 36. The controller 16-4 is independent or connected to the server 16-5, and is configured from a computer, for example. Instead of the connection using the cable 36, a WiFi connection or the like may be adopted as an example of a wireless connection. A plurality of input operating units 40 or display units 42 may be provided in a front panel unit 38 of the controller 16-4.

[0056] The controller 16-4 implements, by means of computer processing, processing and functions such as:

a. The calculation or selection of the torque value τ that is exerted on the bolts 6 or nuts 8 according to the pass

count N of a tightening location, or the tightening location P.

b. The setting of the torque value τ for the tightening tool 14.

c. The gradual or continuous modification to the output
5 torque T of the tightening tool 14 according to the pass count N or the tightening location P.

d. The acquisition of tightening management information from the server 16-5.

e. The acquisition of flange information of the flanges 10-1,
10 10-2.

f. The acquisition of gasket information of the gasket 12.

g. The collation of gasket information.

h. The selection of a tightening condition from tightening
condition information and the inputting thereof to the
15 tightening tool 14.

i. The presentation of tightening result information.

j. The presentation of tightening result evaluation
information.

[0057] The controller 16-4 is connected to the server 16-5
20 by means of a wired or wireless connection as a communication medium 44 which is indicated by a broken line. The server 16-5 is a computer which supports the information processing of the controller 16-4 or which manages the information processing thereof, and a personal computer may be used, for example. The
25 server 16-5 includes, by way of an example, a processing unit 46, an input operating unit 48, and a monitor 50.

[0058] <Tightening tool 14>

Fig. 8A illustrates an example of hardware of the
tightening tool 14. The tightening tool 14 includes a control
30 unit 52, a motor 54, and a torque sensor 56, similarly to a general electrical tool.

[0059] The control unit 52 includes a computer and a motor drive unit, and control information such as the torque value τ is provided by the controller 16-4. The motor 54 is driven

according to tightening information such as the torque value τ , and a drive current is supplied to the motor 54 when the trigger switch 24 is conducting.

[0060] The rotation of the motor 54 is transmitted to the socket 22 that is attached to the rotating shaft 58, and the output torque T is applied to the nut 8 which is made to fit the socket 22. The rotating shaft 58 may include a gear mechanism to enable the rotational force of the motor 54 to be transmitted to the socket 22 at a desired gear ratio.

[0061] The torque sensor 56 detects the output torque T from the motor 54 or the rotating shaft 58, and the detected torque is fed to the control unit 52. The torque sensor 56 may detect the tightening torque of the bolts 6 and nuts 8 and may be provided outside the tightening tool 14.

[0062] Fig. 8B illustrates an example of the bolt 6 which includes the axial force sensor 26. Each bolt 6 includes an axial force sensor 26 which, if the axial force F that is applied to each bolt 6 is detected, is capable of measuring the value of the output torque T of the tightening tool 14 and an increase or decrease in the output torque T . The axial force sensor 26 may use a strain sensor, for example.

[0063] <Controller 16-4>

Fig. 9A illustrates an example of the controller 16-4. The controller 16-4 is control means of the tightening tool 14 and is an example of a seal handling management device for seal tightening.

[0064] The controller 16-4 is configured from a computer, for example, and includes a processor 60, a storage unit 62, an input/output unit (I/O) 64, an input operating unit 40, a communication unit 68, and a display unit 42.

[0065] The processor 60 is an example of processing means and performs information processing of an OS and a seal handling management program, and the like, in the storage unit 62. The information processing includes control to acquire

tightening condition information from the server 16-5, input tightening conditions including the torque value τ of the tightening tool 14, acquire the output torque T from the tightening tool 14, monitor and evaluate a tightening state, display an evaluation result, and output tightening result information, and so forth.

[0066] The storage unit 62 is used to store an OS, a seal handling management program, tightening condition information, and detection information, and the like, and includes a ROM and a RAM. The storage unit 62 may also use a storage element which is capable of holding storage content.

[0067] The I/O 64 is controlled by the processor 60 and is used to input/output control information. A bar code reader 72 and a detachable external memory 74, for example, are connected as external devices to the I/O 64. The bar code reader 72 is an example of an information acquisition unit. The external memory 74 is a memory for fetching log information and may use a USB (Universal Serial Bus) memory, for example.

[0068] The input operating unit 40 includes a key switch and a touch sensor, or the like, and is used to trigger an input of input information, to trigger an output information fetch, and to switch modes, or the like.

[0069] The communication unit 68 is controlled by the processor 60 and is used for a wireless connection or an internet connection to an external device such as the server 16-5.

[0070] The display unit 42 is controlled by the processor 60 and is an example of presentation means which presents input information and output information. The display unit 42 includes, as display means for state information, a green lamp 76-1, a red lamp 76-2, or the like, for example. During normal times, the green lamp 76-1 is made to light up, and during abnormal times, the red lamp 76-2 is made to light up.

[0071] Fig. 9B illustrates an example of storage content of the storage unit 62. The storage unit 62 includes a temporary storage area 78-1 and a storage area 78-2. The temporary storage area 78-1 temporarily stores flange information 80, gasket information 82, worker information 84, and tightening result information 86 that has been acquired from the tightening tool 14, and the like.

[0072] Databases such as a tightening condition table 88 and torque value tables 90-1, 90-2 are constructed in the storage area 78-2. The tightening condition table 88 records tightening condition information that is associated with the flanges 10-1, 10-2. The torque value tables 90-1, 90-2 store torque value information such as pass counts N and torque values τ of different pass modes, and the like.

[0073] <Server 16-5>

Fig. 10 illustrates an example of the server 16-5. The server 16-5 is a support device for the controller 16-4 and is an example of presentation means which presents log information.

[0074] The server 16-5 includes a processor 92, a storage unit 94, an input/output unit (I/O) 96, and a communication unit 98 which are provided in a processing unit 46, and includes the foregoing input operating unit 48 and monitor 50.

[0075] The processor 92 performs information processing of an OS or seal handling management program in the storage unit 94, and the like. The information processing includes processing to provide the controller 16-4 with tightening condition information, acquire information representing a tightening result from the controller 16-4, and present the tightening result information, and so forth.

[0076] The storage unit 94 is used to store an OS, a seal handling management program, tightening condition information, and log information, and the like, and includes a ROM and a RAM. The storage unit 94 may also use a storage device such as

a hard disk or a semiconductor memory which is capable of holding storage content.

[0077] The I/O 96 is controlled by the processor 92 and is used to input/output control information. The communication unit 98 is used to wirelessly connect to the controller 16-4 and the like, for example. The external memory 100, for example, is connected as an external device to the I/O 96.

The communication unit 98 is controlled by the processor 92 and is used for a wireless connection or an internet connection to external devices such as the tightening tool 14 and the controller 16-4.

The input operating unit 48 is used to input input information, to trigger an output information fetch, and to switch modes, or the like.

The monitor 50 is an example of an information presentation unit or a display unit and is used to display the tightening condition table 88 and the torque value tables 90-1, 90-2, for example. The screen display unit of the monitor 50 includes a touch panel 102 and may execute input information which corresponds to display information in place of the input operating unit 48.

[0078] <Tightening condition table 88>

Fig. 11 illustrates an example of the tightening condition table 88. The tightening condition table 88 stores tightening condition information and is provided for the controller 16-4 by the server 16-5. The tightening condition table 88 includes, as an example of tightening condition information, applicable location information, flange information 80, gasket information 82, and tightening result information 86, and the like. The applicable location information is information on the production line and so forth. The flange information 80 is individual information that is used to identify the flanges 10-1, 10-2. The gasket information 82 is individual information that is used to

identify the gasket 12. The tightening conditions include, as torque value information, link information for torque value tables 90-1, 90-2 in which the torque values τ and pass counts N , and the like, are stored.

5 [0079] The tightening condition table 88 includes, as illustrated in Fig. 11, a line information section 104, a flange information section 106, a gasket information section 108, a bolt information section 110, and a tightening condition information section 112, and the like.

10 [0080] The line information section 104 stores, for example, information identifying tightening locations such as pipelines, namely, Line A, Line B, and so forth. The flange information section 106 stores flange numbers and flange dimensions, and the like, which discriminate the flanges 10-1,
15 10-2. The gasket information section 108 stores gasket numbers and gasket dimensions, and the like, which discriminate the gaskets 12. The bolt information section 110 stores numbers of bolts, and the like. The tightening condition information section 112 stores tightening condition numbers, and the like,
20 for discriminating the tightening conditions.

[0081] The tightening condition table 88 is provided by the server 16-5 as tightening condition information, and, together with the server 16-5, the controller 16-4 is capable of grasping required tightening-related tightening condition
25 information and of utilizing this tightening condition information independently.

[0082] <Torque value tables 90-1, 90-2>

The torque value table 90-1 illustrated in Fig. 12 corresponds to the pass mode illustrated in the foregoing Fig.
30 2A. The torque value table 90-1 stores the pass counts N ($=0, 2, \dots n$) of the tightening locations P and the torque values τ ($=\tau_{01}, \tau_{02}, \dots \tau_{nn}$) of the tightening locations P ($=P_1, P_2, \dots P_n$). These torque values τ are calculated and stored according to the pass count N ($=0, 2, \dots n$) corresponding to

the flanges 10-1, 10-2 and gasket 12 which are the tightening target. These values may be calculated at the time of seal handling or precalculated values may be stored and selected.

[0083] The torque value table 90-2 illustrated in Fig. 13

5 corresponds to seal handling in a case where the pass mode illustrated in the foregoing Fig. 2B is preset. When the pass count N of the tightening location P is less than 1 ($N < 1$), the torque value table 90-2 stores the torque values τ ($=\tau_{01}, \tau_{02}, \dots, \tau_{nn}$) of the tightening locations P ($=P_1, P_2, \dots, P_n$)
 10 which are specified by an angle θ of the tightening locations P . As the torque value after one tightening pass ($N=1$), the same torque value τ as the torque value table 90-1 illustrated in Fig. 12 is calculated according to the pass count N ($=2, \dots, n$) and stored. As in the case of the torque value
 15 table 90-1, these values may each be calculated at the time of seal handling or precalculated values may be stored and selected.

[0084] <Processing sequence of seal handling management>

Fig. 14 illustrates a seal handling management processing
 20 sequence of a seal handling management system 2-42.

At the time of seal handling, an initial setting of the tightening tool 14 is performed (S301) and an initial setting of the controller 16-4 is performed (S302). After the initial configuration, the controller 16-4 and the server 16-5 are
 25 linked and the tightening condition information provided by the server 16-5 is fed to the controller 16-4 (S303). The feeding of the tightening condition information is realized by acquiring the tightening condition table 88 and the torque value tables 90-1, 90-2.

30 [0085] The controller 16-4, which has acquired the tightening condition information, selects tightening conditions which correspond to the preselected flanges 10-1, 10-2 and the gasket 12 (S304). The selection of the tightening conditions may also include processing to select a torque

value τ if the torque value τ has been precalculated. Thus, by way of tightening preparatory processing, the controller 16-4 links to each of the axial force sensors 26-1, 26-2, ... 26-n, the axial force sensors 26-1, 26-2, ... 26-n each detect the axial force on each bolt 6 (S305), and the controller 16-4 performs feeding of each detected axial force (S306).

[0086] The controller 16-4 uses each detected axial force to perform a determination of the pass count N of the tightening location P, or the tightening location P (S307).

That is, as mentioned hereinabove, because there are eight of the tightening locations P, for example, any of the tightening locations P1 to P8 can be specified from the number of each of the eight bolts 6 and from variations in the axial forces thereof, and, by taking the tightening instances of the plurality of bolts 6 selected from the tightening locations P1 to P8 as the units of the pass count N and counting a number of passes as one, the pass count N can be specified as N=0 to n.

[0087] The controller 16-4 calculates the torque value τ that is exerted on the bolts 6 or nuts 8 according to the pass count N of the tightening location P, or the tightening location P (S308). In this calculation, the controller 16-4 refers to a selected tightening condition of the gasket 12, or the like, and calculates torque values τ_{01} , τ_{02} , ... for a pass count N=0, torque values τ_{11} , τ_{12} , ... for a pass count N=1, and torque values τ_{21} , τ_{22} , ... for a pass count N=2. In this case, the torque value τ corresponding to the pass count N may also be selected from precalculated torque values τ_0 , τ_{01} , τ_{02} , ... τ_{nn} .

[0088] The torque value τ is provided and set for the tightening tool 14 by the controller 16-4 (S309). The tightening tool 14 generates an output torque T according to the torque value τ . As a result, the output torque T is gradually or continuously modified or maintained according to

the pass count N of the tightening location P, or the tightening location P (S310).

[0089] Furthermore, by means of the tightening tool 14, the technician exerts an output torque T on the bolts 6 or
 5 nuts 8 of the tightening locations and performs tightening (S311). The axial force sensors 26-1, 26-2, ... 26-n each perform detection of the axial forces on the bolts 6 in each of the tightening locations P (S312), and the detected axial forces F are each fed to the controller 16-4 (S313).

10 [0090] The controller 16-4 determines whether or not each detected axial force F has attained a target axial force Fe (S314). If each detected axial force F has not attained the target axial force Fe (NO in S314), the controller 16-4 returns to S307 and repeats the processing of S307 to S313.

15 [0091] If each detected axial force F has attained the target axial force Fe (YES in S314), the tightening is then complete (S315), and the controller 16-4 makes an input to the tightening tool 14 and ends the tightening. The completion of tightening may also be presented by using a display device
 20 such as the monitor 50, for example.

[0092] In this example, after the tightening ends, feeding of the tightening result information from the tightening tool 14 to the controller 16-4 is performed (S316), and the tightening result information is provided from the controller
 25 16-4 to the server 16-5. The server 16-5, which has received the tightening result information, displays the tightening result information (S317). The display may include technician information and tightening evaluation information.

[0093] The procedure may include the following processing.
 30 a) The flanges 10-1, 10-2 may be provided with a flange tag obtained by using a bar code to define the flange information, the flange information may be acquired from the flange tag by using a bar code reader 72, gasket information may be acquired from a gasket tag obtained by using a bar code to define the

gasket 12, and the flange information and gasket information may be referred to in tightening condition information.

b) A determination of whether or not the acquired flange information and gasket information coincide with tightening information may be performed and conformance or non-conformance may be displayed.

c) Technician identification information and skill information may be acquired from the ID card owned by the technician, and the technician information may be reflected in the tightening result information.

[0094] <Seal handling using tightening management>

Fig. 15 illustrates transitions of a detected axial force by means of the foregoing tightening management. In Figs. 15A, 15B, and 15C, a coordinate axis y extends radially from a center O so as to correspond to the tightening locations P ($=P1$ to $P8$), and axial forces are plotted, on the coordinate axis, in a direction moving away from the center O . F is a detected axial force, and F_e is a target axial force. This example illustrates a case where the target axial force F_e is attained when the pass count $N=3$.

[0095] In a case where the pass count N of the tightening location $P = 1$ and the axial force F has been set as 30(%) of the target axial force F_e ($F=0.3F_e$), each detected axial force F of the tightening locations P ($=P1$ to $P8$) illustrated as an example is obtained, as illustrated in Fig. 15A. Even when the same axial force is set, a variation in the detected axial force F can be seen due to the effect of elastic interaction between the flanges 10-1, 10-2, and a slight distortion is generated by the polygon formed by each of the detected axial forces F .

[0096] In a case where the pass count N of the tightening location $P = 2$ and the axial force F has been set as 70(%) of the target axial force F_e ($F=0.7F_e$), each detected axial force F of the tightening locations P ($=P1$ to $P8$) is obtained, as

illustrated in Fig. 15B.

[0097] In a case where the pass count N of the tightening location $P = 3$ and the axial force F has been set as 100(%) of the target axial force F_e ($F = F_e$), each detected axial force F of the tightening locations P ($=P_1$ to P_8) is obtained and the target axial force F_e can be attained, as illustrated in Fig. 15C.

[0098] <Effects of Examples>

(1) Because a compatible tightening condition is automatically selected from the tightening condition information, there is no need to impose management of the tightening conditions on the worker, and the burden on the worker can be reduced by the tightening condition setting. The setting of tightening conditions based on the experience and intuition of a worker can be avoided and automated, and the troublesome work resulting from written instructions, as well as inputting mistakes and tightening errors due to written instructions, can be prevented.

(2) Because the tightening conditions can be individually and specifically provided for the controller 16-4 by the server 16-5, it is possible to avoid a general work where, for example, all the bolts are tightened using the same torque, and to realize a finely tuned tightening result. Highly accurate torque management that is provided by means of tightening condition information can be carried out, and tightening using a different torque τ for each bolt which is the tightening target can be reliably and efficiently performed. Highly accurate seal handling management which far exceeds the individual and intuition-based management of a worker can be realized.

(3) Automated, highly accurate, simple, and highly efficient seal handling can be realized by means of information processing that employs a computer by using a tightening management-capable tightening tool, and highly reliable seal

handling that does not depend on a worker's experience and intuition is possible.

[0099] (Other embodiments)

5 (1) In the foregoing embodiments, a configuration is possible in which the torque value τ is increased or reduced by using detected axial forces of each of the axial force sensors 26-1, 26-2, ... 26-n which detect the axial forces on the bolts 6 on which the output torque T from the tightening tool 14 is exerted. That is, the seal handling management method may be a
10 handling management method which includes detecting the axial forces on the bolts 6 on which the output torque T from the tightening tool 14 is exerted, and increasing or reducing the torque value τ or the output torque T according to each detected axial force.

15 (2) Although the controller 16-4 and server 16-5 are described as standalone devices in the foregoing embodiments and examples, the controller 16-4 may also be provided with the functions of the server 16-5. In other words, the controller 16-4 and server 16-5 may be integrated.

20 (3) The controller 16-4 may also employ a portable information terminal such as a smartphone.

(4) Although, in the foregoing embodiments and examples, an example is illustrated in which the controller 16-4 and the server 16-5 have been set in one tightening tool 14, the
25 controller 16-4 and server 16-5 may also be set in a plurality of tightening tools 14, or a single server 16-5 may be provided in a plurality of controllers 16-4.

[0100] As explained hereinabove, the most preferred embodiments and examples of the present invention have been
30 explained. The present invention is not limited to or by the foregoing descriptions. Various changes and modifications can be made by a person skilled in the art based on the spirit of the inventions which are described within the scope of the claims and which are disclosed in the modes for carrying out

the invention or in the examples. It goes without saying that such changes and modifications lie within the scope of the present invention.

5 Industrial Applicability

[0101] The seal handling management method, seal handling management device, seal handling management program, and seal handling management system of the present invention make it possible to realize automated, highly accurate, simple, and highly efficient seal handling by means of information processing which employs a computer by using a tightening management-capable tightening tool, and highly reliable seal handling that does not depend on a worker's experience and intuition is possible, which is advantageous.

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Reference Signs List

[0102]

- 2-1 Seal handling management device
- 2-2 Seal handling management system
- 20 2-3 Seal handling management device
- 2-4 Seal handling management system
- 4 Seal handling unit
- 6 Bolt
- 8 Nut
- 25 10-1, 10-2 Flange
- 12 Gasket
- 14 Tightening tool
- 16-1, 16-2, 16-3 Control unit
- 16-4 Controller
- 30 16-5 Server
- 18 Grip
- 20 Device main body
- 22 Socket
- 24 Trigger switch

	26-1, 26-2, ... 26-n	Axial force sensor
	28	First function
	30	Second function
	32	Third function
5	34	Tightening condition setting unit
	36	Cable
	38	Front panel unit
	40	Input operating unit
	42	Display unit
10	44	Communication medium
	46	Processing unit
	48	Input operating unit
	50	Monitor
	52	Control unit
15	54	Motor
	56	Torque sensor
	58	Rotating shaft
	60	Processor
	62	Storage unit
20	64	Input/output unit
	68	Communication unit
	72	Bar code reader
	74	External memory
	76-1	Green lamp
25	76-2	Red lamp
	78-1	Temporary storage area
	78-2	Storage area
	80	Flange information
	82	Gasket information
30	84	Worker information
	86	Tightening result information
	88	Tightening condition table
	90-1, 90-2	Torque value table
	92	Processor

	94	Storage unit
	96	Input/output unit (I/O)
	98	Communication unit
	100	External memory
5	102	Touch panel
	104	Line information section
	106	Flange information section
	108	Gasket information section
	110	Bolt information section
10	112	Tightening condition information section

CLAIMS

1. A seal handling management method in which a plurality of tightening locations are set for flanges holding a gasket therebetween and tightening is performed by providing a bolt and a nut in each of the tightening locations, the seal handling management method comprising:

calculating or selecting a torque value that is exerted on the bolt or the nut according to a pass count of the tightening location, or the tightening location;

setting the torque value for the tightening tool; and gradually or continuously modifying an output torque of the tightening tool according to the pass count or the tightening location.

2. The seal handling management method according to claim 1, further comprising:

detecting the pass count, or the tightening location, of the tightening tool.

3. The seal handling management method according to claim 1, further comprising:

setting, for the tightening tool, the pass count of the tightening location, or the tightening location.

4. The seal handling management method according to claim 2, comprising:

detecting the axial force on the bolt; and

detecting the pass count, or the tightening location, of the tightening tool, by using information on variations in the detected axial force, and information identifying the bolt.

5. A seal handling management device in which a plurality of tightening locations are set for flanges holding a gasket therebetween and tightening is performed by providing a bolt and a nut in each of the tightening locations, the seal handling management device comprising:

control means which calculates or selects a torque value that is exerted on the bolt or the nut according to a pass

count of the tightening location, or the tightening location, which sets the torque value for a tightening tool, and which gradually or continuously modifies an output torque of the tightening tool according to the pass count or the tightening location.

6. The seal handling management device according to claim 5, comprising:

detection means which detects the pass count of the tightening location, or the tightening location, of the tightening tool.

7. The seal handling management device according to claim 5, comprising:

setting means which sets the pass count of the tightening location, or the tightening location, for the tightening tool.

8. The seal handling management device according to any of claims 5 to 7, wherein the control means is disposed in the tightening tool or disposed separately from the tightening tool and connected by a wired or wireless connection.

9. The seal handling management device according to claim 6, wherein the detection means comprises an axial force sensor which detects an axial force on the bolt, and

wherein the detection means detects the pass count, or the tightening location, of the tightening tool, by using information on a variation in the axial force detected by the axial force sensor, and information identifying the bolt.

10. A seal handling management program for causing a computer to execute and realize:

a function which calculates or selects a torque value that is exerted on a bolt or nut according to a pass count of a plurality of tightening locations that have been set for flanges holding a gasket therebetween, or to the tightening location;

a function which sets the torque value for a tightening tool; and

a function which gradually or continuously modifies an output torque of the tightening tool according to the pass count or the tightening location.

11. A seal handling management system in which a plurality of tightening locations are set for flanges holding a gasket therebetween and tightening is performed by providing a bolt and a nut in each of the tightening locations, the seal handling management system comprising:

a tightening tool capable of gradually or continuously controlling an output torque that is applied to the bolt or the nut; and

a controller which is connected by a wired or wireless connection to the tightening tool, calculates or selects a torque value that is exerted on the bolt or the nut according to a pass count of the tightening location, or the tightening location, sets the torque value for the tightening tool, and gradually or continuously modifies the output torque of the tightening tool according to the pass count or the tightening location.