

DESCRIPTION

TITLE OF INVENTION: TRAINING DEVICE AND TRAINING METHOD FOR SEALING
WORK

TECHNICAL FIELD

5 [0001]

The present invention relates to a training device and a training method for use in e.g. training of sealing work of a heat exchanger etc.

BACKGROUND ART

10 [0002]

A heat exchanger is used for heat recovery and heat utilization of several hundred degrees of waste-heat fluid. Used as the heat exchanger is a shell & tube type heat exchanger, such as a floating head type heat exchanger, a fixing tube plate type heat exchanger, and a U-tube type heat exchanger. This type of heat exchanger has a plurality of body units each including flange and is assembled by interposing a plurality of gaskets between the flanges, with bolts and nuts being used for fastening of the opposed flanges.

[0003]

20 In relation to fastening of such bolts and nuts, a bolt fastening training device has been known that trains to learn the relationship between a fastening torque applied to the bolts and nuts and a fastening force applied to the gaskets (e.g. Patent Document 1).

25 CITATION LIST

PATENT LITERATURE

[0004]

Patent Literature 1: JP2015-215473A

SUMMARY OF INVENTION

30 TECHNICAL PROBLEM

[0005]

For the installation of such a heat exchanger, it is required to be familiar with the mechanism of the heat exchanger, the structure thereof, the flange structure, the seal structure, the

fastening structure using a plurality of bolts and nuts, the fastening procedure, etc. It is insufficient only to take a general classroom lecture and it is not enough for the sealing work of the heat exchanger merely to receive bolt fastening training using a bolt fastening training device (Patent Document 1), rendering the mastery by the real machine inevitable.

[0006]

Although the real-machine-based work training is effective for the mastery of high-level sealing work, the sealing work training assuming any accident by the real machine placed in the plant is not preferable. It is neither suitable nor practical for the site to stop the operation of the plant for training. Hence, if the mechanism of the large-sized heat exchanger cannot be learned by use of the real machine and if the repetitive training of the assembling and disassembling is unfeasible, the opportunity to master the advanced sealing work may be lost.

[0007]

Even though the real-machine-based work training is effective for the mastery of the advanced sealing work, etc., it cannot be said that the site having the heat exchanger installed in the site is suitable for the training. In the training, there are a plurality of training elements such as assembling and disassembling of the real machine and gasket arrangement, so that it is necessary to visually check them from various angles and to touch them actually. In a narrow and small space, etc., however, the trainee's range of movement and touch is limited, resulting in insufficient training with the need to secure the trainee's safety.

[0008]

Thus, in view of the above problem, an object of the present invention is to provide equipment and a method capable of learning, similarly to the real machine and safely, the mechanism and structure of the heat exchanger, the flange structure, seal structure, fastening structure using a plurality of bolts and nuts, fastening procedure, etc.

SOLUTION TO PROBLEM

[0009]

In order to attain the above object, according to an aspect of a sealing work training device of the present invention, it includes a shell unit; a tube plate unit having a plurality of tubes that are insertable into and removable from the shell unit; a channel unit having a channel flange corresponding to a shell flange of the shell unit, the channel unit having a partition plate that is engaged with a groove of the tube plate unit; bolts and nuts that fix the shell flange and the channel flange together; and a transport support mechanism that supports the tube plate unit movably in a front-back direction, an up-down direction, or a direction intersecting the front-back direction, the transport support mechanism supporting the channel unit movably in the front-back direction, the up-down direction, or the direction intersecting the front-back direction. The sealing work training device enables to fasten and unfasten of the bolts and the nuts on the shell flange and the channel flange; to align position of the tube plate unit and the channel flange with the shell flange or position of the tube plate unit and the partition plate with each other through operation of the transport support mechanism; and to attach and detach gaskets between the tube plate unit and the shell flange and between the tube plate unit and the channel flange.

To attain the above object, according to an aspect of a sealing work training device of the present invention, it includes a shell unit; a tube plate unit having a plurality of tubes that are insertable into and removable from the shell unit; a channel unit having a channel flange corresponding to a shell flange of the shell unit, the channel unit having a partition plate that is engaged with a groove of the tube plate unit; bolts and nuts that fix the shell flange and the channel flange together; and a first transport support mechanism that supports the tube plate unit movably in a front-back direction, an up-down direction, or a direction intersecting the front-back direction, or a second transport

support mechanism that supports the channel unit movably in the front-back direction, the up-down direction, or the direction intersecting the front-back direction. The sealing work training device enables to fasten and unfasten of the bolts and the nuts on the shell flange and the channel flange; to align position of the tube plate unit and the channel flange with the shell flange or position of the tube plate unit and the partition plate with each other through operation of either the first transport support mechanism or the second transport support mechanism; and to attach and detach gaskets between the tube plate unit and the shell flange and between the tube plate unit and the channel flange.

To attain the above object, according to an aspect of a sealing work training device of the present invention, it includes a shell unit; a tube plate unit having a plurality of tubes that are insertable into and removable from the shell unit; a channel unit having a channel flange corresponding to a shell flange of the shell unit, the channel unit having a partition plate that is engaged with a groove of the tube plate unit; bolts and nuts that fix the shell flange and the channel flange together; a first transport support mechanism that allows a frame to support the tube plate unit movably in a front-back direction, an up-down direction, or a direction intersecting the front-back direction; and a second transport support mechanism that allows the frame to support the channel unit movably in the front-back direction, the up-down direction, or the direction intersecting the front-back direction, independently of the first transport support mechanism. The sealing work training device enables to fasten and unfasten of the bolts and the nuts on the shell flange and the channel flange; to align position of the tube plate unit and the channel flange with the shell flange or position of the tube plate unit and the partition plate with each other through operation of either one or both of the first transport support mechanism and the second transport support mechanism; and to attach and detach gaskets between the tube plate unit and the shell flange and between the tube plate

unit and the channel flange.

[0010]

The sealing work training device may include sensors that detect axial forces of the bolts that fix the channel flange to the shell flange; a processing means that calculates an axial force distribution of the bolts from outputs of the sensors; and a display means that displays a position of the bolt and a distribution graph of the axial force.

[0011]

The sealing work training device may include an imaging means that images at least a fastening situation of the bolts; an editing means that edits images obtained by the imaging means, for each of objects to be imaged or in a time series; a display means that displays an image group obtained by the editing means; and a recording means that records either one or both of the images obtained by the imaging means and edit images edited by the editing means.

[0012]

In order to achieve the above object, according to an aspect of a sealing work training method of the present invention, it includes the steps of inserting and removing a tube disposed on a tube plate unit into and from a shell unit; disposing a gasket between the tube plate unit and a shell flange or removing the gasket lying between the tube plate unit and the shell flange; engaging or disengaging a partition plate disposed in the channel unit with or from a groove of the tube plate unit; moving the tube plate unit in a front-back direction, an up-down direction, or a direction intersecting the front-back direction; moving the channel unit in the front-back direction, the up-down direction, or the direction intersecting the front-back direction; positioning the channel flange to the shell flange with interposing the tube plate unit between the channel flange and the shell flange or releasing the positioning; and fixing the shell flange and the channel flange together by bolts and nuts or releasing the fixing.

To achieve the above object, according to an aspect of a sealing work training method of the present invention, it includes the steps of inserting and removing a tube disposed on a tube plate unit into and from a shell unit; disposing a gasket between the tube plate unit and a shell flange or removing the gasket lying
5 between the tube plate unit and the shell flange; engaging or disengaging a partition plate disposed in the channel unit with or from a groove of the tube plate unit; allowing a frame to support the tube plate unit via a first transport support mechanism, to
10 move the tube plate unit in a front-back direction, an up-down direction, or a direction intersecting the front-back direction by the first transport support mechanism; allowing the frame to support the channel unit via a second transport support mechanism, to move the channel unit in the front-back direction, the up-down
15 direction, or the direction intersecting the front-back direction by the second transport support mechanism; positioning the channel flange to the shell flange with interposing the tube plate unit between the channel flange and the shell flange or releasing the positioning; and fixing the shell flange and the channel flange
20 together by bolts and nuts or releasing the fixing.

[0013]

The sealing work training method may further include the step of imparting to the shell flange or the channel flange a marking that suggests coincidence in axis of the shell flange and the channel
25 flange or suggests engagement of the partition plate with the groove of the tube plate unit, at the time of detachment of the shell flange and the channel flange.

[0014]

The sealing work training method may further include the steps
30 of feeding a pressurized gas from a first port into a space part on one hand of the channel part partitioned by the partition plate and keeping the pressurized gas flowing through the tube into a space part on another of the channel unit; and observing a leakage of the pressurized gas between the channel unit and the tube plate

unit or between the shell unit and the tube plate unit.

[0015]

The sealing work training method may further include the steps of detecting axial forces of the bolts that fix the shell flange and the channel flange together; calculating an axial force distribution of the bolts from sensor outputs; and displaying a distribution graph of the axial force, in addition to positions of the bolts.

[0016]

The sealing work training method may further include the steps of imaging at least a fastening situation of the bolt; editing images obtained by an imaging means, for each of objects to be imaged or in a time series; displaying an image group obtained by an editing means; and recording either one or both of the images obtained by the imaging means and edit images edited by the editing means.

ADVANTAGEOUS EFFECTS OF INVENTION

[0017]

According to the present invention, the following effects can be obtained.

[0018]

(1) Since the training device has a similar mechanism to the real machine, there can be trained assembling, disassembling, sealing work, alignment, fastening of bolts and nuts, and fastening procedure thereof, equivalent to the real machine, ensuring sealing work training equivalent to the real machine site or exceeding the real machine site, to achieve the training effect.

[0019]

(2) It is possible to simulate an unavoidable situation assumed that cannot be implemented by the real machine; to practice assembling, alignment, and fastening of the bolts and nuts assuming an unpredictable situation; and to perform hands-on training just like the real machine, such as in the case where the gaskets are broken.

[0020]

(3) Training can be performed of alignment, fastening procedure of bolts and nuts, and adjustment of the axial force assuming uneven fastening status of the gaskets.

[0021]

5 (4) The trainee can master the fastening of the bolts and nuts, change and bias of the axial force arising from the flange resilient interaction, disadvantages thereof, and an avoidance technique thereof.

[0022]

10 (5) The disadvantages arising from misalignment specific to the heat exchanger can be confirmed and the avoidance technique thereof can be trained.

[0023]

 (6) Plural types of tools can be selected to check sealing work and sealing result on a tool-by-tool basis.

15

BRIEF DESCRIPTION OF DRAWINGS

[0024]

 Fig. 1 is a diagram showing a sealing work training device according to a first embodiment.

20 Fig. 2 is a diagram showing part of the sealing work training device, with its device body enlarged.

 Fig. 3 is an exploded perspective view of the device body.

 Fig. 4 shows a perspective view of a fixing tube plate without a tube from the back in A, a perspective view of a channel unit from the back in B, and a perspective view of a channel cover from the back in C.

25

 Fig. 5 is a diagram showing a longitudinal section of the device body.

 Fig. 6 is a flowchart showing a training process.

30 Fig. 7 shows a diagram for explaining the surface state of a gasket contact portion in A and a diagram of the surface state and the repair criteria in B.

 Fig. 8 shows diagrams of markings on a shell flange, the fixing tube plate, and a channel flange in A, B, and C, respectively.

Fig. 9 shows a diagram of the mounting of the gasket on the shell flange in A and a diagram of the mounting of the tube and the fixing tube plate on a shell unit in B.

Fig. 10 shows a diagram of the mounting of the gasket on the fixing tube plate in A and a diagram of the mounting of the channel unit on the shell unit and the fixing tube plate in B.

Fig 11 shows a partial sectional view of the normal state of the shell flange, the fixing tube plate, and the channel flange in A and diagrams of the misalignment state of the shell flange, the fixing tube plate, or the channel flange in B and C.

Fig. 12 shows a diagram of the alignment of the fixing tube plate with respect to the shell flange in A and a diagram of the alignment of the channel flange with respect to the shell flange in B.

Fig. 13 is a diagram showing a bolt fastening procedure.

Fig. 14 is a diagram showing a sealing work training device according to a second embodiment.

Fig. 15 is a diagram showing a bolt and an axial force sensor.

Fig. 16 is a diagram showing a configuration example of a monitoring part.

Fig. 17 is a flowchart showing processing of generating a distribution graph of the axial force.

Fig. 18 is a diagram showing a distribution graph of a detected axial force and a comparative axial force.

Fig. 19 is a diagram showing a distribution graph of the axial force.

Fig. 20 is a diagram for explaining a resilient interaction.

Fig. 21 is a diagram showing a distribution graph before and after the resilient interaction.

Fig. 22 is a diagram showing a fastening procedure for simultaneous fastening of two bolts.

Fig. 23 is a diagram for explaining fastening of a single bolt.

Fig. 24 is a diagram for explaining fastening of a plurality of bolts.

Fig. 25 is a diagram showing a distribution graph of the bolt fastening result.

Fig. 26 is a flowchart showing a processing procedure of monitoring.

5 Fig. 27 is a flowchart showing a processing procedure of pass number-of-times management.

Fig. 28 is a diagram showing a sealing work training device according to a third embodiment.

10 Fig. 29 is a diagram showing a bolt fastening procedure according to another embodiment.

Fig. 30 is a sectional view showing a gasket contact portion of the shell flange or the channel flange according to the another embodiment.

DESCRIPTION OF EMBODIMENTS

15 [0025]

[First Embodiment]

[0026]

20 Fig. 1 shows a sealing work training device according to a first embodiment. The configuration shown in Fig. 1 is an example and the present invention is not limited to such a configuration.
[0027]

This sealing work training device (hereinafter, referred to simply as "training device") 2-1 includes a frame 4, a device body 6, a first transport support mechanism 8-1, and a second transport
25 support mechanism 8-2.

[0028]

30 The frame 4 is a transport housing and is fixed to a floor surface of a training room used for the sealing work training. This frame 4 includes a pair of post members 10 on the front side and a pair of post members 12 on the rear side as a plurality of vertically extending posts; a support member 14 on each of the bearing surface side and the bottom surface side between the front post members 10; a support member 16 on the bearing surface side and the bottom surface side between the rear post members 12; and support members

18 and 20 on the bearing surface side and the bottom surface side between the post members 10 and 12. Due to such a framework structure, a rectangular-parallelepiped space part 22 is formed in the frame 4.

5 [0029]

The under surfaces of the support members 14 and 16 on the bearing surface side of this frame 4 are provided with plural sets of casters 24 and stoppers 26. Accordingly, the frame 4 is movable to a desired position by the casters 24 and is fixed at a
10 predetermined position in a stationary state by the stoppers 26.
[0030]

This frame 4 is provided on its ceiling side with a rail part 28 supported by the support members 18 and 20, the rail part 28 protruding from a side of the support member 18 of the frame 4.
15 This rail part 28 is provided with the first and the second transport support mechanisms 8-1 and 8-2 that support part or all of the device body 6. The transport support mechanism 8-1 includes a hanger part 30 and a lifting part 32. The hanger part 30 is a member supported on the rail part 28. The lifting part 32 is configured by e.g. a
20 chain block allowing rise and fall in the up-down direction (Y-axis direction). The transport support mechanism 8-2 includes a sliding part 34 and lifting parts 36-1 and 36-2. The sliding part 34 includes a plurality of rollers that slide on the rail part 28, the sliding part 34 being movable along the rail part 28 in the
25 front-back direction (X-axis direction). The lifting parts 36-1 and 36-2 are configured by a plurality of, e.g. chain blocks that allow rise and fall independently in the up-down direction (Y-axis direction). The chain blocks for example allowing rise and fall in the up-down direction (Y-axis direction) may be used. Therefore,
30 the transport support mechanisms 8-1 and 8-2 are supported independently and individually on the rail part 28 so as to be movable separately.

[0031]

The device body 6 has a simulated configuration of a shell

& tube type heat exchanger (hereinafter, referred to simply as "heat exchanger") for example. This device body 6 is removably fitted to a support member 40 placed on and between the post members 10 and 12.

5 [0032]

<Device Body 6>

[0033]

Fig. 2 shows the device body 6 in an enlarged manner. This device body 6 includes a shell unit 42, a fixing tube plate 44, and a channel unit 46, as constituent members similar to those of the heat exchanger.

[0034]

The shell unit 42 is equivalent to a shell of the heat exchanger but has a shorter shell length than that of the real machine. Due to the shorter shell length, it is easy for this shell unit 42 to maintain the boost state, leading to safety. This shell unit 42 is provided with a support leg 48 on its lower lateral side at an intermediate portion of the shell unit 42, and the support leg 48 is secured to the support member 40 by means of bolts 50 and nuts 52.

[0035]

The channel unit 46 is secured to the shell unit 42 with the fixing tube plate 44 interposed therebetween, by means of a plurality of bolts 54 and nuts 56, with a channel cover 58 being secured to the channel unit 46 by a plurality of bolts 60 and nuts 62. The fixing tube plate 44 has a hook receiver 64 which engages with a hook 66 so that the fixing tube plate 44 is hung from the lifting part 32 of the transport support mechanism 8-1. The channel unit 46 has a hook receiver 68 which is linked via hook attachments 72 and 73 with a hook 70 of the lifting part 36-1 so that the channel unit 46 is hung from the transport support mechanism 8-2. The channel cover 58 has a hook receiver 74 which is linked via a hook attachment 78 with a hook 76 of the lifting part 36-2 so that the channel cover 58 is hung from the transport support mechanism 8-2.

[0036]

Fig. 3 shows the device body 6 in an exploded manner. The shell unit 42 includes a tubular part 80 and a shell flange 82 as members similar to those of the shell of the heat exchanger. The tubular part 80 is formed to be of a shorter length, dissimilar to the shell of the real machine, the tubular part 80 having a shell cover 84 on the rear side.

[0037]

The shell flange 82 includes an annular gasket contact portion 88 on the opening side of the tubular part 80; a plurality of bolt insertion apertures 90 arranged at a predetermined angular interval along on the circumference of the gasket contact portion 88; and a hook receiver 92 on the outer periphery. An annular gasket 94-1 is disposed on the gasket contact portion 88.

[0038]

The fixing tube plate 44 is an example of a tube plate unit. This fixing tube plate 44 is a fixing member fixing a plurality of tubes 96 and is fixed in a grasped state between the shell flange 82 and the channel unit 46. The tube 96 is an example of a heat exchanging tube through which a fluid to be heated flows. An inlet tube group 96-1 and an outlet tube group 96-2 are disposed as an aggregate of a plurality of tubes 96 on the fixing tube plate 44. The inlet tube group 96-1 is arranged under a partition plate 98 of the channel unit 46, whereas the outlet tube group 96-2 is arranged over the partition plate 98. The tubes 96 are kept parallel to one another by the fixing tube plate 44 and a support plate 100. This support plate 100 is equivalent to a baffle of the real machine. In the real machine, the tubes 96 make up a continuous closed tube path from the inlet tube group 96-1 and the outlet tube group 96-2, whereas in this training device 2-1, the tubes 96 open at their terminal end side, communicating with the interior space of the shell unit 42.

[0039]

The fixing tube plate 44 has, on its front side, fitting

protrusions 102-1 and 102-2 fitting in the channel unit 46. The fitting protrusions 102-1 and 102-2 are shaped into a semicircle, the fixing tube plate 44 having on its center side a fitted groove 104 into which the partition plate 98 fits. The fixing tube plate 44 has on its rear side a fitting protrusion 102 fitting in the shell unit 42, as shown in A of Fig. 4. This fitting protrusion 102 is circular and has a plurality of tube apertures 106 through which the tubes 96 extend.

[0040]

A gasket contact portion 108 is formed along circumferences of these fitting protrusions 102, 102-1, and 102-2. The front gasket contact portion 108 of the fixing tube plate 44 has an annular portion and a bridge so as to form a shape encompassing the fitting protrusions 102-1 and 102-2. On the contrary, the rear gasket contact portion 108 (A of Fig. 4) of the fixing tube plate 44 is of an annular shape encompassing the fitting protrusion 102.

[0041]

The channel unit 46 includes a tubular part 112 having the same diameter as the shell unit 42, and channel flanges 114 and 116 sandwiching the tubular part 112 therebetween. The tubular part 112 includes an inlet port 118-1 (B of Fig. 4), an outlet port 118-2, and the hook receiver 68. The interior of the tubular part 112 is provided with the partition plate 98 bisecting the interior space.

[0042]

The channel flange 114 includes a hook receiver 120 and bolt insertion apertures 122 corresponding to the bolts 54, while the channel flange 116 includes a hook receiver 124 and bolt insertion apertures 126 corresponding to the bolts 60.

[0043]

Each of the channel flanges 114 and 116 includes a gasket contact portion 128. As shown in Fig. 3 and B of Fig. 4, end surfaces of the partition plate 98 coincide with the gasket contact portions 128, so that a common gasket contact surface is formed. A gasket

94-2 is disposed between the gasket contact portion 108 of the fixing tube plate 44 and the gasket contact portion 128 of the channel flange 114.

[0044]

5 The channel cover 58 is a closing member of the channel unit 46 and closes the opening thereof. This channel cover 58 includes the hook receiver 74 and a plurality of bolt insertion apertures 130 allowing the insertion of the bolts 60 therethrough. This channel cover 58 has, on its rear side, fitting protrusions 132-1 and 132-2 between which the partition plate 98 fits, and the fitting protrusions 132-1 and 132-2 fit in the tubular part 112 of the channel unit 46, as shown in C of Fig. 4. The fitting protrusions 132-1 and 132-2 are shaped into a semicircle and define a fitted groove 134 into which the partition plate 98 fits.

15 [0045]

Fig. 5 shows a longitudinal section of this device body 6. In this device body 6, the shell unit 42 has a space part 136 partitioned by the fixing tube plate 44 and the gaskets 94-1 and 94-2, with a space part 138 defined between the shell cover 84 and the support plate 100. The channel unit 46 has two spaces defined therein by the partition plate 98, i.e. an inlet space part 140 and an outlet space part 142. The inlet space part 140 communicates via the inlet tube group 96-1 with the space 138 while the outlet space part 142 communicate via the outlet tube group 96-2 with the space part 138, the inlet space part 140 and the outlet space part 142 being provided with the inlet port 118-1 and the outlet port 118-2, respectively. Hence, by feeding a pressurized fluid from the inlet port 118-1, the pressurized fluid can flow from the inlet space part 140 through the inlet tube group 96-1 into the space part 138 and further flow from this space part 138 through the outlet tube group 96-2 into the outlet space part 142, for final discharge from the outlet port 118-2. Conversely, by feeding a pressurized fluid from the outlet port 118-2, the pressurized fluid can be discharged from the inlet port 118-1.

[0046]

<Sealing Work Training Procedure>

[0047]

Fig. 6 shows a sealing work training procedure. This example
 5 uses the channel unit 46 of which the channel flange 116 is
 previously disposed on the channel cover 58.

[0048]

This training procedure includes a flange surface checking
 step (S11), a marking step (S12), a gasket 94-1 mounting step (S13),
 10 a fixing tube plate 44 mounting step (S14), a gasket 94-2 mounting
 step (S15), a channel flange 114 mounting step (S16), a bolt
 temporary fixing and aligning step (S17), a bolt fastening step
 (S18), and an evaluating step (S19).

[0049]

15 A) Flange Surface Checking Step (S11)

[0050]

At the flange surface checking step (S11), flange surfaces
 are checked of the gasket contact portion 88 of the shell flange
 82, the gasket contact portion 108 of the fixing tube plate 44,
 20 and the gasket contact portion 128 of the channel flange 114, so
 as to check corrosion (rust), flaws, and dints on the gasket
 disposition surfaces of these shell unit 42, the fixing tube plate
 44, and the channel flange 114, as well as cleaning status of the
 gasket after use (S11). As a result of this checking, if not
 25 suitable for the disposition of the gaskets 94-1 and 94-2, repair
 of the gasket disposition surface etc. is carried out.

[0051]

A of Fig. 7 shows as an example the surface state of the gasket
 contact portion 88 of the shell flange 82. In this example, the
 30 shell flange 82 has a plurality of corrosions/dints 144-1 and 144-2
 and a plurality of flaws 146-1, 146-2, 146-3, 146-4, and 146-5.
 The flaws 146-1 and 146-2 extend on the gasket contact portion 88
 in its width direction, whereas the flaws 146-3, 146-4, and 146-5
 extend on the gasket contact portion 88 in its length direction.

Due to the extension in the length direction on the gasket contact portion 88, the flaw 146-3 does not affect the sealing function of the gasket 94-1. Due to the presence outside the gasket contact portion 88, the flaws 146-4 and 146-5 do not affect the sealing function of the gasket 94-1, not causing any problem.

[0052]

Provided that W represents the width of the gasket contact portion 88 and rd represents the width of the corrosion/dint 144 and the flaw 146-1 within the width W in the same direction as the width W , the ratio (rd/W) of the width rd of the corrosion/dint 144 or the flaw 146-1 to the width W of a gasket abutment surface 148 of the gasket contact portion 88, and the depth v thereof become problematic.

[0053]

Although the surface state of the gasket contact portion 88 of the shell flange 82 is shown in this embodiment, the same applies to the gasket contact portions 108 and 128 of the fixing tube plate 44 and of the channel flanges 114 and 116 of the channel unit 46, respectively.

[0054]

B of Fig. 7 shows the allowances of the rd/W and the depth v and the necessity of repair, for each of gaskets. k_1 , k_2 , k_3 , and k_4 are criterion values of the depth v , with the magnitude thereof being $k_1 > k_2 > k_3 > k_4$. For example, according to this table, if $rd/W = 1/4$ or below, the soft gasket does not need the repair when $v = k_1$ or below and the semimetallic or metal gasket does not need the repair when $v = k_2$ or below. If $rd/W = 1/2$ to $3/4$, the soft gasket does not need the repair with $v = k_4$ or below but the semimetallic or metal gasket needs the repair.

[0055]

B) Marking Step (S12)

[0056]

In the marking step (S12), to position the members, marking is performed for the shell flange 82, the fixing tube plate 44,

and the channel flange 114 (S12).

[0057]

A and B of Fig. 8 show the shell flange 82, the fixing tube plate 44, and the channel flange 114 of the device body 6 before disassembling. Previous to the disassembling of the device body 6, a match mark 150 is imparted to the shell flange 82, the fixing tube plate 44, and the channel flange 114 so as to extend thereacross. This match mark 150 includes for example a rectilinear portion 150-1 parallel to the center axis of the fixing tube plate 44, and rectilinear portions 150-2 and 150-3 rising at a right angle along the shell flange 82 and the channel flange 114 at the same position as that of the rectilinear portion 150-1. In the same mode, this match mark 150 may be set to a plurality of points on the shell flange 82, the fixing tube plate 44, and the channel flange 114, e.g. four different formation positions at an angular interval of 90 degrees with respect to the center axis.

[0058]

By imparting such a match mark 150 to a plurality of points, even if the device body 6 is disassembled as shown in C of Fig. 8, the shell flange 82, the fixing tube plate 44, and the channel flange 114 can be arranged at the pre-disassembling positions.

[0059]

C) Gasket 94-1 Mounting Step (S13)

[0060]

At the gasket 94-1 mounting step (S13), the gasket 94-1 is mounted on the gasket contact portion 88 of the shell unit 42, as shown in A of Fig. 9, previous to the mounting of the fixing tube plate 44. When the gasket 94-1 is mounted, the corrosion/dints and flaws on the gasket contact portion 88 are checked and thereafter the gasket 94-1 is positioned and mounted. In the case of finding of the corrosion/dints or flaws on the gasket contact portion 88, it is checked whether repair is required or not and, if necessary, the repair is performed.

[0061]

D) Fixing Tube Plate 44 Mounting Step (S14)

[0062]

At the fixing tube plate 44 mounting step (S14), as shown in B of Fig. 9, the inlet tube group 96-1, the outlet tube group 96-2, and the support plate 100 are inserted into the shell unit 42 mounted with the gasket 94-1 so that the fixing tube plate 44 is mounted on the shell flange 82 with the gasket 94-1 sandwiched between the fixing tube plate 44 and the shell flange 82 (S14). While being hung from the transport support mechanism 8-1 and being held at a position coincident with the position of the shell unit 42, the fixing tube plate 44 is disposed on the shell flange 82 from above of the gasket 94-1 on the shell flange 82.

[0063]

E) Gasket 94-2 Mounting Step (S15)

[0064]

At the gasket 94-2 mounting step (S15), as shown in A of Fig. 10, the gasket 94-2 is mounted on the gasket contact portion 108 of the fixing tube plate 44 fitted to the shell unit 42 (S15). When the gasket 94-2 is mounted, the corrosion/dints 144 and flaws 146 on the gasket contact portion 108 of the fixing tube plate 44 are checked and thereafter the gasket 94-2 is positioned and mounted. In the case of finding of the corrosion/dints or flaws on the gasket contact portion 108, it is checked whether repair is required or not and, if necessary, the repair is performed.

[0065]

F) Channel Flange 114 Mounting Step (S16)

[0066]

At the channel flange 114 mounting step (S16), as shown in B of Fig. 10, the channel flange 114 of the channel unit 46 is mounted on the shell flange 82 with the fixing tube plate 44 sandwiched between the channel flange 114 and the shell flange 82. In this mounting, at the time of movement of the channel unit 46, a careful operation is needed such as avoiding collision of the channel unit 46 with the fixing tube plate 44 or the shell unit 42.

[0067]

G) Bolt Temporary Fixing and Aligning Step (S17)

[0068]

At the bolt temporary fixing and aligning step (S17), the bolts
5 54 and the nuts 56 to be temporarily fixed are attached to the shell
flange 82 and the channel flange 114 so as to align the shell flange
82, the fixing tube plate 44, and the channel flange 114 with each
other (S17).

[0069]

10 When the bolts 54 and the nuts 56 are temporarily fixed, the
bolts 54 and the nuts 56 are selected, as bolts to be temporarily
fixed, e.g. at diagonal four points i.e. at 90-degree intervals
around the center axes of the shell flange 82 and the channel flange
114 so that the bolts 54 and the nuts 56 in the diagonal directions
15 are stepwise fastened for diagonal fixing. In this temporary
fixing as well, uneven fastening is prevented by the stepwise
diagonal fastening.

[0070]

At the time of the alignment, the match marks 150 imparted
20 to a plurality of points before disassembling are used as guides
so that the positions of the shell flange 82, the fixing tube plate
44, and the channel flange 114 coincide with each other by matching
the match marks 150.

[0071]

25 When the shell flange 82, the fixing tube plate 44, and the
channel flange 114 are kept at a normally aligned status, as shown
in A of Fig. 11, the end portion of the partition plate 98 is inserted
into the fitted groove 104 of the fixing tube plate 44, leading
to a normal assembling status. In other words, the riding status
30 of the partition plate 98 caused by the misalignment is avoided
by the bolt temporary fixing and aligning step.

[0072]

If both the fixing tube plate 44 and the channel unit 46 are
misaligned with the shell flange 82, the partition plate 98 does

not enter the fitted groove 104 of the fixing tube plate 44 as shown in B of Fig. 11 but hits the fixing tube plate 44 outside the fitted groove 104, resulting in an abnormal assembling status. In this status, the functions of the gaskets 94-1 and 94-2 do not work.

5 [0073]

If the channel unit 46 is misaligned with the shell flange 82 in spite of the normal alignment of the fixing tube plate 44 with the shell flange 82, the partition plate 98 does not enter the fitted groove 104 of the fixing tube plate 44 as shown in C
10 of Fig. 11 but hits the fixing tube plate 44 outside the fitted groove 104, resulting in an abnormal assembling status. In this status, the function of the gasket 94-2 does not work.

[0074]

In order to modify such hitting of the fixing tube plate 44,
15 as shown in A of Fig. 12, the alignment may be performed by pushing up the fixing tube plate 44 from below by a lifting device 152. With the fixing tube plate 44 resting on a plunger 154 of the lifting device 152, the extent of a gap occurring between the shell flange 82 and the fixing tube plate 44 is visually checked so that the
20 height of the fixing tube plate 44 is adjusted with the plunger 154 of the lifting device 152. Next, as shown in B of Fig. 12, the lifting device 152 is disposed under the channel flange 114 and, with the channel flange 114 resting on the plunger 154, the extent of the gap occurring between the shell flange 82 and the fixing
25 tube plate 44 is visually checked so that the height of the channel flange 114 is adjusted by advancing or retracting the plunger 154 of the lifting device 152.

[0075]

Such a height adjustment enables the shell flange 82, the
30 fixing tube plate 44, and the channel flange 114 to be aligned.

[0076]

H) Bolt Fastening Step (S18)

[0077]

This bolt fastening step includes trainings of

presence/absence of fastening management, fastening tool,
temporary fastening and true fastening, and fastening procedure.
[0078]

5 In the case where the fastening management is present, a
fastening force required for sealing is managed in a proper
procedure using a proper tool together with an instruction of a
fastening torque. In this case, a torque wrench for example capable
of managing the fastening force is used as the fastening tool to
manage the fastening force required for sealing. In the case of
10 presence of the fastening management, fastening can be performed
by a fastening force required for sealing, with a proper tool, in
a correct procedure. In the case where fastening management is
absent, management of the fastening force is left to the trainee
although there is a fastening torque instruction. A tool such as
15 a hand wrench capable of applying a fastening force required for
sealing with a trainee's sense is used as the fastening tool. The
sealing work training may be carried out both under fastening
management and without fastening management.
[0079]

20 Fastening tools include a ratchet torque wrench, a digital
torque wrench, a bolt tensioner, and a hydraulic wrench, capable
of fastening management and also include a ratchet wrench, a hand
wrench, an offset wrench, and a blow offset wrench, hard to perform
fastening management. A bolt having a bolt dimension of less than
25 1 inch is used for a small-diameter flange. Used for fastening of
this bolt is a torque wrench, a ratchet wrench, a wrench, or an
offset wrench. This torque wrench is easy to perform torque-based
fastening management and is available for a site using a high-risk
fluid such as, up to medium pressure and medium temperature, a
30 combustible fluid and a toxic fluid, as a representative use point.
In order to generate a large torque, however, it needs a large work
space to secure a certain length. In the case of the ratchet wrench,
the wrench, and the offset wrench, the fastening force adjustment
is left to the worker's sense, so that a skill is necessitated for

the fastening work, and its representative use points are utilities, etc. including up to low pressure and low temperature site.

[0080]

A bolt having a bolt dimension of 1 inch or more is used for a large-diameter flange. For fastening of this bolt, there is used the hydraulic wrench, the bolt tensioner, or the blow offset wrench. This hydraulic wrench is easy to perform fastening management and can generate a large fastening force and fasten plural bolts at a time, with its use point being a site using a high-risk fluid such as, up to medium temperature and medium pressure, a combustible fluid and a toxic fluid. The bolt tensioner is capable of fastening management with the axial force and can generate a large fastening force, with its use point being a site using a high-risk fluid such as, up to high pressure and high temperature, a combustible fluid and a toxic fluid. The blow offset wrench performs blow fastening and therefore brings about a large dispersion, rendering the fastening management difficult.

[0081]

The temporary fastening and true fastening is a fastening method aiming to reach a target load efficiently and accurately. The temporary fastening precedes the true fastening. The temporary fastening performs stepwise diagonal fastening for target bolts only. This prevents uneven fastening. The true fastening performs round pattern fastening for all the bolts, to achieve a target fastening force. The round pattern fastening reduces the moving distance with the aid of numbering, thus preventing a fastening error and evening up the fastening force, to ensure an efficient fastening work.

[0082]

A of Fig. 13 shows a fastening procedure for temporary fastening that uses 16 bolts. This procedure represents the case where bolts are individually fastened under fastening management. [1] to [16] denote bolt numbers.

[0083]

For this temporary fastening, the torque wrench is used as the fastening tool, with the fastening procedure being the diagonal fastening. In A of Fig. 13, numbers imparted to arrows for the bolt numbers [1] to [16] represent fastening orders. The fastening torque may be increased stepwise such that the first time is 10 [%], the second time is 20 [%], the third time is 60 [%], and the fourth time is 110 [%]. After the termination of each time, the interval between the shell flange 82 and the channel flange 114 is measured at several points, e.g. at four points with a measuring device. The measuring device is for example a vernier caliper. Although fastening with a large fastening force at a time induces uneven fastening, the stepwise fastening can prevent the uneven fastening. It is to be noted that the channel flange 114 provided with 16 bolts is equivalent to the large-diameter flange and thus does not need temporary fastening of all of the bolts.

[0084]

Next, B of Fig. 13 shows a fastening procedure for the true fastening with 16 bolts.

[0085]

For this true fastening, the torque wrench is used as the fastening tool, with the fastening procedure being round fastening. In B of Fig. 13, for the bolt numbers [1] to [16], a rounding arrow designates the fastening order. The fastening torque is increased stepwise up to 110 [%]. Either clockwise or counterclockwise round is employed for 8 or more bolts. The round number-of-times is 4 in the case of a small flange diameter (less than 250 [A]) and 6 in the case of a large flange diameter (250 [A] or more). After the termination of the true fastening, the space between the shell flange 82 and the channel flange 114 is measured at several points, e.g. at four points with the measuring device.

[0086]

Although the true fastening round number-of-times may be about 4 to 6, for the fixing tube plate 44 having the two juxtaposed gaskets 94-1 and 94-2, the round number-of-times is increased to

fastening until reaching the state where all the nuts cannot turn any more. Such increased round number-of-times can prevent the fastening force from lowering under the influence of resilient interaction. The resilient interaction is a phenomenon that the axial forces of bolts adjacent to a fastened bolt become lower.
[0087]

In this manner, according to the round pattern fastening, efficient fastening work can be implemented such as rapid arrival at the even fastening force, reduced moving distance for the fastening, and prevented fastening error caused by numbering. The fastening procedure training is included.

[0088]

I) Evaluating Step (S19)

[0089]

This evaluating step verifies and evaluates mainly the sealability of the device body 6 assembled. For example, by closing the outlet port 118-2 and connecting a compressor to the inlet port 118-1 to feed a pressurized gas through the inlet port 118-1, the inlet space part 140, the inlet tube group 96-1, the space part 138, the outlet tube group 96-2, and the outlet space part 142 can be integrally maintained at a pressurized status so that the gas tightness of the gaskets 94-1, 94-2, and 94-3 as sealing members can be checked. In this gas tightness test, a soapy water film is made to adhere to the sealed portion, for example, and the leakage state is checked from the states of production and expansion of soapy water bubbles arising from leakage.

[0090]

<Effect of First Embodiment>

[0091]

(1) Use of the training device 2-1 enables assembling, disassembling, sealing work, alignment, bolt and nut fastening, and its fastening procedure to be trained similarly to the large-sized heat exchanger and allows sealing work training equivalent to or exceeding the real machine site, achieving a

training effect.

[0092]

(2) Due to the short design of the shell unit 42 having the same caliber as the real machine, the time from introduction of the pressurized fluid up to the boost to a predetermined pressure can be reduced and the trainee's safety can be enhanced with secured safety, dissimilar to the real machine, even if maintained in the boost state.

[0093]

(3) Assembling, alignment, and bolt and nut fastening can be trained assuming situations which should not be practiced by the real machine even if assumed in the real machine or assuming unpredictable situations, and hands-on training just like the real machine, such as in the case where the gaskets are broken, can be performed.

[0094]

(4) Training of alignment, bolt and nut fastening procedure, and axial force adjustment can be carried out on a daily basis in assuming the uneven fastening status of the gaskets.

[0095]

(5) Training can be carried out such as verifying the disadvantages arising from misalignment peculiar to the heat exchanger and simultaneously mastering the avoidance technique of the disadvantages.

[0096]

(6) By selecting plural types of tools, practical training can be performed on a tool-by-tool basis.

[0097]

[Second Embodiment]

[0098]

Fig. 14 shows a training device (sealing work training device) 2-2 according to a second embodiment. This training device 2-2 includes the training device 2-1 and a monitoring unit 162. The monitoring unit 162 is means monitoring the training situation of

the training device 2-1 and, as an example, detects the axial forces of the bolts 54 of the training device 2-1 to create a distribution graph from the detected axial forces, to thereby monitor the work status.

5 [0099]

The training device 2-1 has the simulated configuration of the heat exchanger as described above and has been detailed in the first embodiment, and therefore the description thereof will be omitted.

10 [0100]

The monitoring unit 162 includes a sensor group 164, a data logger 166, a personal computer (PC) 168, and a monitor 170.

[0101]

The sensor group 164 includes a plurality of sensors 164-1, 15 164-2, ..., 164-16 detecting the axial forces of 16 bolts for example of the training device 2-1, and the sensors detect the axial forces of bolts 54, respectively. The sensors 164-1, 164-2, ..., 164-16 can be sensors outputting the axial force F as an electrical signal and can be any one of a pressure sensor, a strain gauge, a 20 displacement meter, a load meter, etc., or may be a sensor directly detecting the fastening force of the gasket 8.

[0102]

Each sensor output of the sensor group 164 is fed into the data logger 166 and accumulated therein. Each detected axial force 25 is in the form of an electrical signal for example and is electrically accumulated in the data logger 166. The data logger 166 is an example of a data accumulating unit and may be configured by a computer or may be substituted with the PC 168.

[0103]

30 Each detected axial force is imported from the data logger 166 into the PC 168 at a predetermined timing. This PC 168 is an example of an information generating unit. This PC 168 digitalizes and imports each detected axial force and executes information processing for creating a distribution graph of the detected axial

forces.

[0104]

This information processing includes processes such as,

a) importing and storing each detected axial force;

5 b) creating position information of each detected axial force
and drawing information representative of a distribution of the
detected axial forces;

c) creating coordinates deploying an axial force
distribution; and

10 d) creating drawing information of a comparative axial force
corresponding to the detected axial force. Since in this example
the detected axial force corresponds to the fixing tube plate 44,
the axial force information of the normal flange is used as the
comparative axial force.

15 [0105]

The coordinates and the drawing information obtained by this
information processing are provided to the monitor 170. The
monitor 170 is an example of information presenting means that
presents a distribution graph of the axial force, and present an
20 axial force graph together with the coordinates on a screen of this
monitor 170. The monitor 170 may be connected wiredly or wirelessly
to the PC 168 or a PC display may be used.

[0106]

<Sensors 164-1, 164-2, ..., 164-16>

25 [0107]

Fig. 15 shows the bolt 54 having a sensor 164-1. Each bolt
54 has in its interior the sensor 164-1 detecting the axial force.
This sensor 164-1 is the strain gauge for example. The sensor 164-1
detects a strain of the bolt 54 caused by the torque T applied to
30 the nut 56, this strain being the axial force F. A cable 172 is
connected to the sensor 164-1. Through the cable 172, the detected
axial force F is exported as sensor output. The same applies to
the other sensors 164-2, ..., 164-16, that is, in this example, axial
forces of 16 bolts 54 are exported as sensor outputs from their

respective sensors 164.

[0108]

<PC 168>

[0109]

5 The PC 168 includes, as shown in Fig. 16, a processor 174, a storing unit 176, an input/output unit (I/O) 178, a communicating unit 180, and an operation input unit 182.

[0110]

10 The processor 174 executes information processing of various computer programs such as an operating system (OS) and a work monitoring program in the storing unit 176. This information processing includes various processes executable by the computer, such as calculation of the fastening force, recording of work history, control of the monitor 170, work monitoring, and work
15 management, in addition to the processes including the above processes a) to d).

[0111]

20 The storing unit 176 includes, for example, as storage devices, a read-only memory (ROM) and a random-access memory (RAM), the ROM storing the OS and the monitoring program. This storing unit 176 has a database (DB) 184 disposed to store detection information, drawing information, etc., the DB 184 storing detection information imported from the data logger 166. The detection information includes sensor outputs obtained from the sensor group 164.

25 [0112]

 The I/O 178 is used for transmission/reception of image data to/from the monitor 170. The data logger 166 is connected via a cable 186 to the communicating unit 180.

[0113]

30 The operation input unit 182 is configured from e.g. input equipment such as a keyboard and a mouse and is used for operation of the screen and input of information.

[0114]

<Monitoring Process>

[0115]

Fig. 17 shows a processing procedure of monitoring of the detected axial force. This processing procedure is an example of a sealing work training program of the present invention.

5 [0116]

In this processing procedure, it is determined whether fastening of the bolts 54 is made (S101) and, if affirmative (YES of S101), each sensor output is imported from the sensor group 164 into the data logger 166 so that the detected axial force is accumulated in the data logger 166 (S102). This accumulation is equivalent to the above information processing a) importing and storing each detected axial force.

[0117]

The drawing process of the detected axial force and the comparative axial force is carried out (S103). This process includes the above b) creating position information of each detected axial force and drawing information representative of a distribution of the detected axial force; c) creating coordinates deploying an axial force distribution; and d) creating drawing information representative of a distribution of the comparative axial force by use of the comparative axial force and the position information.

[0118]

After this drawing process, the monitor 170 displays a distribution graph of the detected axial force and the comparative axial force on the coordinates (S104).

[0119]

During this display, changes in the detected axial force are monitored to determine whether fastening of the bolts 54 is completed (S105). If fastening of the bolts 54 is not completed (NO of S105), the processes at S102 to S105 are continued. This allows the changes in the detected axial force to be reflected on the distribution graph displayed on the monitor 170, so that the detected axial force is dynamically displayed as changes on the

distribution graph.

[0120]

If fastening of the bolts 54 is completed (YES of S105), a distribution graph of the detected axial force and the comparative axial force is displayed on the coordinates at the time of completion of fastening (S106), and this work monitoring process is ended. As a result of comparison of the detected axial force with the comparative axial force, the difference on the axial force distribution can be recognized between the case of the fixing tube plate 44 and the case of the normal flange.

[0121]

<Distribution Graph Display>

[0122]

Fig. 18 shows a presentation image created on the screen of the monitor 170. This presentation image 188 appears with coordinates 190 on which a distribution graph 192 of the detected axial force and a distribution graph 194 of the comparative axial force are displayed.

[0123]

On the coordinates 190 with its center O there are a plurality of radially extending coordinate axes $y_1, y_2, \dots$, and y_{16} at angular intervals of $\theta=22.5$ degrees. [1], [2], ..., and [16] denote bolt numbers, with the coordinate axes $y_1, y_2, \dots$, and y_{16} corresponding to the arrangement of the plurality of bolts 54. Although in this example there are a corresponding number of coordinate axes to the number 16 of bolts, the number of the coordinate axes y is set in accordance with the number of bolts arranged. The coordinate axes $y_1, y_2, \dots$, and y_{16} has, in a direction away from the center O, a scale 196 indicative of a positive axial force level. From this scale and plot points of the detected axial force, the magnitude of the detected axial force, changes thereof, and axial force values can visually be recognized.

[0124]

The distribution graph 192 is formed by plotting detected

axial forces $F_1, F_2, \dots$, and F_{16} of the bolts 54 and joining adjacent plot points by a straight line. The distribution graph 194 is formed by plotting recommended axial forces $F_{ref1}, F_{ref2}, \dots$, and F_{ref16} as the comparative axial forces and joining adjacent plot points by a straight line. These recommended axial forces $F_{ref1}, F_{ref2}, \dots$, and F_{ref16} are axial force values through 4 rounds of true fastening of the bolts 54.

[0125]

By comparison between the distribution graphs 192 and 194, excess and deficiency in the value of the detected axial force with respect to the comparative axial force can easily be visually recognized. In this case, at the bolt No. [16], the detected axial force F_{16} is substantially coincident with the recommended axial force F_{ref16} and then reaches the recommended value. The other detected axial forces $F_1, \dots$, and F_{15} do not reach the recommended axial forces $F_{ref1}, \dots, F_{ref15}$, so that it can be seen that the axial force needs to be increased thereat.

[0126]

A of Fig. 19 shows a display of a distribution graph in the case without fastening management. In the case of absence of the fastening management, fastening is left to the trainee's discretion, so that the distribution graph 192-1 of the detected axial force has a large deviation from the distribution graph 194-1 of the comparative axial force.

[0127]

B of Fig. 19 shows a display of a distribution graph in the case of presence of fastening management. In the case of presence of the fastening management, fastening is managed at a proper value, with the result that the distribution graph 192-2 of the detected axial force does not have a large deviation from the distribution graph 194-2 of the comparative axial force, rendering it possible to visually recognize the acquisition of the substantially uniform work status. Shown in this case are the distribution graphs 192-2 and 194-2 of the detected axial force and the comparative axial

force through 6 rounds of true fastening.

[0128]

<Resilient Interaction>

[0129]

5 The training device 2-1 simulates a the heat exchanger and, when showing the fastened portion of the gaskets 94-1 and 94-2 in an extractive manner, as shown in A of Fig. 20, the fixing tube plate 44 intervenes between the shell flange 82 and the channel flange 114, the gaskets 94-1 and 94-2 are disposed on the back and
10 front of the fixing tube plate 44, respectively, and they are fastened together by bolts 54 and nuts 56.

[0130]

 For the purpose of explanation, let the center bolt 54 and the left-hand bolt 54 be bolts 54N and 54S, respectively. When a
15 torque τ is applied to the nut 56 on the bolt 54N, as shown in B of Fig. 20, the shell flange 82, the channel flange 114, the fixing tube plate 44, and the gaskets 94-1 and 94-2 are fastened together around the bolt 54N. At this time, an axial force F is generated in the bolt 54N in accordance with the fastening torque τ . Let this
20 axial force F be F_1 .

[0131]

 When in this state the torque τ is applied to the nut 56 on the bolt 54S, as shown in C of Fig. 20, the shell flange 82, the channel flange 114, the fixing tube plate 44, and the gaskets 94-1
25 and 94-2 are fastened together around the bolt 54S. Similar to the bolt 54N, an axial force F is generated in the bolt 54S in accordance with the fastening torque τ . Let this axial force F be F_1 .

[0132]

 At this time, the center bolt 54N adjacent to the bolt 54S
30 undergoes influence of the resilient interaction of the fixing tube plate 44, the shell flange 82, and the channel flange 114, whereupon the axial force F_1 applied to the bolt 54N lowers to an axial force F_2 . Specifically, due to application of the axial force F to the bolt 54S, the resilient interaction of the fixing tube plate 44,

the shell flange 82, and the channel flange 114 cause the axial force F_1 applied to the bolt 54N to lower to the axial force F_2 , so that the axial force is changed by axial force $-\Delta F$ in the negative direction, as shown in Equation (1).

5 $F_2 - F_1 = -\Delta F \quad \dots(1)$

This axial force change is greater than that in fastening of a simple flange joint. In the structure having the fixing tube plate 44 between the shell flange 82 and the channel flange 114, large influence of the resilient interaction works and the dispersion
10 of the fastening force easily occurs. In this case, when an axial force complementing the negative axial force ΔF is applied to the bolt 54N, its influence affects the bolt 54S, so that plural times of complementary fastening are required for necessity of re-complementing.

15 [0133]

<Visualization of Resilient Interaction>

[0134]

A of Fig. 21 shows the distribution graph 192 of the detected axial force on the coordinates 190. For ease of explanation, the
20 distribution graph 192 indicates an ideal axial force distribution of the axial force F_1 .

[0135]

In this state, when the axial force in the bolt 54 of the bolt No. [1] is increased from the axial force F_1 to the axial force
25 F_2 , as shown in B of Fig. 21, the axial force F_1 of the adjacent bolts 54 of the bolt Nos. [2] and [16] fall to the axial forces F_3 and F_4 , respectively, under the resilient interaction described above. Such changes in the axial force under the resilient interaction can visually be recognized as changes of the graph.

30 [0136]

<Single fastening and Multi-fastening>

[0137]

Fastening between the shell flange 82 and the channel flange 114 by the bolts 54 and the nuts 56 may be performed by either single

fastening or multi-fastening. The single fastening fastens a single bolt 54 and nut 56 at a time, while the multi-fastening fastens 2 or plural bolts 54 and nuts 56 at a time.

[0138]

5 A to D of Fig. 22 show steps 1a, 1b, 1c, and step 2 in which two bolts 54 and nuts 56 are fastened at the same time under fastening management. At step 1a, as shown in A of Fig. 22, two confronting bolts 54 of the bolt Nos. [1] and [9] and corresponding nuts 56 are selected and fastened at the same time with the same torque
10 $\tau=30$ [%], after which two bolts 54 of the bolt Nos. [5] and [13] and corresponding nuts 56 orthogonal to the two bolts 54 of the bolt Nos. [1] and [9] and corresponding nuts 56 are fastened at the same time with the torque $\tau=30$ [%].

[0139]

15 Next, at step 1b, as shown in B of Fig. 22, the fastening objects return to the two bolts 54 of the bolt Nos. [1] and [9] and corresponding nuts 56, which are fastened at the same time but with the torque $\tau=70$ [%]. The fastening objects then shift to the two bolts 54 of the bolt Nos. [5] and [13] and corresponding nuts
20 56, which are fastened at the same time with the torque $\tau=70$ [%].

[0140]

 Next, at step 1c, as shown in C of Fig. 22, the fastening objects return to the two bolts 54 of the bolt Nos. [1] and [9] and corresponding nuts 56, which are fastened at the same time but
25 with the torque $\tau=100$ [%]. The fastening objects then shift to the two bolts 54 of the bolt Nos. [5] and [13] and corresponding nuts 56, which are fastened at the same time with the torque $\tau=100$ [%].

[0141]

 Then, at step 2, as shown in D of Fig. 22, starting from the
30 two bolts 54 of the bolt Nos. [1] and [9] and corresponding nuts 56, fastening can be performed for the bolts 54 of the bolt Nos. [2]-[10], [3]-[11], ..., and [9]-[1] and corresponding nuts 56 in the rounding direction order indicated by arrows until the target fastening torque $\tau=100$ [%] is reached and until the bolt rotations

stop. Although the clockwise rounding order is exemplified in this example, the order may be counterclockwise as long as it is in the same direction.

[0142]

5 A and B of Fig. 23 schematically shows the case where the single fastening has been performed for the bolts 54 and nuts 56 fastening the gasket 94-1 between the shell flange 82 and the channel flange 114. Many fastening number-of-times are required to even the axial forces of the above 16 bolts 54. For example, as shown in A of Fig. 10 23, when the axial force F_1 is applied to a bolt 54L, the channel flange 114 tilts with respect to the shell flange 82 from its parallel state to the shell flange 82, whereupon a bolt 54R experiences an axial force change of an axial force ΔF_2 . When the axial force F_2 is applied to the bolt 54R, the channel flange 114 15 tilts to cause an axial force change by an axial force ΔF_1 on the bolt 54L. For this reason, uneven fastening is easy to occur and many fastening number-of-times are needed to even the axial forces of the bolts 54.

[0143]

20 On the contrary, A and B of Fig. 24 schematically shows the case where simultaneous fastening of a plurality of, e.g. 2 bolts and nuts has been carried out for the bolts 54 and nuts 56 fastening the gasket 94-1 between the shell flange 82 and the channel flange 114. As shown in A of Fig. 24, when the axial force F_1 is 25 simultaneously applied to the bolts 54L and 54R, the bolts 54L and 54R have a common axial force F_1 , resulting in a reduced flange-to-flange tilt between the shell flange 82 and the channel flange 114. Thus, the simultaneous fastening of plural bolts and nuts advantageously reduces the fastening number-of-times and hence 30 uneven fastening is hard to occur.

[0144]

A of Fig. 25 shows distribution graphs 192-3 and 194-3 of a detected axial force and a comparative axial force in the single fastening. The distribution graph 192-3 represents a detected

axial force after 6 rounds of true fastening with the single fastening, while the distribution graph 194-3 represents a recommended fastening force. In this case, the single-fastening distribution graph 192-3 has a dispersion of the detected axial force, from the axial force distribution of the distribution graph 194-3. Fastening needs time of the order of 40 minutes, with 16 times of temporary fastening and 96 times of true fastening, one-time fastening requiring time of the order to 20 seconds. [0145]

On the other hand, B of Fig. 25 shows distribution graphics 192-4 and 194-4 of the detected axial force in the multi-fastening and of a comparative axial force, respectively. The distribution graph 192-4 represents a detected axial force after 2 rounds of true fastening with two-bolts fastening, while the distribution graph 194-4 represents a recommended fastening axial force. In this case, the multi-fastening distribution graph 192-4 has a negligible detected axial force dispersion, from the axial force distribution of the distribution graph 194-4. The fastening time is reduced to approximate 15 minutes with 6 times of temporary fastening and 16 times of true fastening, one-time fastening needing time of the order of 40 seconds. The multi-fastening can achieve a remarkable reduction in the fastening number of times and time shortening.

[0146]

<Fastening Management Present/Absent and Monitoring>

[0147]

Fig. 26 shows a fastening procedure of the bolts 54 and the nuts 56. Prior to fastening, work conditions are selected and input (S301). These work conditions are pieces of premise information of selection of the gaskets 94-1 and 94-2 and the magnitude of fastening force.

[0148]

The gaskets 94-1 and 94-2 conforming to these work conditions are selected (S302). The selection of the gaskets 94-1 and 94-2

is to select gaskets 94-1 and 94-2 meeting the purpose of sealing between the shell flange 82 and the channel flange 114, and if a mistake occurs in the gasket selection, proper sealing status cannot be obtained even though the fastening procedure and alignment is proper.

[0149]

The presence/absence of the fastening management is selected (S303). The fastening management is to manage the fastening tool, the fastening force applied, the fastening procedure.

Specifically, it needs at least,

h) selecting a proper fastening tool;

i) obtaining a fastening force necessary for sealing by use of the proper fastening tool; and

j) performing fastening in a correct procedure. Accordingly, the fastening management "present" means satisfying the above, whereas the fastening management "absent" means not satisfying the above or leaving it to worker's discretion.

[0150]

If the fastening management is present (YES of S303), the fastening force in accordance with the working conditions is calculated (S304). This fastening force is calculated by using e.g. a gasket fastening force (full load), a fastening torque, a bolt diameter, a recommended fastening surface pressure, a gasket contact area, a torque coefficient, and the number of bolts.

[0151]

Let W_g , σ_g , and A_g be the gasket fastening force, the recommended fastening surface pressure, the gasket contact area, respectively, then the gasket fastening force W_g is

$$W_g = \sigma_g \times A_g \quad \dots (2).$$

A gasket contact area A_{g1} of the gasket 94-1 is expressed, from the contact outer diameter and the contact inner diameter of the gasket 94-1, as

$$A_{g1} = (\pi/4) \times \{ (\text{contact outer diameter})^2 - (\text{contact inner diameter})^2 \} \quad \dots (3).$$

[0152]

A gasket contact area A_{g2} of the gasket 94-2 is expressed, from the contact outer diameter and the contact inner diameter of the gasket 94-2 and the width and length (end surface area) of the partition plate 98, as

$$A_{g2} = (\pi/4) \times \{ (\text{contact outer diameter})^2 - (\text{contact inner diameter})^2 - (\text{width} \times \text{length of the partition plate 98}) \} \quad \dots(4).$$

[0153]

Let W_g , T [$N \cdot m$], k , d , and b_n represent the gasket fastening force, the fastening torque, the torque coefficient (0.2), the outer diameter (m) of male screw, the number of bolts, respectively, then the fastening torque T is given as

$$T = k \times W_g \times d / b_n \quad \dots(5).$$

The torque coefficient k is 0.14 through 0.20 to 0.26 for general machinery fats and oils, e.g. spindle oil, machine oil, and turbine oil; 0.10 through 0.15 to 0.20 for low friction fats and oils such as molybdenum disulfide; and 0.25 to 0.55 for non-lubrication.

[0154]

After such a calculation result, a fastening tool and a fastening procedure are specified (S305) and fastening is carried out with the specified fastening tool and the specified fastening procedure (S306). This fastening may be performed by a predetermined fastening procedure, e.g. a fastening procedure complying with the standards of Japanese Industrial Standards (JIS) or of American Society of Mechanical Engineers (ASME), this procedure including the rounding direction of the fastening order, the round number-of-times, and the measurement of the space between flanges with the vernier caliper.

[0155]

The fastening tool is placed on each nut 56 temporarily fastened to the bolt 54, to impart the torque T to the nut 56, thereby applying a proper fastening force. This fastening force is transmitted from the bolts 54 to the shell flange 82 and the channel flange 114.

[0156]

The axial forces F of the bolts 54 cause resilient interactions in the fixing tube plate 44, the shell flange 82, and the channel flange 114. The resilient interaction is a phenomenon e.g. that
 5 when a bolt 54 is fastened, bolts 54 adjacent to the bolt 54 become loose, resulting in a reduced fastening force between the bolts 54.

[0157]

During this fastening, a work monitoring process is performed
 10 (S307). In this work monitoring process, a distribution graph of the detected axial force is dynamically displayed on the coordinates.

[0158]

In the work monitoring process, it is determined whether the
 15 fastening has been completed (S308). If the fastening is continued (NO of S308), the step at S306 to S308 is repeated, whereas if the fastening is complete (YES of S308), this process comes to an end.

[0159]

If at S303 the fastening management is "absent" (NO of S303),
 20 a work is performed instead of S304 to S308. That is, the work is left to the trainee's discretion and the fastening is performed by any fastening tool and fastening procedure, relying on the trainee's intuition (S309). This fastening status is subjected to the work monitoring similarly to S307 (S310), and the work is
 25 terminated by the trainee's will.

[0160]

<Round Management>

[0161]

Fig. 27 shows a processing procedure of the monitoring process
 30 at S307 and S310 in the flowchart of Fig. 26. This processing procedure is an example of the execution procedure of a program run by the computer.

[0162]

This monitoring includes steps of temporary fastening and

true fastening. The temporary fastening is a process executed before the true fastening and includes attaching the nuts 56 to the bolts 54, adjusting the alignment, and fastening the nuts 56 before true fastening. The alignment adjustment includes position setting of the gaskets 94-1 and 94-2 and the bolts 54. The true fastening imparts the torque T to the bolts 54 with the fastening tool, to allow a stepwise arrival at the comparative fastening force (target fastening force).

[0163]

In this work monitoring process, the processor 174 runs a program to import detected axial forces from the sensor group 164 (S401), performing graphic processing of the detected axial force F and the comparative axial force Fref (S402).

[0164]

Under control of the processor 174, the monitor 170 dynamically displays the distribution graph 192 of the detected axial force F and the distribution graph 194 of the comparative axial force Fref on the coordinates (S403).

[0165]

During the graphic processing of the detected axial force etc. and fastening work, it is monitored whether the fastening process has reached a predetermined round number-of-times (S404). If the predetermined round number-of-times, e.g. the round number-of-times of 4 to 6 has not been reached (NO of S404), S401 to S404 are continuously executed. Then, if the fastening process has reached the predetermined round number-of-times (YES of S404), the sealing work comes to completion (S405), and this process is terminated.

[0166]

<Effect of Second Embodiment>

[0167]

(1) The trainee can master fastening of bolts and nuts, occurrence of a change or bias of the axial force, its disadvantages, and its avoidance technology.

[0168]

(2) Training can be done while the distribution graph of the detected axial force and the distribution graph of the comparative axial force are simultaneously displayed, the comparative axial force being representative of the target axial force or the recommended axial force.

[0169]

(3) While the uneven fastening and leakage arising from the resilient interactions are verified, its repair can be recognized as a change in the distribution graph, so that the bolt fastening skill can be enhanced.

[0170]

(4) The fastening tool can be for example the ratchet torque wrench, digital torque wrench, bolt tensioner, ratchet wrench, wrench, offset wrench, or blow wrench. The fastening results by use of these tools are compared with one another in the form of distribution graphs, so that selection information can be obtained to select a proper tool for a high-quality sealing work.

[0171]

(5) An ideal sealing status can be realized through the operation that the detected axial force reaches the comparative axial force while distribution graphs of the detected axial force and the comparative axial force are compared with each other on the common coordinates.

[0172]

(6) It is possible to recognize a change in the distribution graph in accordance with the detected axial force; to easily recognize influence of resilient interaction of the flanges; to impart a fastening force in consideration of the influence of resilient interaction; and to improve the fastening work skill.

[0173]

[Third Embodiment]

[0174]

Fig. 28 shows a training device (seal work training device)

2-3 according to a third embodiment. This training device 2-3 includes the training device 2-1 and a monitoring unit 198. The monitoring unit 198 is means monitoring the training situation on the training device 2-1 and, for example, shoots the training contents of the training device 2-1 to monitor the work status on the basis of the training video.

[0175]

The training device 2-1 has the simulated configuration of the heat exchanger as described above and has been detailed in the first embodiment, and therefore the description of the training device 2-1 will be omitted.

[0176]

The monitoring unit 198 includes a plurality of cameras 200-1, 200-2, ..., and 200-N, an image capturing unit 202, a PC 204, a memory unit 206, and monitors 208-1, 208-2, ..., and 208-N.

[0177]

The cameras 200-1, 200-2, ..., and 200-N are an example of imaging means that shoots the training contents from a desired location. The cameras 200-1, 200-2, ..., and 200-N shoot the entirety to individual portions, such as the overall view, the trainee, the device body 6, the shell unit 42, the fixing tube plate 44, the channel unit 46, the gaskets 94-1, 94-2, and 94-3, the bolts 54 and the nuts 56, and shoot at least the fastening situations of the bolts 54, and compression situations of the gaskets 94-1, 94-2 and 94-3. The optical systems of the cameras 200-1, 200-2, ..., and 200-N may include a zoom lens or a macro lens. The cameras 200-1, 200-2, ..., and 200-N are put in the continuous shooting state for example so that imaging outputs are fed into the image capturing unit 202.

[0178]

The image capturing unit 202 is controlled by the PC 204 and captures all or individual ones of the imaging outputs of the cameras 200-1, 200-2, ..., and 200-N at a predetermined time interval or in a continuous time.

[0179]

The PC 204 is an example of image processing means and performs selection or editing of required images from the image outputs captured into the image capturing unit 202. In other words, the PC 204 is used as editing means that edits images obtained from one or plural ones of the cameras 200-1, 200-2, ..., 200-N, for each of objects to be imaged or in a time series. This PC 204 may be substituted by the PC 168 of the second embodiment.

[0180]

Images processed by the PC 204 are stored as database into the memory unit 206. Specifically, edit images are stored in association with the trainee so that after training, image playback may be performed for verification and evaluation of the training contents.

[0181]

The monitors 208-1, 208-2, ..., and 208N are an example of image displaying means that displays a plurality of different images. The number of the monitors 208-1, 208-2, ..., and 208-N to be installed may be equal to the number of the camera 200-1, 200-2, ..., and 200-N, but the both may not necessarily be equal and the monitors 208-1, 208-2, ..., and 208-N should not be construed as being included of a plurality of monitors. Specifically, a single monitor screen may be divided for a plurality of image display areas or time sharing may be employed to allow a single screen to implement functions similar to those of the plural monitors 208-1, 208-2, ..., and 208-N. The monitor 170 of the second embodiment may serve as the monitors 208-1, 208-2, ..., and 208-N.

[0182]

<Effect of Third Embodiment>

[0183]

(1) The contents of training of the trainee and the situations of the gaskets 94-1 and 94-2 etc. can be checked from images.

[0184]

(2) The supervisor can check the training contents by images

at a position apart from the trainee, to thereby increase the trainee's degree of freedom in operation, so that training management can easily be achieved.

[0185]

- 5 (3) Referring to recorded images, the trainee can objectively verify and evaluate the trainee's training contents, so that the training effect and the sealing work accuracy can be increased, contributing to an improvement in reliability.

[0186]

- 10 [Other Embodiments]

[0187]

- (1) About Bolt Fastening Order: In the case where the bolts are individually fastened with the presence of fastening management, a fastening method to efficiently and accurately reach the target
- 15 load includes performing a stepwise diagonal fastening only for the object bolts in the temporary fastening and performing round pattern fastening of all the bolts in the true fastening. In the shell flange 82 and the channel flange 114 as fastening object, number of bolts differs by size of the flanges, and the bolt
- 20 fastening procedure differs between the small-diameter flange whose number of bolts is 8 or less and the large-diameter flange whose number of bolts is more than 8. In the case of the small-diameter flange needing 4 bolts, all the bolts are fastened in the order of numbers imparted to the bolts as shown in A of Fig. 29. In the
- 25 case of the small-diameter flange needing 8 bolts, all the bolts are fastened in the order of numbers imparted to the bolts as shown in B of Fig. 29. In the case of the large-diameter flange needing 12 to 24 bolts or the large-diameter flange needing more than 24 bolts, 4 or 8 equiangularly spaced bolts are fastened in the order
- 30 of numbers imparted to the bolts as shown in C and D of Fig. 29. The large-diameter flange does not need temporary fastening of all the bolts.

[0188]

- (2) About Gasket Contact Portion 88 of Shell Flange 82 and

Gasket Contact Portion 128 of Channel Flange 114: Although in the first embodiment the gasket contact portion 88 protrudes from the front surface of the shell flange 82 as shown in Figs. 11 and 12 while similarly the gasket contact portion 128 protrudes from the front surface of the channel flange 114, the mode may be such that as shown in Fig. 30 they retreat from the front surfaces of the shell flange 82 and the channel flange 114 so that flange side peripheral members surround the gasket contact portions 88 and 128. As the training device, however, the mode is desirable in which the peripheries of the gaskets 94-1, 94-2, and 94-3 are exposed so as to allow the training status to be checked.

(3) Although in the above embodiments, the first transport support mechanism 8-1 and the second transport support mechanism 8-2 are provided, a single transport support mechanism may be configured that has either one or both of the function of the first transport support mechanism 8-1 and the function of the second transport support mechanism 8-2.

(4) Although the first transport support mechanism 8-1 and the second transport support mechanism 8-2 use the frame as support means, a structure other than the frame may be employed as the support means.

[0189]

As set forth hereinabove, the most preferred embodiments and examples of the present invention have been described. The present invention is not limited to the above description. Based on the gist of the present invention defined in the claims or disclosed in the description of embodiments or in the examples, various modifications and alterations are feasible by those skilled in the art. It is natural that such modifications and alterations be encompassed in the scope of the present invention.

INDUSTRIAL APPLICABILITY

[0190]

According to the sealing work training device and training method of the present invention, training similar to that with the

real machine can be done using the structure similar to the heat exchanger as the real machine, and the training can be done assuming the situations hard to be trained with the real machine, thereby enhancing the trainee's skill and accuracy of the sealing work, to consequently contribute to the improvement in the reliability.

REFERENCE SIGNS LIST

[0191]

	2-1, 2-2, 2-3	sealing work training device
	4	frame
10	6	device body
	8-1	first transport support mechanism
	8-2	second transport support mechanism
	10, 12	post member
	14, 16, 18, 20	support member
15	22	space part
	24	caster
	26	stopper
	28	rail part
	30	hanger part
20	32	lifting part
	34	sliding part
	36-1, 36-2	lifting part
	38	roller
	40	support member
25	42	shell unit
	44	fixing tube plate
	46	channel unit
	48	support leg
	50	bolt
30	52	nut
	54	bolt
	56	nut
	58	channel cover
	60	bolt
35	62	nut

	64	hook receiver
	66	hook
	68	hook receiver
	70	hook
5	72	hook attachment
	73	hook attachment
	74	hook receiver
	76	hook
	78	hook attachment
10	80	tubular part
	82	shell flange
	84	shell cover
	88	gasket contact portion
	90	bolt insertion aperture
15	92	hook receiver
	94-1, 94-2, 94-3	gasket
	96	tube
	96-1	inlet tube group
	96-2	outlet tube group
20	98	partition plate
	100	support plate
	102, 102-1, 102-2	fitting protrusion
	104	fitted groove
	106	tube aperture
25	108	gasket contact portion
	112	tubular part
	114, 116	channel flange
	118-1	inlet port
	118-2	outlet port
30	120	hook receiver
	122	bolt insertion aperture
	124	hook receiver
	126	bolt insertion aperture
	128	gasket contact portion

	130	bolt insertion aperture
	132-1, 132-2	fitting protrusion
	134	fitted groove
	136	space part
5	138	space part
	140	inlet space part
	142	outlet space part
	144-1, 144-2	corrosion/dint
	146-1, 146-2, 146-3, 146-4, 146-5	flaw
10	148	gasket abutment surface
	150	mark
	150-1, 150-2, 150-3	rectilinear portion
	152	lifting device
	154	plunger
15	160	training system
	162-1, 162-2	monitoring unit
	164	sensor group
	164-1, 164-2, ..., 164-16	sensor
	166	data logger
20	168	PC
	170	monitor
	172	cable
	174	processor
	176	storing unit
25	178	input/output unit (I/O)
	180	communicating unit
	182	operation input unit
	184	DB
	186	cable
30	188	presentation image
	190	coordinates
	192	distribution graph of detected axial force
	194	distribution graph of comparative axial force
	196	scale

198 monitoring unit
200-1, 200-2, ..., 200-N camera
202 image capturing unit
204 PC
5 206 memory unit
208-1, 208-2, ..., 208-N monitor

CLAIMS

1. A sealing work training device comprising:

a shell unit;

5 a tube plate unit having a plurality of tubes that are insertable into and removable from the shell unit;

a channel unit having a channel flange corresponding to a shell flange of the shell unit, the channel unit having a partition plate that is engaged with a groove of the tube plate unit;

10 bolts and nuts that fix the shell flange and the channel flange together; and

a transport support mechanism that supports the tube plate unit movably in a front-back direction, an up-down direction, or a direction intersecting the front-back direction, the transport support mechanism supporting the channel unit movably in the front-back direction, the up-down direction, or the direction intersecting the front-back direction, wherein

the sealing work training device enables to fasten and unfasten of the bolts and the nuts on the shell flange and the channel flange; to align position of the tube plate unit and the channel flange with the shell flange or position of the tube plate unit and the partition plate with each other through operation of the transport support mechanism; and to attach and detach gaskets between the tube plate unit and the shell flange and between the tube plate unit and the channel flange.

25

2. A sealing work training device comprising:

a shell unit;

a tube plate unit having a plurality of tubes that are insertable into and removable from the shell unit;

30 a channel unit having a channel flange corresponding to a shell flange of the shell unit, the channel unit having a partition plate that is engaged with a groove of the tube plate unit;

bolts and nuts that fix the shell flange and the channel flange together; and

a first transport support mechanism that supports the tube plate unit movably in a front-back direction, an up-down direction, or a direction intersecting the front-back direction, or a second transport support mechanism that supports the channel unit movably in the front-back direction, the up-down direction, or the direction intersecting the front-back direction, wherein

the sealing work training device enables to fasten and unfastening of the bolts and the nuts on the shell flange and the channel flange; to align position of the tube plate unit and the channel flange with the shell flange or position of the tube plate unit and the partition plate with each other through operation of either the first transport support mechanism or the second transport support mechanism; and to attach and detach gaskets between the tube plate unit and the shell flange and between the tube plate unit and the channel flange.

3. A sealing work training device comprising:

a shell unit;

a tube plate unit having a plurality of tubes that are insertable into and removable from the shell unit;

a channel unit having a channel flange corresponding to a shell flange of the shell unit, the channel unit having a partition plate that is engaged with a groove of the tube plate unit;

bolts and nuts that fix the shell flange and the channel flange together;

a first transport support mechanism that allows a frame to support the tube plate unit movably in a front-back direction, an up-down direction, or a direction intersecting the front-back direction; and

a second transport support mechanism that allows the frame to support the channel unit movably in the front-back direction, the up-down direction, or the direction intersecting the front-back direction, independently of the first transport support mechanism, wherein

the sealing work training device enables to fasten and unfasten of the bolts and the nuts on the shell flange and the channel flange; to align position of the tube plate unit and the channel flange with the shell flange or position of the tube plate unit and the partition plate with each other through operation of either one or both of the first transport support mechanism and the second transport support mechanism; and to attach and detach gaskets between the tube plate unit and the shell flange and between the tube plate unit and the channel flange.

4. The sealing work training device of any one of claims 1 to 3, comprising:

sensors that detect axial forces of the bolts that fix the channel flange to the shell flange;

a processing means that calculates an axial force distribution of the bolts from outputs of the sensors; and

a display means that displays a position of the bolts and a distribution graph of the axial forces.

5. The sealing work training device of any one of claims 1 to 4, comprising:

an imaging means that images at least a fastening situation of the bolts;

an editing means that edits images obtained by the imaging means, for each of objects to be imaged or in a time series;

a display means that displays an image group obtained by the editing means; and

a recording means that records either one or both of the images obtained by the imaging means and edit images edited by the editing means.

6. A sealing work training method comprising the steps of:

inserting and removing a tube disposed on a tube plate unit into and from a shell unit;

disposing a gasket between the tube plate unit and a shell flange or removing the gasket lying between the tube plate unit and the shell flange;

engaging or disengaging a partition plate disposed in the
5 channel unit with or from a groove of the tube plate unit;

moving the tube plate unit in a front-back direction, an up-down direction, or a direction intersecting the front-back direction;

moving the channel unit in the front-back direction, the
10 up-down direction, or the direction intersecting the front-back direction;

positioning the channel flange to the shell flange with interposing the tube plate unit between the channel flange and the shell flange or releasing the positioning; and

15 fixing the shell flange and the channel flange together by bolts and nuts or releasing the fixing.

7. A sealing work training method comprising the steps of:

inserting and removing a tube disposed on a tube plate unit
20 into and from a shell unit;

disposing a gasket between the tube plate unit and a shell flange or removing the gasket lying between the tube plate unit and the shell flange;

engaging or disengaging a partition plate disposed in the
25 channel unit with or from a groove of the tube plate unit;

allowing a frame to support the tube plate unit via a first transport support mechanism, to move the tube plate unit in a front-back direction, an up-down direction, or a direction intersecting the front-back direction by the first transport
30 support mechanism;

allowing the frame to support the channel unit via a second transport support mechanism, to move the channel unit in the front-back direction, the up-down direction, or the direction intersecting the front-back direction by the second transport

support mechanism;

positioning the channel flange to the shell flange with interposing the tube plate unit between the channel flange and the shell flange or releasing the positioning; and

5 fixing the shell flange and the channel flange together by bolts and nuts or releasing the fixing.

8. The sealing work training method of claim 6 or 7, further comprising the step of:

10 imparting to the shell flange or the channel flange a marking that suggests coincidence in axis of the shell flange and the channel flange or suggests engagement of the partition plate with the groove of the tube plate unit, at the time of detachment of the shell flange and the channel flange.

15

9. The sealing work training method of any one of claims 6 to 8, further comprising the steps of:

feeding a pressurized gas from a first port into a space part on one hand of the channel part partitioned by the partition plate and keeping the pressurized gas flowing through the tube into a
20 space part on another of the channel unit; and

observing a leakage of the pressurized gas between the channel unit and the tube plate unit or between the shell unit and the tube plate unit.

25

10. The sealing work training method of any one of claims 6 to 9, further comprising the steps of:

detecting axial forces of the bolts that fix the shell flange and the channel flange together;

30 calculating an axial force distribution of the bolts from sensor outputs; and

displaying a distribution graph of the axial forces, in addition to positions of the bolts.

11. The sealing work training method of any one of claims 6 to 10, further comprising the steps of:

imaging at least a fastening situation of the bolts;

5 editing images obtained by an imaging means, for each of objects to be imaged or in a time series;

displaying an image group obtained by an editing means; and

recording either one or both of the images obtained by the imaging means and edit images edited by the editing means.