

DESCRIPTION

TITLE OF INVENTION: FASTENING PRACTICE DEVICE, FASTENING PRACTICE METHOD, FASTENING PRACTICE PROGRAM AND FASTENING PRACTICE SYSTEM

5 TECHNICAL FIELD

[0001]

The present invention relates to a practice technique for experiencing and learning a fastening process of a bolt and a nut with a fastening tool.

10 BACKGROUND ART

[0002]

In a fastening work of bolts and nuts used for fastening components to each other, it is important to apply a force depending on a strength of the components derived from the material, size, etc. of the components and types of bolts and nuts. Excessive application of this force may lead to a damage of the components, a breakage of the bolt, etc., and conversely, the insufficient force may result in loosening of the fastened bolt and nut or may cause release of the fastened components. How the force is applied is affected by worker's experience.

[0003]

Regarding experience of such bolt fastening, a correlation between an axial force of a bolt and a torque value applied to a tool can be experienced with a device having vertically arranged rotation allowing parts with screw holes formed in different diameters and a load cell arranged between the rotation allowing parts, by fastening a bolt penetrating through the load cell (e.g., Patent Literature 1).

CITATION LIST

30 PATENT LITERATURE

[0004]

Patent Literature 1: Japanese Laid-Open Patent Publication No. 2015-90359

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005]

In a fastening work of bolts and nuts, optimum fastening may not necessarily be achieved by simply comprehending a torque value applied through a tool, and it is also important to understand a difference in surface state of the bolts and the nuts. A difference in surface state results in a difference in an axial force acting on the bolt, i.e., a fastening force between the bolts and the nuts. The surface state is, for example, a difference in frictional resistance to a contact surface between the bolt and the nut. When friction occurs between components, the contact surface is subjected to treatment such as applying a lubricant, changing to a bolt and a nut made of a low-resistance material, and coating for reducing resistance; however, the functions and effects of the treatment are not uniform. Unless fastening is performed with such a difference in surface state into consideration, an appropriate fastening state is not achieved, so that there is a problem that the fastening function of the bolt and the nut cannot sufficiently be fulfilled.

20 [0006]

A fastening experience with an actual machine with interposition of a member to be fastened such as a flange is influenced by a thickness and a material of the member to be fastened and therefore has a problem that it is difficult to experience a difference in a fastened state with respect to a difference in surface states of the bolt and the nut.

[0007]

In view of the problems, an object of the present invention is to improve a worker's technique of fastening a bolt and a nut.

30 [0008]

Another object of the present invention is to visualize an influence of surface states of a bolt and a nut on the fastening.

SOLUTION TO PROBLEM

[0009]

To achieve the objects, an aspect of the present invention provides a fastening practice device comprising a plurality of bolts disposed in a manner enabling fastening of the bolts; an axial force sensor detecting an axial force applied to each of the bolts; and
5 a comparison means correlating identification information of the bolts with the detected axial force to compare the detected axial force between the bolts.

To achieve the objects, an aspect of the present invention provides a fastening practice device comprising a plurality of bolts
10 having different thread surface states; an axial force sensor detecting an axial force generated in the bolts due to fastening of nuts with a fastening tool; and a processing means receiving a sensor output from the axial force sensor, correlating identification information including the surface states of the
15 bolts with the detected axial force, and generating a comparative graphic output representative of a magnitude relation of the axial force between the bolts.

[0010]

The fastening practice device may further comprise a display
20 means connected to the processing means, the display means displaying the comparative graphic output received from the processing means.

[0011]

The fastening practice device may comprise a support case
25 supporting the bolts and the axial force sensors stored in the support case, the bolts being arranged in a line, and the processing means may generate the comparative graphic output in which pieces of the identification information are arranged in accordance with the arrangement of the bolts in the support case.

30 [0012]

The fastening practice device may comprise a memory part storing the identification information of the arranged bolts, and the processing means may start reading the identification information of the bolts detected from the memory part with the

detection of the axial force as a trigger so as to generate the comparative graphic output.

[0013]

In the fastening practice device, the identification
5 information may include a torque coefficient indicative of a surface state of the bolts, and the processing means may correlate the torque coefficient with the axial force display of the comparative graphic output to display the torque coefficient.

[0014]

10 In the fastening practice device, the processing means may calculate a fastening torque from the detected axial force and the identification information of the bolts and may generate the comparative graphic output including information indicative of a magnitude relation of the fastening torque between the bolts.

15 [0015]

To achieve the objects, an aspect of the present invention provides a fastening practice method comprising the steps of disposing a plurality of bolts in a manner enabling fastening of the bolts; detecting an axial force applied to each of the bolts
20 by an axial force sensor; and correlating identification information of the bolts with the detected axial force to compare the detected axial force between the bolts.

To achieve the objects, an aspect of the present invention provides a fastening practice method comprising the steps of
25 fastening nuts with a fastening tool to a plurality of bolts having different thread surface states; detecting by an axial force sensor an axial force generated in the bolts due to fastening of the nuts with a fastening tool; acquiring a sensor output of the axial force sensor; and correlating identification information including the
30 surface states of the bolts with information of the axial force and generating a comparative graphic output representative of a magnitude relation of the axial force between the bolts.

[0016]

To achieve the objects, an aspect of the present invention

provides a fastening practice program executed by a computer of a fastening practice device, the fastening practice program operable to drive the computer to execute functions of acquiring an axial force of each of a plurality of bolts disposed in a manner enabling fastening of the bolts by an axial force sensor; and correlating identification information of the bolts with the detected axial force to compare the detected axial force between the bolts.

To achieve the objects, an aspect of the present invention provides a fastening practice program executed by a computer of a fastening practice device, the fastening practice program operable to drive the computer to execute functions of fastening nuts with a fastening tool to a plurality of bolts having different thread surface states; acquiring by an axial force sensor a sensor output of an axial force generated in the bolts due to fastening of the nuts; and correlating identification information including the surface states of the bolts with the axial force and generating a comparative graphic output representative of a magnitude relation of the axial force between the bolts.

[0017]

In the fastening practice program, the fastening practice program may be operable to drive the computer to execute functions of calculating a fastening torque from the detected axial force and the identification information of the bolts, and generating the comparative graphic output including information indicative of a magnitude relation of the fastening torque between the bolts.

[0018]

To achieve the objects, an aspect of the present invention provides a fastening practice system in which fastening of a nut to a bolt is practiced. The fastening practice system comprises a plurality of bolts disposed in a manner enabling fastening of the bolts; an axial force sensor detecting an axial force applied to each of the bolts; and a comparison means correlating identification information of the bolts with the detected axial

force acquired from the axial force sensor to compare the detected axial force between the bolts.

To achieve the objects, an aspect of the present invention provides a fastening practice system in which fastening of a nut to a bolt is practiced. The fastening practice system comprises a fastening practice part including a plurality of bolts and an axial force sensor, the bolts having different thread surface states, the axial force sensor detecting an axial force generated in the bolts due to fastening of nuts with a fastening tool; a processing means connected to the axial force sensor to receive a sensor output, correlating identification information including the surface states of the bolts with the detected axial force, and generating a comparative graphic output representative of a magnitude relation of the axial force between the bolts; and a monitor connected to the processing means to display the comparative graphic output.

ADVANTAGEOUS EFFECTS OF INVENTION

[0019]

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

[0020]

(1) By displaying a comparison image of the axial force among bolts and nuts having different surface states, a trainee can recognize a difference in fastening force.

[0021]

(2) By comparing the difference in the surface state of bolts and nuts, the trainee can learn adjustment skills of the fastening work corresponding to the surface state.

[0022]

(3) The trainee can fasten bolts and nuts with an appropriate fastening force, and the safety of fastened components can be improved.

[0023]

(4) By learning knowledge about the surface state and the fastening skills, bolts and nuts can be selected from a wider range

according to components to be fasted and application conditions such as working environment.

BRIEF DESCRIPTION OF DRAWINGS

[0024]

5 Fig. 1 is a diagram of a configuration example of a fastening practice device according to an embodiment.

 Fig. 2 is a flowchart of an example of a fastening practice process.

 Fig. 3 is a diagram of an example of a comparative graphic.

10 Fig. 4 is a view of an example of a fastening practice system.

 Fig. 5 is a partial cross-sectional view of a configuration example of a practice part.

 Fig. 6 is a plan view of a configuration of an upper surface side of the practice part.

15 Fig. 7 is a view of a configuration example of an appearance of a load cell.

 Fig. 8 is a view of a configuration example of an intermediate plate.

 Fig. 9 is a diagram of a configuration example of a PC.

20 Fig. 10 is a diagram of an example of a database.

 Fig. 11 is a diagram of an example of the comparative graphic.

 Fig. 12 is a flowchart of an example of a fastening practice process.

 Fig. 13 is a diagram of an example of the comparative graphic.

25 Fig. 14 is a flowchart of an example of a fastening practice process.

DESCRIPTION OF EMBODIMENTS

[0025]

[Embodiment]

30 [0026]

 Fig. 1 shows a configuration example of a fastening practice device according to an embodiment. The configuration shown in Fig. 1 is an example, and the present invention is not limited to this configuration.

[0027]

This fastening practice device 2 is an example of a device for experiencing a fastening process of bolts 4 and nuts 6 through a manual fastening work and visually comprehending a difference in a fastened state of bolt between multiple bolts. The fastening practice device 2 includes multiple bolts 4-1, 4-2, ...4-N having different surface states and multiple nuts 6-1, 6-2, ...6-N having the same surface states as the bolts. The fastening practice device 2 also includes sensors 10-1, 10-2, ...10-N, an information processing part 12, and a monitor 14.

[0028]

The bolts 4-1, 4-2, ...4-N and the nuts 6-1, 6-2, ...6-N have identification information set based on a type of the surface state, for example, and are identified by the identification information. The bolts 4-1, 4-2, ...4-N having respective different surface states is disposed on the fastening apprentice device 2, so that fastening of the respective bolts can be experienced and a difference in the surface states can visually be confirmed. The surface states include, for example, formation of a film (coating film) of plating, paint, resin, etc. for providing a function; formation with application of lubricating oil before fastening; a normal surface without coating etc.; or formation with adhesion of rust etc. due to aging or usage environment. A bolt and a nut having the same surface states are combined to perform a fastening practice with a fastening tool 8.

[0029]

The sensors 10-1, 10-2, ...10-N detecting axial force F generated in the axial direction are disposed on or near the bolts 4-1, 4-2, ...4-N. The axial force F is a force generated by fastening the nuts 6-1, 6-2, ...6-N against the bolts 4-1, 4-2, ...4-N and is affected by a torque of fastening of the nuts 6-1, 6-2, ...6-N and a fastening amount of the nuts 6-1, 6-2, ...6-N, as well as the surface state of the bolts 4-1, 4-2, ...4-N. Thus, it is necessary to adjust how the nuts 6-1, 6-2, ...6-N are fastened depending on a difference

in the surface states of the bolts 4-1, 4-2, ...4-N. The fastening practice device 2 provides experience of a degree of fastening of the nuts 6-1, 6-2, ...6-N and a visual recognition of the influence of the degree of the fastening in terms of the difference in the surface states.

[0030]

The information processing part 12 is an example of a processing means of the present disclosure and is an example of a comparing means acquiring detection information of the sensors 10-1, 10-2, ...10-N and generating a comparative graphic for comparing a fastening state of the bolts 4-1, 4-2, ...4-N. The information processing part 12 correlates axial force information from the sensors 10-1, 10-2, ...10-N with the identification information of the bolts 4-1, 4-2, ...4-N and the nuts 6-1, 6-2, ...6-N subjected to the fastening, and generates the comparative graphic of the axial force F of the bolts 4-1, 4-2, ...4-N.

[0031]

The monitor 14 is an example of a display means of the present disclosure displaying the comparative graphic generated by the information processing part 12.

[0032]

The monitor 14 may be, for example, a display device performing display by receiving a signal from an external information processing means or may be a display part of an information processing device integrated with the information processing part 12.

[0033]

Additionally, a fastened member not shown, for example, may be disposed on or near the bolts 4-1, 4-2, ...4-N such that a tensile force (axial force) in the axial direction is applied to the fastened member due to fastening of the nuts 6-1, 6-2, ...6-N. Specifically, instead of allowing the nuts 6-1, 6-2, ...6-N to rotationally move along threads of the bolts 4-1, 4-2, ...4-N due to fastening, the axial force F being pulled in the axial direction may be applied

to the bolts 4-1, 4-2, ...4-N due to the fastening to the fastened member. For this fastened member, for example, a member made of an equivalent material and having the same height may be used so as to make the fastening torques and the fastening heights of the nuts 6-1, 6-2, ...6-N coincident with each other.

[0034]

<Fastening Practice Process>

[0035]

Fig. 2 shows an example of a fastening practice process. This fastening practice process is an example of a fastening practice process method or a fastening practice process program of the present disclosure, and the present invention is not limited to the process procedures and process contents thereof.

[0036]

The information processing part 12 acquires the identification information of the bolts 4-1, 4-2, ...4-N used for a fastening practice (S1). The information processing part 12 may read the identification information with selection of the bolts 4-1, 4-2, ...4-N as an opportunity. For example, the identification information may be read from a database not shown stored in advance in a memory part of the information processing part 12 or may be input by a trainee or a supervisor thereof using an input means. The fastening practice device 2 may acquire the information through communication with an external device.

[0037]

When the nuts 6-1, 6-2, ...6-N are fastened (S2), the respective sensor outputs of the sensors 10-1, 10-2, ...10-N are acquired, and the detected axial force is accumulated (S3).

[0038]

The information processing part 12 correlates the acquired identification information with the axial force F to make them a graphic and generates a comparative graphic output for comparing the axial forces of the bolts 4-1, 4-2, ...4-N (S4).

[0039]

When such a comparative graphic output is generated, the comparative graphic output may be displayed on the monitor 14, for example, or the data thereof may be supplied to an external information processing device etc.

5 [0040]

<Comparative Graphic>

[0041]

Fig. 3 shows an example of a comparative graphic.

[0042]

10 In the comparative graphic shown in Fig. 3, the identification information for identifying the bolts is set on the horizontal axis, and the detected axial force F is set on the vertical axis. The identification information for the bolts 4-1, 4-2, ...4-N may be set as a bolt A, a bolt B, ...a bolt N according to the order of fastening.

15 In this example, the fastening order is the order of fastening performed according to arrangement in the fastening practice device 2, and the bolts 4-1, 4-2, ...4-N are represented as the bolts A, B, ...N, respectively.

[0043]

20 The bolts A and B show detection results in the case of using, for example, the bolt having a bolt surface provided with a highly functional coating that is high lubrication for reducing frictional resistance. The bolt N indicates a detected axial force of a bolt having an ordinary metal surface, for example, without coating or application of lubricating oil etc. While an axial force F_A of the bolt A and an axial force F_B of the bolt B are detected as high values, an axial force F_N of the bolt N is detected as a lower value as compared to the axial forces F_A , F_B .

[0044]

30 Such a difference in axial force represents a fastening force of a bolt and a nut. Thus, it is understood that a stronger fastening force is obtained by using the bolt A or B having a larger detected axial force, while the bolt N having a small detected axial force results in a weaker fastening force as compared to the bolts A and

B. Therefore, it is understood that when the bolt N is used, the nut must be fastened with a larger force.

[0045]

From another point of view, when the fastening strength set
5 for the fastened component is small, fastening is more easily
adjusted by using the bolt A or B that has a small frictional
resistance and that makes it easier to obtain the fastening strength
with respect to the applied torque. Conversely, since a larger
torque is applied to the bolt N in which the fastening strength
10 is hardly obtained, the bolt N makes adjustment of fastening
difficult. Such ease of adjustment of fastening affects the
product safety of the fastened components, variations in quality,
etc. Thus, it is important to experience fastening characteristics
of bolts and nuts used for fastening and to recognize a difference
15 in characteristics from other bolts and nuts, and according to the
present invention, such a practice can be implemented. Moreover,
experiencing the influence of the fastening process from the
difference in the surface state of bolts and nuts can allow a trainee
to recognize that it is important to select the bolt and the nut
20 in consideration of a state of an object to be fastened and a use
environment. Specifically, by experiencing a difference in
fastening properties between a state of a surface having rust etc.
and a state of a surface with rust-proof or rust-preventive coating,
the trainee can experience the importance of selection of the bolt
25 and the nut with awareness of the use environment of the object
to be fastened.

[0046]

<Effects of Embodiment>

[0047]

30 According to this configuration, the following effects can
be obtained.

[0048]

(1) Fastening of nuts can be experienced when the bolts and
the nuts have different surface states, and a difference in axial

force generated by the fastening is shown as a comparative image, so that the experience of such a fastening practice can visually be recognized.

[0049]

5 (2) Adjustment skills for a fastening work can be learned according to the surface state of bolts and nuts.

[0050]

 (3) Since the proper fastening can be performed according to the surface state, a fastening function of a fastened component
10 to be fastened such as a gasket to be fastened can be improved and the safety of the fastened component can be enhanced.

[0051]

 (4) By allowing a trainee to recognize the axial force of fastening of bolts and nuts based on a type of fastened components
15 and working environments, optimum bolts and nuts can be employed from a wider range according to installation conditions.

[0052]

 (5) A trainee can more rapidly learn a fastening process of nuts to bolts, and an expert can improve a degree of skills of the
20 nut fastening work or can make a correction thereof to acquire higher skills.

[0053]

[Example 1]

[0054]

25 <Fastening Practice System 20>

[0055]

 Fig. 4 is a view of an example of a fastening practice system 20. The configuration shown in Fig. 4 is an example, and the present invention is not limited to this configuration.

30 [0056]

 For example, as shown in Fig. 4, the fastening practice system 20 includes a practice part 22 including a plurality of bolts 4-1, 4-2, 4-3, 4-4 having different surface states and load cells 24 detecting strain generated in the bolts, a strain measuring device

26, and a PC (personal computer) 28. In the fastening practice system 20, a fastening practice is performed for comprehension of a fastened state resulting from fastening of nuts 6-1, 6-2, 6-3, 6-4 to the bolts 4-1, 4-2, 4-3, 4-4 having different surface states.

5 [0057]

The practice part 22 is an example of a device for experiencing a fastening work of a nut to a bolt, and the load cells 24 and large portions of the bolts 4-1, 4-2, 4-3, 4-4 are housed inside a housing. On the ceiling side of the practice part 22, screw portions on one end sides of the bolts 4-1, 4-2, 4-3, 4-4 are exposed, and the nuts 6-1, 6-2, 6-3, 6-4 are screwed thereto.

10 [0058]

The strain measuring device 26 is connected to the load cells 24 and is an example of a means for amplifying a detection signal of a strain of a shaft portion of a bolt detected by the load cells 24 and converting the amplified detection signal of the strain into computer readable data. The strain measured by the strain measuring device 26 represents the axial force F.

15 [0059]

The PC 28 is an example of the information processing part 12 of the present disclosure and acquires the axial force F (strain data) from the strain measuring device 26 to generate a comparative image of the bolts 4-1, 4-2, 4-3, 4-4. The PC 28 is, for example, a notebook computer, and includes a main body part 30 having an information processing function and an information input part such as a keyboard, and a monitor 32 displaying a comparative image etc.

20 [0060]

The PC 28 may be any computer as long as the computer can correlate the detected axial force F with the identification information of the bolt and generate a comparative image between the bolts. The PC 28 is not limited to the notebook PC. For example, the PC 28 may have a main body and a monitor separately configured, or on the contrary, may be a portable terminal device in which the monitor and the main body part are integrated.

30

[0061]

<Practice Part 22>

[0062]

Fig. 5 is a partial cross-sectional view of a configuration
5 example of the practice part.

[0063]

The practice part 22 has a storage part 40 inside an exterior
housing, and the storage part 40 stores the bolts 4-1, 4-2, 4-3,
4-4 and the load cells 24 disposed on or near the bolts. The storage
10 part 40 is an example of a support case of the present disclosure
and arranges and supports the bolts 4-1, 4-2, 4-3, 4-4 and the load
cells 24 in a line such that the bolts and the load cells are prevented
from being displaced within the housing part 40 or being detached
to the outside. An intermediate plate 42 on which the bolts 4-1,
15 4-2, 4-3, 4-4 and the load cells 24 are placed at a predetermined
height is disposed in the storage part 40, and is configured to
eliminate the influence of parallelism and unevenness of a floor
etc. on which the practice part 22 is disposed. On the ceiling side
of the storage part 40, a top plate 44 is disposed at a height covering
20 upper surface portions of the load cells 24. This top plate 44 is
provided with opening portions 52 (Fig. 6) for projecting tips of
the bolts 4-1, 4-2, 4-3, 4-4 arranged with the threaded shaft side
facing upward. Threaded shaft portions of the bolts 4-1, 4-2, 4-3,
4-4 have length set such that the nuts 6-1, 6-2, 6-3, 6-4 can be
25 fastened to the portions projecting from the top plate 44.

[0064]

Additionally, the practice part 22 has a portion of a side
surface provided with opening portions 46 through which cables 48
of the load cells 24 are inserted. On the bottom side of the housing,
30 leg portions 50 are formed on both left and right end sides for
maintaining the intermediate plate 42 at a predetermined height.
The leg portions 50 may have threaded holes formed for fixation
to a bottom plate member or a measuring device not shown, for example.
By fixing the practice part 22, a trainee can more easily perform

a fastening work, and unnecessary vibration, swinging, or variation in the fastening direction can be reduced at the time of fastening of the nut, so that variation in bolt strain detection hardly occurs.
[0065]

5 For example, as shown in Fig. 6, the opening portions 52 formed in the top plate 44 of the practice part 22 have an opening width W1 made larger than a diagonal dimension W2 of the nuts 6-1, 6-2, 6-3, 6-4. Thus, in the nut fastening practice, the nuts 6-1, 6-2, 6-3, 6-4 are moved inside the opening portions 52 with the fastening
10 tool 8 and are fastened with the end surfaces of the nuts brought into contact with the upper surface portion sides of the load cells 24. Thus, the top plate 44 may be made thinner than the width in the longitudinal direction of the nuts 4-1, 4-2, 4-3, 4-4, or the width W1 of the opening portions 52 may be set to a size allowing
15 insertion of the fastening tool 8.
[0066]

 The top plate 44 is in contact with the upper surface sides of the load cells 24 to prevent displacement in the storage part 40 and detachment from the storage part 40. The top plate 44 is
20 fixed to a housing side surface portion or the leg portions 50 by screws disposed at four corners, for example. The top plate 44 is disposed in a detachable manner as needed so as to dispose or exchange the bolts 4-1, 4-2, 4-3, 4-4 and the load cells 24 used for practice.
25 [0067]

 To fix the positions at which the load cells 24 are disposed, for example, a support piece etc. not shown may be formed on the top plate 44 and brought into contact with the side surfaces of the load cells 24.

30 [0068]

<Load Cell 24>

[0069]

 The load cell 24 shown in Fig. 7 is formed into a cylindrical shape, for example, and includes an exterior housing 54 on the curved

surface side and surface portions 55 on the top and bottom surface sides. The load cell 24 includes a through-hole 56 formed in a central portion and a contact part 58, the through-hole 56 allows an object to be measured to penetrate in the through-hole 56, and
5 the contact part 58 has a predetermined width and is formed on inner circumferential edges of the surface portions 55 along the through-hole 56.

[0070]

As described above, the through-hole 56 allows the object to
10 be measured, i.e., one of the bolts 4-1, 4-2, 4-3, 4-4 to penetrate in the through-hole 56, and the through-hole 56 then covers the circumferential surface of the threaded shaft thereof. An opening width W3 of the through-hole 56 may be a dimension not allowing displacement of the bolt inside, for example, and is set equal to
15 or slightly larger than the nominal diameter of the bolts 4-1, 4-2, 4-3, 4-4.

[0071]

The contact part 58 is, for example, a cylindrical strain generating body arranged along the through-hole 56 and includes
20 a strain gauge in a portion not shown. The contact part 58 is deformed when the upper surface side is pressed by one of the nuts 6-1, 6-2, 6-3, 6-4 fastened to the bolt. The internal strain gauge detects the deformation (strain), and a voltage value corresponding to the amount of deformation is output. The strain of the contact
25 part 58 is equivalent to the strain generated in the bolt when the bolt and the nut are fastened via a fastened member, and the axial force F acting in the bolt is measured from the voltage value of the strain gauge.

[0072]

30 A formation width W4 of the contact part 58 is, for example, a width allowing contact with the nut and is set equal to the diagonal distance W2 of the nut.

[0073]

<Intermediate Plate 42>

[0074]

In the intermediate plate 42 shown in Fig. 8, for example, opening portions 60 are formed at the positions at which the bolts are disposed. To the opening portions 60, for example, the head portions 62-1, 62-2, 62-3, 62-4 of the bolts 4-1, 4-2, 4-3, 4-4 are fitted so that the threaded shaft portions are projected upward. The opening portions 60 are formed into a hexagonal shape to restrain the bolts from turning due to the nut fastening work while preventing the bolts from being detached when the head portions 62-1, 62-2, 62-3, 62-4 are fitted thereto. The formation interval of the opening portions 60 is set wider than at least the width of the load cells 24 and is set such that the nut fastening work is easily performed to the adjacent bolts.

[0075]

Two through-holes 63 are formed in the intermediate plate 42 in accordance with a formation position of each of the opening portions 60, for example. The through-holes 63 are holes for disposing supporting components not shown, and the load cells 24 can fixedly be supported by bringing the supporting components into contact with exterior portions of the load cells 24. The supporting components may be, for example, shaft components or screw components that can be engaged with the exterior housings of the load cells 24.

[0076]

25 <PC 28>

[0077]

Fig. 9 shows a configuration example of a PC. The PC 28 has a function of storing the identification information of the bolts 4-1, 4-2, 4-3, 4-4 and the detected axial force F , and a function of correlating these pieces of information with each other to generate a comparative graphic.

[0078]

The PC 28 includes, for example, a processor 64, a memory part 66, an input operation part 68, a communication part 70, and an

input/output part (I/O) 72.

[0079]

The processor 64 performs an arithmetic processing for executing an OS (operating system) and a fastening practice program in the memory part 66. This arithmetic processing includes acquisition of axial force information from the strain measuring device 26 and reading of the input identification information of bolts and nuts, as well as a comparative graphic generation process, etc.

10 [0080]

The memory part 66 is used for storing the OS, the fastening practice program, the identification information, the axial force information, etc., and includes a ROM (read only memory) and a RAM (random access memory). The memory part 66 is implemented by using a storage device such as a hard disk and a semiconductor memory capable of retaining storage contents. A database (DB) 74 for managing the input identification information, the detected axial force information, etc. is formed in the memory part 66.

[0081]

20 The input operation part 68 is an example of an operation means used for information input etc., and, for example, a keyboard and a mouse are used.

[0082]

The communication part 70 is controlled by the processor 64 and is used for wireless connection with the strain measuring device 26, wireless connection with an external device not shown, and Internet connection.

[0083]

The I/O 72 is controlled by the processor 64, is used for input and output of control information, and is connected to the strain measuring device 26 and the monitor 32.

[0084]

<Database 74>

[0085]

Fig. 10 shows a configuration example of a database.

[0086]

In the memory part 66 of the PC 28, for example, as shown in Fig. 10, the database 74 is formed for storing the identification information of bolts used in the fastening practice, the detected axial force information, etc. For example, pieces of the identification information 76 registered in the database 74 are bolt names, coating information indicative of a surface state, age information, torque coefficients, dimensions, etc. The identification information 76 may be input by a trainee or a supervisor when the fastening practice is performed, for example, or may be read out from preset information.

[0087]

The database 74 may store a detected axial force value and a calculated torque value as practice information 78, for example.

[0088]

The memory part 66 of the PC 28 may comprise a worker database including, for example, information on workers performing the fastening practice and information on supervisors. This worker database may store, for example, ID (identification) information, company name information, worker name information, dates and times, types of bolts, the number of times, etc. in terms of the performed fastening practices, and may be correlated with the database 4 described above. This worker database may be utilized as information indicative of whether a worker has experience of fastening when bolts and nuts used for an actual machine are selected, for example.

[0089]

Fig. 11 shows an example of a comparative graphic generated based on the detected axial force. Graph shapes and numerical values shown in Fig. 11 are examples, and the present invention is not limited to these contents.

[0090]

In the comparative graphic shown in Fig. 11, as described above,

the horizontal axis indicates the bolt identification information and the vertical axis indicates the detected axial force F . This example shows the case of the fastening practice performed with the fastening torque values of the nuts 6-1, 6-2, 6-3, 6-4 set within a predetermined range so as to compare the influence of the surface state on the fastening axial force. The comparative graphic also includes information on such fastening torque. For example, torque coefficient information indicative of a surface state is displayed as the identification information of each of the bolts near each axial-force graph display.

[0091]

The detected values of the axial force F of the bolt shown in the comparative graphic may be arranged according to the order in which the fastening practice was performed, or the results may be displayed in accordance with the arrangement of the bolts 4-1, 4-2, 4-3, 4-4.

[0092]

As a result, differences in the surface state of the bolt A, the bolt B, the bolt C, and the bolt D fastened with the nut at the same torque are represented in the comparative graphic as differences in the axial force F indicative of the strength of the fastening.

[0093]

<Fastening Process>

[0094]

Fig. 12 shows an example of a fastening practice process. This fastening practice process is an example of a fastening practice method or a fastening practice program of the present disclosure.

[0095]

In the fastening practice process, the trainee (worker) or the supervisor selects the bolts 4-1, 4-2, 4-3, 4-4 and the nuts 6-1, 6-2, 6-3, 6-4 used in the practical practice (S11) and disposes them on the practice part 22. After the bolts and the nuts are

selected, the identification information of the bolts and the nuts is input to the PC 28 (S12). The input of the identification information may be performed by keying information indicated on main body portions of the bolts and the nuts or on a storage means of the bolts and the nuts, for example, or by capturing barcode information etc. Alternatively, a combination of pluralities of bolts and nuts used in the practice may be set in advance, and identification information linked with combination information may be stored in the database 74.

10 [0096]

For preparation of the practice, an operation strength applied by a tool used for fastening the nuts, i.e., a fastening torque value, is set (S13). The fastening torque value is set in accordance with the nominal diameter of the bolts used for the practice, for example. This torque value may be set to different values depending on the size of the nominal diameter so as not to destroy the bolts by fastening, for example. In the fastening practice, for example, a torque wrench may be used as a tool with which the fastening torque can be measured, or a normal spanner etc. may be used. If the torque value cannot be measured with a tool used, for example, a fastening motion may be set rather than setting a specific fastening torque value. For this fastening motion, the strength (fastening torque) may be applied to a spanner for nominal designation of thread by using, as a guide, for example, a utilized technique such as "strength by wrist only is applied", "strength by elbow and down is applied" and "strength by shoulder and down is applied" (VALQUA HAND BOOK Technical Data: Revised September 30, 2010, published by Nippon Valqua Industries, Ltd., p.116).

30 [0097]

When the fastening process is performed based on the set condition (S14), the PC 28 acquires the sensor output (S15). For example, for preparation of generation of the comparative graphic, the PC 28 matches the information of the detected axial force F

and the identification information of the load cell 24 that is the sensor having detected the axial force F (S16). Through this matching process, the PC 28 correlates the identification of the bolts used for the practice of fastening, the order of fastening, and the detected axial force F with each other.

[0098]

The PC 28 reads the identification information of the bolts and the nuts and correlates the identification information with the detected axial force F (S17). In this process, information related to the axial force F is correlated with information used for generation of the comparative graphic, such as the type of coating and the information of the torque coefficient of the bolts and nuts.

[0099]

The acquisition of the axial force F and the matching with the identification information are performed until the fastening practice is completed (NO of S18). When the fastening practice is completed (YES of S18), a comparative graphic of the axial force is generated by using the correlated information, and the generated comparative graphic is displayed on the monitor 32 (S19).

[0100]

The comparative graphic may be arranged in the order of acquisition of the axial force or may be arranged in a predetermined order. The comparative graphic generation process is not limited to the case of executing the process after all the fastening practices are completed, and real-time graphic generation may be triggered by detection of the axial force F and the display contents thereof may be updated.

[0101]

<Effects of Example 1>

[0102]

(1) Since the fastening of the nuts can be experienced in the case that the bolts and the nuts have different surface states, and the difference in the axial force generated by this fastening

can be shown by a comparative image, the experience of such fastening practice can visually be recognized.

[0103]

(2) Adjustment skills of fastening work can be learned
5 according to the surface state of the bolts and the nuts.

[0104]

(3) By continuously performing the fastening practice of multiple bolts with a common fastening torque, a difference in the fastening state due to the surface state can be learned, and a
10 difference in the fastening state can visually be recognized by using the detected axial force F .

[0105]

(4) The practice part 22 allows the top plate 44 of the housing part to be attached and detached, has a configuration in which the
15 head portions of the bolts 4-1, 4-2, 4-3, 4-4 are engaged with and supported by the intermediate plate 42 in the storage part, and thus provides an improved ability to replace the bolts 4-1, 4-2, 4-3, 4-4.

[0106]

(5) since the intermediate plate 42 is attachable to and
20 detachable from the housing, replacement with bolts and nuts different in nominal diameter can easily be performed, so that bolts and nuts can be replaced with those having different sizes, and thus, the convenience of the fastening practice device is enhanced.

25 [0107]

(6) Since the practice part 22 is provided with the leg portions 50 to separate the intermediate plate 42 on which the bolts and the load cells 24 are placed from an installation surface of the practice part 22, the influences of inclination, vibrations,
30 etc. of the installation surface can be reduced at the time of the fastening process.

[0108]

(7) By storing the load cell 24 in the storage part 40 of the practice part 22 and supporting the upper end portion 55 of the

load cell 24 by contact with the top plate 44, the load cell 24 can be restrained from being displaced and can be prevented from being pressed and damaged due to contact with the fastening tool 8 etc.

5 [0109]

[Example 2]

[0110]

Fig. 13 shows a comparative graphic according to Example 2.

[0111]

10 In the comparative graphic shown in Fig. 13, a torque value calculated based on the detected axial force F is displayed. In Example 2, for comprehension of the influence of the fastening process due to a difference in the surface state of the bolts and the nuts, for example, a process of calculating a torque necessary
15 for fastening is performed with respect to the detected axial force F. The relationship between the axial force F and the fastening torque T satisfies the following equation:

$$T=kFd \quad \dots(1)$$

where k is a torque coefficient indicative of a surface state, and
20 d is a nominal diameter of a bolt.

[0112]

In the fastening process, the torque is calculated from the detected axial force F in the case that the same fastening amount is achieved for the bolt A, the bolt B, the bolt C, and the bolt
25 D. In the fastening process, for example, the number of times of fastening is counted and the fastening the same number of times for all the bolts is performed, so that the nut passes through the same number of threads and the same fastening amount can be achieved. If the fastening amount is made identical, the axial force acting
30 on the bolt has a similar value.

[0113]

In the comparative graphic, for example, the identification information of the bolt is displayed on the horizontal axis and the calculated torque value is displayed on the vertical axis. In

this comparative graphic, the bolt A and the bolt B show examples of calculation results in the case that low-friction surface coating is applied, for example; the bolt C shows an example of calculation results in the case that lubricating oil is applied, for example; and the bolt D shows an example of calculation results in the case without coating. The coating of the bolt A and the bolt B has a smaller value of the torque coefficient as compared to the bolt C and the bolt D. Considering the axial force result from an equivalent fastening amount, the larger and smaller values of the torque coefficient due to differences in the surface state make the value of the fastening torque smaller in the case of using the bolt A and the bolt B and the value of the fastening torque larger in the case of the bolt C and the bolt D.

[0114]

From the results of this comparative graphic, it can be learned that a difference in the surface state results in a large difference in the torque value required for fastening. Specifically, the results represent that necessary fastening can be performed by applying a small fastening torque in the case of a bolt provided with a high-performance coating having a small torque coefficient, while application of a large fastening torque is required for the necessary fastening of a bolt having a surface state with a large torque coefficient.

[0115]

In the comparative graphic, the torque coefficient information may be displayed as the identification information of the bolts, or the value of the set axial force F may be displayed.

[0116]

<Practice Process of Example 2>

[0117]

Fig. 14 shows an example of a fastening practice process.

[0118]

In the fastening practice, bolts and nuts are selected (S21) and disposed on the practice part 22, and the identification

information of the bolts and the nuts is input to the PC 28 (S22). After the preparation for the fastening process is completed, the fastening process is performed until the nut reaches a set position, as a predetermined fastening amount (S23). The PC 28 acquires the
 5 sensor output of the axial force F due to the fastening (S24), reads the torque coefficient and the nominal diameter of the bolt from the database 74, and calculates the fastening torque (S25). Then, the value of the detected axial force F, the calculated torque value T, and the identification information are correlated (S26).

10 [0119]

The detection of the axial force F and the calculation process of the torque value T are repeated until the fastening process is completed (NO of S27). When the fastening process is completed (YES of S27), the comparative graphic is generated and displayed on the
 15 monitor 32 (S28).

[0120]

In Example 2, for example, when a torque wrench is used as the fastening tool 8, the detected torque value of the torque wrench may be acquired by the PC 28 to make comparison between the detected
 20 torque value and the calculated torque value T.

[0121]

<Effects of Example 2>

[0122]

The fastening torque value is calculated by using the detected
 25 axial force and a comparison is made between the bolts, so that a degree of strength of fastening can be experienced in accordance with the difference in the surface state of the bolts, and since the comparison result is displayed, the degree of strength can visually be recognized.

30 [0123]

[Modification Examples]

[0124]

Modification examples of the embodiment and examples described above will hereinafter be listed.

[0125]

(1) In the embodiment or examples described above, the fastening process of the bolts of which identification information is known is described, and the identification information indicates the surface state of the thread such as the type of coating and torque coefficient; however, the embodiment or examples is not limited thereto. Two or more types of bolts and nuts with different thread surface states may be selected for performing the practice to experience the fastening work thereof and compare the detected axial force. According to such a configuration, a trainee can learn a fastening technique for nuts having different surface states, can comprehend the fastening state of the selected bolts and nuts and can compare the influence of the surface state etc.

[0126]

(2) In the fastening practice, a temperature condition may be added to the fastening practice. For example, the fastening practice device 2 may include a heating means and a temperature detecting means in the housing and may heat the bolts 4-1, 4-2, ...4-N to detect the axial force F with respect to a predetermined temperature condition. In the fastening practice process, for example, one or more temperature conditions may be set, and the axial force may be compared between the bolts with the temperature conditions taken into consideration. By performing the fastening practice during heating, the trainee can experience a change in the surface state corresponding to the temperature condition. In the selection of bolts/nuts, the trainee can also learn the importance of considering the thermal characteristics with respect to the type of coating.

[0127]

(3) In the embodiment and examples, the comparative graphic correlating the axial force F with the identification information has been described; the embodiment and examples are not limited thereto. For example, in the comparative graphic, a comparison result of evaluation information may be displayed to indicate

whether the detected axial force has a sufficient value between multiple bolts. This comparative graphic may include, for example, information of the detected axial force F together with information of evaluation criteria and evaluation information. For example, the PC 28 may store a reference axial force serving as a threshold value of evaluation in the memory part 66 to evaluate the detected axial force in generation of the comparative graphic and may generate the evaluation information representing the evaluation result with graphs, characters, numerical values, etc. In addition to the evaluation information, the PC 28 may also display advice information indicating insufficient or excessive axial force values and suggesting an increase or a decrease in the fastening torque corresponding thereto.

[0128]

(4) In the embodiment, the axial force is detected by fastening only the bolts and nuts; however, the embodiment is not limited thereto. In the fastening practice device of the present invention, for example, a flange or a gasket may be interposed as in the actual device to be fastened, the flange and the gasket may be fastened with a bolt and a nut, and the axial force of the bolt may be detected in such a state. In this case, to detect the axial force of the bolt, a sensor other than the load cell 24 may be used. Such a configuration can allow the worker to experience the influence of the difference in the surface state of the bolt together with the influence due to the material and dimensions of the flange and the gasket and can give the worker recognition through the comparative graphic.

[0129]

(5) In the fastening process of the present invention, for example, a torque may be applied until any of the bolts is broken, and the axial force F at the time of breakage of any of the bolts may be compared. According to such a practice, the trainee can experience the ease of fastening due to a difference in the surface state and the importance of the fastening work corresponding to

the surface state.

[0130]

As described above, the most preferable embodiments etc. of the present invention have been described. The present invention is not limited to the above description. Various modifications and changes can be made by those skilled in the art based on the spirit of the invention described in claims or disclosed in description of embodiments. Such modifications and changes obviously fall within the scope of the present invention.

10 INDUSTRIAL APPLICABILITY

[0131]

According to the present invention, for a plurality of bolts having different surface states, the identification information indicative of the surface states is correlated with the detected axial force of the fastening, so that a trainee can experience the magnitude relation of the axial force between the bolts and visually recognize the influence thereof, and that improvements are achieved in the selection of bolts according to a surface state difference and in the bolt fastening skill.

20 REFERENCE SIGNS LIST

[0132]

- 2 fastening practice device
- 4, 4-1, 4-2, ...4-N bolt
- 6, 6, 6-2, ...6-N nut
- 25 8 fastening tool
- 10, 10-1, 10-2, ...10-N sensor
- 12 information processing part
- 14, 32 monitor
- 20 fastening practice system
- 30 22 practice part
- 24 load cell
- 26 strain measuring device
- 28 PC
- 30 main body part

	40	storage part
	42	intermediate plate
	44	top plate
	46, 52, 60	opening portion
5	48	cable
	50	leg portion
	54	exterior housing
	55	surface portion
	56, 63	through-hole
10	58	contact part
	60	opening portion
	62	head portion
	64	processor
	66	memory part
15	68	input operation part
	70	communication part
	72	input/output part (I/O)
	74	database DB
	76	identification information
20	78	practice information

CLAIMS

1. A fastening practice device comprising:
a plurality of bolts disposed in a manner enabling fastening
5 of the bolts;

an axial force sensor detecting an axial force applied to each
of the bolts; and

a comparison means correlating identification information of
the bolts with the detected axial force to compare the detected
10 axial force between the bolts.

2. A fastening practice device comprising:

a plurality of bolts having different thread surface states;

an axial force sensor detecting an axial force generated in
15 the bolts due to fastening of nuts with a fastening tool; and

a processing means receiving a sensor output from the axial
force sensor, correlating identification information including the
surface states of the bolts with the detected axial force, and
generating a comparative graphic output representative of a
20 magnitude relation of the axial force between the bolts.

3. The fastening practice device according to claim 2,
further comprising a display means connected to the processing means,
the display means displaying the comparative graphic output
25 received from the processing means.

4. The fastening practice device according to claim 2 or
3, comprising a support case supporting the bolts and the axial
force sensors stored in the support case, the bolts being arranged
30 in a line, wherein

the processing means generates the comparative graphic output
in which pieces of the identification information are arranged in
accordance with the arrangement of the bolts in the support case.

5. The fastening practice device according to any one of claims 2 to 4, comprising a memory part storing the identification information of the arranged bolts, wherein

the processing means starts reading the identification
5 information of the bolts detected from the memory part with the detection of the axial force as a trigger so as to generate the comparative graphic output.

6. The fastening practice device according to any one of
10 claims 2 to 5, wherein

the identification information includes a torque coefficient indicative of a surface state of the bolts, and wherein

the processing means correlates the torque coefficient with the axial force display of the comparative graphic output to display
15 the torque coefficient.

7. The fastening practice device according to any one of claims 2 to 6, wherein

the processing means calculates a fastening torque from the
20 detected axial force and the identification information of the bolts and generates the comparative graphic output including information indicative of a magnitude relation of the fastening torque between the bolts.

25 8. A fastening practice method comprising the steps of:
disposing a plurality of bolts in a manner enabling fastening of the bolts;

detecting an axial force applied to each of the bolts by an axial force sensor; and

30 correlating identification information of the bolts with the detected axial force to compare the detected axial force between the bolts.

9. A fastening practice method comprising the steps of:

fastening nuts with a fastening tool to a plurality of bolts having different thread surface states;

detecting by an axial force sensor an axial force generated in the bolts due to fastening of the nuts with a fastening tool;

5 acquiring a sensor output of the axial force sensor; and
 correlating identification information including the surface states of the bolts with information of the axial force and generating a comparative graphic output representative of a magnitude relation of the axial force between the bolts.

10

10. A fastening practice program executed by a computer of a fastening practice device, the fastening practice program operable to drive the computer to execute functions of:

 acquiring an axial force of each of a plurality of bolts
15 disposed in a manner enabling fastening of the bolts by an axial force sensor; and

 correlating identification information of the bolts with the detected axial force to compare the detected axial force between the bolts.

20

11. A fastening practice program executed by a computer of a fastening practice device, the fastening practice program operable to drive the computer to execute functions of:

 fastening nuts with a fastening tool to a plurality of bolts
25 having different thread surface states;

 acquiring by an axial force sensor a sensor output of an axial force generated in the bolts due to fastening of the nuts; and

 correlating identification information including the surface states of the bolts with the axial force and generating a comparative
30 graphic output representative of a magnitude relation of the axial force between the bolts.

12. The fastening practice program according to claim 11, wherein the fastening practice program is operable to drive the

computer to execute functions of:

calculating a fastening torque from the detected axial force and the identification information of the bolts, and

generating the comparative graphic output including
5 information indicative of a magnitude relation of the fastening torque between the bolts.

13. A fastening practice system in which fastening of a nut to a bolt is practiced, the fastening practice system comprising:

10 a plurality of bolts disposed in a manner enabling fastening of the bolts;

an axial force sensor detecting an axial force applied to each of the bolts; and

a comparison means correlating identification information of
15 the bolts with the detected axial force acquired from the axial force sensor to compare the detected axial force between the bolts.

14. A fastening practice system in which fastening of a nut to a bolt is practiced, the fastening practice system comprising:

20 a fastening practice part including a plurality of bolts and an axial force sensor, the bolts having different thread surface states, the axial force sensor detecting an axial force generated in the bolts due to fastening of nuts with a fastening tool;

a processing means connected to the axial force sensor to
25 receive a sensor output, correlating identification information including the surface states of the bolts with the detected axial force, and generating a comparative graphic output representative of a magnitude relation of the axial force between the bolts; and

a monitor connected to the processing means to display the
30 comparative graphic output.