

DESCRIPTION

Title of Invention:

GASKET, CONTROL METHOD AND SYSTEM THEREFOR, AND PROGRAM

5 Technical Field

[0001] The present disclosure relates to a gasket used, for example, for tightening a piping system and a technique for controlling the gasket.

Background Art

10 [0002] For tightening a gasket, tightening torque applied to a flange by a bolt or a bolt axial force value has been traditionally used. The tightening torque and the bolt axial force value are information related to bolt tightening to tighten between flanges.

15 [0003] As for the gasket tightening, a system has been known which uses a tightening surface pressure corresponding to the gasket and a type of internal fluid, a plurality of tightening forces, information on a bolt in order to grasp tightening torque (e.g., refer to Patent Literature 1). As for
20 bolt tightening, a technique of creating data on strain on the bolt and making a state in which the bolt is tightened visible has been known (e.g., refer to Patent Literature 2).

Citation List

25 Patent Literature

[0004] Patent Literature 1: JP 2014-225219 A
Patent Literature 2: JP 2015-141345 A

Summary of Invention

30 Technical Problem

[0005] Incidentally, the reason why tightening torque and an axial force value of a bolt are used for gasket tightening control includes the following: the bolt is a means for tightening between flanges; and a tightening force applied

from the bolt can be easily found by measuring bolt strain.

[0006] However, as a result of examining a relationship between the bolt, the flange and the gasket very carefully, the tightening force of the bolt acts on the flange, and acts
5 on the gasket only indirectly through the flange. That is, the flange is subject to a load due to the tightening of the bolt, and the load merely acts on the gasket through the flange. The torque value and the axial force value acting on the bolt are loads acting on a part of the flange, and do not represent a
10 surface pressure acting on the gasket.

[0007] In light of the above, the gasket tightening control has the following issues.

[0008] a) A torque value and an axial force value acquired from a bolt are information on the bolt, and it cannot be said
15 that a surface pressure to which the gasket is subjected is measured.

[0009] b) In view of the surface pressure applied to the gasket from a flange, the torque value and the axial force value of the bolt are merely indirect information, and are
20 merely rough standards of the surface pressure.

[0010] c) The torque value and the axial force value of the bolt are influenced by a state in which the bolt and the flange are tightened, and this fluctuation tendency cannot be ignored.

[0011] In a case where the surface pressure on the gasket is estimated based on the torque value and the axial force value measured by a torque wrench or a bolt axial force meter, the relationship between the surface pressure (= estimated surface pressure) applied to the gasket and the surface
25 pressure (= actual surface pressure) to which the gasket is actually subjected under the influence of the state in which the bolt and the flange are tightened is as follows:

 estimated surface pressure $\neq$ actual surface pressure.

 Even if the measurement accuracy of the torque value and

the axial force value is increased, the estimated surface pressure and the actual surface pressure on the gasket do not match. The surface pressure to which the gasket is subjected cannot be perceived.

5 [0012] Regarding such issues, the inventor has obtained findings that a change in the shape of a gasket depends on a load applied from between flanges and it is beneficial to observe the shape change in order to control the gasket tightening. Patent Literatures 1 and 2 do not disclose or
10 suggest such issues. The configuration disclosed in Patent Literatures 1 and 2 cannot solve such issues.

[0013] Therefore, an object of the present disclosure is to directly observe a change in the shape of a gasket that is subjected to a load between flanges and to use the observation
15 result for the gasket tightening control to improve the gasket and a technique for controlling the gasket based on the issues and findings described above.

Solution to Problem

20 [0014] In order to achieve the above object, a gasket according to one aspect of the present disclosure includes an outer cut formed in a non-restrained portion adjacent to a restrained portion restrained between flanges, in which a shape of the outer cut changes due to a load applied to the
25 restrained portion.

[0015] In order to achieve the above object, a control method according to one aspect of the present disclosure includes a step of placing, between flanges, a gasket including an outer cut of which a shape changes in response to
30 a load applied, a step of applying a load to the gasket restrained between the flanges, and a step of measuring the shape of the outer cut changed in response to the load applied, in which tightening the gasket is controlled based on the shape.

[0016] In order to achieve the above object, a control system according to one aspect of the present disclosure includes a measurement unit configured to measure a shape of an outer cut provided in a gasket, a control server configured to generate control information for controlling tightening between flanges based on the shape, and an information presentation unit configured to present the control information.

[0017] In order to achieve the above object, a program according to one aspect of the present disclosure is a program for causing a computer to implement a function of acquiring shape information of an outer cut provided in a gasket that is restrained between flanges and is subjected to a load, a function of generating control information for controlling tightening of the gasket based on the shape information, and a function of presenting the control information.

Advantageous Effects of Invention

[0018] According to the present invention, any one of the following effects can be obtained.

[0019] (1) Strain is caused in the gasket due to the load applied to the gasket from between the flanges, the strain can be made apparent as the shape change of the outer cut of the gasket, and the strain can be made visible as the shape change of the outer cut and easily recognized.

[0020] (2) In a case where the shape change of the outer cut is observed, the load applied to the gasket can be easily perceived without the influence of a state in which the bolt is tightened, so that the gasket tightening control can be appropriately performed.

[0021] (3) If the load applied to the gasket is estimated from the shape change of the outer cut, the load is equivalent to the actual surface pressure applied to the gasket from the flange, and it is possible to increase the accuracy of the

gasket control such as tightening control and gasket life prediction.

[0022] (4) Since the shape change of the outer cut and the load estimated from the shape change reflect directly a state in which the gasket is tightened unlike the torque value and the axial force value of the bolt, the accuracy of the gasket control can be increased irrespective of the skill of an operator by observing such a shape change and estimating the load.

[0023] Other objects, features, and advantages of the technology of the present disclosure will become more apparent from the accompanying drawings and the exemplary embodiments.

Brief Description of Drawings

[0024] Fig. 1A is a plan view illustrating a gasket according to a first embodiment, and Fig. 1B is an enlarged perspective view illustrating an IB part of Fig. 1A.

Fig. 2 is a diagram illustrating a flange tightening portion according to the first embodiment.

Fig. 3 is a diagram illustrating an end surface cut along the line III-III in Fig. 2.

Fig. 4A is an enlarged view illustrating an outer cut portion, and Fig. 4B is a view illustrating a shape change of the outer cut.

Figs. 5A and 5B are views illustrating modifications to the outer cut.

Fig. 6 is a diagram illustrating a gasket control system according to the first embodiment.

Fig. 7 is a diagram illustrating a gasket control database.

Fig. 8A is a diagram illustrating a comparative example, and Fig. 8B is a diagram illustrating setting of a shape observation portion.

Fig. 9 is a diagram illustrating a relationship between a

shape change and a load in a comparative example.

Fig. 10 is a diagram illustrating a relationship between a shape change and a load in an example.

5 Description of Embodiments

[0025] [First Embodiment]

A of Fig. 1 illustrates a gasket 2 according to the first embodiment. The configuration illustrated in the drawings is an example, and the present disclosure is not limited to such a configuration. In Fig. 1, an X-axis, a Y-axis, and a Z axis are also illustrated as an example.

[0026] The gasket 2 is, for example, a sheet gasket processed with a material made by combining polytetrafluoroethylene tetrafluoroethylene resin (polytetrafluoroethylene: PTFE) and a filler. The gasket 2 may be made of a resin material other than PTFE or a rubber material.

[0027] The gasket 2 has a restrained portion 2-1 on the inner diameter side, and a non-restrained portion 2-2 on the outer diameter side. The restrained portion 2-1 is a region that contacts flanges 16-1 and 16-2 (Figs. 2 and 3) and is subjected to a load F from between the flanges 16-1 and 16-2. On the other hand, the non-restrained portion 2-2 is a region that does not contact the flanges 16-1 and 16-2.

[0028] The non-restrained portion 2-2 has outer cuts 4-1, 4-2, 4-3, and 4-4 (hereinafter, simply referred to as an outer cut 4 when no specific position is designated) formed therein. Each outer cut 4 is a cutout portion formed by partially cutting the outermost edge portion of the gasket 2 to be opened, and is a means for facilitating detection of a change in the shape of the gasket 2. Therefore, each outer cut 4 constitutes a shape observation portion with which to observe the shape change of the gasket 2 in a case where the load F is applied to the restrained portion 2-1.

[0029] <Outer cut 4>

B of Fig. 1 illustrates the outer cut 4 at an IB part of A of Fig. 1 in an enlarged manner. The outer cut 4 is a vertical groove that is cut out by a constant length L from the peripheral surface of the outermost edge portion of the gasket 2 toward the center direction and is opened with a width W, and the vertical groove penetrates the upper and lower surfaces of the gasket 2. Therefore, the outer cut 4 has a vertical surface portion 6 and opposed surface portions 8-1 and 8-2 in the non-restrained portion 2-2 of the gasket 2. The vertical surface portion 6 is exposed toward the peripheral surface direction of the gasket 2, and the opposed surface portions 8-1 and 8-2 having a length L and a height D face each other with the constant width W therebetween. The height D is a thickness of the gasket 2 before deformation. That is, the opening width between the opposed surface portions 8-1 and 8-2 of the outer cut 4 can be measured.

[0030] In order to detect a shape change of the gasket 2, the outer cuts 4 may be provided in a plurality of positions of the gasket 2. In order to avoid the influence of elastic interaction received from the flanges 16-1 and 16-2 and increase the accuracy of observation of the shape change, it is preferable that the positions at which to provide the outer cuts 4 are balanced. In this embodiment, the outer cuts 4 are provided at four positions on the X-axis and the Y-axis, which allows a shape change to be observed in a wide range.

[0031] <Flange tightening portion 12>

Fig. 2 illustrates the flange tightening portion 12 including the gasket 2 in a cut-away manner. The flange tightening portion 12 is an example, and the present disclosure is not limited to the configuration illustrated in Fig. 1.

[0032] The flange tightening portion 12 includes the flange 16-1 on a pipeline 14-1 side, the flange 16-2 (Fig. 3)

on a pipeline 14-2 side, the gasket 2, and a plurality of bolts 18 and nuts 20.

[0033] The flange 16-1 is integrally formed with an end surface of the pipeline 14-1, and similarly, the flange 16-2 is integrally formed with an end surface of the pipeline 14-2. The flanges 16-1 and 16-2 have a diameter larger than that of the pipelines 14-1 and 14-2, and the plurality of bolts 18 and nuts 20 is attached at predetermined angular intervals. The gasket 2 is disposed between the flanges 16-1 and 16-2 inward from the bolts 18 and the nuts 20. The gasket 2 constitutes a sealing member of the flange tightening portion 12. Therefore, in a case where the bolts 18 and the nuts 20 are tightened, the gasket 2 is subjected to a load due to the load F applied to the flanges 16-1 and 16-2, and sealing is achieved together with the tightening of the pipelines 14-1 and 14-2.

[0034] The restrained portion 2-1 of the gasket 2 is sandwiched between the flanges 16-1 and 16-2, and is restrained in contact with the flanges 16-1 and 16-2. The non-restrained portion 2-2 protrudes around the restrained portion 2-1 and does not contact the flanges 16-1 and 16-2, that is, is not restrained by the flanges 16-1 and 16-2. The restrained portion 2-1 is subjected to the load F from the flanges 16-1 and 16-2 by tightening the bolts 18 and the nuts 20. On the other hand, the non-restrained portion 2-2 constitutes a free end that is not subjected to the load F.

[0035] When the load F acts on the restrained portion 2-1 from the flanges 16-1 and 16-2, load strain on the restrained portion 2-1 due to the load F spreads to the non-restrained portion 2-2 integrated with the restrained portion 2-1, which causes a shape change in the outer cut 4. Thus, each outer cut 4 of the non-restrained portion 2-2 constitutes a portion with which to observe a shape change occurring in the gasket 2.

[0036] <Relationship between restrained portion 2-1, non-restrained portion 2-2, and flanges 16-1 and 16-2>

Fig. 3 illustrates an end surface cut along the line III-III in Fig. 2. The restrained portion 2-1 of the gasket 2 is sandwiched and restrained between gasket seats 22 of the flanges 16-1 and 16-2. On the other hand, the non-restrained portion 2-2 protrudes in a gap 24 between the flanges 16-1 and 16-2. The non-restrained portion 2-2 is integrally formed with the restrained portion 2-1, is supported between the flanges 16-1 and 16-2, and protrudes toward the gap 24 to form a free end. That is, the non-restrained portion 2-2 is in a cantilever state.

[0037] The strain, deformation, and the like caused in the restrained portion 2-1 in response to the load F applied from the flanges 16-1 and 16-2 appear as a shape change in the non-restrained portion 2-2. The shape change can be easily observed from the outer cut 4. That is, the shape change of the gasket 2 occurring in the non-restrained portion 2-2 is strain or deformation due to being pushed out from between the gasket seats 22, and represents a load that the restrained portion 2-1 of the gasket 2 is subjected to from the flanges 16-1 and 16-2.

[0038] <Observation of shape change from outer cut 4>

The outer cut 4 is formed to make the strain caused in the non-restrained portion 2-2 apparent as a remarkable shape change and to facilitate the observation.

As illustrated in A of Fig. 4, if the tangential direction of the gasket 2 is regarded as the X-axis, the center of the outer cut 4 is regarded as the Y-axis, and a direction in which the load F is applied is regarded as the Z-axis, in response to the load F applied to the restrained portion 2-1 from the flanges 16-1 and 16-2, a shape change (=strain) occurs in an interval direction between the flanges 16-1 and 16-2 and in a crossing direction with respect to the interval direction. The shape change includes a shape change of the gasket 2 in the circumferential direction.

[0039] The shape change in the X-axis and Y-axis directions due to the shape change is described with reference to B of Fig. 4. The non-restrained portion 2-2 is extended in the radial direction as indicated by arrows "a" and "b". $\Delta Y1$ indicates that the non-restrained portion 2-2 is extended in the radial direction, and $\Delta Y2$ indicates that the vertical surface portion 6 of the outer cut 4 is displaced in the radial direction. With such a change, the width W of the vertical surface portion 6 is extended to the width W1, and the width W between the end portions of the opposed surface portions 8-1 and 8-2 is extended to the width W2 ($> W1$). Such a shape change increases and decreases in proportion to the load F applied to the gasket 2 from the flanges 16-1 and 16-2. In this example, the shape change in the X-Y axis direction is exemplified and, needless to say, the shape change in the Z-axis direction and the shape change in the thickness direction also occur in the shape of the outer cut 4.

[0040] Therefore, the strain caused in the restrained portion 2-1 and the non-restrained portion 2-2 in response to the load F applied from the flanges 16-1 and 16-2 is increased and made apparent as the shape change of outer cut 4, which can facilitate observing the shape change.

[0041] <Modification to outer cut 4>

The outer cut 4 is not limited to a rectangular shape including the vertical surface portion 6 and the opposed surface portions 8-1 and 8-2 illustrated in B of Fig. 1. A and B of Fig. 5 illustrate modifications to the outer cut 4. In Fig. 5, portions corresponding to those in B of Fig. 1 are denoted by the same reference numerals.

[0042] As illustrated in A of Fig. 5, it is possible to form the outer cut 4 by forming the opposed surface portions 8-1 and 8-2 as non-parallel surfaces without the vertical surface portion 6 so that the cross section is formed in a "V" shape, or, alternatively, as illustrated in B of Fig. 5, it is

possible to form the vertical surface portion 6 as a curved surface. Even in such a form, the shape change occurring in the non-restrained portion 2-2 in response to the load F applied to the restrained portion 2-1 can be easily observed from the outer cut 4.

[0043] Incidentally, a sensor member such as metal or resin may be placed in a space of the outer cut 4, and a shape change of the outer cut 4 may be found by the sensor member.

[0044] <Control process for gasket 2>

The control process for the gasket 2 is an example of the control method of the present disclosure. The control process includes a step S1 of generating the restrained portion 2-1 and the non-restrained portion 2-2, a step S2 of applying the load F, a step S3 of acquiring shape information, and a step S4 of presenting the shape information and the like. The signs S1 to S4 given to the steps exemplify the order of the steps, and the cited terms are merely used for convenience.

[0045] Step S1 of generating the restrained portion 2-1 and the non-restrained portion 2-2: The gasket 2 is placed between the flanges 16-1 and 16-2, a portion of the gasket 2 in contact with the flanges 16-1 and 16-2 functions as the restrained portion 2-1, and a portion of the gasket 2 not in contact with the flanges 16-1 and 16-2 functions as the non-restrained portion 2-2. In other words, the restrained portion 2-1 and the non-restrained portion 2-2 of the gasket 2 are generated in response to the gasket 2 placed between the flanges 16-1 and 16-2.

[0046] Step S2 of applying the load F: In the gasket 2, the load F is applied to the restrained portion 2-1 restrained by the flanges 16-1 and 16-2 by tightening the flanges 16-1 and 16-2. In response to the load F applied, strain is caused in the restrained portion 2-1 of the gasket 2 and a shape change occurs in the non-restrained portion 2-2.

[0047] Step S3 of acquiring shape information: Regarding

the shape change occurring in the non-restrained portion 2-2, a control server 30 (Fig. 6) receives a detection output of the strain sensor 28 and acquires the shape information on the outer cut 4.

5 [0048] Step S4 of presenting the shape information and the like: The control server 30 generates presentation information including the shape information and presents the presentation information with an information presentation unit 32 (Fig. 6).

[0049] Note that the shape information acquired in step S3
10 of acquiring the shape information may be subjected to N-th order differentiation (multistage differentiation) to perform processing of highlighting a change point of the shape information. By reflecting the processing result in the presentation information in the presentation step S4, the
15 change point of the shape information can be clarified.

[0050] <Gasket control system 26>

Fig. 6 illustrates the gasket control system 26 for executing the control process by information processing. The configuration illustrated in Fig. 6 is an example, and the
20 present disclosure is not limited to such a configuration. In Fig. 6, the same portions as those in Fig. 3 are denoted by the same reference numerals.

[0051] The gasket control system 26 includes a strain sensor 28, the control server 30, and the information
25 presentation unit 32.

[0052] The strain sensor 28 measures a shape change occurring in the outer cut 4 of the gasket 2 to output a detection signal indicating the shape change. The strain sensor 28 is an example of a means that detects a shape change
30 to convert the shape change into an electric signal. As a means for observing the shape change, a laser displacement meter, a camera, or the like may be used in addition to the strain sensor 28. The laser displacement meter applies laser light to the outer cut 4, detects a shape change of the outer

cut 4 with reflected light, and observes a change amount thereof. The camera captures an image of the outer cut 4, and the control server 30 detects strain occurring in the outer cut 4 by using the number of pixels and acquires shape information corresponding to the strain.

[0053] The control server 30 is implemented by a computer having a communication function. The control server 30 includes a processor 34, a storage unit 36, an input/output (I/O) unit 38, and a communication unit 40. The processor 34 executes an operating system (OS) and a control program stored in the storage unit 36 to perform information processing for gasket control. The storage unit 36 includes a storage medium that stores the OS and the control program. The storage unit 36 stores, therein, a gasket control database (DB) 42 (Fig. 7). The communication unit 40 inputs and presents information in cooperation with a control terminal (not illustrated) under the control of the processor 34. The control terminal is also used for acquisition of shape information, writing to and reading from the gasket control DB 42, and so on.

[0054] Further, under the control of the control server 30, the information presentation unit 32 presents control information including load information and determination information associated with the shape information.

[0055] <Information processing by control server 30>

The information processing by the control server 30 includes:

a) processing of capturing a detection output of the strain sensor 28;

b) acquisition of the shape Information on the outer cut 4;

c) generation of presentation information including the shape information; and

d) presentation of estimation information with the information presentation unit 32.

[0056] <Gasket control DB 42>

Fig. 7 illustrates an example of the gasket control DB 42. The gasket control DB 42 stores a gasket control file 44 therein.

5 [0057] The gasket control file 44 includes a gasket information section 46, an outer cut information section 47, a time information section 48, a load information section 50, a strain sensor information section 52, a detection information section 54, a determination information section 56, and a
10 history information section 58.

In the gasket information section 46, specification information for identifying the gasket 2 and identification information of the gasket 2 are stored.

[0058] In the outer cut information section 47, outer cut
15 information such as shapes representing the shapes of the outer cuts 4-1, 4-2, 4-3, and 4-4 and arrangement positions and sizes thereof is stored.

[0059] In the time information section 48, time information such as a measurement date and time is stored.

20 [0060] In the load information section 50, load information indicating a load F applied to the gasket 2 from the flanges 16-1 and 16-2 is stored.

[0061] In the strain sensor information section 52, sensor information including a type, identification information, and
25 the like of the strain sensor 28 (= 28-1, 28-2, 28-3, 28-4) is stored.

[0062] In the detection information section 54, measurement information such as a shape change obtained from each outer cut 4 (= 4-1, 4-2, 4-3, 4-4) is stored.

30 [0063] In the determination information section 56, determination information indicating a determination result of the measurement information on the outer cut 4 and a determination result such as load information estimated from the measurement information is stored.

[0064] In the history information section 58, history information such as acquisition of the shape information is stored.

[0065] <Effects of first embodiment>

5 According to the first embodiment, any one of the following effects can be obtained.

[0066] (1) Since the gasket 2 includes the outer cut 4, the restrained portion 2-1 is subjected to the load F from the flanges 16-1 and 16-2, the strain caused in the restrained
10 portion 2-1 can be visualized as the shape change of the outer cut 4 of the non-restrained portion 2-2. That is, the shape change corresponding to the load F can be easily observed from the outer cut 4.

[0067] (2) The shape information of the outer cut 4 is
15 acquired from the outer cut 4 by the detection output of each strain sensor 28, and the load applied to the gasket 2 from the flanges 16-1 and 16-2 can be estimated from the shape change.

[0068] (3) The strain of the gasket 2 can be observed with
20 the shape change of the outer cut 4, and the load applied to the gasket 2 can be estimated from the shape change and a state in which the gasket 2 is tightened can be determined without the influence of the tightening torque or the axial force of the bolt 18.

25 [0069] (4) The state in which the gasket 2 is tightened is not affected by the skill of an operator, and the accuracy of the control can be increased.

[0070] [Second Embodiment]

The control method for the gasket 2 according to the
30 second embodiment further includes an estimation step S5 based on inflection point information in addition to the control step of the first embodiment.

[0071] In the estimation step S5 based on the inflection point information, the shape information including the shape

change occurring in the outer cut 4 includes inflection point (Figs. 9 and 10) information with respect to a specific load, and the control server 30 can estimate, from the inflection point, the state in which the gasket 2 is tightened, that is, the surface pressure applied to the gasket 2 from the flanges 16-1 and 16-2.

[0072] <Effects of second embodiment>

According to the second embodiment, any one of the following effects can be obtained.

[0073] (1) The shape information can include an inflection point as singular information on a load.

[0074] (2) By correlating a load to be set with the inflection point, the specific load can be set by confirming the inflection point in the shape information.

[0075] (3) The load F , that is, the surface pressure can be estimated from the shape change of the outer cut 4 that the gasket 2 is subjected to, and setting and adjusting the load on the gasket 2 can be facilitated.

Examples

[0076] Examples of the gasket 2 of the present disclosure will be described together with a comparative example.

<Comparative example>

A of Fig. 8 illustrates the gasket 2 according to the comparative example. In the comparative example, no outer cut 4 is provided unlike the example in which the restrained portion 2-1 and the non-restrained portion 2-2 are set concentrically with the same width or substantially the same width.

[0077] In the comparative example, as illustrated in B of Fig. 8, shape observation portions 60-1, 60-2, 60-3, and 60-4 are provided at positions corresponding to the positions of the outer cuts 4 of the examples. The shape observation portions 60-1, 60-2, 60-3, and 60-4 are arranged at angular intervals of a center angle of 90 degrees in the non-

restrained portion 2-2.

[0078] <Example>

The shape of the outer cut 4 of the gasket 2 according to the examples, the measurement results thereof, and the like are shown in Table 1.

[0079] [Table 1]

		Comparative example	Example
		No outer cut	With outer cut
Shape	Width [mm]	—	1
	Length [mm]	—	3
Opening width W2 [mm] of outer cut 54 at applying load 125 kN		—	2.5
Inflection point load [kN] of strain in circumferential direction		1 4 0	1 2 5

[0080] Table 1 shows the shape, the shape change, and the load in a comparative example (= no outer cut) and an example (= with outer cut).

In the comparative example, the outer cut 4 is not formed.

In the example, the outer cut 4 having a width W1 = 1 mm and a length L1 = 3 mm was formed.

[0081] In the comparative example, the inflection point load = 140 kN was obtained from the strain in the circumferential direction and no minimum point load was obtained. Similarly, in the example, it was confirmed that the inflection point load = 125 kN was obtained from the strain in the circumferential direction, and a change occurred in the opening width of the outer cut 4.

[0082] <Inflection point information in shape change>

In Fig. 9, the horizontal axis shows the load [kN] and the vertical axis shows the strain, and the relationship between the shape change and the load is shown. In Fig. 9, for example, angles = 0 (deg), 45 (deg), and 90 (deg) are used as parameters, and the shape change occurring in the gasket 2

according to the comparative example is shown as a measurement value with the strain sensor 28.

In Fig. 9, m1 represents deformation of the gasket 2 in the 0 (deg) direction (= the circumferential direction of the gasket 2), m2 represents deformation of the gasket 2 in the 45 (deg) direction, and m3 represents deformation in the 90 (deg) direction (= the thickness direction of the gasket 2).

[0083] As described above, in response to the load F applied to the restrained portion 2-1 from the flanges 16-1 and 16-2, the shape change corresponding to the load F occurs in the non-restrained portion 2-2. In the example also, measurement results similar to those in Fig. 9 were obtained.

[0084] An inflection point is generated in the shape change, and an optimum load F can be identified from the relationship between the load F applied to the gasket 2 and the inflection point of the shape change, and the optimum load F can be used as information in order to determine the initial tightening completion.

[0085] In Fig. 10, the horizontal axis shows the load [kN] and the vertical axis shows an opening width [mm] of the outer cut 4, and the relationship between the shape change occurring in the gasket 2 according to the example and the load is shown. Similarly, Table 2 shows a relationship between a load on the outer cut 4 and an opening width W2 of the outer cut 4.

[0086] [Table 2]

Load [kN]	Opening width W2[mm]
0	1
25	1.1
50	1.3
75	1.5
100	1.7
125	2.5
150	3.2

[0087] In a case where the load F is applied to the

restrained portion 2-1 from the flanges 16-1 and 16-2 and the load F increases, the opening width of the outer cut 4 increases according to the load. In the shape change, a remarkable inflection point different from that in the comparative example is generated. Therefore, according to the gasket 2 of the example, if the inflection point of the shape change occurring in each outer cut 4 or any one of the outer cuts 4 is targeted, the relationship between the shape change and the load can be specified.

[0088] Thus, in the gasket 2 according to the example, an inflection point can be generated in shape information corresponding to a specific load. As a result, at the time of tightening the flanges 16-1 and 16-2, the specific load can be estimated from the inflection point of the shape information, and can be used as criteria for determining tightening completion.

[0089] <Detection of inflection point of shape information and tightening criteria>

In the gasket 2 according to the example, an inflection point can be generated in shape information corresponding to a specific load. As a result, at the time of tightening the flanges 16-1 and 16-2, the specific load can be estimated from the inflection point of the shape information, and can be used as criteria for determining tightening completion.

[0090] <Effects of examples>

The shape change occurring in the gasket 2 can be observed from the opening width W2 of the outer cut 4. That is, the opening width W2 of the outer cut 4 is measured in advance for each load on the gasket 2, and the load can be easily estimated by comparing the opening width W2 with a measured value. In the estimation, the opening width W2 of the outer cut 4 is stored as a database for each load, and an accurate load can be easily estimated in comparison with the measured value of the shape change.

[0091] In monitoring and measuring such a shape change, unlike torque control and measurement of bolt axial force, a shape change occurring in the outer cut 4 of the non-restrained portion 2-2 is measured, and shape information
5 representing the load can be acquired from the gasket 2. Therefore, the load can be estimated from the shape change of the gasket 2 due to the load F applied to the flanges 16-1 and 16-2 without the influence of the bolt 18 and the flanges 16-1 and 16-2.

10 [0092] As for the processing shape of the outer cut 4, it was confirmed that the gasket 2 is also adaptable to various diameters and thicknesses.

[0093] <Appendices>

15 With regard to the embodiments and examples described above, the following appendices are disclosed.

[0094] (Appendix 1) A gasket placed between flanges of a flange tightening portion, the gasket including:

a restrained portion that is restrained between the flanges and is subjected to a load;

20 a non-restrained portion that is not restrained between the flanges; and

a cutout portion provided in the non-restrained portion; in which

25 a change occurs in the cutout portion in response to the load.

[0095] (Appendix 2) A control system for controlling a flange tightening portion having a gasket between flanges, the control system including:

30 a restrained portion that is restrained between the flanges and is subjected to a load, a non-restrained portion that is not restrained between the flanges, and a cutout portion provided in the non-restrained portion;

a gasket that causes a change in the cutout portion in response to the load applied;

a measurement unit configured to measure the change in the cutout portion in a contact manner or a non-contact manner with the gasket;

5 a control server configured to acquire measurement information from the measurement unit to generate control information including a tightening force between the flanges; and

10 an information presentation unit configured to present the control information in association with the gasket or the flange tightening portion.

[0096] (Appendix 3) A recording medium in which a program is recorded, the program causing a computer to implement:

15 a function of acquiring, in response to being restrained between flanges and a load applied from between the flanges, shape information including a change occurring, due to the load, in a cutout portion formed in a non-restrained portion of a gasket;

20 a function of generating control information including a tightening force between the flanges based on the shape information; and

a function of presenting the control information.

[0097] [Other Embodiments]

25 (1) In the embodiments and the examples described above, regarding the initial tightening in the flange tightening portion 12, the shape change occurring in the gasket 2 in response to a load applied from between the flanges is observed; however, the present disclosure is not limited to the initial tightening in the flange tightening.

30 [0098] (2) Regarding the outer cut 4, the vertical surface portion 6 and the opposed surface portions 8-1 and 8-2 are exemplified in the example. This form of the outer cut 4 is an example, and may be a shape having no vertical surface portion 6, or a cutout shape having a polygonal shape or a rectangular shape, in addition to a V-shape in which the opposed surface

portions 8-1 and 8-2 are not parallel, for example.

[0099] (3) In the embodiments, the comparative example, and the examples described above, the load F applied to the gasket 2 sandwiched between the flanges 16-1 and 16-2 and the shape change of the gasket 2 are described. The load F applied to the gasket 2 is equivalent to the surface pressure applied to the gasket 2 from the flanges 16-1 and 16-2, and there is no qualitative difference therebetween. That is, the surface pressure of the gasket 2 can be estimated with the shape change from the relationship between the load F applied to the gasket 2 and the shape change occurring in the outer cut 4.

[0100] (4) In the presentation step (S4) of the shape information and the like of the control process for the gasket 2, the control server 30 may generate the presentation information by performing processing such as multistage differentiation on the acquired shape information, or may present a display unit to clearly indicate a change point in the information presentation unit 32 (Fig. 6).

[0101] As described above, the most preferred embodiment and the like of the present disclosure have been described. The present disclosure is not limited to the above description. Various modifications and changes can be made by those skilled in the art based on the gist of the invention described in the claims or disclosed in the embodiments for carrying out the invention. It goes without saying that such modifications and changes are included in the scope of the present disclosure.

Industrial Applicability

[0102] According to the gasket, control method and system therefor, and program of the present disclosure, a shape change of the outer cut that deforms in response to the load F applied from the flanges can be easily observed, the load and the surface pressure can be estimated without the influence of

a state in which the bolt or the flange is tightened, and a state in which the gasket is tightened can be controlled.

Reference Signs List

- | | | | |
|----|----------------------------|---|-----------------------------------|
| 5 | [0103] | 2 | GASKET |
| | 2-1 | | RESTRAINED PORTION |
| | 2-2 | | NON-RESTRAINED PORTION |
| | 4, 4-1, 4-2, 4-3, 4-4 | | OUTER CUT |
| | 6 | | VERTICAL SURFACE PORTION |
| 10 | 8-1, 8-2 | | OPPOSED SURFACE PORTION |
| | 12 | | FLANGE TIGHTENING PORTION |
| | 14-1, 14-2 | | PIPELINE |
| | 16-1, 16-2 | | FLANGE |
| | 18 | | BOLT |
| 15 | 20 | | NUT |
| | 22 | | GASKET SEAT |
| | 24 | | GAP |
| | 26 | | GASKET CONTROL SYSTEM |
| | 28, 28-1, 28-2, 28-3, 28-4 | | STRAIN SENSOR |
| 20 | 30 | | CONTROL SERVER |
| | 32 | | INFORMATION PRESENTATION UNIT |
| | 34 | | PROCESSOR |
| | 36 | | STORAGE UNIT |
| | 38 | | INPUT/OUTPUT (I/O) UNIT |
| 25 | 40 | | COMMUNICATION UNIT |
| | 42 | | GASKET CONTROL DATABASE (DB) |
| | 44 | | GASKET CONTROL FILE |
| | 46 | | GASKET INFORMATION SECTION |
| | 47 | | OUTER CUT INFORMATION SECTION |
| 30 | 48 | | TIME INFORMATION SECTION |
| | 50 | | LOAD INFORMATION SECTION |
| | 52 | | STRAIN SENSOR INFORMATION SECTION |
| | 54 | | DETECTION INFORMATION SECTION |
| | 56 | | DETERMINATION INFORMATION SECTION |

58 HISTORY INFORMATION SECTION

60-1, 60-2, 60-3, 60-4 SHAPE OBSERVATION PORTION

CLAIMS

1. A gasket comprising: an outer cut formed in a non-restrained portion adjacent to a restrained portion restrained between flanges; wherein a shape of the outer cut changes due to a load applied to the restrained portion.
2. A control method comprising:
 - a step of placing, between flanges, a gasket including an outer cut of which a shape changes in response to a load applied;
 - a step of applying a load to the gasket restrained between the flanges; and
 - a step of measuring the shape of the outer cut changed in response to the load applied; wherein tightening the gasket is controlled based on the shape.
3. A control system comprising:
 - a measurement unit configured to measure a shape of an outer cut provided in a gasket;
 - a control server configured to generate control information for controlling tightening between flanges based on the shape; and
 - an information presentation unit configured to present the control information.
4. A program for causing a computer to implement:
 - a function of acquiring shape information of an outer cut provided in a gasket that is restrained between flanges and is subjected to a load;
 - a function of generating control information for controlling tightening of the gasket based on the shape information; and
 - a function of presenting the control information.