

DESCRIPTION

Title of Invention:

GASKET AND METHOD, SYSTEM, AND PROGRAM FOR MANAGEMENT OF SAME

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.

10 Background Art

[0002] For gasket tightening control, 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 tightening information related to a bolt
15 to tighten between flanges.

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
20 torque (e.g., refer to Patent Literature 1). As for 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). In addition, a device has been known which measures a force applied to a
25 part of a gasket by tightening with a sheet-type pressure sensor embedded inside the gasket (e.g., refer to Patent Literature 3).

Citation List

30 Patent Literature

[0003] Patent Literature 1: JP 2014-225219 A
Patent Literature 2: JP 2015-141345 A
Patent Literature 3: JP 4699935 B2

Summary of Invention

Technical Problem

[0004] 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.

[0005] 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 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 it cannot be said that the torque value and the axial force value acting on the bolt represent a surface pressure acting on the gasket.

[0006] In light of the above, the gasket tightening control has the following issues.

[0007] a) A torque value and an axial force value acquired from a bolt are information on the bolt, and it cannot be said that a surface pressure to which the gasket is subjected is measured.

[0008] 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 merely rough standards of the surface pressure.

[0009] 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.

[0010] 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 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.

[0011] 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 to 3 do not disclose or suggest such issues. The configuration disclosed in Patent Literatures 1 to 3 cannot solve such issues.

[0012] 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 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

[0013] In order to achieve the above object, a gasket according to one aspect of the present disclosure includes an inner cut formed in a non-restrained portion adjacent to a restrained portion restrained between flanges, in which a shape of the inner cut changes due to a load applied to the restrained portion.

[0014] In the gasket, minimum point information is acquired based on a shape change of the inner cut.

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

[0016] The control method may further include a step of
10 acquiring minimum point information based on a shape change of the inner cut.

[0017] 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
15 an inner cut formed in a peripheral edge of a gasket, a control server configured to generate control information for controlling tightening of the gasket based on the shape, and an information presentation unit configured to present the control information.

[0018] 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 inner cut provided in a gasket that is restrained between flanges and is subjected to a load, a
25 function of generating control information for controlling tightening of the gasket based on the shape information, and a function of presenting the control information.

[0019] The program further causes the computer to implement a function of acquiring minimum point information
30 based on a shape change of the inner cut.

Advantageous Effects of Invention

[0020] According to the present invention, any one of the following effects can be obtained.

[0021] (1) Strain is caused in the gasket due to the load applied to the gasket from between the flanges, and the strain can be made apparent as the shape change of the inner cut of the gasket. The shape change of the inner cut can then be made visible and easily recognized.

[0022] (2) In a case where the shape change of the inner 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.

[0023] (3) The load applied to the gasket is estimated from the shape change of the inner cut. The estimated load is equivalent to the actual surface pressure applied to the gasket from the flange. For this reason, according to the approach, the accuracy of the gasket control such as tightening control and gasket life prediction can be increased.

[0024] (4) The shape of the inner 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. Therefore, by observing such a shape change and estimating the load, the accuracy of the gasket control can be increased irrespective of the skill of an operator.

[0025] 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

[0026] 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 inner cut, and Fig. 4B is a view illustrating a shape change of the inner cut.

Figs. 5A, 5B, and 5C are views illustrating modifications to the inner 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 according to Example 1, Example 2, Example 3, and Example 4.

Fig. 10 is a diagram illustrating a relationship between a minimum point appearing in a shape change and a load.

Fig. 11 is a diagram illustrating a relationship between an inflection point (no minimum point) appearing in a shape change and a load.

Fig. 12A is a diagram illustrating the shape of a gasket according to Example 5, Fig. 12B is a diagram illustrating an example of a state before a load is applied, and Fig. 12C is a diagram illustrating an example of a state in a case where a load of a predetermined value is applied.

Fig. 13 is a diagram illustrating an example of shape observation according to Example 5.

Description of Embodiments

[0027] [First Embodiment]

A of Fig. 1 illustrates a gasket 2 according to the first embodiment. The configuration illustrated in Fig. 1 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.

[0028] The gasket 2 is, for example, a sheet gasket
5 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. Alternatively, the gasket 2 may be made of a metal
10 material, or a combination of a metal material and ceramic, a
heat-resistant fiber material, other materials, or the like.
Further, examples of the gasket 2 include a spiral wound
gasket 70 (Fig. 12), a flat gasket to which a sheet such as
PTFE or graphite is attached, a Kammprofile gasket in which a
15 groove is formed on the gasket surface or a flange portion is
provided in an outer edge portion, and the like.

[0029] 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
20 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.

[0030] The non-restrained portion 2-2 has inner cuts 4-1,
25 4-2, 4-3, and 4-4 (hereinafter, simply referred to as an inner
cut 4 when no specific position is designated) formed therein.
Each inner cut 4 is a through hole penetrating the front and
back of the non-restrained portion 2-2 of the gasket 2, and is
a means for facilitating detection of a change in the shape of
30 the gasket 2. Therefore, each inner 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.

[0031] <Inner cut 4>

B of Fig. 1 illustrates the inner cut 4 at an IB part of A of Fig. 1 in an enlarged manner. The inner cut 4 is a through hole that has a constant arc-shaped long side length L and a width W in the circumferential direction of the gasket 2 and penetrates the upper and lower surfaces of the gasket 2. Each inner cut 4 has vertical surface portions 6-1 and 6-2 having the constant width W facing each other, and an inner surface portion 8-1 and an outer surface portion 8-2 having the long side length L facing each other. The height D is a thickness of the gasket 2 before deformation.

[0032] In order to detect a shape change of the gasket 2, the inner 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 detection of the shape change, it is preferable that the positions at which to provide the inner cuts 4 are balanced. In this embodiment, the inner cuts 4 are provided at four positions on the X-axis and the Y-axis, which allows a shape change to be detected in a wide range.

[0033] <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. 2.

[0034] 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.

[0035] 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.

[0036] 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.

[0037] 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.

[0038] The non-restrained portion 2-2 is a free end that is not subjected to the load F while 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.

[0039] 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 inner cut 4. Thus, each inner cut 4 of the non-restrained portion 2-2 constitutes a portion that detects a shape change occurring in the gasket 2. Assuming that the load F acts in the Z-axis direction, the strain is caused, for example, in the X-axis and Y-axis directions.

[0040] <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
5 end. That is, the non-restrained portion 2-2 is in a cantilever state.

[0041] 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-
10 restrained portion 2-2. The shape change can be easily observed from the inner 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
15 portion 2-1 of the gasket 2 is subjected to from the flanges 16-1 and 16-2.

[0042] <Observation of shape change of inner cut 4>

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

[0043] A of Fig. 4 illustrates an original shape of the inner cut 4. If the tangential direction of the gasket 2 is regarded as the X-axis, the center of the inner cut 4 is regarded as the Y-axis, and a direction in which the load F is
25 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
30 change includes a shape change of the gasket 2 in the circumferential direction.

[0044] As illustrated in B of Fig. 4, the non-restrained portion 2-2 expands by ΔY in the radial direction (indicated by arrow "a") of the gasket 2, and the inner surface portion

8-1, the outer surface portion 8-2, and the vertical surface portions 6-1 and 6-2 also move in the radial direction of the gasket 2. At the same time, the width W of the inner cut 4 is narrowed to the width ΔW as the interval distance between the inner surface portion 8-1 and the outer surface portion 8-2 is indicated by an arrow "b" and an arrow "c". They are shape changes of the gasket 2 representing the load F applied to the restrained portion 2-1, that is, the load that the gasket 2 is subjected to. 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 inner cut 4.

[0045] 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 made apparent as the shape change of the inner cut 4, which can facilitate observing the shape change.

[0046] <Modification to inner cut 4>

20 The inner cut 4 is not limited to the form illustrated in B of Fig. 1. A, B, C of Fig. 5 illustrate modifications to the inner cut 4. In Fig. 5, portions corresponding to those in B of Fig. 1 are denoted by the same reference numerals.

[0047] As illustrated in A of Fig. 5, the inner cut 4 may be formed to have a parallel surface or a non-parallel surface of linear opposed surface portions 9-1 and 9-2 instead of the inner surface portion 8-1 and the outer surface portion 8-2 described above, or, alternatively, as illustrated in B of Fig. 5, the inner cut 4 may be formed to have a square or fan shape including four surfaces of opposed surface portions 7-1 and 7-2 and the opposed surface portions 9-1 and 9-2.

30 Alternatively, as illustrated in C of Fig. 5, the inner cut 4 may be formed by forming surface portions 9-11 and 9-12 in the opposed surface portion 9-1 so that a distance between the

opposed surface portions 9-1 and 9-2 is partially different, such as W_a and W_b ($W_a < W_b$). 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 detected from the inner cut 4.

[0048] Incidentally, a sensor member such as metal or resin may be placed in a space of the inner cut 4, and a shape change of the inner cut 4 may be found by the sensor member.

[0049] <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.

[0050] 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.

[0051] 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.

[0052] 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 inner cut 4.

5 [0053] 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).

[0054] 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.

[0055] <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.

[0056] The gasket control system 26 includes a strain sensor 28, the control server 30, and the information
25 presentation unit 32.

[0057] The strain sensor 28 measures a shape change occurring in the inner 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 inner cut 4, detects a shape change of the inner

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

[0058] 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.

[0059] Further, the information presentation unit 32 presents shape information including a load and determination information under the control of the control server 30.

[0060] <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 inner cut 4;

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

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

[0061] <Gasket control DB 42>

Fig. 7 illustrates an example of the gasket control DB 42. The gasket control DB 42 is used for processing of estimating a load from the shape information, and the like. The gasket control DB 42 stores a gasket control file 44 therein.

[0062] The gasket control file 44 includes a gasket information section 46, an inner 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 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.

[0063] In the inner cut information section 47, shape information such as shapes representing the inner cuts 4-1, 4-2, 4-3, and 4-4 and arrangement positions and sizes thereof is stored.

[0064] In the time information section 48, time information such as a measurement date and time is stored.

[0065] In the load information section 50, load information indicating a load F applied between the flanges 16-1 and 16-2 by tightening the bolt 18 is stored.

[0066] In the strain sensor information section 52, sensor information including a type, identification information, and the like of the strain sensor 28 (= 28-1, 28-2, 28-3, 28-4) that detects a shape is stored.

[0067] In the detection information section 54, a shape detection value obtained from each inner cut 4 (= 4-1, 4-2, 4-3, 4-4) is stored.

[0068] In the determination information section 56, estimated load information is stored which indicates a load estimated from the shape information by the information processing by the control server 30.

[0069] In the history information section 58, history information such as acquisition of the shape information and estimation processing is stored.

[0070] <Effects of first embodiment>

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

[0071] (1) Since the gasket 2 includes the inner 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 inner cut 4 of the non-restrained portion 2-2, and the shape change corresponding to the load F can be easily observed in the inner cut 4.

[0072] (2) The shape information of the inner cut 4 is
15 acquired from the inner 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.

[0073] (3) The strain of the gasket 2 can be observed with
20 the shape change of the inner 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 [0074] (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.

[0075] [Second Embodiment]

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

[0076] In the estimation step S5 based on the minimum point information, the shape information including the shape

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

[0077] <Effects of second embodiment>

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

10 [0078] (1) The shape information can include a minimum point as singular information on a load.

[0079] (2) By correlating the minimum point with a load to be set, the specific load can be set by confirming the minimum point in the shape information.

15 [0080] (3) The load F , that is, the surface pressure can be estimated from the shape change of the inner cut 4 that the gasket 2 is subjected to, and monitoring or adjusting the state in which the gasket 2 is tightened can be facilitated.

Examples

20 [0081] 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, the restrained portion 2-1 and the non-restrained portion 2-2 are set concentrically with the same width or substantially the same width.

[0082] In the gasket 2 according to 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 inner 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. The arrangement

positions of the shape observation portions 60-1, 60-2, 60-3, and 60-4 are positions not overlapping with the arrangement positions of the bolts 18.

[0083] <Example 1-4>

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

[0084] [Table 1]

			Example 1	Example 2	Example 3	Example 4	Comparative example
Shape of inner cut	Long side length	mm	65	65	16	16	No inner cut
	Short side length (Distance between long sides)	mm	1	3	1	3	
	Circumferential length	mm	327	327	327	327	
	Long side length/Circumferential length	—	0.20	0.20	0.05	0.05	
	Aspect ratio	—	65	22	16	5	
Distance between long sides at completion of tightening		mm	0	0	0.6	2.6	—
Minimum point load		k N	145	195	—	—	—

10 [0085] Table 1 shows the shape of the inner cut 4, a distance between long sides at the completion of tightening, a minimum point load in Example 1, Example 2, Example 3, and Example 4, and dimensional information and load information of the comparative example.

15 [0086] In Example 1, a long side length = 65 mm, a short side length (distance between long sides) = 1 mm, a circumferential length of the gasket 2 = 327 mm, long side length/circumferential length = 0.20, an aspect ratio = 65, a distance between long sides at the completion of tightening =
20 0 mm, and a minimum point load = 145 kN were obtained.

[0087] In Example 2, in a long side length = 65 mm, a short side length (distance between long sides) = 3 mm, a circumferential length of the gasket 2 = 327 mm, long side length/circumferential length = 0.20, and an aspect ratio =
25 22, a distance between long sides at the completion of tightening = 0 mm and a minimum point load = 195 kN were

obtained.

[0088] In Example 3, in a long side length = 16 mm, a short side length (distance between long sides) = 1 mm, a circumferential length of the gasket 2 = 327 mm, long side length/circumferential length = 0.05, and an aspect ratio = 16, a distance between long sides at the completion of tightening = 0.6 mm and a minimum point load = unspecified were obtained.

[0089] In Example 4, in a long side length = 16 mm, a short side length (distance between long sides) = 3 mm, a circumferential length of the gasket 2 = 327 mm, long side length/circumferential length = 0.05, and an aspect ratio = 5, a distance between long sides at the completion of tightening = 2.6 mm and a minimum point load = unspecified were obtained.

[0090] In the comparative example, since there is no inner cut 4, there is no corresponding data.

[0091] <Relationship between distance between long sides of inner cut and load>

Fig. 9 illustrates a relationship between a shape change (change in a distance between long sides) and a load according to Example 1, Example 2, Example 3, and Example 4.

[0092] Regarding the relationship between a change in the distance between long sides and the load, n1 represents a change in Example 1, n2 represents a change in Example 2, n3 represents a change in Example 3, and n4 represents a change in Example 4.

Comparison therebetween indicates that the shape changes in n1 and n2 are remarkable and observing the shape change facilitates specifying the load applied to the gasket 2.

[0093] <Minimum point information in shape change>

As for a case where the long side length L of the inner cut 4 is long, in Fig. 10, the horizontal axis shows the load and the vertical axis shows the strain, and the relationship between the minimum point information in shape change and the

load is shown.

[0094] In Fig. 10, o1 represents a shape change in the 0 (deg) direction, o2 represents a shape change in the 45 (deg) direction, and o3 represents a shape change in the 90 (deg) direction.

As described above, the minimum point is generated in the shape change in Examples 1 and 2.

[0095] <Inflection point information in shape change>

As for a case where the long side length L of the inner cut 4 is short, Fig. 11 illustrates the relationship between the inflection point appearing in the shape change and the load.

[0096] In Fig. 11, p1 represents a shape change in the 0 (deg) direction, p2 represents a shape change in the 45 (deg) direction, and p3 represents a shape change in the 90 (deg) direction.

In the case where the long side length L of the inner cut 4 is short, there is no contact with the inner surface portion 8-1 and the outer surface portion 8-2 of the inner cut 4. Therefore, no minimum point is generated in the shape change. That is, in Examples 3 and 4, only the inflection point is obtained in the strain in the circumferential direction of the 0 (deg) direction.

[0097] <Effects of examples>

As is apparent from the examples, the relationship between the shape change and the load can be specified by measuring the shape change of the inner cut 4.

[0098] In all of Examples 1-4, the inflection point information or the minimum point information can be obtained, but in a case where the long side length L of the inner cut 4 is increased, the minimum point information can be obtained. Based on the minimum point information, the state in which the gasket 2 is tightened, that is, the load (= surface pressure) applied to the gasket 2 from the flanges 16-1 and 16-2 can be

estimated, and the tightening state in the flange tightening portion 12 can be determined.

[0099] In monitoring and measuring such a shape change, unlike torque control and measurement of bolt axial force, a shape change occurring in the inner cut 4 of the non-restrained portion 2-2 is measured, and shape information 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.

[0100] As for the processing shape of the inner cut 4, it was confirmed that the gasket 2 is also adaptable to various diameters and thicknesses.

[0101] <Example 5>

Fig. 12 illustrates an example of the configuration of the gasket 70 according to Example 5.

[0102] For example, the gasket 70 is a laminate in which a plurality of members having different diameters is coaxially arranged, and the gasket 70 is a spiral wound gasket including an outer ring 701, a gasket body 702, and an inner ring 703.

In the gasket 70, for example, only the inner ring 703, a part or the whole of the inner ring 703 and the gasket body 702, or a part of the outer ring 701 serves as the restrained portion

2-1 that is in contact with the gasket seats 22 (Fig. 3) and is subjected to the load F. In short, a part or the whole of the outer ring 701 of the gasket 70 serves as the non-restrained portion 2-2. In the gasket 70, the gasket body 702 is deformed in response to the load F applied from the flanges 16-1 and 16-2, which causes strain in the outer ring 701.

[0103] In the gasket 70, one or more inner cuts 4 are formed in a part of the outer ring 701. The inner cut 4 is formed, for example, at a position of 5 [mm], as a predetermined distance t, from the outer edge portion of the

outer ring 701. In Example 5, for example, by observing a shape change Qa of the outer edge portion along the position at which the inner cut 4 is formed, the shape of the inner cut 4 is measured, and the surface pressure state of the gasket 70 is controlled. For example, the strain sensor 28 of the gasket control system 26 may be used to observe the shape change Qa. The gasket control system 26 calculates the shape of the inner cut 4 based on the measured shape change Qa. Processing for controlling the state in which the gasket 70 is tightened may be performed in a manner similar to that in the above embodiment.

[0104] <Configuration of gasket 70>

The outer ring 701 and the inner ring 703 are made of, for example, a metal material such as stainless steel, carbon steel, or titanium, and are formed in an annular shape having a predetermined thickness or a shape close thereto. The gasket body 702 is configured by winding a laminate of a thin plate-like member made of, for example, a metal material and a buffer material (filler) such as graphite or fluororesin in a spiral shape between an inner wall surface of the outer ring 701 and an outer wall surface of the inner ring 703. The laminate constituting the gasket body 702 is formed to have, for example, a "V" shape in cross section, or a waveform shape close thereto. The laminate has end surfaces, for example, adhered to the outer ring 701 and the inner ring 703 by spot welding.

[0105] As illustrated in B of Fig. 12, for example, in the outer ring 701, an inner cut 4a is opened with a predetermined width before the load F from the flanges 16-1 and 16-2 is applied to the gasket body 702. When the load F acts through the gasket body 702, for example, as illustrated in C of Fig. 15, a part or the whole of the opening of the outer ring 701 is deformed to form a closed inner cut 4b.

[0106] In Fig. 13, the horizontal axis shows the load [kN]

and the vertical axis shows the strain (shape change), and the shape change Q_a (Fig. 12) in the circumferential direction occurring in the outer edge of the outer ring 701 is shown as a measurement value measured by the strain sensor 28.

5 [0107] In the measurement result, in a case where the load on the gasket increases, for example, there is no large change from the start of application of the load to a predetermined value, and thereafter, when the load exceeds a predetermined value, a negative value is measured in the strain sensor. This
10 shows, for example, a shape change showing that the outer edge portion of the outer ring 701 is compressed in the circumferential direction. The value of the strain in the circumferential direction increases in the positive direction after a minimum point appears around 220 kN of the load, for
15 example.

[0108] <Effects of Example 5>

(1) The shape change of the outer ring 701 of the spiral wound gasket 70 sandwiched between the flanges 16-1 and 16-2 is measured, so that the surface pressure on the gasket 70 due
20 to the load F can be perceived.

[0109] (2) In a case where the spiral wound gasket 70 is used, a change representing the load F can be acquired from the gasket 8 by measuring the shape change of the inner cut 4 based on the shape change Q_a occurring in the outer ring 801,
25 unlike the torque control and the measurement of bolt axial force in monitoring and measuring the shape change. Therefore, the load F applied to the flanges 16-1 and 16-2 can be estimated from the shape change of the gasket 70 without the influence of the bolt 18 and the flanges 16-1 and 16-2.

30 [0110] <Appendices>

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

[0111] (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;

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

5 a through hole provided in the non-restrained portion; in which

a change occurs in the through hole in response to the load.

[0112] (Appendix 2) A control system for controlling a
10 flange tightening portion having a gasket between flanges, the control system including:

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 through hole
15 provided in the non-restrained portion;

a gasket that causes a change in the through hole in response to the load applied;

a measurement unit configured to measure the change in the through hole in a contact manner or a non-contact manner
20 with the gasket;

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

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

[0113] (Appendix 3) A recording medium in which a program is recorded,

30 the program causing a computer to implement:

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 through hole formed in a non-restrained portion of

a gasket;

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

5 a function of presenting the control information.

[0114] [Other Embodiments]

[0115] (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.

[0116] (2) The shape of the inner cut 4 described above is an example, and may be an arcuate shape through hole having no vertical surface portion 6, or a polygonal shape or rectangular through hole having a linear parallel surface portion or a non-parallel surface.

[0117] (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 inner cut 4.

[0118] (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).

[0119] 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.

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Industrial Applicability

[0120] According to the gasket and the method, system, and program for controlling the same of the present disclosure, as for the gasket used for tightening between the flanges, a shape change of the inner cut of the gasket can be observed; therefore, it can be used for control information such as gasket tightening control and gasket replacement without the influence of a state in which the bolt or the flange is tightened.

20

Reference Signs List

[0121] 2, 70 GASKET
 2-1 RESTRAINED PORTION
 2-2 NON-RESTRAINED PORTION
 4, 4-1, 4-2, 4-3, 4-4, 4a, 4b INNER CUT
 6, 6-1, 6-2, VERTICAL SURFACE PORTION
 7-1, 7-2, 9-1, 9-2 OPPOSED SURFACE PORTION
 8-1 INNER SURFACE PORTION
 8-2 OUTER SURFACE PORTION
 9-11, 9-12 SURFACE PORTION
 12 FLANGE TIGHTENING PORTION
 14-1, 14-2 PIPELINE
 16-1, 16-2 FLANGE
 18 BOLT

30

	20	NUT
	22	GASKET SEAT
	24	GAP
	26	GASKET CONTROL SYSTEM
5	28	STRAIN SENSOR
	30	CONTROL SERVER
	32	INFORMATION PRESENTATION UNIT
	34	PROCESSOR
	36	STORAGE UNIT
10	38	INPUT/OUTPUT (I/O) UNIT
	40	COMMUNICATION UNIT
	42	GASKET CONTROL DATABASE (DB)
	44	GASKET CONTROL FILE
	46	GASKET INFORMATION SECTION
15	47	INNER CUT INFORMATION SECTION
	48	TIME INFORMATION SECTION
	50	LOAD INFORMATION SECTION
	52	STRAIN SENSOR INFORMATION SECTION
	54	DETECTION INFORMATION SECTION
20	56	DETERMINATION INFORMATION SECTION
	58	HISTORY INFORMATION SECTION
	60-1, 60-2, 60-3, 60-4	SHAPE OBSERVATION PORTION
	701	OUTER RING
	702	GASKET BODY
25	703	INNER RING

CLAIMS

1. A gasket comprising: an inner cut formed in a non-restrained portion adjacent to a restrained portion restrained between flanges; wherein a shape of the inner cut changes due to a load applied to the restrained portion.
2. The gasket according to claim 1, wherein minimum point information is acquired based on a shape change of the inner cut.
3. A control method comprising:
 - a step of placing a gasket including an inner cut of which a shape changes in response to a load applied;
 - a step of applying a load to the gasket restrained between flanges from between the flanges; and
 - a step of measuring the shape of the inner cut changed due to the load; wherein tightening between the flanges is controlled based on the shape.
4. The control method according to claim 3, further comprising a step of acquiring minimum point information based on a shape change of the inner cut.
5. A control system comprising:
 - a measurement unit configured to measure a shape of an inner cut formed in a peripheral edge of a gasket;
 - a control server configured to generate control information for controlling tightening of the gasket based on the shape; and
 - an information presentation unit configured to present the control information.
6. A program for causing a computer to implement:
 - a function of acquiring shape information of an inner 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.

7. The program according to claim 6, further causing the computer to implement a function of acquiring minimum point

5 information based on a shape change of the inner cut.