

DESCRIPTION

INNER CIRCUMFERENCE SEALING STRUCTURE, SEAT STRUCTURE, AND VALVE

TECHNICAL FIELD

[0001]

The invention of the present application relates to an inner circumference sealing structure and a seat structure, which constitute a valve such as a butterfly valve, and to the valve.

BACKGROUND ART

[0002]

Heretofore, a butterfly valve (valve) has been used to close or open a flow of fluid. FIG. 7 illustrates a butterfly valve 100 as an example. The butterfly valve 100 includes a valve box 102, a seat ring 104, and a valve body 106. The valve box 102 and the seat ring 104 are engaged and combined with each other. The valve body 106 is placed in a flow path 108 of the seat ring 104. The valve body 106 is configured to rotate around a center of rotation C0. On an inner circumference 104i, the seat ring 104 has a convex sealing portion (inner circumference sealing structure) 110 against which the valve body 106 abuts.

[0003]

When stopping the fluid, the valve body 106 is rotated to a fully closed position illustrated in FIG. 7. In the butterfly valve 100, at the fully closed position, an outer circumferential surface 106s of the valve body 106 made of metal such as stainless steel enters the sealing portion 110 of the seat ring 104 made of an elastic member such as rubber (in FIG. 7, a sealing amount that is a depth of the entrance is indicated by SW). In order to rotate the valve body 106 to the fully closed position for the purpose of closing the same, operating torque that resists urging force and fluid pressure from the sealing portion 110 is required. That is, when the SW is deep and the urging force from the sealing portion 110 increases, the operating torque increases. However, as the operating torque increases, a scale of a rotary drive unit for rotating the valve body 106 increases. There is a document that relates to the rotary drive unit of the butterfly valve (see Patent Document 1). However, there is none that relates to the invention of the present application.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004]

Patent Document 1: Japanese Unexamined Patent Application

Publication No. 2003-185047

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005]

An object of the invention of the present application is to provide an inner circumference sealing structure, a seat structure, and a valve, which are capable of reducing operating torque for closing a valve body.

MEANS FOR SOLVING THE PROBLEMS

[0006]

An inner circumference sealing structure of the invention of the present application is an inner circumference sealing structure that is provided on a seat ring of a valve, swells from an inner circumferential surface of the seat ring, and allows an outer circumferential surface of a valve body to abut thereagainst, the valve body being to be applied with fluid pressure, the inner circumference sealing structure including:

a first sealing surface that has a concave shape and allows the outer circumferential surface of the valve body to abut thereagainst and stop there;

an engaging convex portion that allows the valve body to be engaged therewith and restricts rotation of the valve body; and

an engaging sealing surface that allows the outer

circumferential surface of the valve body to abut thereagainst when the valve body is engaged with the engaging convex portion, and

the inner circumference sealing structure is configured so that the engaging sealing surface has a larger depth than the first sealing surface, the depth being a depth by which the outer circumferential surface of the valve body enters.

[0007]

Moreover, in the above inner circumference sealing structure, an inner circumference sealing structure of the invention of the present application is characterized in that the first sealing surface, the engaging sealing surface, and the engaging convex portion are arranged in this order in a direction in which the outer circumferential surface of the valve body moves by the rotation of the valve body.

[0008]

Further, in the above inner circumference sealing structure, an inner circumference sealing structure of the invention of the present application is characterized in that a second sealing surface is provided, the second sealing surface having a concave shape, allowing the outer circumferential surface of the valve body to abut thereagainst and stop there, and being continuous with the first sealing surface,

the first sealing surface, the second sealing surface,

the engaging sealing surface, and the engaging convex portion are arranged in this order in the direction in which the outer circumferential surface of the valve body moves by the rotation of the valve body,

the inner circumference sealing structure is configured so that the second sealing surface has a larger sealing amount than the first sealing amount, and

the inner circumference sealing structure is configured so that the engaging sealing surface has a larger sealing amount than the second sealing surface.

[0009]

Moreover, a seat structure of the invention of the present application is a seat structure provided on a seat ring of a valve, including:

the above inner circumference sealing structure;

a seat-side valve rod hole portion into which a valve rod constituting a center of rotation of the valve body is inserted;

a seat-side abutment surface that is provided around the seat-side valve rod hole portion and allows a valve body-side abutment surface to abut thereagainst, the valve body-side abutment surface being provided around a valve body-side valve rod hole portion provided in the valve body;

a continuous first sealing surface that is continuous with the first sealing surface and extends to the seat-side

abutment surface;

a continuous engaging convex portion that is continuous with the engaging convex portion and extends to the seat-side abutment surface; and

a continuous engaging sealing surface that is continuous with the engaging sealing surface and extends to the seat-side abutment surface,

characterized in that each of the continuous first sealing surface, the continuous engaging convex portion, and the continuous engaging sealing surface has a shape whose entirety comes into close contact with a side of a valve body continuous connecting surface when abutting thereagainst, the valve body continuous connecting surface being continuously connected between the outer circumferential surface of the valve body and a valve body-side abutment surface.

[0010]

Further, a valve of the invention of the present application includes the inner circumference sealing structure.

EFFECTS OF THE INVENTION

[0011]

According to the inner circumference sealing structure of the invention of the present application, the first sealing surface that allows the outer circumferential surface

of the valve body to abut thereagainst and stop there is provided separately from the engaging sealing surface that allows the outer circumferential surface of the valve body to abut thereagainst and stop there. Therefore, the operating torque can be set so that the outer circumferential surface of the valve body is not stopped at the engaging sealing surface that has a larger sealing amount than the first sealing surface, but is stopped at the first sealing surface that has a small sealing amount and has smaller urging force applied from the seat ring. Thus, the valve body can be rotated and closed with smaller operating torque, and the operating torque can be reduced. Therefore, the scale of the rotary drive unit for rotating the valve body can be reduced. Note that, when the fluid pressure is small, the sealing performance can be maintained even if the outer circumferential surface of the valve body is stopped at the first sealing surface that has a small sealing amount. Hence, the sealing performance can be maintained while reducing the operating torque for closing the valve body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 is a plan view illustrating an inner circumference sealing structure according to the invention of the present application.

FIG. 2 is sectional plan views for explaining the inner circumference sealing structure illustrated in FIG. 1: FIG. 2(a) is a view illustrating a state immediately before a valve body abuts against a seat ring; FIG. 2(b) is a view illustrating a state in which the valve body is abutting against a first sealing surface; FIG. 2(c) is a view illustrating a state in which the valve body is abutting against a second sealing surface; and FIG. 2(d) is a view illustrating a state in which the valve body is engaged with an engaging convex portion.

FIG. 3(a) is a perspective view illustrating a seat structure according to the invention of the present application, and FIG. 3(b) is a perspective view illustrating the valve body.

FIG. 4 is a sectional front view illustrating an example of a valve including the inner circumference sealing structure and the seat structure according to the invention of the present application.

FIG. 5 is views for explaining actions and effects due to a concave curved surface shape of a sealing surface: FIG. 5(a) is a schematic plan view illustrating the sealing surface according to the invention of the present application; FIG. 5(b) is a schematic plan view illustrating a sealing surface according to a conventional technology; and FIG. 5(c) is a graph comparing the sealing surface according

to the invention of the present application and the sealing surface according to the conventional technology with regard to a sealing amount.

FIG. 6 is views for explaining actions and effects of a joint portion between the inner circumference sealing structure (sealing portion) and a seat-side abutment surface: FIG. 6(a) is a schematic perspective view illustrating the joint portion according to the invention of the present application; and FIG. 6(b) is a schematic perspective view illustrating a joint portion according to the conventional technology.

FIG. 7 is a sectional front view illustrating a conventional valve.

FIG. 8 is a cross-sectional view of a cut portion along a line A-A, illustrating another embodiment of the seat ring according to the invention of the present application.

FIG. 9 is a conceptual diagram for explaining an example of a method of forming a concave curved surface of the seat ring illustrated in FIG. 8.

BEST MODE FOR CARRYING OUT THE INVENTION

[0013]

Embodiments of an inner circumference sealing structure, a seat structure, and a butterfly valve (valve) according to the invention of the present application will be

described with reference to the drawings. In FIGS. 1 to 4, reference numeral 16 denotes the inner circumference sealing structure of the invention of the present application. In FIGS. 3 and 4, reference numeral 34 denotes the seat structure of the invention of the present application. In FIGS. 2 and 4, reference numeral 10 denotes the butterfly valve of the invention of the present application.

[0014]

(Configuration)

As illustrated in FIG. 2, the butterfly valve 10 includes a valve box 114, and a seat ring 12 combined with the valve box 114. The valve box 114 is formed of, for example, aluminum (pure aluminum or an aluminum alloy). The valve box 114 may be formed of metal other than aluminum. The seat ring 12 is formed of, for example, ethylene propylene rubber (EPDM) or nitrile rubber (NBR), and may be formed of another rubber or resin. Moreover, the butterfly valve 10 includes a valve body 14 placed in the seat ring 12, and two valve rods 22 (illustrated in FIG. 3(b)) fixed to an upper part and lower part of the valve body 14. The valve body 14 has a substantially disc shape or a substantially circular plate shape. The valve body 14 is formed of, for example, stainless steel. The valve body 14 may be formed of metal other than stainless steel. The valve body 14 is provided with, at an upper part and lower part thereof, valve

body-side valve rod holes 26 (illustrated in FIG. 3(b)) which allow the valve rods 22 to be inserted thereinto and fix the same. The valve rods 22 are formed of stainless steel, and may be made of metal other than stainless steel. The valve rods 22 are allowed to rotatably penetrate seat-side valve rod holes 24 (illustrated in FIG. 3(a)) of the valve box 114 and the seat ring 12. The butterfly valve 10 includes a fixing unit 140 (illustrated in FIG. 4) coupled to the valve box 114 and fixed to a valve drive unit (not illustrated) having a rotary drive unit. The fixing unit 140 is formed of, for example, aluminum, and may be formed of metal other than aluminum.

[0015]

(Inner Circumference Sealing Structure (Sealing Portion) 16)

As illustrated in FIG. 1, the seat ring 12 includes the inner circumference sealing structure 16 that swells from an inner circumferential surface 12i of the seat ring 12 and allows an outer circumferential surface 14s of the valve body 14 to abut thereagainst, the valve body 14 being to be applied with fluid pressure. As illustrated in FIG. 4, the inner circumference sealing structure 16 is provided at each of two right and left locations of the seat ring 12 (which are symmetrical positions with a center of rotation C1 as an axis of symmetry) in front view. The inner circumference

sealing structure 16 includes: a first sealing surface 18(1) that enables the outer circumferential surface 14s of the valve body 14 to abut thereagainst and stop there; and a second sealing surface 18(2) that allows the outer circumferential surface 14s of the valve body 14 to abut thereagainst and stop there and is continuous with the first sealing surface 18(1). The first sealing surface 18(1) and the second sealing surface 18(2) have a concave curved surface shape in order to reduce a sealing amount as much as possible. Moreover, the inner circumference sealing structure 16 includes: an engaging sealing surface 18(3) that allows the outer circumferential surface 14s of the valve body 14 to abut thereagainst and stop there and is continuous with the second sealing surface 18(2); and an engaging convex portion 20 that allows the outer circumferential surface 14s of the valve body 14 to be engaged therewith and restricts the valve body 14 from rotating. The outer circumferential surface 14s of the valve body 14 is configured to be able to abut against the engaging sealing surface 18(3) and stop there by being engaged with the engaging convex portion 20. Moreover, in the inner circumference sealing structure 16, the first sealing surface 18(1), the second sealing surface 18(2), the engaging sealing surface 18(3) and the engaging convex portion 20 are arranged in this order in a direction in which the outer circumferential surface 14s of the valve

body 14 moves by the rotation of the valve body 14.

[0016]

The inner circumference sealing structure 16 is configured so that the engaging sealing surface 18(3) has a larger sealing amount, which is a depth by which the outer circumferential surface 14s of the valve body 14 enters, than the first sealing surface 18(1). Here, the sealing amount of the first sealing surface 18(1) is indicated by SW1, and the sealing amount of the engaging sealing surface is indicated by SW3. Moreover, the inner circumference sealing structure 16 is configured so that the second sealing surface 18(2) has a larger sealing amount than the first sealing surface 18(1). Here, the sealing amount of the second sealing surface 18(2) is indicated by SW2. Further, the inner circumference sealing structure 16 is configured so that the engaging sealing surface 18(3) has a larger sealing amount than the second sealing surface 18(2). That is, urging force from the seat ring 12 increases in the order of the case of stopping the outer circumferential surface 14s of the valve body 14 at the first sealing surface 18(1), the case of stopping the outer circumferential surface 14s of the valve body 14 at the second sealing surface 18(2), and the case of stopping the outer circumferential surface 14s of the valve body 14 at the engaging sealing surface 18(3). Therefore, operating torque for closing the valve body 14 increases in the order of the

case of stopping the outer circumferential surface 14s of the valve body 14 at the first sealing surface 18(1), the case of stopping the outer circumferential surface 14s of the valve body 14 at the second sealing surface 18(2), and the case of stopping the outer circumferential surface 14s of the valve body 14 at the engaging sealing surface 18(3).

[0017]

(Seat Structure 34)

As illustrated in FIG. 3, the seat ring 12 includes a seat structure 34 including two (right and left in front view) inner circumference sealing structures 16. In FIG. 3(a), alternate long and short dash lines indicating other than the center of rotation C1 indicate centerlines (valley lines) in the case of the sealing surfaces, and indicate ridge lines in the case of the convex portions. Moreover, in FIG. 3(a), a dotted line is a line indicating a boundary between the inner circumference sealing structures 16 and seat continuous connecting surfaces 31 to be described later. In FIG. 3(b), a dotted line is a line indicating a boundary between the outer circumferential surface 14s of the valve body 14 and valve body continuous connecting surfaces 32 to be described later, and chain double-dashed lines are lines indicating boundaries between the valve body continuous connecting surfaces 32 and a valve body-side abutment surface 28 to be described later. The seat structure 34 is provided

at each of two locations on the upper side and lower side of the seat ring 12 in FIG. 4.

[0018]

As illustrated in FIG. 3(a), the seat structure 34 is provided with a seat-side valve rod hole 24 that allows the valve rod 22 to be inserted therein, the valve rod 22 constituting the center of rotation C1 of the valve body 14. Moreover, the seat structure 34 includes a seat-side abutment surface 30 that is provided around the seat-side valve rod hole 24 and allows the valve body-side abutment surface 28 to abut thereagainst, the valve body-side abutment surface 28 being provided around the valve body-side valve rod hole 26 which the valve body 14 has. Note that, in FIG. 3A, a range of a broken line indicating the seat-side abutment surface 30 is a range that abuts against the valve body-side abutment surface 28. Moreover, the seat structure 34 includes: a continuous first sealing surface 18(1)ex that is continuous with the first sealing surface 18(1) and extends to the seat-side abutment surface 30; and a continuous second sealing surface 18(2)ex that is continuous with the second sealing surface 18(2) and extends to the seat-side abutment surface 30. Further, the seat structure 34 includes: a continuous engaging sealing surface 18(3)ex that is continuous with the engaging sealing surface 18(3) and extends to the seat-side abutment surface 30; and a continuous engaging convex portion

20ex that is continuous with the engaging convex portion 20 and extends to the seat-side abutment surface 30. Each of the continuous first sealing surface 18(1)ex, the continuous second sealing surface 18(2)ex, the continuous engaging sealing surface 18(3)ex, and the continuous engaging convex portion 20ex has a curved shape whose entirety comes into close contact with a curved side 32si of the valve body continuous connecting surface 32 when abutting thereagainst, the valve body continuous connecting surface 32 being continuously connected between the outer circumferential surface 14s of the valve body 14 and the valve body-side abutment surface 28. The sealing amount of each of the continuous first sealing surface 18(1)ex, the continuous second sealing surface 18(2)ex, and the continuous engaging sealing surface 18(3)ex decreases toward the seat-side abutment surface 30.

[0019]

(Actions and Effects)

(Inner Circumference Sealing Structure 16)

Actions and effects of the inner circumference sealing structure 16 of the butterfly valve 10 of the invention of the present application will be described below with reference to FIGS. 1 and 2. In the inner circumference sealing structure 16, the operating torque required to close the valve body 14 increases in an ascending order of the

sealing amount, that is, in order from the first sealing surface 18(1) that has a smallest sealing amount SW1 through the second sealing surface 18(2) that has a sealing amount larger than SW2 and smaller than SW3 to the engaging sealing surface 18(3) that has SW3 as a largest sealing amount. Moreover, it is necessary to increase the sealing amount as the fluid pressure is larger. Therefore, the operating torque can be set, for example, so that the outer circumferential surface 14s of the valve body 14 is stopped at the first sealing surface 18(1) to close the valve body 14 when the fluid pressure is 0.5 MPa, that the outer circumferential surface 14s of the valve body 14 is stopped at the second sealing surface 18(2) to close the valve body 14 when the fluid pressure is 1.0 MPa, and that the outer circumferential surface 14s of the valve body 14 is stopped at the engaging sealing surface 18(3) to close the valve body 14 when the fluid pressure exceeds 1.0 MPa. The operating torque is the smallest when the operating torque is set so that the outer circumferential surface 14s of the valve body 14 is stopped at the first sealing surface 18(1) to close the valve body 14. Therefore, the valve body 14 can be closed with small operating torque, and a scale of the rotary drive unit of the valve body can be reduced. Moreover, the outer circumferential surface 14s of the valve body 14 is allowed to abut against the first sealing surface 18(1) with the

small sealing amount SW1, whereby lifetimes of the seat ring 12 and the valve body 14 can be extended. In this case, the sealing amount SW1 is the smallest, but the fluid pressure received by the valve body 14 is the smallest at 0.5 MPa, which is accordingly sufficient for maintaining the sealing performance. Therefore, the valve body 14 can be closed with small operating torque, and the sealing performance can be maintained.

[0020]

Further, according to the inner circumference sealing structure 16, even if the fluid pressure is 1.0 MPa and the operating torque is set so that the outer circumferential surface 14s of the valve body 14 is stopped at the second sealing surface 18(2) to close the valve body 14, the valve body 14 can be closed with small operating torque as compared to the case where the operating torque is set so that the outer circumferential surface 14s of the valve body 14 is stopped at the engaging sealing surface 18(3) to close the valve body 14. Moreover, according to the inner circumference sealing structure 16, as compared to the case where the outer circumferential surface 14s of the valve body 14 is stopped at the engaging sealing surface 18(3) to close the valve body 14, either the first sealing surface 18(1) or the second sealing surface 18(2) can be selected as a method for closing the valve body 14 with small operating torque.

Further, according to the inner circumference sealing structure 16, when the fluid pressure is a high pressure exceeding 1.0 MPa, the engaging sealing surface 18(3) can be selected as a position where the outer circumferential surface 14s of the valve body 14 is stopped to close the valve body 14. In this case, even if unexpectedly large operating torque is generated, the valve body 14 is engaged with the engaging convex portion 20 and stops, and the valve body 14 does not separate from the engaging sealing surface 18(3).

[0021]

Further, when the valve body 14 overruns, is engaged with the engaging convex portion 20, and stops at the engaging sealing surface 18(3), the sealing amount (an amount by which the valve body 14 crushes the inner circumference sealing structure 16, that is, the depth at which the valve body 14 enters) is large, and the sealing performance is improved. However, the operating torque increases by that amount. That is, if the valve body 14 is rotated with the set operating torque, the sealing performance can be maintained. In adjustment work for an opening angle of the valve body, it becomes unnecessary to worry about passage and shake-off of the valve body 14 through the sealing portion, and workability is improved. Moreover, the sealing performance decreases due to wear of the inner circumference

sealing structure 16 (FIG. 5(a) illustrates a worn sealing surface 19). At this time, as illustrated by a chain double-dashed line in FIG. 5(a), the valve body 14 is adjusted so as to be rotated more than the fully closed position in the direction of closing the valve body 14 (the adjustment includes adjustment of a stopper of a drive unit, and the like), whereby recovery of the sealing performance can be easily expected. Therefore, the lifetime of the product can be extended. Note that, in the case of the conventional technology, in order to prolong the lifetime of the product, it is necessary to largely set the sealing amount so that the sealing performance can be maintained even if the seal wears. For example, as illustrated by a chain double-dashed line in FIG. 5(b), it is necessary to largely set the sealing amount so as to form a larger sealing surface 113. Therefore, the required operating torque increases.

[0022]

Moreover, according to the inner circumference sealing structure 16, the first sealing surface 18(1), the second sealing surface 18(2), the engaging sealing surface 18(3), and the engaging convex portion 20 are arranged in this order in the direction in which the outer circumferential surface 14s of the valve body 14 moves by the rotation of the valve body 14. Accordingly, when the operating torque is set so that the valve body 14 stops at the first sealing surface

18(1), the outer circumferential surface 14s of the valve body 14 surely abuts against the first sealing surface 18(1) and stops. That is, without fail, the valve body 14 does not abut against the engaging convex portion 20 or stops, and the outer circumferential surface 14s reaches the first sealing surface 18(1).

[0023]

Here, actions and effects due to the concave curved surface shape of the sealing surface will be described below with reference to FIG. 5. In FIG. 5, an X-axis shows a moving amount of the outer circumferential surface of the valve body. In FIGS. 5(a) and 5(b), shaded and hatched portions are portions crushed by the valve body in the sealing portion of the seat ring. In FIG. 5(c), a Y-axis shows the sealing amount. In FIG. 5(c), a solid line shows a change in the sealing amount in the invention of the present application, and a chain double-dashed line shows a change in the sealing amount in the conventional technology. In FIG. 5, DL is a fully closed position. As illustrated in FIG. 5(c), in the case of the invention of the present application, the sealing amount gradually increases. On the other hand, in the case of the conventional technology, the sealing amount sharply increases from the 0 point. Therefore, as compared to the conventional technology, in the invention of the present application, a total amount of

crushing the sealing portion decreases, and the operating torque for rotating and closing the valve body decreases.

[0024]

(Seat Structure 34)

Actions and effects of the seat structure 34 of the butterfly valve 10 of the invention of the present application will be described below with reference to FIG. 3. As mentioned above, each of the continuous first sealing surface 18(1)ex, the continuous second sealing surface 18(2)ex, the continuous engaging sealing surface 18(3)ex, and the continuous engaging convex portion 20ex has a curved shape whose entirety comes into close contact with the curved side 32si of the valve body continuous connecting surface 32 when abutting thereagainst, the valve body continuous connecting surface 32 being continuously connected between the outer circumferential surface 14s of the valve body 14 and the valve body-side abutment surface 28. Therefore, when the valve body 14 is set to abut against the first sealing surface 18(1) and to be closed, the side 32si of the valve body 14 abuts against the continuous first sealing surface 18(1)ex of the seat ring 12. That is, the entire curved side 32si abuts against the curved continuous first sealing surface 18(1)ex. At this time, the valve body continuous connecting surface 32 abuts against the seat continuous connecting surface 31. Thus, an abutment area between the

valve body 14 and the seat ring 12 can be widened, and the sealing performance can be improved. Moreover, the side 32si of the valve body 14 enters the continuous first sealing surface 18(1)ex by a predetermined sealing amount.

Therefore, the sealing performance can be improved. Also when the valve body 14 is set to abut against the second sealing surface 18(2) and to be closed, and also when the valve body 14 is set to abut against the engaging sealing surface 18(3) and to be closed, the sealing performance between the side 32si of the valve body 14 and the seat-side abutment surface 30 can be improved in a similar way. In particular, when the valve body 14 is set to abut against the engaging sealing surface 18(3) and to be closed, the entire side 32si of the valve body 14 abuts against the continuous engaging convex portion 20. Accordingly, the abutment area can be further widened, and the sealing performance can be improved.

[0025]

Next, actions and effects of a joint portion 35 between the inner circumference sealing structure (sealing portion) 16 and the seat-side abutment surface 30 in the seat structure 34 of the invention of the present application will be described with reference to FIG. 6. In FIG. 6(a), the joint portion 35 is hatched and shaded. In FIG. 6(b), a joint portion 112 is hatched and shaded. In FIG. 6(a), a

sealing line (valve seat) VS is illustrated by a chain double-dashed line. In FIG. 6(b), a valve seat ridge line VS is illustrated by a chain double-dashed line. In the seat structure 34 of the invention of the present application, since each of the inner circumference sealing structure 16 and the seat-side abutment surface 30 has a concave shape, the shape of the inner circumference sealing structure 16 and the seat-side abutment surface 30 can be smoothly joined to each other at the joint portion 35. Therefore, excessive operating torque is not required in the joint portion 35. On the other hand, in the conventional technology, as illustrated in FIG. 6(b), the sealing portion 110 has a convex shape, whereas the seat-side abutment surface 114 has a concave shape. For this reason, the joint portion 112 requires a switching portion from convex to concave. Accordingly, in order to smoothly join the shape of the sealing portion 110 and the shape of the seat-side abutment surface 114 to each other, a shape 112ov having a width larger than a theoretically required shape 112or has been required. Thus, the required operating torque has increased. Moreover, since this switching portion is likely to cause a design defect in the sealing performance, it has been necessary to check the sealing performance on an actual machine. Therefore, in the case of the conventional technology, a lot of development man-hours have been

required. However, the invention of the present application eliminates such work and leads to facilitation of development.

[0026]

Further, in the seat ring 12 according to the invention of the present application, a seat portion 300 against which an outer circumferential surface 30S of the valve body 14 abuts may have a concave curved surface 28CC on a surface thereof close to the valve body 14 as illustrated in FIGS. 8 and 9. In this case, the valve body 14 is configured to stop at a sealing position illustrated in FIG. 8 after the valve body 14 rotates clockwise around the center of rotation C1 of the valve rod, the outer circumferential surface 30S abuts against the concave curved surface 28CC, and the sealing amount SW by which the outer circumferential surface 30S enters the concave curved surface 28CC gradually increases. The sealing position is a position where the valve body 14 that has rotated completely stops due to resistance from a seat convex portion 28CV. The sealing position is determined by rotational torque of the valve body 14, elastic modulus of the seat ring 12, and dimensions of the seat convex portion 28CV. In the case of the seat portion 300 illustrated in FIG. 8, the valve body 14 stops at the sealing position in a state in which the sealing amount SW by which the outer circumferential surface 30S enters the concave curved surface

28CC gradually increases, and rotational speed of the valve body 14 gradually decreases due to the resistance from the concave curved surface 28CC and sufficiently decreases. Therefore, the valve body 14 can be surely stopped at the sealing position.

[0027]

An example of a method of forming this concave curved surface 28CC will be described below. On a CAD screen, first, for example, a rotation locus circle R1 of the outer circumferential surface of the valve body is drawn, and a plurality of pitch circles whose radii become smaller at a constant pitch are drawn with respect to the rotation locus circle R1. Moreover, a straight line ST0 is drawn, which passes through the center of rotation C1 and a point where the outer circumferential surface comes into contact with the concave curved surface at the sealing position, and a plurality of pitch straight lines are drawn, which pass through the center of rotation C1 and are rotated counterclockwise at a constant angle pitch with respect to the straight line ST0. Next, such predetermined intersections which can form concave curved surface are selected from among intersections of the rotation locus circle R1 and the pitch circles and intersections of the straight line ST0 and the pitch straight lines. A spline curve that passes through the selected intersections is

drawn, and this spline curve becomes the concave curved surface 28CC.

[0028]

The example of the method of forming the concave curved surface 28CC will be specifically described below with reference to FIG. 9. A radius of the rotation locus circle R1 that takes as a center the center of rotation C1 of the valve body 14 is defined as r_1 . First, the rotation locus circle R1 is drawn. Next, a plurality of circles whose radii become smaller at a pitch of d mm (for example, 1 mm) with respect to the rotation locus circle R1 are drawn. That is, drawn are: a pitch circle R2 with a radius of $r_1 - d$ mm; a pitch circle R3 with a radius of $r_1 - 2 \cdot d$ mm; a pitch circle R4 with a radius of $r_1 - 3 \cdot d$ mm; a pitch circle R5 with a radius of $r_1 - 4 \cdot d$ mm; and a pitch circle R0 with a radius of $r_1 - 5 \cdot d$ mm. An order of drawing the respective circles is not limited.

[0029]

When the valve body 14 is at the sealing position, θ (rotation angle of the valve body 14) is defined to be equal to 0° ($= 0^\circ$). Drawn is the straight line ST0 that passes through the center of rotation C1 and a point P0 where the outer circumferential surface 30S comes into contact with the concave curved surface 28CC at the sealing position. Next, drawn are the plurality of pitch straight lines which pass

through the center of rotation C1 and are rotated counterclockwise at an angle θ_1 (for example, 3°) with respect to ST0. That is, drawn are: the straight line ST0 that passes through C1 when $\theta = 0$; a pitch straight line ST5 when $\theta = -\theta_1$; a pitch straight line ST4 when $\theta = -2 \cdot \theta_1$; a pitch straight line ST3 when $\theta = -3 \cdot \theta_1$; a pitch straight line ST2 when $\theta = -4 \cdot \theta_1$; and a pitch straight line ST1 when $\theta = -5 \cdot \theta_1$. An order of drawing the respective straight lines is not limited.

[0030]

Plotted are: an intersection P5 between ST1 and the rotation locus circle R1; an intersection P4 between ST2 and R2; an intersection P3 between ST3 and R3; an intersection P2 between ST4 and R4; an intersection P1 between ST5 and R5; and an intersection P0 between ST0 and R0. Next, a spline curve that passes through these intersections P5 and the like is drawn. This spline curve becomes the concave curved surface 28CC. P5 is a point where the outer circumferential surface 30S of the valve body 14 begins to contact the concave curved surface 28CC of the seat ring 12. A sealing amount SW0 is equal to 0 mm (= 0 mm) at P5, a sealing amount SW4 is equal to $1 \cdot d$ mm (= $1 \cdot d$ mm) at P4, a sealing amount SW3 is equal to $2 \cdot d$ mm (= $2 \cdot d$ mm) at P3, and a sealing amount SW2 is equal to $3 \cdot d$ mm (= $3 \cdot d$ mm) at P2, and a sealing amount SW1 is equal to $4 \cdot d$ mm (= $4 \cdot d$ mm) at P1, and a sealing amount SW0

is equal to $5 \cdot d$ mm (= $5 \cdot d$ mm) at P0. Although the example of the method of forming the concave curved surface 28CC has been described above, the method of forming the concave curved surface 28CC is not limited.

[0031]

Although the embodiments of the invention of the present application have been described above, the invention of the present application is not limited to the above-mentioned embodiments, and can be appropriately modified within the range in which the same actions and effects are produced. For example, the valve of the invention of the present application is not limited to the butterfly valve, and the type of valve is not limited. Moreover, the butterfly valve of the invention of the present application includes uniaxial eccentric, biaxial eccentric and triaxial eccentric ones. Further, the butterfly valve may be configured to include only either one of the first sealing surface 18(1) and the second sealing surface 18(2). In this case, the operating torque is set so as to close the valve body 14 on either one of the first sealing surface 18(1) and the second sealing surface 18(2), whereby the valve body 14 can be closed with smaller operating torque than when the valve body 14 is closed on the engaging sealing surface 18(3). Moreover, a concave surface may be formed of the first sealing surface 18(1), the second sealing surface

18(2), and the engaging sealing surface 18(3).

REFERENCE SIGNS LIST

[0032]

- 10 Butterfly valve (valve)
- 12 Seat ring
- 12i Inner circumferential surface
- 14 Valve body
- 14s Outer circumferential surface
- 16 Inner circumference sealing structure
- 18(1) First sealing surface
- 18(1)ex Continuous first sealing surface
- 18(2) Second sealing surface
- 18(2)ex Continuous second sealing surface
- 18(3) Engaging sealing surface
- 18(3)ex Continuous engaging sealing surface
- 20 Engaging convex portion
- 20ex Continuous engaging convex portion
- 22 Valve rod
- 24 Seat-side valve rod hole
- 26 Valve body-side valve rod hole
- 28 Valve body-side abutment surface
- 30 Seat-side abutment surface
- 31 Seat continuous connecting surface
- 32 Valve body continuous connecting surface

32si Side

33 Seat-side abutment surface

34 Seat structure

C1 Center of rotation

SW1, SW2, SW3 Sealing amount

CLAIMS

1. An inner circumference sealing structure that is provided on a seat ring of a valve, swells from an inner circumferential surface of the seat ring, and allows an outer circumferential surface of a valve body to abut thereagainst, the valve body being to be applied with fluid pressure, the inner circumference sealing structure comprising:

a first sealing surface that has a concave shape and allows the outer circumferential surface of the valve body to abut thereagainst and stop there;

an engaging convex portion that allows the valve body to be engaged therewith and restricts rotation of the valve body; and

an engaging sealing surface that allows the outer circumferential surface of the valve body to abut thereagainst and stop there when the valve body is engaged with the engaging convex portion,

wherein the inner circumference sealing structure is configured so that the engaging sealing surface has a larger sealing amount than the first sealing surface, the sealing amount being a depth by which the outer circumferential surface of the valve body enters.

2. The inner circumference sealing structure according to

claim 1, wherein the first sealing surface, the engaging sealing surface, and the engaging convex portion are arranged in this order in a direction in which the outer circumferential surface of the valve body moves by the rotation of the valve body.

3. The inner circumference sealing structure according to claim 1 or 2, wherein

a second sealing surface is provided, the second sealing surface having a concave shape, allowing the outer circumferential surface of the valve body to abut thereagainst and stop there, and being continuous with the first sealing surface,

the first sealing surface, the second sealing surface, the engaging sealing surface, and the engaging convex portion are arranged in this order in the direction in which the outer circumferential surface of the valve body moves by the rotation of the valve body,

the inner circumference sealing structure is configured so that the second sealing surface has a larger sealing amount than the first sealing surface, and

the inner circumference sealing structure is configured so that the engaging sealing surface has a larger sealing amount than the second sealing surface.

4. A seat structure provided on a seat ring of a valve, comprising:

the inner circumference sealing structure according to claim 1 or 2;

a seat-side valve rod hole portion into which a valve rod constituting a center of rotation of the valve body is inserted;

a seat-side abutment surface that is provided around the seat-side valve rod hole portion and allows a valve body-side abutment surface to abut thereagainst, the valve body-side abutment surface being provided around a valve body-side valve rod hole portion provided in the valve body;

a continuous first sealing surface that is continuous with the first sealing surface and extends to the seat-side abutment surface;

a continuous engaging convex portion that is continuous with the engaging convex portion and extends to the seat-side abutment surface; and

a continuous engaging sealing surface that is continuous with the engaging sealing surface and extends to the seat-side abutment surface,

wherein each of the continuous first sealing surface, the continuous engaging convex portion, and the continuous engaging sealing surface has a shape whose entirety comes into close contact with a side of a valve body continuous

connecting surface when abutting thereagainst, the valve body continuous connecting surface being continuously connected between the outer circumferential surface of the valve body and a valve body-side abutment surface.

5. A valve comprising the inner circumference sealing structure according to any one of claims 1 to 3.