

HYDRAULIC ROTARY ACTUATOR FOR OPENING AND CLOSING BUTTERFLY VALVE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a hydraulic rotary actuator and, more particularly, to a hydraulic rotary actuator for opening and closing a butterfly valve, which is connected with an exposed portion of a valve shaft of a butterfly valve and is configured to open and close the butterfly valve by rotating the valve shaft of the butterfly valve using hydraulic pressure.

Description of the Related Art

In general, valves are used to control the flow rate, flow velocity, pressure or the like of a fluid flowing through a conduit. As one example of various types of valves, a butterfly valve is used in many industrial fields, particularly, in order to control the flow of a fluid, such as industrial water, oil, sea water or the like, to be stopped or to be maintained. Compared with other types of valves, the butterfly valve has the advantages of smooth opening/closing operation, a simple structure and good space utilization.

As shown in FIG. 1, a general butterfly valve

comprises a valve body 11 mounted in a conduit (not shown) for feeding a fluid, a disc 12 rotatably mounted in the valve body 11 in order to open and close the conduit, and a valve shaft 13 coupled to the disc 12 to rotate the disc 12 and having one end that is exposed outside the valve body 11. By rotating the valve shaft 13 exposed outside the valve body 11, the disc 12 coupled to the valve shaft 13 is rotated, thereby achieving opening/closing operation.

In order to rotate the valve shaft 13, a rotation driving device is mounted above the valve body 11. Rotational force is transmitted to the valve shaft 13 through a power transmission unit from various kinds of power sources. For example, the power source may be a worker's manual operation for rotating a handle, an electric motor, a hydraulic actuator, a pneumatic actuator or the like. The rotational force generated from the power source is transmitted to the valve shaft 13 through a power transmission unit. The power transmission unit may be embodied as engagement of a plurality of gears, kinematic links or the like.

A rubber butterfly valve disclosed in Korean Patent Laid-open Publication No. 10-2002-0003769 is structured such that the power source is a worker's manual operation for rotating a handle and the power transmission unit is the engagement of a plurality of gears. An actuator for a

rotary valve disclosed in Korean Patent Registration No. 10-0482906 is structured such that the power source is an electric motor and the power transmission unit is a worm gear. However, manually rotating a handle naturally has many limitations on efficient operation. Also, in the case of using an electric motor, if the power required to operate the valve is relatively large, an electric motor having a large capacity and size is needed, which causes problems such that the whole device is enlarged and wiring and gear engagement structures are complicated.

In order to solve these problems, currently used is a hydraulic rotary actuator that has a rapid response time and generates a relatively high torque in small spaces using hydraulic pressure. The hydraulic rotary actuator is configured such that a piston is made to reciprocate linearly by hydraulic pressure and the linear motion is transmitted to an output shaft connected with the piston and converted into rotary motion. The converted rotary motion is transferred to the valve shaft 13 of the butterfly valve 10, thereby opening and closing the disc 12 of the butterfly valve 10.

The hydraulic rotary actuator mostly uses hydraulic pressure as a power source and a rack-and-pinion mechanism or scotch-yoke mechanism as a power transmission unit. As shown in FIG. 2, a rack-and-pinion mechanism 20 includes a

pair of cylinders 21 provided on left and right sides, a pair of pistons 23, each of which is mounted in a respective cylinder 21, a rack gear 22 provided between the pistons 23, a pinion gear 24 tooth-engaged with the rack gear 22 so as to be rotated, and a rotating shaft 25 coupled to the pinion gear 24. As shown in FIG. 3, a scotch-yoke mechanism 30 includes a pair of cylinders 31 provided on left and right sides, a pair of pistons 33, each of which is mounted in a respective cylinder 31, a scotch 32 provided between the pistons 33 and protruding outwards, a yoke 34 linked with the scotch 32 so as to be rotated, and a rotating shaft 35 coupled to the yoke 34.

However, since the rack-and-pinion mechanism 20 and the scotch-yoke mechanism 30 have commonly a pair of cylinders 21 and 31 and a pair of pistons 23 and 33, space utilization is deteriorated due to the increase in size of the device, and accordingly manufacturing costs are increased. In order to solve these problems, as disclosed in Korean Patent Registration No. 10-0554689, Korean Patent Registration No. 10-0578538 and Korean Patent Registration No. 10-1424423, a hydraulic rotary actuator has been devised, in which a single piston is mounted in a single cylinder, a rotating shaft is mounted coaxially with the piston, and the rotating shaft is rotated in forward and reverse directions corresponding to vertical motion of the

piston, thereby decreasing the size of the device, enhancing space utilization, and remarkably reducing manufacturing costs.

5 The rotating shaft of the above-described hydraulic rotary actuator must be coupled to the valve shaft 13 of the butterfly valve 10. However, since the valve and the actuator are separately manufactured by valve manufacturing companies and actuator manufacturing companies, there are problems whereby the valve shaft and the rotating shaft of
10 the actuator have various shapes, dimensions and tolerances according to the manufacturing company, product type and size. Thus, in order to couple the valve shaft and the rotating shaft, the actuator manufacturing company faces the inconvenience of shaping diverse rotating shafts of the
15 actuator to intermesh with different valve shafts of the butterfly valves supplied from valve manufacturing companies.

SUMMARY OF THE INVENTION

20 The present invention is devised to solve the above problems, and it is an object of the present invention to provide a hydraulic rotary actuator for opening and closing a butterfly valve, in which a new connection structure is realized using a valve connection part that
25 can be easily formed and replaced corresponding to diverse

shapes of a valve shaft of a butterfly valve, and a rotating shaft having a uniform shape can be used regardless of the shape of the valve shaft of the butterfly valve, thereby enhancing productivity.

5 In accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of a hydraulic rotary actuator for opening and closing a butterfly valve including a cylinder formed in a cylindrical shape having an open top and bottom,
10 a piston having a shaft hole formed through a center portion thereof and inserted into the cylinder so as to be vertically reciprocatingly moved in the cylinder according to supply and discharge of hydraulic pressure, a rotating shaft inserted through the shaft hole in the piston,
15 configured to be rotated in forward and reverse directions corresponding to the vertical reciprocating motion of the piston, and having a spline connection groove which is formed longitudinally in a lower end portion thereof, an upper cover coupled to the top of the cylinder and formed
20 with an upper cover hole, through which an upper end portion of the rotating shaft is inserted and supported so as to be rotated, a lower cover coupled to the bottom of the cylinder and formed with a lower cover hole, through which a lower end portion of the rotating shaft is
25 inserted and supported so as to be rotated, and a valve

connection part inserted into the rotating shaft to be spline-engaged with the spline connection groove in the rotating shaft, into which an exposed end portion of a valve shaft of the butterfly valve is fitted.

5 The cylinder may have a pair of opposite fastening holes which are formed through a circumferential surface thereof and to which a guide pin for guiding the vertical reciprocating motion of the piston is fastened. The piston may have a pair of opposite guide slits which are formed
10 through a circumferential surface thereof and extend longitudinally and through which the guide pin is inserted so as to allow the piston to move vertically and reciprocatingly with respect to the cylinder, and a pair of opposite rotation slits which are formed through the
15 circumferential surface thereof and extend diagonally and through which the rotation pin for guiding rotary motion of the rotating shaft is inserted. The rotating shaft may have through-holes which are formed through a circumferential surface thereof and through which the
20 rotation pin is inserted so as to allow the rotating shaft to be rotated in the forward and reverse directions with respect to the piston corresponding to the vertical reciprocating motion of the piston.

 The rotating shaft may have a rotation angle of 90°
25 with respect to the piston.

The upper cover may be formed with an upper hydraulic pressure port, through which the hydraulic pressure is supplied or discharged into/from a region above the piston in the cylinder, and the lower cover may be formed with a lower hydraulic pressure port, through which the hydraulic pressure is supplied or discharged into/from a region below the piston in the cylinder.

The upper cover and the lower cover may be coupled to each other by a plurality of stud bolts.

The rotating shaft may have a rotation angle indication line provided on a top surface thereof in order to indicate a rotation angle, and the upper cover may have a rotation angle indication scale provided on a top surface thereof, which corresponds to the rotation angle indication line based on an actual rotation angle of the rotating shaft.

The valve connection part may have a spline which is formed longitudinally around an outer circumferential surface thereof so as to be inserted into the rotating shaft and spline-engaged with the spline connection groove in the rotating shaft, and a valve connection hole which is formed longitudinally therethrough and has a cross-section of the same shape as a cross-section of the exposed end portion of the valve shaft of the butterfly valve so that the end portion of the valve shaft can be

fitted into the valve connection hole.

The cross-section of the end portion of the valve shaft may have a polygonal shape or a "D" shape.

5 The end portion of the valve shaft and the valve connection hole in the valve connection part may be key-coupled to each other.

10 The end portion of the valve shaft of the butterfly valve may have a circular cross-section. The valve connection part may include a cylindrical-shaped valve connector which has a spline which is formed longitudinally around an outer circumferential surface thereof so as to be inserted into the rotating shaft and spline-engaged with the spline connection groove in the rotating shaft, and a truncated conical-shaped fixing
15 chuck which is narrow at the top and wide at the bottom, has a plurality of slits formed longitudinally around a circumferential surface thereof, and is configured to be longitudinally fitted into or drawn out of a lower end portion of the valve connector. When the fixing chuck is
20 fitted into the lower end portion of the valve connector, a diameter of the fixing chuck may be decreased, and when the fixing chuck is drawn out of the lower end portion of the valve connector, the diameter of the fixing chuck may be increased, and when the end portion of the valve shaft
25 of the butterfly valve is inserted into the fixing chuck,

the diameter of the fixing chuck may be decreased by being fitted into the lower end portion of the valve connector, thereby tightly holding the circumferential surface of the end portion of the valve shaft.

5 The valve connector may have a slide pin insertion hole which is formed through a side surface of the lower end portion thereof, the fixing chuck may have a pin slide slot which is formed through a side surface thereof at a position corresponding to the slide pin insertion hole in
10 the valve connector and extends longitudinally farther than the slide pin insertion hole, and the valve connection part may further include a slide pin which is inserted into the pin slide slot in the fixing chuck through the slide pin insertion hole in the valve
15 connector. A distance by which the fixing chuck is fitted into or drawn out of the valve connector may be determined by a longitudinal length of the pin slide slot.

 The valve connection part may further include a spring which is disposed in the valve connector and is
20 configured to apply an elastic force in a direction of drawing out the fixing chuck.

BRIEF DESCRIPTION OF THE DRAWINGS

 The above and other objects, features and other
25 advantages of the present invention will be more clearly

understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view illustrating a general butterfly valve;

5 FIG. 2 is a partially cut perspective view illustrating a conventional rack-and-pinion type hydraulic rotary actuator;

10 FIG. 3 is a partially cut perspective view illustrating a conventional scotch-yoke type hydraulic rotary actuator;

FIG. 4 is a perspective view illustrating a hydraulic rotary actuator for opening and closing a butterfly valve according to an embodiment of the present invention;

15 FIG. 5 is a partially cut perspective view illustrating an essential portion of the embodiment depicted in FIG. 4;

FIG. 6 is an exploded perspective view of the embodiment depicted in FIG. 5;

20 FIGS. 7 and 8 are main portion perspective views illustrating rotary motion of a rotating shaft corresponding to vertical motion of a piston of the embodiment depicted in FIG. 4;

25 FIG. 9 is a main portion perspective view illustrating a first embodiment of a valve connection part of the hydraulic rotary actuator for opening and closing a

butterfly valve according to the present invention;

FIG. 10 is a main portion perspective view illustrating a second embodiment of a valve connection part of the hydraulic rotary actuator for opening and closing a butterfly valve according to the present invention;

FIG. 11 is a main portion perspective view illustrating a third embodiment of a valve connection part of the hydraulic rotary actuator for opening and closing a butterfly valve according to the present invention;

FIG. 12 is a side sectional view illustrating an assembled state of the embodiment depicted in FIG. 11; and

FIGS. 13 and 14 are side sectional views illustrating operation of a valve connection part of the embodiment depicted in FIG. 12.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, preferred embodiments of a hydraulic rotary actuator for opening and closing a butterfly valve according to the present invention will be described in detail with reference to the attached drawings.

A hydraulic rotary actuator for opening and closing a butterfly valve according to the present invention, as shown in FIGS. 4 through 14, comprises a cylinder 100, a piston 200, a rotating shaft 300, an upper cover 400, a lower cover 500 and a valve connection part 600, and may further

comprise stud bolts 700. The hydraulic rotary actuator may further comprise a guide pin 110 and a rotation pin 230, by which the rotating shaft 300 is rotated corresponding to vertical motion of the piston 200.

5 The cylinder 100, as shown in FIGS. 4 through 6, is embodied as a hydraulic cylinder, which is formed in a cylindrical shape having an open top and bottom and serves to vertically reciprocatingly move the piston 200 mounted therein using hydraulic pressure. In other words, the
10 cylinder 100 is formed in a cylindrical shape having an open top and bottom so as to accommodate the piston 200 and the rotating shaft 300 therein. The cylinder 100 has a pair of opposite fastening holes 120 formed through a circumferential surface thereof, to which the guide pin 110
15 for guiding vertical reciprocating motion of the piston 200 is fastened. The open top and bottom of the cylinder 100 are closed by the upper cover 400, the lower cover 500 and the rotating shaft 300, which will be described later.

20 The fastening hole 120 formed through the circumferential surface of the cylinder 100 and the guide pin 110 are respectively formed with female threads and male threads, so that the guide pin 110 is engaged with the fastening hole 120. A packing means (not shown) is provided in the fastening hole 120 in order to prevent hydraulic
25 pressure supplied or discharged into/from the cylinder 100

from leaking between the engaged surfaces of the guide pin 110 and the fastening hole 120.

The piston 200, as shown in FIGS. 5 through 8, has a shaft hole 210 that is formed through the center portion thereof, and is inserted into the cylinder 100. According to the supply and discharge of the hydraulic pressure, the piston 200 is vertically reciprocatingly moved in the cylinder 100. In other words, the piston 200 is vertically reciprocatingly moved in the cylinder 100 by the hydraulic pressure supplied or discharged into/from the cylinder 100, and the shaft hole 210, through which the rotating shaft 300 is inserted, is formed through the piston 200.

The rotating shaft 300, as shown in FIGS. 4 through 8, is inserted through the shaft hole 210 in the piston 200, and is configured to be rotated in forward and reverse directions corresponding to the vertical reciprocating motion of the piston 200. The rotating shaft 300 has a spline connection groove 310 that is formed longitudinally around an inner circumferential surface of a lower end portion of the rotating shaft 300. The spline connection groove 310 functions to transmit rotational force of the rotating shaft 300 to the valve shaft 13 through connection with the valve connection part 600, which will be described later. The rotating shaft 300, as shown in FIGS. 7 and 8, is rotated in forward and reverse

directions corresponding to the vertical reciprocating motion of the piston 200. To achieve this, the cylinder 100, the piston 200 and the rotating shaft 300 are formed with fastening holes 120, guide slits 220, rotation slits 240 and through-holes 320, which are linked with the guide pin 110 and the rotation pin 230.

More particularly, the piston 200 has a pair of opposite guide slits 220, which are formed through the circumferential surface of the piston 200 and extend longitudinally, and through which the guide pin 110 is inserted so as to allow the piston 200 to move vertically and reciprocatingly with respect to the cylinder 100. The piston 200 also has a pair of opposite rotation slits 240, which are formed through the circumferential surface of the piston 200 and extend diagonally, and through which the rotation pin 230 for guiding the rotary motion of the rotating shaft 300 is inserted.

That is, the piston 200 is formed in a hollow cylindrical shape, which is opened on the top and bottom by the shaft hole 210 and has the guide slits 220 and the rotation slits 240, which are formed through the circumferential surface of the piston 200. The piston 200 has an outer diameter which is smaller than an inner diameter of the cylinder 100 by about 0.1mm or less, so as to ensure smooth vertical reciprocating motion due to the

hydraulic pressure supplied or discharged into/from the cylinder 100. The piston 200 is not rotated by the guide slit 220 extending vertically, along which the guide pin 110 fastened to the fastening hole 120 of the cylinder 100 slides, and moves vertically and reciprocatingly in the cylinder 100. At this time, by virtue of the rotation slits 240 which extend diagonally and along which the rotation pin 230 inserted through the through-holes 320 in the rotating shaft 300 slides, as shown in FIG. 7, when the piston 200 ascends vertically in the cylinder 100, the rotation pin 230 is moved to the lowermost end of the rotation slits 240, and accordingly the rotating shaft 300 is rotated in a forward direction (or clockwise direction). Conversely, as shown in FIG. 8, when the piston 200 descends vertically in the cylinder 100, the rotation pin 230 is moved to the uppermost end of the rotation slits 240, and accordingly the rotating shaft 300 is rotated in a reverse direction (or counterclockwise direction). In order to allow the rotating shaft 300 to be rotated in the forward and reverse directions with respect to the piston 200 corresponding to the vertical reciprocating motion of the piston 200, the rotating shaft 300 has the through-holes 320, which are formed through the circumferential surface of the rotating shaft 300 and through which the rotation pin 230 is inserted.

The rotation slits 240 of the piston 200 are formed to have a diagonal or spiral shape with a predetermined length and an inclination angle in the range of 20° through 60° , and are formed to set the rotation angle of the rotating shaft 300 to be 90° when the rotation pin 230, inserted through the rotating shaft 300, is moved from the lowermost end of the rotation slits 240 to the uppermost end of the rotation slits 240 and vice versa. In other words, the rotating shaft 300 has a rotation angle of 90° with respect to the piston 200, and can be applied to the butterfly valve 10 illustrated in FIG. 1 or other types of valves, such as a ball valve, whose valve shaft is configured to be rotated 90° to open and close the valve, although not illustrated in the drawings.

More particularly, the rotation angle of the rotating shaft 300 is set to be 90° by the rotation slit 240, and the stroke, i.e., the vertical moving range of the piston 200, and the output torque of the rotating shaft 300 connected with the valve shaft 13 are determined by the inclination angle between the lowermost end and the uppermost end of the rotation slit 240. As the inclination angle of the rotation slit 240 is small, the stroke of the piston 200 becomes short, and the output torque of the rotating shaft 300 is reduced. The term "stroke" refers to the one-way distance of the vertical reciprocating motion

of the piston 200 in the cylinder 100. The longer the stroke of the piston 200 is, the more the output torque of the rotating shaft 300 is increased. Therefore, the hydraulic rotary actuator for opening and closing a butterfly valve according to the present invention may be manufactured such that the inclination angle of the rotation slit 240 is variably determined based on the required output torque and the size of the cylinder 100.

The piston 200 is provided with an O-ring, which is made of a silicon or rubber material, around the circumferential surface thereof, in order to create a seal at the interface with the cylinder 100, thereby facilitating the vertical reciprocating motion of the piston 200 due to the hydraulic pressure supplied or discharged into/from the cylinder 100.

The upper cover 400, as shown in FIGS. 4 through 6, is coupled to the top of the cylinder 100, and is formed with an upper cover hole 410, through which the upper end portion of the rotating shaft 300 is inserted and supported so as to be rotated. The lower cover 500 is coupled to the bottom of the cylinder 100, and is formed with a lower cover hole 510, through which the lower end portion of the rotating shaft 300 is inserted and supported so as to be rotated. The rotating shaft 300 may be provided with thrust bearings in order to reduce

frictional resistance with the upper cover hole 410 in the upper cover 400 and the lower cover hole 510 in the lower cover 500.

The upper cover 400, as shown in FIG. 5, is formed with an upper hydraulic pressure port 420, through which the hydraulic pressure is supplied or discharged into/from the region above the piston 200 in the cylinder 100. The lower cover 500 is formed with a lower hydraulic pressure port 520, through which the hydraulic pressure is supplied or discharged into/from the region below the piston 200 in the cylinder 100. Therefore, when the hydraulic pressure is supplied to the upper hydraulic pressure port 420 in the upper cover 400, the piston 200 is moved downward, as shown in FIG. 8. When the hydraulic pressure is supplied to the lower hydraulic pressure port 520 in the lower cover 500, the piston 200 is moved upward, as shown in FIG. 7. The upper cover 400 and the lower cover 500 may be securely coupled to each other by a plurality of stud bolts 700.

The rotating shaft 300 may have a rotation angle indication line 330 provided on the top surface thereof in order to indicate the rotation angle of the rotating shaft 300, and the upper cover 400 may have a rotation angle indication scale 430 provided on the top surface thereof, which corresponds to the rotation angle indication line

330 based on the actual rotation angle of the rotating shaft 300. Using the rotation angle indication line 330 and the rotation angle indication scale 430, a worker can easily check the orientation of the rotating shaft 300 and whether the butterfly valve 10 is opened or closed.

In the hydraulic rotary actuator for opening and closing a butterfly valve according to the present invention having the constitution described above with reference to FIG. 5, on the condition that the rotation in the forward direction (or clockwise direction) of the rotating shaft 300, as shown in FIG. 7, is associated with the closing of the butterfly valve 10, if the butterfly valve 10 is required to be closed, the hydraulic pressure is supplied to the lower hydraulic pressure port 520 in the lower cover 500 so that the hydraulic pressure is discharged from the upper hydraulic pressure port 420 in the upper cover 400. Accordingly, the piston 200 ascends in the cylinder 100 without being rotated by the guide pin 110 and the guide slit 220, the rotation pin 230 inserted through the rotating shaft 300 slides to the lowermost end of the rotation slit 240, and the rotating shaft 300 and the valve shaft 13 of the butterfly valve 10 connected with the rotating shaft 300 are rotated in the forward direction. As a result, the butterfly valve 10 is closed.

Conversely, on the condition that the rotation in the

reverse direction (or counterclockwise direction) of the rotating shaft 300, as shown in FIG. 8, is associated with the opening of the butterfly valve 10, if the butterfly valve 10 is required to be opened, the hydraulic pressure is supplied to the upper hydraulic pressure port 420 in the upper cover 400 so that the hydraulic pressure is discharged from the lower hydraulic pressure port 520 in the lower cover 500. Accordingly, the piston 200 descends in the cylinder 100 without being rotated by the guide pin 110 and the guide slit 220, the rotation pin 230 inserted through the rotating shaft 300 slides to the uppermost end of the rotation slit 240, and the rotating shaft 300 and the valve shaft 13 of the butterfly valve 10 connected with the rotating shaft 300 are rotated in the reverse direction. As a result, the butterfly valve 10 is opened.

The valve connection part 600, as shown in FIGS. 4, 6, and 9 through 14, is inserted into the rotating shaft 300 to be spline-engaged with the spline connection groove 310 in the rotating shaft 300. The exposed end portion of the valve shaft 13 of the butterfly valve 10 is fitted into the valve connection part 600. Accordingly, the rotational force of the rotating shaft 300, which is rotated corresponding to the vertical reciprocating motion of the piston 200 in the cylinder 100, is transmitted to the valve shaft 13 of the butterfly valve 10 through the

valve connection part 600, thereby opening and closing the butterfly valve 10.

In detail, as shown in FIGS. 9 and 10, the valve connection part 600 has a spline *S* that is formed longitudinally around the outer circumferential surface of the valve connection part 600 so as to be inserted into the rotating shaft 300 and spline-engaged with the spline connection groove 310 in the rotating shaft 300. The valve connection part 600 also has a valve connection hole 610 that is formed longitudinally through the valve connection part 600. The valve connection hole 610 has a cross-section of the same shape as a cross-section of the exposed end portion of the valve shaft 13 of the butterfly valve 10, so that the end portion of the valve shaft 13 can be fitted into the valve connection hole 610. By way of example, it is illustrated in FIG. 9 that the end portion of the valve shaft 13 has a cross-section having a tetragonal shape, however, the cross-section of the end portion of the valve shaft 13 may have other polygonal shapes, e.g., a pentagonal or hexagonal shape, or may have a "D" shape. Alternatively, as shown in FIG. 10, the end portion of the valve shaft 13 and the valve connection hole 610 in the valve connection part 600 may be key-coupled to each other.

Accordingly, even if the end portion of the valve

shaft 13 of the butterfly valve 10 has diverse shapes, the end portion of the valve shaft 13 and the rotating shaft 300 can be easily connected merely by forming the spline connection groove 310 to have the same shape and size in the lower end portion of the rotating shaft 300 and forming the valve connection hole 610 corresponding to the end portion of the valve shaft 13 in the valve connection part 600.

On the other hand, in the case in which the end portion of the valve shaft 13 of the butterfly valve 10 has a circular cross-section, the valve connection hole 610 also has a circular cross-section, which may cause a problem in that the rotational force of the rotating shaft 300 cannot be transmitted to the valve shaft 13 of the butterfly valve 10 through the valve connection part 600. In this case, without the necessity of reprocessing the end portion of the valve shaft 13 and the valve connection hole 610 in the aforementioned shapes, as shown in FIGS. 11 through 14, the valve connection part 600 may be configured to include a valve connector 620 and a fixing chuck 630, and may further include a slide pin 640 and a spring 650.

In detail, as shown in FIG. 11, the valve connector 620 of the valve connection part 600 is formed in a cylindrical shape, and has a spline S that is formed

longitudinally around the outer circumferential surface of the valve connection part 600 so as to be inserted into the rotating shaft 300 and spline-engaged with the spline connection groove 310 in the rotating shaft 300. The fixing chuck 630 of the valve connection part 600 is formed in a truncated conical shape that is narrow at the top and wide at the bottom, and has a plurality of slits 631 formed longitudinally around the circumferential surface of the fixing chuck 630. The fixing chuck 630 is configured to be longitudinally fitted into or drawn out of the lower end portion of the valve connector 620. When the fixing chuck 630 is fitted into the lower end portion of the valve connector 620, the diameter of the fixing chuck 630 is decreased. When the fixing chuck 630 is drawn out of the lower end portion of the valve connector 620, the diameter of the fixing chuck 630 is increased. As shown in FIGS. 12 through 14, the end portion of the valve shaft 13 of the butterfly valve 10 is inserted into the fixing chuck 630, and the fixing chuck 630, contracted by being fitted into the lower end portion of the valve connector 620, tightly holds the outer circumferential surface of the end portion of the valve shaft 13.

In further detail, the fixing chuck 630 has a truncated conical shape, in which the upper diameter is less than the lower diameter, and the slits 631 are formed

longitudinally around the circumferential surface of the fixing chuck 630. Therefore, if external force is applied to the fixing chuck 630 in the radial direction, the diameter of the fixing chuck 630 is decreased due to the slits 631, and if the external force is removed, the diameter of the fixing chuck 630 is increased, and thus the fixing chuck 630 is restored to its original shape. Accordingly, as shown in FIGS. 13 and 14, in the case in which the fixing chuck 630 can be longitudinally fitted into or drawn out of the lower end portion of the valve connector 620, when the fixing chuck 630 is fitted into the lower end portion of the valve connector 620, the diameter of the fixing chuck 630 is decreased by the force applied inwardly in the radial direction, and when the fixing chuck 630 is drawn out of the lower end portion of the valve connector 620, the force applied inwardly in the radial direction is removed, the diameter of the fixing chuck 630 is increased, and thus the fixing chuck 630 is restored to its original shape.

That is, as shown in FIGS. 12 through 14, as the end portion of the valve shaft 13 of the butterfly valve 10 is inserted into the fixing chuck 630, the fixing chuck 630 is moved upward in the lower end portion of the valve connector 620. At the same time, the diameter of the fixing chuck 630 is decreased by being fitted into the

lower end portion of the valve connector 620, thereby tightly holding the circumferential surface of the end portion of the valve shaft 13 inserted into the fixing chuck 630.

5 In order to allow the fixing chuck 630 to be fitted into or drawn out of the lower end portion of the valve connector 620, the valve connector 620 is formed with a slide pin insertion hole 621, the fixing chuck 630 is formed with a pin slide slot 632, and the slide pin 640 is
10 separately provided. In detail, as shown in FIGS. 11 through 14, the slide pin insertion hole 621 is formed through the side surface of the lower end portion of the valve connector 620, and the pin slide slot 632 is formed through the side surface of the fixing chuck 630 at a
15 position corresponding to the slide pin insertion hole 621 in the valve connector 620, and extends longitudinally farther than the slide pin insertion hole 621. The slide pin 640 is inserted into the pin slide slot 632 in the fixing chuck 630 through the slide pin insertion hole 621
20 in the valve connector 620, and the longitudinal length of the pin slide slot 632 serves to determine the distance by which the fixing chuck 630 is fitted into or drawn out of the valve connector 620.

25 Since the valve connector 620 and the fixing chuck 630 are coupled to each other by the slide pin 640, and

the pin slide slot 632 in the fixing chuck 630 extends longitudinally farther than the slide pin insertion hole 621 in the valve connector 620, the fixing chuck 630 can slide vertically with respect to the valve connector 620.

5 The vertical sliding motion of the fixing chuck 630 with respect to the valve connector 620 refers to the motion of the fixing chuck 630 that is fitted into or drawn out of the lower end portion of the valve connector 620.

As described above, when the end portion of the valve shaft 13 is inserted into the fixing chuck 630, the diameter of the fixing chuck 630 is decreased by the valve connector 620, thereby tightly holding the circumferential surface of the end portion of the valve shaft 13. Conversely, if the valve connector 620 is lifted upward, 15 the end portion of the valve shaft 13 inserted into the fixing chuck 630 is separated and released from the fixing chuck 630. At this time, if the diameter of the fixing chuck 630 is maintained in a decreased state, that is, if the fixing chuck 630 is kept in the state of being fitted 20 into the lower end portion of the valve connector 620, it may be hard to disassemble the valve connector 620 and the fixing chuck 630 when they need to be repaired or replaced.

In order to assist the fixing chuck 630 fitted into 25 the valve connector 620 to be drawn out to its original

position, as shown in FIGS. 11 through 14, the valve connection part 600 may further include a spring 650 disposed in the valve connector 620 and configured to apply an elastic force in the direction of drawing out the fixing chuck 630. Accordingly, the fixing chuck 630 is kept in the state of being drawn out of the valve connector 620 by the elastic force of the spring 650, and when the valve shaft 13 is inserted into the fixing chuck 630, the fixing chuck 630 is fitted into the lower end portion of the valve connector 620 against the elastic force of the spring 650, thereby tightly holding the valve shaft 13. If the valve shaft 13 is removed from the fixing chuck 630, the fixing chuck 630 can be kept in the state of being drawn out of the valve connector 620 by the elastic force of the spring 650 plus the weight of the fixing chuck 630 or elastic force due to the slits 631.

As described above, the hydraulic rotary actuator for opening and closing a butterfly valve according to the present invention is formed to have a cylindrical shape, in which the cylinder 100 and the piston 200 are mounted coaxially with the rotating shaft 300 by the upper cover 400 and the lower cover 500. Accordingly, compared to conventional actuators including a rack-and-pinion mechanism or a scotch-yoke mechanism, the hydraulic rotary actuator according to the present invention has advantages

in that the size of the device is reduced, space utilization is enhanced, assembly and disassembly processes for installation and repair are facilitated, and work efficiency in installation or maintenance is remarkably enhanced because there is no interference with ambient pipes or devices during connection with the valve shaft 13 of the butterfly valve 10.

Further, the hydraulic rotary actuator according to the present invention adopts a new connection structure using the spline-formed valve connection part 600 that can be easily formed and replaced corresponding to the diverse shapes of the valve shaft 13 of the butterfly valve 10. Accordingly, since the rotating shaft 300 having the uniform shape can be used regardless of the shape of the valve shaft 13 of the butterfly valve 10, productivity is enhanced.

Furthermore, even when the end portion of the valve shaft 13 of the butterfly valve 10 has a circular cross-section, the rotational force from the rotating shaft 300 can be perfectly transmitted to the valve shaft 13 due to the valve connection part 600, which is configured to include the valve connector 620 and the fixing chuck 630. In addition, the valve connector 620 and the fixing chuck 630 are structured to be easily coupled and separated. As a result, reliability and durability are improved.

Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and sprit of the invention, the scope of which is defined in
5 the claims and their equivalents.

WHAT IS CLAIMED IS:

1. A hydraulic rotary actuator for opening and closing a butterfly valve comprising:

5 a cylinder formed in a cylindrical shape having an open top and bottom;

a piston having a shaft hole formed through a center portion thereof and inserted into the cylinder so as to be vertically reciprocatingly moved in the cylinder according to supply and discharge of hydraulic pressure;

10 a rotating shaft inserted through the shaft hole in the piston, configured to be rotated in forward and reverse directions corresponding to the vertical reciprocating motion of the piston, and having a spline connection groove formed longitudinally in a lower end portion thereof;

15 an upper cover coupled to the top of the cylinder and formed with an upper cover hole, through which an upper end portion of the rotating shaft is inserted and supported so as to be rotated;

20 a lower cover coupled to the bottom of the cylinder and formed with a lower cover hole, through which a lower end portion of the rotating shaft is inserted and supported so as to be rotated; and

25 a valve connection part inserted into the rotating

shaft to be spline-engaged with the spline connection groove in the rotating shaft, into which an exposed end portion of a valve shaft of the butterfly valve is fitted.

5 2. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 1, wherein the cylinder has a pair of opposite fastening holes which are formed through a circumferential surface thereof and to which a guide pin for guiding the vertical reciprocating
10 motion of the piston is fastened,

the piston has a pair of opposite guide slits which are formed through a circumferential surface thereof and extend longitudinally and through which the guide pin is inserted so as to allow the piston to move vertically and
15 reciprocatingly with respect to the cylinder, and a pair of opposite rotation slits which are formed through the circumferential surface thereof and extend diagonally and through which the rotation pin for guiding rotary motion of the rotating shaft is inserted, and

20 the rotating shaft has through-holes which are formed through a circumferential surface thereof and through which the rotation pin is inserted so as to allow the rotating shaft to be rotated in the forward and reverse directions with respect to the piston corresponding to the
25 vertical reciprocating motion of the piston.

3. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 2, wherein the rotating shaft has a rotation angle of 90° with respect to the piston.

4. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 1, wherein the upper cover is formed with an upper hydraulic pressure port, through which the hydraulic pressure is supplied or discharged into/from a region above the piston in the cylinder, and

the lower cover is formed with a lower hydraulic pressure port, through which the hydraulic pressure is supplied or discharged into/from a region below the piston in the cylinder.

5. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 1, wherein the upper cover and the lower cover are coupled to each other by a plurality of stud bolts.

6. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 1, wherein the rotating shaft has a rotation angle indication line

provided on a top surface thereof in order to indicate a rotation angle, and

the upper cover has a rotation angle indication scale provided on a top surface thereof, which corresponds to the rotation angle indication line based on an actual rotation angle of the rotating shaft.

7. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 1, wherein the valve connection part has a spline formed longitudinally around an outer circumferential surface thereof so as to be inserted into the rotating shaft and spline-engaged with the spline connection groove in the rotating shaft, and a valve connection hole formed longitudinally therethrough and having a cross-section of the same shape as a cross-section of the exposed end portion of the valve shaft of the butterfly valve so that the end portion of the valve shaft can be fitted into the valve connection hole.

8. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 7, wherein the cross-section of the end portion of the valve shaft has a polygonal shape or a "D" shape.

9. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 7, wherein the end portion of the valve shaft and the valve connection hole in the valve connection part are key-coupled to each other.

10. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 1, wherein the end portion of the valve shaft of the butterfly valve has a circular cross-section,

the valve connection part includes:

a cylindrical-shaped valve connector having a spline formed longitudinally around an outer circumferential surface thereof so as to be inserted into the rotating shaft and spline-engaged with the spline connection groove in the rotating shaft; and

a truncated conical-shaped fixing chuck which is narrow at the top and wide at the bottom, has a plurality of slits formed longitudinally around a circumferential surface thereof, and is configured to be longitudinally fitted into or drawn out of a lower end portion of the valve connector,

and wherein when the fixing chuck is fitted into the lower end portion of the valve connector, a diameter of the fixing chuck is decreased, and when the fixing chuck

is drawn out of the lower end portion of the valve connector, the diameter of the fixing chuck is increased, and

when the end portion of the valve shaft of the butterfly valve is inserted into the fixing chuck, the diameter of the fixing chuck is decreased by being fitted into the lower end portion of the valve connector, thereby tightly holding the outer circumferential surface of the end portion of the valve shaft.

11. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 10, wherein the valve connector has a slide pin insertion hole formed through a side surface of the lower end portion thereof,

the fixing chuck has a pin slide slot formed through a side surface thereof at a position corresponding to the slide pin insertion hole in the valve connector and extending longitudinally farther than the slide pin insertion hole, and

the valve connection part further includes a slide pin inserted into the pin slide slot in the fixing chuck through the slide pin insertion hole in the valve connector,

and wherein a distance by which the fixing chuck is fitted into or drawn out of the valve connector is

determined by a longitudinal length of the pin slide slot.

12. The hydraulic rotary actuator for opening and closing a butterfly valve according to claim 11, wherein
5 the valve connection part further includes a spring disposed in the valve connector and configured to apply an elastic force in a direction of drawing out the fixing chuck.