

Description

PNEUMATIC ACTUATOR AND METHOD FOR MANUFACTURING PNEUMATIC
ACTUATOR

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Technical Field

[0001] The present invention relates to a pneumatic actuator and a method for manufacturing the pneumatic actuator and, in particular, relates to a pneumatic actuator in which air is supplied and exhausted through an airport to cause a piston to make reciprocating movements, and a
10 method for manufacturing the pneumatic actuator.

Background Art

[0002] Conventionally, as one of driving sources for opening and closing a valve, a pneumatic actuator operating with air pressure is used.

15 As pneumatic actuators operating with air pressure, any of two types has been often used: a double-acting type using air pressure for both of opening action and closing action of the valve or a single-acting type using a spring force of a spring for either one of opening action and closing action of the valve.

[0003] For example, PTL 1 describes a double-acting valve-specific actuator in which two
20 communication ports 43 provided to a cylinder portion 3 and communicating outside serve as supply/exhaust ports (air ports) and air pressure is supplied alternately to both surface sides of an inner piston 42 through these communication ports 43 to cause the piston 42 to make reciprocating movements. With these reciprocating movements of the piston 42, a scotch yoke 33 rotates via a piston rod 30 and a lock pin 31 and a shaft 32 integrated with this scotch yoke 33
25 rotates, thereby causing both of opening operation and closing operation with air pressure to be performed.

In this double-acting valve-specific actuator described in PTL 1, as depicted in FIG. 8 of PTL 1, the communication ports 43 on a piston rod side 30 are each formed in a bent shape provided with a lateral hole (hole in a reciprocating movement direction of the piston 42) without
30 linearly penetrating inside the cylinder portion 3, and communicate with the inside of the cylinder portion 3.

[0004] In the valve-specific actuator described in PTL 1 as described above, the communication ports 43 (air ports) provided at an end portion of the cylinder portion 3 on a side

from which the piston rod 30 is led out, that is, end portion on a rod side, communicate with the inside of the cylinder portion 3 via the lateral hole provided in a wall of the cylinder portion 3.

Citation List

5 Patent Literatures

[0005] PTL 1: Japanese Patent No. 6430173

Summary of Invention

Technical Problem

10 [0006] However, in the valve-specific actuator described in PTL 1, the communication ports 43 (air ports) provided at the end portion on the rod side of the cylinder portion 3 has a bent shape provided with the lateral hole in the reciprocating movement direction of the piston. Thus, hole forming is performed from two directions, which is cumbersome. Also, since it is required to allocate a space for performing lateral-hole forming, this poses a problem of an
15 increase in dimension in the reciprocating movement direction of the piston.

Also, since the hole diameter dimension of the lateral holes is limited to the wall thickness of the cylinder, the hole diameter dimension has to fall within the wall thickness of the cylinder. Depending on the wall thickness of the cylinder, it is difficult to ensure sufficient supply/exhaust air quantity of air and, as a result, there is a fear that it is difficult to obtain a
20 desired cylinder response speed.

Furthermore, in the case of the double-acting type, in consideration of assembling capability of an external connection device such as a speed controller to the two communication ports 43 provided at the end portion on the rod side and the end portion of the head side of the cylinder portion 3, it is desired to widen a space between the two communication ports 43 by
25 putting the communication port 43 on the rod side close to the rod side at maximum, and so forth.

However, the requirement of an improvement in assembling capability of the external connection device as described above is contradictory to making the device compact, and it is difficult to satisfy both of these requirements, that is, an improvement in assembling capability of the external connection device and making the device compact.

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[0007] The present invention was developed to solve the conventional problem, and has an object of providing a pneumatic actuator and a method for manufacturing the pneumatic actuator that is easy to be formed,

easy to obtain a desired response speed of a cylinder, and, furthermore, can be made compact, in particular, in the case of a double-acting type, can be made compact while a space between two air ports is widened.

5 Solution to Problem

[0008] To achieve the above-described object, an invention according to claim 1 is directed to a pneumatic actuator having a cylinder in which at least one air port is provided to an end portion on a rod side provided with a piston rod guide and from which a piston rod is led out, the cylinder having formed therein a piston reciprocating movement space where a piston makes reciprocating movements with air supplied and exhausted through the air port, wherein the cylinder has an enlarged diameter portion provided by enlarging an inner diameter in an area adjacent to the piston rod guide in a reciprocating movement direction of the piston, and the air port provided on the end portion on the rod side has a prepared hole including a penetrating portion penetrating inside the cylinder by communicating with the enlarged diameter portion, with part of the penetrating portion on a rod side in a radial direction overlapping in the reciprocating movement direction of the piston, and a non-penetrating portion not penetrating inside the cylinder with part of the non-penetrating portion in the radial direction not overlapping the enlarged diameter portion.

[0009] An invention according to claim 2 is directed to the pneumatic actuator in which the enlarged diameter portion is provided as gradually enlarging the inner diameter from a lead-out side toward a lead-in side of the piston rod in the reciprocating movement direction of the piston.

[0010] An invention according to claim 3 is directed to the pneumatic actuator in which the pneumatic actuator has a housing having a driving space provided with a rotation conversion mechanism that converts reciprocating movements of the piston to rotating movements for transfer to an output shaft and is coupled from the cylinder from the end portion on the rod side, and the pneumatic actuator is used as being mounted on a valve in a state in which the output shaft and a valve stem are coupled.

[0011] An invention according to claim 4 is directed to a method for manufacturing a pneumatic actuator having a cylinder in which at least one air port is provided to an end portion on a rod side provided with a piston rod guide and from which a piston rod is led out, the cylinder having formed therein a piston reciprocating movement space where a piston makes reciprocating movements, with air supplied and exhausted through the air port, the method

including: a step of providing the pneumatic actuator with a cylinder having an enlarged diameter portion by enlarging an inner diameter in an area adjacent to the piston rod guide in a reciprocating movement direction of the piston, and a step of forming, as a prepared hole of the air port at the end portion on the rod lead-in side, a hole including a penetrating portion penetrating inside the cylinder by communicating with the enlarged diameter portion with part of the penetrating portion on a rod side in a radial direction overlapping the enlarged diameter portion in the reciprocating movement direction of the piston and a non-penetrating portion not penetrating inside the cylinder with part of the non-penetrating portion in the radial direction not overlapping the enlarged diameter portion.

Advantageous Effects of Invention

[0012] From the invention according to claim 1, the pneumatic actuator has a cylinder in which at least one air port is provided to an end portion on a rod side provided with a piston rod guide and from which a piston rod is led out, the cylinder having formed therein a piston reciprocating movement space where a piston makes reciprocating movements with air supplied and exhausted through this air port, wherein the cylinder has an enlarged diameter portion provided by enlarging an inner diameter in an area adjacent to the piston rod guide in a reciprocating movement direction of the piston, and the air port provided on the end portion on the rod side has a prepared hole including a penetrating portion penetrating inside the cylinder by communicating with the enlarged diameter portion, with part of the penetrating portion on a rod side in a radial direction overlapping in the reciprocating movement direction of the piston, and a non-penetrating portion not penetrating inside the cylinder with part of the non-penetrating portion in the radial direction not overlapping the enlarged diameter portion.

In this manner, the air port is not directly made penetrate the inside of the cylinder, but part of the prepared hole is made communicate with the enlarged diameter

portion and other portions are formed as not-penetrating portions. With this, it is not required to separately provide a hole for letting the air port penetrate inside the cylinder.

5 When the piston making reciprocating movements along the inner wall surface of the cylinder passes through the penetrating hole of the air port provided in the cylinder wall surface, there is a possibility of damages on the piston and a piston seal member, and it is therefore required to provide a penetrating hole outside the stroke of the piston. However, the size of the cylinder is increased by that distance.

10 In the invention according to claim 1, as described above, it is possible to make the air port communicate with the cylinder without separately providing a penetrating hole directly communicating inside the cylinder. Thus, it is possible to also avoid an increase in size of the cylinder while avoiding damages on the piston and the piston seal member.

15 Also, in the invention according to claim 1, the air port communicates inside the cylinder through the enlarged diameter portion not via a lateral hole. Thus, cumbersome forming of a lateral hole is not required, and the air port can be easily formed.

Also, by adjusting the degree of overlapping between the enlarged diameter
20 portion and the prepared hole, it is possible to sufficiently ensure an air supply/exhaust amount.

Also, since a lateral hole is not provided and, furthermore, portions other than a portion where the air port overlaps the enlarged diameter portion in the radial direction can be taken as a stroke area of the piston. Thus, as a whole, the dimensions of the
25 cylinder can be reduced. Furthermore, in the case of a double-acting type, the air port provided at the end portion of the cylinder on the rod side can be provided as being distanced from the air port provided at the end portion of the cylinder on the head side.

Therefore, forming is easy, it is easy to obtain a desired cylinder speed, and, furthermore, it is possible to make the actuator compact, in particular, in the case of a double-acting type, make it compact while a space between two air ports is widened.

[0013] From the invention according to claim 2, the enlarged diameter portion is provided as gradually enlarging the inner diameter from a lead-out side toward a lead-in side of the piston rod in the reciprocating movement direction of the piston. With this, when the cylinder is formed by using a mold, it can be easily formed, compared with the enlarged diameter portion as a groove having a constant depth.

Also, in the invention according to claim 2, the enlarged diameter portion is also gradually enlarged from an edge portion side toward an inner diameter side of the enlarged diameter portion. Thus, by adjusting the depth of the prepared hole to be provided, it is possible to easily adjust the diameter of the communicating portion, and it is also possible to easily set the air supply/exhaust amount.

[0014] From the invention according to claim 3, the pneumatic actuator has a housing having formed therein a driving space provided with a rotation conversion mechanism that converts reciprocating movements of the piston to rotating movements for transfer to an output shaft and is coupled from the cylinder from the end portion on the rod side, and the pneumatic actuator is used as being mounted on a valve in a state in which the output shaft provided to the rotation conversion mechanism and a valve stem are coupled. With this, the reciprocating movements of the piston inside the cylinder made compact are converted into rotating operation of the valve stem via the rotation conversion mechanism to open and close the valve. Thus, the present invention can be used as a valve actuator that can be assembled on the valve in a compact manner.

[0015] From the invention according to claim 4, in a method for manufacturing a pneumatic actuator having a cylinder in which at least one air port is provided to an end portion on a rod side

provided with a piston rod guide and from which a piston rod is led out, the cylinder having formed therein a piston reciprocating movement space where a piston makes reciprocating movements, with air supplied and exhausted through the air port, the method includes: a step of providing the cylinder having an enlarged diameter portion provided by enlarging an inner
5 diameter in an area adjacent to the piston rod guide in a reciprocating movement direction of the piston, and a step of forming, as a prepared hole of the air port at the end portion on the rod side, a hole including a penetrating portion penetrating inside the cylinder by communicating with the enlarged diameter portion with part of the penetrating portion in a radial direction overlapping the enlarged diameter portion in the reciprocating movement direction of the piston and a non-
10 penetrating portion not penetrating inside the cylinder with part of the non-penetrating portion in the radial direction not overlapping the enlarged diameter portion.

With this, for example, when a scheme of forming the cylinder by using a mold such as casting, it is only required to form the cylinder so that the enlarged diameter portion is formed in advance and then form a predetermined prepared hole so that it partially communicates with the
15 enlarged diameter portion. Thus, the air port can be easily formed at low cost. In particular, the air port communicates inside the cylinder through the enlarged diameter portion not via a lateral hole. Thus, cumbersome forming of a lateral hole is not required, and the air port can be easily formed.

Also, by adjusting the degree of overlapping between the enlarged diameter portion and
20 the prepared hole, it is possible to sufficiently ensure an air supply/exhaust amount.

Also, since a lateral hole is not provided and, furthermore, portions other than a portion where the air port overlaps the enlarged diameter portion in the radial direction can be taken as a stroke area of the piston. Thus, as a whole, the dimensions of the cylinder can be reduced. Furthermore, in the case of a double-acting type, the air port provided at the end portion of the
25 cylinder on the rod side can be provided as being distanced from the air port provided at the end portion of the cylinder on the head side.

Therefore, forming is easy, it is easy to obtain a desired cylinder speed, and, furthermore, it is possible to make the actuator compact, in particular, in the case of a double-acting type, make it compact while a space between two air ports is widened.

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Brief Description of Drawings

[0016] FIG. 1 is a perspective view of a pneumatic actuator according to an embodiment of the present invention.

FIG. 2 is a sectional view of the pneumatic actuator with a piston head being at a stroke ending end position on a head side inside a cylinder.

FIG. 3 is a sectional view of the pneumatic actuator with the piston head being at a stroke ending end position on a rod side inside the cylinder.

5 FIG. 4 is an enlarged perspective view of a portion near an enlarged diameter portion of the pneumatic actuator depicted in FIG. 3.

FIG. 5 is a drawing of an opening viewed from an inner wall surface side of the cylinder, the opening where a prepared hole of an air port provided at an end portion on a rod side serves as a portion communicating with the enlarged diameter portion.

10 FIG. 6 is a perspective view of the driven actuator in a partially cutout state, with a speed controller attached to two air ports, the driven actuator being assembled to a valve.

Description of Embodiments

[0017] Embodiments of the pneumatic actuator and the method for manufacturing the pneumatic actuator according to the present invention are described in detail based on the drawings.

FIG. 1 is a perspective view of a pneumatic actuator 1 according to an embodiment of the present invention. FIG. 2 is a sectional view of the pneumatic actuator with a piston head 22 being at a stroke ending end position on a head side inside a cylinder 10. FIG. 3 is a sectional view of the pneumatic actuator 1 with the piston head 22 being at a stroke ending end position on a rod side inside the cylinder 10. FIG. 4 is an enlarged perspective view of a portion near an enlarged diameter portion 14 of the pneumatic actuator 1 depicted in FIG. 3. FIG. 5 is a drawing of an opening 15ac viewed from an inner wall surface 12a side of the cylinder 10, the opening where a prepared hole 15a of an air port 15 provided at an end portion 10a on a rod side serves as a portion communicating with the enlarged diameter portion 14. FIG. 6 is a perspective view of the driven actuator 1 in a partially cutout state, with a speed controller 200 attached to two air ports 15 and 16, the driven actuator being assembled to a valve 100.

30 The pneumatic actuator 1 according to the embodiment of the present invention is one of driving sources for opening and closing a valve not depicted, and adopts a double-acting type using air pressure for both of opening action and closing action of the valve.

[0018] The pneumatic actuator 1 has a cylinder 10, a piston 20 making reciprocating movements by air pressure, a housing 30 provided with a rotation conversion mechanism 60 that

converts reciprocating movements of the piston 20 to rotating movements and coupled to the cylinder 10, a housing cap 40 that closes an opening at one end of the housing 30, and a piston rod guide 50 that guides a piston rod 21 of the piston 20.

5 The cylinder 10, the housing 30, and the housing cap 40 are mutually coupled in an axial direction so as to be concentric with the axial center of the piston rod 21, thereby configuring the outer hull of the pneumatic actuator 1 with the axial direction of the piston rod 21 being taken as a longitudinal direction.

While the cylinder 10, the housing 30, and the housing cap 40 are manufactured by casting in the present embodiment, another manufacturing method may be used, or various
10 manufacturing methods may be combined. For example, the inside of the cylinder 10 after casting may be subjected to cutting.

[0019] (Regarding Cylinder 10)

In the cylinder 10, in a reciprocating movement direction of the piston 20, when an end portion on a side from which the piston rod 21 is led out is taken as the end portion 10a on a rod side and an end portion on a side to which the piston rod 21 is led in is taken as an end portion
15 10b on a head side, the cylinder has formed therein a piston reciprocating movement space 13 where the piston 20 makes reciprocating movement while air is supplied and exhausted through two air ports 15 and 16 provided on the end portions 10a and 10b, respectively.

This cylinder 10 has a circumferential side wall 12 and a closed wall 11 provided at the
20 end portion 10b on the head side, forming a substantially cylindrical shape with the end portion 10a on the rod side opposed to the closed wall 11 being open.

[0020] The cylinder 10 has one air port 15 (hereinafter referred to as "rod-side air port") provided at the end portion 10a on the rod side and another air port 16 (hereinafter referred to as "head-side air port") provided at the end portion 10b on the head side.

25 To form these two air ports 15 and 16, prepared holes 15a and 16a are formed in the circumferential side wall 12, and then tap holes 15b and 16b are formed.

Note that, in the present embodiment, as depicted in FIG. 1, the rod-side air port 15 is provided so as to partially overlap a flange portion 10aa of the cylinder 10.

In the present embodiment, an external connection device such as a speed controller not
30 depicted is attached to the two air ports 15 and 16 by being screwed into the tap holes 15b and 16b. The two air ports 15 and 16 are connected to a directional valve via air piping connected to the speed controller.

[0021] To the two air ports 15 and 16, an external device, for example, a speed controller 200 as in FIG. 6, is attached. An attachment space for the external device depends on a distance between the air ports 15 and 16. For example, when the speed controller is attached as being screwed into the tap holes provided in the air ports 15 and 16, the speed controller in a rectangular parallelepiped shape as depicted in the drawing is screwed as being screwed.

Thus, when each of the air ports 15 and 16 is screwed in, it is required to, for example, grip and rotate the speed controller. In a relevant area, a space where a device is simply accommodated is not enough, but more clearance is required.

With that, the two air ports 15 and 16 are preferably spaced as much as possible.

In the present embodiment, making the prepared hole 15a of the air port 15 communicated with an enlarged diameter portion 14 provided inside the cylinder 10 allows air supply from the air port 15 to the inside of the cylinder 10. Since this enlarged diameter portion 14 is provided in an area adjacent to a piston rod guide 50, the air port 15 to be made communicated with this can be provided as being put close to a position (for example, partially or entirely overlapping the flange portion 10aa) at maximum on a piston rod 21 side.

With this, the air port 15 normally has to be provided at a midway position on the wall surface of the cylinder 10 for communication with the inside of the cylinder 10, and it is difficult to sufficiently distance the two airports 15 and 16 from each other.

By contrast, in the present embodiment, the air ports 15 and 16 can be distanced as much as possible, which is advantageous in attachment of the external device such as the speed controller 200.

[0022] Also, the cylinder 10 has the enlarged diameter portion 14 provided so as to have an enlarged inner diameter in an area adjacent to the piston rod guide 50 in the reciprocating movement direction of the piston 20.

This enlarged diameter portion 14 is formed as a groove provided in the inner wall surface 12a of the circumferential side wall 12 along an inner circumferential direction, and is provided so that its inner diameter is gradually enlarged from a lead-out side to a lead-in side of the piston rod 21 in the reciprocating movement direction of the piston 20.

Note that in the present embodiment, the cylinder 10 and the housing 30 are coupled via the flange portions 10aa and 30aa provided to their end portions 10a and 30a. Thus, the wall thickness of the circumferential side wall 12 at the end portion 10a of the cylinder 10 on the rod side is thicker compared with its periphery because the wall thickness of the flange portion 10aa adds up.

[0023] That is, at the end portion 10a on the rod side of the circumferential side wall 12 of the cylinder 10, the flange portion 10aa overhanging from a portion of the circumferential side wall 12 other than the end portion 10a to an outer diameter side is provided.

The enlarged diameter portion 14 is provided to the flange portion 10aa serving as this
 5 wall-thick portion, and is provided so that its outermost diameter position is positioned on an outer diameter side from an external wall surface 12b of the circumferential side wall 12 of the cylinder 10 other than the flange portion 10aa.

That is, the enlarged diameter portion 14 is provided to the circumferential side wall 12
 10 of the cylinder 10 by effectively using a portion where the wall thickness is thickened by the flange portion 10aa of the cylinder 10.

As will be described further below, the rod-side air port 15 is provided so as to have the prepared hole 15a communicating with this enlarged diameter portion 14. Thus, it is not required to separately provide a penetrating hole for supplying air to the inside of the cylinder 10 in a portion of the circumferential side wall 12 of the cylinder 10 other than the flange portion
 15 10aa.

[0024] In this manner, in the present embodiment, with the enlarged diameter portion 14 provided to the portion of the flange portion 10aa of the cylinder 10, no interference occurs to the circumferential side wall 12 of the cylinder 10 except this flange portion 10aa, that is, a normal reciprocating movement (stroke) range of the piston head 22. As a result, an increase in size of
 20 the cylinder 10 due to provision of the enlarged diameter portion 14 is prevented.

Note that the enlarged diameter portion 14 may be provided by enlarging the inner diameter in an area adjacent to the piston rod guide 50 in the reciprocating movement direction of the piston 20 and, for example, may be a groove with a constant depth provided to the inner wall surface 12a of the circumferential side wall 12.

25 [0025] The rod-side air port 15 has the prepared hole 15a communicating with the enlarged diameter portion 14.

This prepared hole 15a includes a penetrating portion 15a penetrating inside the cylinder 10 by communicating with the enlarged diameter portion 14 with part of the penetrating portion in a radial direction overlapping in the reciprocating movement direction of the piston 20
 30 and a non-penetrating portion 15ab not penetrating inside the cylinder 10 with part of the non-penetrating portion in the radial direction not overlapping the enlarged diameter portion 14.

Since the non-penetrating portion 15ab of the prepared hole 15a does not penetrate through the circumferential side wall 12 of the cylinder 10, as depicted in FIG. 2 to FIG. 4, the

depth side of the prepared hole 15a forms an area A of the inner wall surface 12a where the piston head 22 can slide.

[0026] Also, the non-penetrating portion 15ab has a depth equal to or at a position shallower than the outer wall surface 12b of the circumferential side wall 12 of the cylinder 10 other than the flange portion 10aa. Here, "the depth of the non-penetrating portion 15ab is equal to or shallower than the outer wall surface 12b of the circumferential side wall 12 of the cylinder 10" means that, for example, it is only required that a uniform portion of the prepared hole 15a, for example, a portion formed when the prepared hole is formed by drilling except a portion with its diameter reducing toward a tip, be equal to or shallower than the outer wall surface 12b of the circumferential side wall 12 of the cylinder 10. With the non-penetrating portion 15ab formed as described above, the strength of the circumferential side wall 12 of the cylinder 10 can be sufficiently kept even if the prepared hole 15a is provided, and the operation of the piston 20 can be unhindered.

[0027] Also, with part of the prepared hole in the radial direction overlapping the enlarged diameter portion 14 in the reciprocating movement direction of the piston 20, the prepared hole 15a can be provided at a position where the rod-side air port 15 is put close to the end portion 10a of the cylinder 10 on the rod side at maximum, that is, a position where it is put close to the piston rod guide 50.

Also, in the present embodiment, the enlarged diameter portion 14 is provided to the flange portion 10aa, that is, a portion outside the range of reciprocating movements of the piston 20 to begin with. Thus, it is possible to widen the distance from the head-side air port 16 without increasing the diameter of the piston 20 in the reciprocating movement direction.

[0028] The penetrating portion 15aa of the rod-side air port 15 penetrates, as depicted in FIG. 4 and FIG. 5, through the inner wall surface 12a of the cylinder 10 including an inclined surface 14a of the enlarged diameter portion 14 to form an opening.

In other words, the prepared hole 15a penetrates through the inner wall surface 12a of the cylinder 10 including the surfaces 14a and 14b that are different in orientation and form the enlarged diameter portion 14 to form the opening 15ac.

Thus, the opening area of the opening 15ac can be adjusted based on the degree of overlap between the enlarged diameter portion 14 and the prepared hole 15a.

Also, the opening 15ac is formed over a plurality of surfaces in different directions, the opening area can be increased compared with a case in which the opening is formed in one surface.

Note that the opening area of the opening 15ac can support various types of specifications by changing, for example, the shape of the enlarged diameter portion 14 or the shape of the prepared hole 15a, in addition to the degree of overlap between the enlarged diameter portion 14 and the prepared hole 15a in a radial direction and a depth direction.

Thus, the opening area of the opening 15ac can be increased compared with the conventional opening area with a lateral hole, the conventional opening area of which dimensions are determined by the wall thickness of the circumferential side wall 12 of the cylinder 10. Furthermore, it is possible to support various opening shapes.

[0029] The opening area of the opening 15ac is adjusted so that a desired cylinder response speed can be obtained.

More specifically, the opening area of the opening 15ac is adjusted so as to be equal to or larger than the hole sectional area of air piping connected to the rod-side air port 15.

In this manner, the rod-side air port 15 is formed by making the enlarged diameter portion 14 provided inside the cylinder 10 and the prepared hole 15a communicate with each other. Thus, compared with a case in which a lateral hole is provided, air and so forth can be more linearly supplied and exhausted to the cylinder 10. Also, since that opening 15ac is also adjusted so as to have an opening area in which a desired cylinder response speed can be obtained, responsiveness for opening and closing the valve also becomes excellent.

[0030] For example, if the enlarged diameter portion 14 is used only for the inside of the cylinder 10 and the outside communicating with each other, it is only required to provide a small air port having only the penetrating portion 15aa communicating with the enlarged diameter portion 14. In that case, however, there is a fear that the amount of supply of air to the inside of the cylinder 10 is insufficient.

By contrast, according to the present embodiment, the rod-side air port 15 having a large diameter including the penetrating portion 15aa and the non-penetrating portion 15ab is provided, air piping capable of supplying a sufficient amount of air can be connected.

Also, with the opening 15ac provided so as to have an appropriate opening area, air supplied from the air piping can also be sufficiently supplied to the inside of the cylinder 10.

While having a sufficiently large diameter, the rod-side air port 15 has the penetrating portion 15aa on the rod side and the non-penetrating portion 15ab on the head side away from the rod side farther than the penetrating portion 15aa, and therefore is not required to have a penetrating hole that interferes with the stroke area of the piston 20.

As a result, in the pneumatic actuator 1, the entire size can be made compact, and the response speed, which indicates performance that inherently contradicts making compact, can be kept sufficiently high.

[0031] (Regarding Piston 20)

5 The piston 20 has a piston rod 21 and a piston head 22 provided at one end portion of the piston rod 21.

The piston head 22 makes reciprocating movements integrally with the piston rod 21 with supply and exhaustion of air through the two air ports 15 and 16.

10 This piston head 22 has attached on its circumferential surface a sealing-purpose O ring 22a made of an elastic member to prevent air from moving between the circumferential surface of the piston head 22 and the inner wall surface 12a of the cylinder 10.

Thus, while partitioning the inside of the cylinder 10 into two air chambers, the piston head 22 makes reciprocating movements in the axial direction as causing the sealing-purpose O ring 22a to make sliding contact with the inner wall surface 12a of the cylinder 10.

15 A stroke ending end position of the piston head 22 on the rod side inside the cylinder 10 is adjusted so as to be a position near the enlarged diameter portion 14.

That is, the piston head 22 can make reciprocating movements as including the area A (refer to FIGs. 2 and 3) of the inner wall surface 12a serving as the non-penetrating portion 15ab of the prepared hole 15a of the rod-side air port 15 in the range of reciprocating movements of
20 the piston head 22.

Note that the stroke range of the piston 20 is limited by stoppers 17 and 41 provided to the closed wall 11 of the cylinder 10 and the housing cap 40, respectively, so as to be able to abut on each end portion of the piston rod 21.

[0032] (Regarding Housing 30)

25 The housing 30 has a driving space 31 provided with the rotation conversion mechanism 60 that converts reciprocating movements of the piston 20 to rotating movements for transfer to an output shaft and is coupled to the cylinder 10 from the end portion 10a on the rod side.

30 The rotation conversion mechanism 60 provided inside this housing 30 adopts a so-called Scotch yoke mechanism, and has a scotch yoke 62 engaging with a pin 61 provided to protrude in an outward radial direction of the piston rod 21 and a shaft 63 coupled to this scotch yoke 62 with a key 64 for rotational driving as an output shaft.

That is, the rotation conversion mechanism 60 converts reciprocating movements of the piston 20 into rotation movements of the shaft 63 via the scotch yoke 62.

The shaft 63 extends to an axial direction orthogonal to the piston rod 21 to be coupled to a valve stem not depicted, and rotational movements of this valve stem causes a valve disk of
5 a butterfly valve, ball valve, or the like to open and close.

Note that while the Scotch yoke scheme is adopted as the rotation conversion mechanism 60, this is not meant to be restrictive and, for example, a rack-and-pinion mechanism may be adopted.

[0033] (Regarding Housing Cap 40)

10 The housing cap 40 has a guide portion that guides, in the axial direction, the piston rod 21 making reciprocating movements so as to go into and out from the housing 30, and is attached to the housing 30 from an opening side of an end portion of the housing 30.

[0034] (Regarding Piston Rod Guide 50)

The piston rod guide 50 makes a partition between the piston reciprocating movement
15 space 13 and the driving space 31 to guide the piston rod 21.

This piston rod guide 50 has a circumferential edge portion interposed and fixed between the cylinder 10 and the housing 30 in a state of being superposed on a seal member 52, more specifically, between the flange portion 10aa provided at the end portion 10a of the cylinder 10 on the rod side and a flange portion 30aa provided at an end portion 30a of the
20 housing 30.

The piston rod guide 50 has a penetrating hole 51 where the piston rod 21 is inserted so as to freely make reciprocating movements, and guides the piston rod 21 in the axial direction.

[0035] Next, the operation of the pneumatic actuator 1 is described.

Here, a series of reciprocating operations of the piston 20 is described. That is, a
25 series of operations is described in which the piston 20 becomes, from a state of leading the piston rod 21 in the inside of the cylinder 10, in a state of leading the piston rod 21 out from the cylinder 10 and then returning again to the state of leading the piston rod 21 in the inside of the cylinder 10.

[0036] First, as depicted in FIG. 2, in a state in which the piston rod 21 is led into the inside of
30 the cylinder 10, that is, in a state in which the piston head 22 is at the stroke ending end position on the head side inside the cylinder 10, when air is supplied to the inside of the cylinder 10 through the head-side air port 16, the piston head 22 receives a thrust by air to start moving toward the rod-side end portion 10a of the cylinder 10.

Note that in the state in which the piston head 22 is at the stroke ending end position on the head side inside the cylinder 10, the piston rod 21 bump against on the stopper 17 provided on the closed wall 11 of the cylinder 10, thereby causing the piston head 22 to stop at a position away from the closed wall 11 of the cylinder 10.

5 Thus, in the state in which the piston head 22 is at the stroke ending end position on the head side inside the cylinder 10, with air flowing through the head-side air port 16 into an air chamber between the closed wall 11 and the piston head 22, a thrust occurs to move the piston head 22 toward the stroke ending end position on the rod side inside the cylinder 10.

[0037] Then, as depicted in FIG. 3, the piston head 22 moves to a state of leading the piston
10 rod 21 out from the cylinder 10, that is, to the stroke ending end position on the rod side inside the cylinder 10.

At this time, air inside the cylinder 10 is exhausted through the rod-side air port 15 to the outside. More specifically, air inside the cylinder 10 passes from the enlarged diameter portion 14 through the rod-side air port 15 to be exhausted outside.

15 Also, the piston head 22 moves to the position near the enlarged diameter portion 14 as causing the sealing-purpose O ring 22a attached to the circumferential surface to make sliding contact with the inner wall surface 12a of the cylinder 10. Here, the piston head 22 passes through the area A (refer to FIGs. 2 and 3) of the inner wall surface 12a where the prepared hole 15a does not penetrate.

20 Note that in the state in which the piston head 22 is at the stroke ending end position on the rod side, with the piston rod 21 bump against on the stopper 41 provided to the housing cap 40, the piston head 22 stops at the position away from the enlarged diameter portion 14 of the cylinder 10.

[0038] Then, with air flowing through the rod-side air port 15 into the inside the cylinder 10, a
25 thrust that moves the piston head 22 toward the stroke ending end position on the head side occurs, and the piston head 22 starts moving toward the stroke ending end position on the head side.

Here, air supplied through the rod-side air port 15 flows via the enlarged diameter portion 14 into the air chamber between the piston rod guide 50 and the piston head 22.

30 At this time, air inside the cylinder 10 is exhausted outside through the head-side air port 16.

[0039] Then, the pneumatic actuator 1 becomes, as depicted in FIG. 2, in a state of leading the piston rod 21 in the inside of the cylinder 10. That is, the piston head 22 moves to the stroke

ending end position on the head side to complete the series of reciprocating operations of the pneumatic actuator 1.

[0040] Next, a method for manufacturing the pneumatic actuator 1 is described.

Note that a method for manufacturing the cylinder 10 is described herein.

5 First, the enlarged diameter portion 14 with an enlarged inner diameter is provided to the cylinder 10 in an area on the periphery of the end portion 10a on the rod side.

This process of providing the enlarged diameter portion 14 to the cylinder 10 is included in a process of forming the cylinder 10 by casting. That is, in this process, the cylinder 10 having the enlarged diameter portion 14 is formed by casting.

10 Note that the cylinder 10 having the enlarged diameter portion 14 can be formed with a general sand casting by providing a portion corresponding to the enlarged diameter portion 14 to a sand mold for casting the cylinder 10. That is, a workload by providing the enlarged diameter portion 14 to the cylinder 10 is very little.

Here, in the present embodiment, the enlarged diameter portion 14 is provided as
15 gradually enlarging the inner diameter in the reciprocating movement direction of the piston 20 from a lead-out side toward a lead-in side of the piston rod 21. Thus, in the case of sand casting, molten metal flows on a tilted surface of the sand mold corresponding to the enlarged diameter portion 14 at the time of pouring, and therefore turbulence is hard to occur. Since molten metal smoothly flows into the sand mold, it is possible to prevent sand from coming off and, as a result,
20 defects in quality such as sand inclusion hardly occur, thereby providing easy forming.

Note that the enlarged diameter portion 14 may be formed by performing cutting on the inside of the cast cylinder 10. In this manner, by combining casting and cutting, various shapes of the enlarged diameter portion 14 can be formed in accordance with the air supply/exhaust amount.

25 [0041] Next, the rod-side air port 15 and the head-side air port 16 are formed.

In this process, the rod-side air port 15 and the head-side air port 16 are respectively formed by forming the prepared holes 15a and 16a, respectively, and then forming the tap holes 15b, and 16b, respectively.

The rod-side air port 15 is formed by forming, as the prepared hole 15a, a hole
30 including the penetrating portion 15aa penetrating inside the cylinder 10 by communicating with the enlarged diameter portion 14 with part of the rod side in the radial direction overlapping in the reciprocating movement direction of the piston 20 and the non-penetrating portion 15ab not

penetrating inside the cylinder 10 with part of the non-penetrating portion in the radial direction not overlapping the enlarged diameter portion 14, and then forming the tap hole 15b.

In this manner, as for the rod-side air port 15, with the prepared hole 15a formed at a position partially overlapping the enlarged diameter portion 14 in the radial direction, while the non-penetrating portion 15ab not penetrating inside the cylinder 10 is left, an air flow path penetrating inside the cylinder 10 through the enlarged diameter portion 14 is formed.

On the other hand, the head-side air port 16 is formed by forming the prepared hole 16a penetrating inside the cylinder 10 and then forming the tap hole 16b.

[0042] From the pneumatic actuator 1 according to the embodiment of the present invention, the cylinder 10 has the enlarged diameter portion 14 provided by enlarging an inner diameter in an area adjacent to the piston rod guide 50 in a reciprocating movement direction of the piston 20, and the rod-side air port 15 provided on the end portion 10a on the rod side has the prepared hole 15a including the penetrating portion 15aa penetrating inside the cylinder 10 by communicating with the enlarged diameter portion 14, with part of the penetrating portion 15aa in a radial direction overlapping in the reciprocating movement direction of the piston 20, and the non-penetrating portion 15ab not penetrating inside the cylinder 10 with part of the non-penetrating portion 15ab in the radial direction not overlapping the enlarged diameter portion 14.

In this manner, the rod-side air port 15 is not directly made penetrate the inside of the cylinder 10, but part of the prepared hole 15a in the radial direction is made communicate with the enlarged diameter portion 14 and other portions are formed as not-penetrating portions. With this, it is not required to separately provide a hole for letting the rod-side air port 15 penetrate inside the cylinder 10.

When the piston 20 making reciprocating movements along the inner wall surface 12a of the cylinder 10 passes through the penetrating hole of the rod-side air port 15 provided in the wall surface of the cylinder 10, there is a possibility of damages on the piston 20 and the sealing-purpose O ring 22a as a piston seal member, and it is therefore required to provide a penetrating hole outside the stroke of the piston 20. However, the size of the cylinder 10 is increased by that distance.

From the pneumatic actuator 1 according to the embodiment of the present invention, as described above, it is possible to make the rod-side air port 15 communicate with the cylinder 10 without separately providing a penetrating hole directly communicating inside the cylinder 10. Thus, it is possible to also avoid an increase in size of the cylinder 10 while avoiding damages on the piston 20 and the sealing-purpose O ring 22a.

Also, the rod-side air port 15 communicates inside the cylinder 10 through the enlarged diameter portion 14 not via a lateral hole. Thus, cumbersome forming of a lateral hole is not required, and the rod-side air port 15 can be easily formed.

Also, by adjusting the degree of overlapping between the enlarged diameter portion 14
5 and the prepared hole 15a, it is possible to sufficiently ensure an air supply/exhaust amount.

Further, since a lateral hole is not provided and, furthermore, portions other than a portion where the rod-side air port 15 overlaps the enlarged diameter portion 14 in the radial direction can be taken as a stroke area of the piston 20. Thus, as a whole, the dimensions of the cylinder 10 can be reduced. Furthermore, in the case of a double-acting type, the rod-side air
10 port 15 of the cylinder 10 can be provided as being distanced from the head-side air port 16 of the cylinder 10.

Therefore, forming is easy, it is easy to obtain a desired cylinder speed, and, furthermore, it is possible to make the actuator compact, in particular, in the case of a double-acting type, make it compact while a space between two air ports is widened.

[0043] From the pneumatic actuator 1 according to the embodiment of the present invention, by widening the space between the two air ports 15 and 16, when external connection devices such as speed controllers are attached to the air ports 15 and 16 by being screwed into the tap holes 15b and 16b, respectively, the external connection devices neither interfere with nor obstruct each other. Thus, the external connection devices can be respectively assembled to the
20 air ports 15 and 16 with ease.

[0044] Also, from the pneumatic actuator 1 according to the embodiment of the present invention, the enlarged diameter portion 14 is provided as gradually enlarging the inner diameter from a lead-out side toward a lead-in side of the piston rod 21. Thus, for example, in the case of sand casting, molten metal flows on a tilted surface of the sand mold corresponding to the enlarged diameter portion 14 at the time of pouring, and therefore turbulence is hard to occur and it is possible to prevent sand from coming off. As a result, defects in quality such as sand inclusion hardly occur, thereby providing easy machining, compared with the enlarged diameter portion provided as a groove having a constant depth.

Furthermore, from the pneumatic actuator 1 according to the embodiment of the present invention, the enlarged diameter portion 14 is also gradually enlarged from an edge portion side toward an inner diameter side of the enlarged diameter portion 14. Thus, by adjusting the depth of the prepared hole 15a to be provided, it is possible to easily adjust the diameter of the communicating portion, and it is also possible to easily set the air supply/exhaust amount.

[0045] Also, from the pneumatic actuator 1 according to the embodiment of the present invention, the pneumatic actuator 1 has the housing 30 having the driving space 31 provided with the rotation conversion mechanism 60 that converts reciprocating movements of the piston 20 to rotating movements for transfer to the shaft 63 and is coupled to the cylinder 10 from the end
 5 portion 10a on the rod side, and the pneumatic actuator 1 is used as being mounted on a valve in a state in which the shaft 63 and a valve stem are coupled. With this, the reciprocating movements of the piston 20 inside the cylinder 10 made compact are converted into rotating operation of the valve stem via the rotation conversion mechanism 60 to open and close the valve. Thus, the present invention can be used as a valve actuator that can be assembled on the valve in
 10 a compact manner.

[0046] From the method for manufacturing the pneumatic actuator according to the embodiment of the present invention, the method includes a step of providing the cylinder 10 having the enlarged diameter portion 14 with an enlarged inner diameter in an area adjacent to the piston rod guide 50 in a reciprocating movement direction of the piston 20, and a step of
 15 forming, as the prepared hole 15a of the rod-side air port 15, the prepared hole 15a including the penetrating portion 15aa penetrating inside the cylinder 10 by communicating with the enlarged diameter portion 14 with part of the penetrating portion 15aa on a rod side in a radial direction overlapping the enlarged diameter portion 14 in the reciprocating movement direction of the piston 20 and the non-penetrating portion 15ab not penetrating inside the cylinder 10 with part of
 20 the non-penetrating portion 15ab in the radial direction not overlapping the enlarged diameter portion 14.

With this, for example, when a scheme of forming the cylinder 10 by using a mold such as casting, it is only required to form the cylinder 10 so that the enlarged diameter portion 14 is formed in advance and then form the predetermined prepared hole 15a so that it partially
 25 communicates with the enlarged diameter portion 14. Thus, the rod-side air port 15 can be easily formed at low cost. In particular, the rod-side air port 15 communicates inside the cylinder 10 through the enlarged diameter portion 14 not via a lateral hole. Thus, cumbersome forming of a lateral hole is not required, and the rod-side air port 15 can be easily formed.

Also, by adjusting the degree of overlapping between the enlarged diameter portion 14 and the prepared hole 15a, it is possible to sufficiently ensure an air supply/exhaust amount.
 30

Also, since a lateral hole is not provided and, furthermore, portions other than a portion where the rod-side air port 15 overlaps the enlarged diameter portion 14 in the radial direction can be taken as a stroke area of the piston 20. Thus, as a whole, the dimensions of the cylinder

10 can be reduced. Furthermore, in the case of a double-acting type, the rod-side air port 15 of the cylinder 10 can be provided as being distanced from the head-side air port 16 of the cylinder.

Therefore, forming is easy, it is easy to obtain a desired cylinder speed, and, furthermore, it is possible to make the actuator compact, in particular, in the case of a double-acting type, make it compact while a space between two air ports is widened.

[0047] While the embodiment of the present invention has been described above in detail, the present invention is not meant to be limited to the above-described embodiment, and can be variously changed in a scope not deviating from the spirit of the invention described in the scope of the claims of the present invention.

[0048] While the double-acting type is adopted as the pneumatic actuator 1 in the above-described embodiment, a single-acting type using a spring force of a spring for either one of reciprocating movements of the piston 20 may be adopted as long as the actuator has the cylinder 10 in which air is supplied and exhausted through one air port 15 on the rod side and the piston 20 makes reciprocating movement.

For example, the present invention may be adopted for a lead-in type of the single-acting pneumatic actuator 1. Note that the lead-in type is such that, when air is supplied from on air port 15 on the rod side, the piston rod 21 is lead into the inside of the cylinder and, when air is exhausted from that one air port 15, the piston rod 21 is pushed out from the cylinder with a spring force.

[0049] Also, while the pneumatic actuator 1 is exemplarily described as a driving source for opening and closing a valve in the above-described embodiment, the pneumatic actuator 1 may be used as a driving source for anything other than the valve and, for example, may be used as a driving source for an industrial robot.

Reference Signs List

[0050]	1	pneumatic actuator
	10	cylinder
	10a	end portion on a rod side
	10aa	flange portion
	10b	end portion on a head side
	11	closed wall
	12	circumferential side wall
	12a	inner wall surface

	12b	outer wall surface
	13	piston reciprocating movement space
	14	enlarged diameter portion
	14a, 14b	surface
5	15	rod-side air port (air port)
	15a	prepared hole
	15aa	penetrating portion
	15ab	non-penetrating portion
	15ac	opening
10	15b	tap hole
	16	head-side air port (air port)
	16a	prepared hole
	16b	tap hole
	17	stopper
15	20	piston
	21	piston rod
	22	piston head
	22a	sealing-purpose O ring
	30	housing
20	30a	end portion
	30aa	flange portion
	31	driving space
	40	housing cap
	41	stopper
25	50	piston rod guide
	51	penetrating hole
	52	seal member
	60	rotation conversion mechanism
	61	pin
30	62	scotch yoke
	63	shaft (output shaft)
	100	valve
	200	speed controller

CLAIMS

1. A pneumatic actuator having a cylinder in which at least one air port is provided to an end portion on a rod side provided with a piston rod guide and from which a piston rod is led out,
5 the cylinder having formed therein a piston reciprocating movement space where a piston makes reciprocating movements with air supplied and exhausted through the air port, wherein
the cylinder has an enlarged diameter portion provided by enlarging an inner diameter in an area adjacent to the piston rod guide in a reciprocating movement direction of the piston, and
10 the air port provided on the end portion on the rod side has a prepared hole including a penetrating portion penetrating inside the cylinder by communicating with the enlarged diameter portion, with part of the penetrating portion on a rod side in a radial direction overlapping in the reciprocating movement direction of the piston, and a non-penetrating portion not penetrating inside the cylinder with part of the non-penetrating portion in the radial direction not overlapping
15 the enlarged diameter portion.
2. The pneumatic actuator according to claim 1, wherein
the enlarged diameter portion is provided as gradually enlarging the inner diameter from a lead-out side toward a lead-in side of the piston rod in the reciprocating movement
20 direction of the piston.
3. The pneumatic actuator according to claim 1 or 2, wherein
the pneumatic actuator has a housing having a driving space provided with a rotation conversion mechanism that converts reciprocating movements of the piston to rotating
25 movements for transfer to an output shaft and is coupled from the cylinder from the end portion on the rod side, and
the pneumatic actuator is used as being mounted on the valve in a state in which the output shaft and a valve stem are coupled.
- 30 4. A method for manufacturing a pneumatic actuator having a cylinder in which at least one air port is provided to an end portion on a rod side provided with a piston rod guide and from which a piston rod is led out, the cylinder having formed therein a piston reciprocating

movement space where a piston makes reciprocating movements, with air supplied and exhausted through the air port, the method comprising:

a step of providing the cylinder having an enlarged diameter portion provided by enlarging an inner diameter in an area adjacent to the piston rod guide in a reciprocating movement direction of the piston, and

a step of forming, as a prepared hole of the air port at the end portion on the rod side, a hole including a penetrating portion penetrating inside the cylinder by communicating with the enlarged diameter portion with part of the penetrating portion on a rod side in a radial direction overlapping the enlarged diameter portion in the reciprocating movement direction of the piston and a non-penetrating portion not penetrating inside the cylinder with part of the non-penetrating portion in the radial direction not overlapping the enlarged diameter portion.

5. The pneumatic actuator according to claim 1, wherein

a flange portion overhanging from a portion of the circumferential side wall other than the end portion to an outer diameter side is provided at the end portion on the rod side of the circumferential side wall of the cylinder,

the enlarged diameter portion is provided to the flange portion, and is provided so that an outermost diameter position of this enlarged diameter portion is positioned on an outer diameter side from an external wall surface of the circumferential side wall other than the flange portion, and

the non-penetrating portion of the prepared hole of the air port has a depth substantially equal to or at a position shallower than the outer wall surface of the circumferential side wall other than the flange portion.

6. The pneumatic actuator according to claim 1, wherein

the penetrating portion is provided to the rod side, and

the non-penetrating portion is provided to a side away from the rod side farther than the penetrating portion.

7. A pneumatic actuator having a cylinder in which at least one air port is provided to an end portion on a rod side provided with a piston rod guide and from which a piston rod is led out, the cylinder having formed therein a piston reciprocating movement space where a piston makes reciprocating movements with air supplied and exhausted through the air port, wherein

the cylinder has a flange portion having the end portion on the rod side overhanging to an outer diameter side more than a portion other than the end portion, and an enlarged diameter portion provided to the flange portion by enlarging an inner diameter, and

the cylinder

- 5 is provided with an air port provided to the end portion on the rod side so that at least part of the air port overlaps the flange portion, and has a penetrating hole communication with the enlarged diameter portion.