

DESCRIPTION

ROTARY FLUID DEVICE

5 **Technical Field**

[0001] The present invention relates to a rotary fluid device and specifically to a rotary fluid device having a compression chamber and an expansion chamber.

Background Art

10 [0002] Conventionally, there has been a fluid device including a compression mechanism and an expansion mechanism as disclosed in Patent Document 1. The fluid device has a rotary compressor accommodated in the lower part of the casing and a scrollable expander accommodated in the upper part of the casing. The fluid device also includes an electric motor between the compressor and the expander. The compressor and expander are coupled to both ends of a drive shaft which is connected to the motor.

15 [0003] The compressor compresses a refrigerant. The compressed refrigerant discharges heat in a heat exchanger and is then expanded by the expander. The expanded refrigerant absorbs heat in another heat exchanger and returns to the compressor. This cycle is repeated. In the expander, rotational power generated by the expansion of the
20 refrigerant is recovered. The recovered rotational power and the rotational power of the electric motor drive the compressor. As a result, efficient driving is realized.

[Patent Document 1] Japanese Laid-Open Patent Publication No. 2003-138901

Disclosure of Invention

25 **Problems to be solved by the invention**

[0004] However, in the conventional fluid device, the compressor and the expander are placed on different planes. Therefore, the overall size of the device is large, and the

number of parts is also large. Specifically, the compressor is placed in the lower part of the casing while the expander is placed in the upper part of the casing, and this arrangement increases the overall vertical dimension of the device. Further, the compressor and the expander are completely separate from each other so as not to have any common part, and
5 therefore, the overall device has a large number of parts.

[0005] Embodiments of the present invention was conceived in view of the above problems. Embodiments of the present invention seek to reduce the number of parts and decrease the overall dimensions of the device.

Means for solving the problems

10 [0006] As shown in FIG. 1, an aspect of the invention provides a rotary fluid device comprising a rotation mechanism, the rotation mechanism including: a cylinder having an annular cylinder chamber; an annular piston which is accommodated in the cylinder chamber to be eccentric relative to the cylinder, the annular piston dividing the cylinder chamber into an outer working chamber and an inner working chamber; and a blade placed in the cylinder
15 chamber and partitioning each of the working chambers into a high-pressure space and a low-pressure space, the cylinder and the piston being relatively rotatable, wherein one of the two working chambers constitutes a compression chamber which compresses and discharges a sucked fluid with the progress of the relative rotation of the cylinder and the piston, the other of the two working chambers constitutes an expansion chamber which expands and
20 discharges a sucked fluid with the progress of the relative rotation of the cylinder and the piston, the piston has the shape of C formed by removing a part of its annular structure to make a slit, the blade extends between an inner peripheral wall surface and an outer peripheral wall surface of the cylinder chamber through the slit of the piston, a pair of generally semiarc-shape swing bushes are provided in the slit of the piston, the swing bush
25 being in surface contact with the piston and the blade such that the blade is reciprocatable and the blade is swingable relative to the piston, the rotary fluid device includes a suction mechanism which allows the refrigerant to be introduced into the

expansion chamber in a predetermined rotation angle range of the piston such that an expansion process of the fluid in the expansion chamber occurs in a predetermined range within one rotation cycle of the piston relative to the cylinder, and the suction mechanism includes a first path, one end of which is on an inlet port formed in the expansion chamber, and a second path formed in a drive shaft which relatively rotates the cylinder and the piston, the second path having the shape of an arc defined around the shaft center of the drive shaft, and the second path communicating with the other end of the first path in a predetermined rotation angle range of the piston to allow a fluid to be sucked into the expansion chamber .

[0007] In an embodiment of the invention, as the rotation mechanism (20) is driven, the cylinder (21) and the piston (22) relatively rotate, so that the volume of the compression chamber (51) decreases to compress the fluid, while the volume of the expansion chamber (52) increases to expand the fluid. The expansion of the fluid may allow recovery of power.

[0008] In an embodiment, a suction mechanism (60) may further be provided to allow the refrigerant to be introduced into the expansion chamber (52) in a predetermined rotation angle range of the piston (22) such that an expansion process of the fluid in the expansion chamber (52) occurs in a predetermined range within one rotation cycle of the piston (22) relative to the cylinder (21).

[0009] In an embodiment, the fluid may be introduced into the expansion chamber (52) by the suction mechanism (60) within a predetermined rotation angle range of the piston (22). As a result, the expansion process of the fluid in the expansion chamber (52) occurs in a predetermined range within one rotation cycle of the piston (22) relative to the cylinder (21), such that the pressure and expansion work of the fluid may be recovered.

[0010] According to an embodiment, the compression chamber (51) may be a working chamber formed outside the cylinder chamber (50), and the expansion chamber (52) may be a working chamber formed inside the cylinder chamber (50).

[0011] In an embodiment, the compression chamber (51) may be formed outside the cylinder chamber (50) while the expansion chamber (52) may be formed inside the cylinder chamber (50). Therefore, a predetermined compression capacity may be achieved.

[0012] According to an embodiment, a drive mechanism (30) for driving the rotation mechanism (20) may further be provided. The rotation speed of the drive mechanism (30) may be variably controlled.

[0013] In an embodiment, the rotation of the drive mechanism (30) may be controlled. Therefore, the operation may be carried out according to required performance such that the efficiency may further be improved.

[0014] According to an embodiment, the piston (22) has the shape of C formed by removing a part of its annular structure to make a slit. The blade (23) extends between an inner peripheral wall surface and an outer peripheral wall surface of the cylinder chamber (50) through the slit of the piston (22). A swing

bush (27) is provided in the slit of the piston (22) so as to be in surface contact with the piston (22) and the blade (23) such that the blade (23) is reciprocable and swingable relative to the piston (22).

[0015] In an embodiment, the blade (23) reciprocates in the swing bush (27) while the blade (23) and the swing bush (27) integrally swing relative to the piston (22). With this structure, the cylinder (21) and the piston (22) rotate while relatively swinging such that the rotation mechanism (20) performs predetermined compression and expansion operations.

Effects of the invention

[0016] According to an embodiment of the present invention, the compression chamber (51) and the expansion chamber (52) are formed outside and inside the piston (22), respectively. Therefore, the overall size of the device is decreased.

[0017] Since the compression chamber (51) and the expansion chamber (52) are located adjacent to each other on the same plane, some components can be shared therebetween, resulting in a decrease in the number of components.

[0018] According to an embodiment of the invention, since introduction of the refrigerant into the expansion chamber (52) is limited only to a predetermined rotation angle, even expansion work can also be recovered. Therefore, the efficiency is further improved.

[0019] According to an embodiment, since the compression chamber (51) is formed outside the cylinder chamber (50) and the expansion chamber (52) is formed inside the cylinder chamber (50), the compression capacity is fully utilized.

[0020] According to an embodiment, since the rotation of the drive mechanism (30) is controlled, the operation efficiency is further improved.

[0021] According to an embodiment, the swing bush (27) is provided as a coupling member for coupling the piston (22) and the blade (23) and is configured to be substantially in surface contact with the piston (22) and the blade (23). This arrangement

avoids the wearing-away of the piston (22) and the blade (23) and the burning of the contact portions therebetween during operation.

[0022] Since the swing bush (27) is provided to be in surface contact with the piston (22) and the blade (23), the contact portions achieves excellent sealing characteristics. Therefore, leakage of a refrigerant from the compression chamber (51) and the expansion chamber (52) is surely prevented, and decreases in the compression efficiency and expansion efficiency are also prevented.

[0023] Since the blade (23) is integrally provided to the cylinder (21) and supported at both ends by the cylinder (21), it is less likely to apply an abnormal concentrated load to the blade (23) and cause stress concentration during operation. Thus, the slidable portion is more resistant to damage. This feature also improves the reliability of the mechanism.

Brief Description of Drawings

[0024] FIG. 1 is a vertical cross-sectional view of an expansion/compression unit according to an embodiment of the present invention.

FIG. 2 is a circuit diagram showing a refrigerant circuit which has an expansion/compression unit.

FIG. 3 is a horizontal cross-sectional view of an expansion/compression mechanism.

FIG. 4 shows horizontal cross-sectional views which illustrate an operation of an expansion/compression mechanism.

Description of Reference Numerals

- [0025] 1 Compressor
- 10 Casing
- 20 Expansion/compression mechanism (rotational mechanism)
- 21 Cylinder

- 22 Piston
- 23 Blade
- 24 External cylinder
- 25 Internal cylinder
- 5 27 Swing bush
- 30 Electric motor (driving mechanism)
- 33 Drive shaft
- 50 Cylinder chamber
- 51 Compression chamber
- 10 52 Expansion chamber
- 60 Suction mechanism
- 61 First path
- 62 Second path

15 **Best Modes for Carrying Out the Invention**

[0026] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

[0027] <Embodiment 1>

Referring to FIG. 1 to FIG. 3, this embodiment is an application of the present invention to an expansion/compression unit (1) which is a compressor including an expander. The expansion/compression unit (1) is included in a refrigerant circuit (100).

[0028] The refrigerant circuit (100) uses, for example, carbon dioxide (CO₂) as a refrigerant and is configured to perform at least any of a cooling operation and a heating operation by compressing CO₂ over the critical pressure. The refrigerant circuit (100) includes, as shown in FIG. 2, an exterior heat exchanger (101) serving as a heat source-side heat exchanger and an interior heat exchanger (102) serving as a use-side heat exchanger, which are connected to the expansion/compression unit (1). For example, the refrigerant

compressed by the expansion/compression unit (1) discharges heat in the exterior heat exchanger (101) and is then expanded by the expansion/compression unit (1). The expanded refrigerant absorbs heat in the interior heat exchanger (102) and returns to the expansion/compression unit (1). This cycle is repeated, whereby indoor air is cooled by the interior heat exchanger (102). The refrigerant circuit (100) further includes a bypass passage (104) having an expansion mechanism (103), such as an expansion valve, or the like, such that the mass flow rate of the refrigerant in a compression chamber (51), which will be described later, and the mass flow rate of the refrigerant in an expansion chamber (52) are in harmony with each other. Specifically, part of the refrigerant which has discharged heat in the exterior heat exchanger (101) flows through the bypass passage (104), thereby bypassing the expansion/compression unit (1) to flow into the interior heat exchanger (102).

[0029] The expansion/compression unit (1) is a completely hermetic rotary fluid device wherein an expansion/compression mechanism (20) and an electric motor (30) are contained in a casing (10).

[0030] The casing (10) includes a cylindrical barrel (11), a top end plate (12) fixed to the top end of the barrel (11), and a bottom end plate (13) fixed to the bottom end of the barrel (11). The barrel (11) has a suction pipe (14) and discharge pipe (15) penetrating through the barrel (11). The suction pipe (14) is connected to the interior heat exchanger (102), while the discharge pipe (15) is connected to the exterior heat exchanger (101). The top end plate (12) has an inlet pipe (1a) and an outlet pipe (1b) penetrating through the top end plate (12). The inlet pipe (1a) is connected to the exterior heat exchanger (101), while the outlet pipe (1b) is connected to the interior heat exchanger (102).

[0031] The expansion/compression mechanism (20) constitutes a rotational mechanism as shown in FIG. 3 and is configured to carry out compression and expansion of refrigerant on the same plane at the same time. The expansion/compression

mechanism (20) is provided between an upper housing (16) and a lower housing (17) which are fixed to the casing (10). The expansion/compression mechanism (20) includes a cylinder (21) having an annular cylinder chamber (50), an annular piston (22) which is contained in the cylinder chamber (50) and which divides the cylinder chamber (50) into a compression chamber (51) and an expansion chamber (52), and a blade (23) which divides each of the compression chamber (51) and the expansion chamber (52) into a high pressure space and a low pressure space as shown in FIG. 3. The piston (22) in the cylinder chamber (50) is configured to make eccentric revolutions relative to the cylinder (21). Specifically, relative eccentric rotation is made between the piston (22) and the cylinder (21). In embodiment 1, the cylinder (21) having the cylinder chamber (50) is movable, while the piston (22) contained in the cylinder chamber (50) is stationary.

[0032] The electric motor (30) includes a stator (31) and a rotor (32) to constitute a driving mechanism. The stator (31) is placed below the expansion/compression mechanism (20) and fixed to the barrel (11) of the casing (10). A drive shaft (33) is coupled to the rotor (32) such that the drive shaft (33) rotates together with the rotor (32). The drive shaft (33) vertically penetrates through the cylinder chamber (50).

[0033] The drive shaft (33) is provided with an oil-supply passage (not shown) extending axially within the drive shaft (33). An oil-supply pump (34) is provided at the lower end of the drive shaft (33). The oil-supply passage extends upwardly from the oil-supply pump (34). Lubricating oil accumulated in the bottom of the casing (10) is supplied to slidable part of the compression mechanism (20) through the oil-supply passage by the oil-supply pump (34).

[0034] Part of the drive shaft (33) which is contained in the cylinder chamber (50) is eccentric part (35). The eccentric part (35) has a larger diameter than the other parts of the drive shaft (33) above and below the eccentric part (35) and is eccentric from the axial center of the drive shaft (33) by a predetermined amount.

[0035] The cylinder (21) includes an outer cylinder (24) and an inner cylinder (25). The outer cylinder (24) and the inner cylinder (25) are integrally coupled at their lower ends by an end plate (26) to each other. The inner cylinder (25) is slidably fitted to the eccentric part (35) of the drive shaft (33).

5 [0036] The piston (22) is formed integrally with the upper housing (16). The upper housing (16) and the lower housing (17) have bearings (1c, 1d) for supporting the drive shaft (33). Thus, the expansion/compression unit (1) of this embodiment takes on a through-axis structure wherein the drive shaft (33) vertically penetrates through the cylinder chamber (50) and parts of the drive shaft (33) on both axial sides of the eccentric
10 part (35) are supported by the bearings (1c, 1d) in the casing (10).

[0037] The expansion/compression mechanism (20) includes a swing bush (27) through which the piston (22) and the blade (23) are movably coupled to each other. The piston (22) has the shape of C formed by removing a part of an annular structure to make a slit. The blade (23) extends between an inner peripheral wall surface and an outer
15 peripheral wall surface of the cylinder chamber (50) through the slit of the piston (22) in a radial direction of the cylinder chamber (50) and is fixed to the outer cylinder (24) and the inner cylinder (25). The swing bush (27) constitutes, at the slit of the piston (22), a coupling member for coupling the piston (22) and the blade (23).

[0038] The inner peripheral surface of the outer cylinder (24) and the outer peripheral
20 surface of the inner cylinder (25) represent concentrically disposed cylindrical surfaces, between which a single cylinder chamber (50) is formed. The outer peripheral surface of the piston (22) has a smaller diameter than the inner peripheral surface of the outer cylinder (24), and the inner peripheral surface of the piston (22) has a larger diameter than the outer peripheral surface of the inner cylinder (25). Thus, a compression chamber (51)
25 serving as a working chamber is between the outer peripheral surface of the piston (22) and the inner peripheral surface of the outer cylinder (24), and an expansion chamber (52)

serving as a working chamber is between the inner peripheral surface of the piston (22) and the outer peripheral surface of the inner cylinder (25).

[0039] The piston (22) and the cylinder (21) are configured as follows: when the outer peripheral surface of the piston (22) substantially makes contact with the inner peripheral surface of the outer cylinder (24) at one point (strictly, there is a gap on the order of microns but no significant leak of a refrigerant from the gap), the inner peripheral surface of the piston (22) substantially makes contact with the outer peripheral surface of the inner cylinder (25) at one point which is different in phase by 180 degrees from the contact point between the outer peripheral surface of the piston (22) and the inner peripheral surface of the outer cylinder (24).

[0040] The swing bush (27) is formed by a discharge-side bush (2a) on the discharge side relative to the blade (23) and a suction-side bush (2b) on the suction side relative to the blade (23). The discharge-side bush (2a) and the suction-side bush (2b) are formed in the same shape to both have generally semicircular cross sections and disposed to have their flat surfaces opposed to each other. The space between the opposed surfaces of the discharge-side bush (2a) and suction-side bush (2b) forms a blade groove (28).

[0041] The blade (23) is inserted into the blade groove (28). The flat surfaces of the swing bush (27) are substantially in surface contact with the blade (23), and arc-shaped outer peripheral surfaces of the swing bush (27) are substantially in surface contact with the piston (22). The swing bush (27) is configured such that the blade (23) reciprocates within the blade groove (28) along the surfaces of the blade (23) with the blade (23) caught in the blade groove (28). The swing bush (27) is also configured to swing integrally with the blade (23) relative to the piston (22). In other words, the swing bush (27) is configured such that the blade (23) and the piston (22) are swingable relative to each other with the central point of the swing bush (27) being the swing center, and the blade (23) is reciprocable relative to the piston (22) along the surfaces of the blade (23).

[0042] Although in the example described in this embodiment the discharge-side bush (2a) and the suction-side bush (2b) are independent of each other, both of the buses (2a, 2b) may be partly coupled to each other so as to form an integral structure.

[0043] With the above structure, the rotation of the drive shaft (33) allows the outer cylinder (24) and the inner cylinder (25) to swing with the central point of the swing bush (27) being the swing center while the blade (23) reciprocates in the blade groove (28). This swing action allows the contact points between the piston (22) and the cylinder (21) to move sequentially from (A) through (D) in FIG. 4. In this sequence, the outer cylinder (24) and the inner cylinder (25) revolve around the drive shaft (33) but do not rotate.

[0044] Furthermore, the volume of the compression chamber (51) outside the piston (22) is reduced in the order of (C), (D), (A) and (B) as shown in FIG. 4. The volume of the expansion chamber (52) inside the piston (22) is reduced in the order of (A), (B), (C) and (D) as shown in FIG. 4.

[0045] The upper housing (16) has a suction space (41) at a position on the outer periphery of the outer cylinder (24). The suction pipe (14) is connected to the suction space (41). The outer cylinder (24) has a suction port (42). The suction port (42) allows communication between the compression chamber (51) and the suction space (41). The suction port (42) is provided in the vicinity of the blade (23), for example, on the right side of the blade (23) in FIG. 3.

[0046] The upper housing (16) has a discharge port (43). The discharge port (43) penetrates the upper housing (16) in its axial direction. The lower end of the discharge port (43) is open to the high pressure space of the compression chamber (51). Specifically, the discharge port (43) is formed near the blade (23) and positioned opposite to the suction port (42) relative to the blade (23). The upper end of the discharge port (43) communicates with a discharge space (45) through a discharge valve (44) which is a reed valve for opening/closing the discharge port (43).

[0047] The discharge space (45) is provided above the upper housing (16) and under the lower housing (17). The discharge space (45) provided above the upper housing (16) and the discharge space (45) provided under the lower housing (17) communicate with each other through a discharge path (46). The discharge space (45) communicates with the discharge pipe (15).

[0048] The inlet pipe (1a) penetrates through the upper housing (16) to have an opening in the lower surface of the upper housing (16). The opening of the inlet pipe (1a) faces the upper surface of the inner cylinder (25) and the upper surface of the eccentric part (35) of the drive shaft (33). The opening of the inlet pipe (1a) is closed by the inner cylinder (25) or the eccentric part (35) of the drive shaft (33).

[0049] A suction mechanism (60) is formed in the lower surface of the upper housing (16) and the upper surface of the eccentric part (35) of the drive shaft (33). The suction mechanism (60) allows the refrigerant to be introduced into the expansion chamber (52) in a predetermined rotation angle range of the piston (22) such that a refrigerant expansion process in the expansion chamber (52) occurs in a predetermined range within one rotation cycle of the piston (22) relative to the cylinder (21). Specifically, the suction mechanism (60) is formed by two paths, a first path (61) and a second path (62).

[0050] The first path (61) is formed by a groove having a U-shaped cross section in the lower surface of the upper housing (16). One end of the first path (61) has an opening in the vicinity of the blade (23) on the side closer to the suction port (42). When the piston (22) rotates from the bottom dead point (the state shown in FIG. 4(A)), the one end of the first path (61) is on an inlet port (4a) formed in the expansion chamber (52). The first path (61) extends in the axial direction of the drive shaft (33). The other end has an opening in the vicinity of the inlet pipe (1a).

[0051] The second path (62) is formed by a groove having a U-shaped cross section in the upper surface of the eccentric part (35) of the drive shaft (33). The second path (62) has the shape of an arc defined around the shaft center of the drive shaft (33) so as to allow

communication between the first path (61) and the inlet pipe (1a) in a predetermined rotation angle range. Specifically, the second path (62) allows communication between the first path (61) and the inlet pipe (1a) during a period when the piston (22) rotates 90° from the bottom dead point (during a period when the state changes from FIG. 4(A) to FIG. 4(B)) such that the refrigerant flows into the expansion chamber (52).

[0052] The upper housing (16) includes a low-pressure chamber (4b). The low-pressure chamber (4b) has an outlet port (4c) and communicates with the outlet pipe (1b). The outlet port (4c) is provided at a position in the vicinity of the blade (23), which is opposite to the one end of the first path (61), but on the same side with the discharge port (43), relative to the blade (23), and opens on the expansion chamber (52).

[0053] A seal ring (29) is disposed in the lower housing (17). The seal ring (29) is inserted into an annular groove of the lower housing (17) and pressed against the lower surface of the end plate (26) of the cylinder (21). Furthermore, high-pressure lubricating oil is introduced into the interface (contact surface) between the cylinder (21) and the lower housing (17) only radially inside the seal ring (29). In the above structure, the seal ring (29) constitutes a compliance mechanism for adjusting the axial location of the cylinder (21), such that axial gaps among the piston (22), the cylinder (21) and the upper housing (16) are reduced.

[0054] The rotation speed of the electric motor (30) is controlled by a controller (70) having a control circuit, such as an inverter, or the like.

[0055] --- Running Operation ---

Next, a running operation of the expansion/compression unit (1) is described.

[0056] When the electric motor (30) is started, the rotation of the rotor (32) is transferred to the outer cylinder (24) and inner cylinder (25) of the expansion/compression mechanism (20) via the drive shaft (33). Then, the blade (23) reciprocates (moves forth and back) through the swing bush (27), while the blade (23) and the swing bushing (27) integrally swing relative to the piston (22). As a result, the outer cylinder (24) and inner

cylinder (25) revolve while swinging relative to the piston (22), whereby the expansion/compression mechanism (20) performs predetermined compression and expansion operations.

[0057] Specifically, when the piston (22) is at the top dead center as shown in FIG. 3(C) and then the drive shaft (33) rotates clockwise, the suction process is started. Subsequently, the structure transitions sequentially in the order of (D), (A) and (B) of FIG. 4, so that the volume of the compression chamber (51) increases and the refrigerant is introduced through the suction port (42).

[0058] When the piston (22) is at the top dead center as shown in FIG. 4(C), the compression chamber (51) forms a single compression chamber outside the piston (22). In this state, the volume of the compression chamber (51) is substantially the maximum. Then, as the drive shaft (33) rotates clockwise to change the structure in the order of (D), (A) and (B) of FIG. 4, the volume of the compression chamber (51) decreases so that the refrigerant is compressed. When the pressure in the compression chamber (51) reaches a predetermined value and the pressure difference between the compression chamber (51) and the discharge space (45) reaches a set value, the discharge valve (44) is opened by the high-pressure refrigerant of the compression chamber (51), so that the high-pressure refrigerant is released from the discharge space (45) through the discharge pipe (15).

[0059] When the piston (22) is at the bottom dead center as shown in FIG. 4(A), the expansion chamber (52) forms a single expansion chamber inside the piston (22). In this state, the volume of the expansion chamber (52) is the maximum. Then, as the drive shaft (33) rotates clockwise to change the structure in the order of (B), (C) and (D) of FIG. 4, the volume of the expansion chamber (52) decreases so that low-pressure refrigerant is released from the outlet port (4c) to the outlet pipe (1b) through the low-pressure chamber (4b).

[0060] As for the expansion chamber (52), when the piston (22) is at the bottom dead center as shown in FIG. 4(A), communication is established between the first path (61) and

the second path (62) while the inlet pipe (1a) communicates with the second path (62), whereby the suction process is started. Thereafter, as the drive shaft (33) rotates clockwise, the first path (61) communicates with the expansion chamber (52) so that the high-pressure liquid refrigerant flows into the expansion chamber (52). Then, when the drive shaft (33) rotates 90° to form the structure of FIG. 4(B), the communication between the first path (61) and the second path (62) is interrupted. Thereafter, as the drive shaft (33) rotates to change the structure as shown in FIG. 4(C) and then FIG. 4(D), the volume of the expansion chamber (52) increases so that the high-pressure refrigerant expands, whereby the structure is returned to the state of FIG. 4(A). The pressure and expansion work of the high-pressure refrigerant are recovered for the rotation of the drive shaft (33).

[0061] As described above, the refrigerant is compressed in the compression chamber (51), and heat is released in the exterior heat exchanger (101). Meanwhile, the high-pressure refrigerant from the exterior heat exchanger (101) expands in the expansion chamber (52), heat is absorbed in the interior heat exchanger (102), and the low-pressure refrigerant returns to the compression chamber (51).

[0062] --- Effects of Embodiment ---

As described above, according to this embodiment, the compression chamber (51) and the expansion chamber (52) are formed outside and inside the piston (22), respectively. Therefore, the overall size of the device is decreased.

[0063] Since the compression chamber (51) and the expansion chamber (52) are located adjacent to each other on the same plane, some components can be shared therebetween, resulting in a decrease in the number of components.

[0064] Since introduction of the refrigerant into the expansion chamber (52) is limited only to a predetermined rotation angle, even expansion work can also be recovered. Therefore, the efficiency is further improved.

[0065] Since the compression chamber (51) is formed outside the cylinder chamber (50) and the expansion chamber (52) is formed inside the cylinder chamber (50), the compression capacity is fully utilized.

[0066] Since the rotation of the electric motor (30) is controlled by the controller (70),
5 the operation efficiency is further improved.

[0067] The swing bush (27) is provided as a coupling member for coupling the piston (22) and the blade (23) and is configured to be substantially in surface contact with the piston (22) and the blade (23). This arrangement avoids the wearing-away of the piston (22) and the blade (23) and the burning of the contact portions therebetween during
10 operation.

[0068] Since the swing bush (27) is provided to be in surface contact with the piston (22) and the blade (23), the contact portions achieves excellent sealing characteristics. Therefore, leakage of a refrigerant from the compression chamber (51) and the expansion chamber (52) is surely prevented, and decreases in the compression
15 efficiency and expansion efficiency are also prevented.

[0069] Since the blade (23) is integrally provided to the cylinder (21) and supported at both ends by the cylinder (21), it is less likely to apply an abnormal concentrated load to the blade (23) and cause stress concentration during operation. Thus, the slidable portion is more resistant to damage. This feature also improves the reliability of the mechanism.

20 [0070] <Other embodiments>

According to the present invention, the above-described embodiment may be modified to have the following alternative structures.

[0071] For example, the cylinder (21) may be fixed while the piston (22) may be movable.

25 [0072] The cylinder (21) may be integrated by coupling the outer cylinder (24) and the inner cylinder (25) at their upper ends by the end plate (26), and the piston (22) may be formed integrally with the lower housing (17).

[0073] The piston (22) may be formed in the form of a complete ring from which no part is removed, while the blade (23) may be divided into an outer blade (23) and an inner blade (23), such that the outer blade (23) advances from an outer cylinder (21) to make contact with the piston (22), and the inner blade (23) advances from an inner cylinder (21) to make contact with the piston (22).

[0074] The refrigerant circuit (100) may only perform heating operation or may be switched between cooling and heating operations.

[0075] Furthermore, the refrigerant of the refrigerant circuit (100) is not limited to CO₂.

Industrial Applicability

[0076] As described above, the present invention is useful for a rotary fluid device having a compression chamber and an expansion chamber and especially suitable for a rotary fluid device having a compression chamber and an expansion chamber on the same plane.

CLAIMS

1. A rotary fluid device comprising a rotation mechanism, the rotation mechanism including: a cylinder having an annular cylinder chamber; an annular piston which is accommodated in the cylinder chamber to be eccentric relative to the cylinder, 5 the annular piston dividing the cylinder chamber into an outer working chamber and an inner working chamber; and a blade placed in the cylinder chamber and partitioning each of the working chambers into a high-pressure space and a low-pressure space, the cylinder and the piston being relatively rotatable,

wherein one of the two working chambers constitutes a compression chamber 10 which compresses and discharges a sucked fluid with the progress of the relative rotation of the cylinder and the piston,

the other of the two working chambers constitutes an expansion chamber which expands and discharges a sucked fluid with the progress of the relative rotation of the cylinder and the piston,

15 the piston has the shape of C formed by removing a part of its annular structure to make a slit,

the blade extends between an inner peripheral wall surface and an outer peripheral wall surface of the cylinder chamber through the slit of the piston,

a pair of generally semiarc-shape swing bushes are provided in the slit of the 20 piston, the swing bush being in surface contact with the piston and the blade such that the blade is reciprocable and the blade is swingable relative to the piston,

the rotary fluid device includes a suction mechanism which allows the refrigerant to be introduced into the expansion chamber in a predetermined rotation angle range of the piston such that an expansion process of the fluid in the expansion chamber occurs in 25 a predetermined range within one rotation cycle of the piston relative to the cylinder, and

the suction mechanism includes a first path, one end of which is on an inlet port formed in the expansion chamber, and a second path formed in a drive shaft which relatively rotates the cylinder and the piston, the second path having the shape of an arc

defined around the shaft center of the drive shaft, and the second path communicating with the other end of the first path in a predetermined rotation angle range of the piston to allow a fluid to be sucked into the expansion chamber.

5

2. The rotary fluid device of claim 1, further comprising a suction mechanism which allows the refrigerant to be introduced into the expansion chamber in a predetermined rotation angle range of the piston such that an expansion process of the fluid in the expansion chamber occurs in a predetermined range within one rotation cycle of the piston relative to the cylinder.

10

3. The rotary fluid device of claim 1, wherein:

the compression chamber is a working chamber formed outside the cylinder chamber; and

15

the expansion chamber is a working chamber formed inside the cylinder chamber.

4. The rotary fluid device of claim 1, further comprising a drive mechanism for driving the rotation mechanism,

wherein the rotation speed of the drive mechanism is variably controlled.

20

5. The rotary fluid device of claim 1, wherein:

the piston has the shape of C formed by removing a part of its annular structure to make a slit;

25

the blade extends between an inner peripheral wall surface and an outer peripheral wall surface of the cylinder chamber through the slit of the piston;

a swing bush is provided in the slit of the piston, the swing bush being in surface contact with the piston and the blade such that the blade is reciprocable and the blade is swingable relative to the piston.