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Wobble plate compressor with variable displacement mechanism.

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Description

This invention relates to a wobble plate compressor with a variable displacement mechanism suitable for use in an automotive air conditioning system.

It is conventionally known to use a wobble plate compressor with a variable displacement mechanism in an automotive air conditioning system. The compressor includes a drive shaft and an inclined plate connected thereto and the rotation of the inclined plate is converted to nutation motion of a wobble plate. The nutating motion of the wobble plate is converted to reciprocating motion of pistons. The variable displacement mechanism controls the pressure in a crank chamber in accordance with external conditions, and varies the angle of the inclined plate. Accordingly, the stroke of the pistons is changed in accordance with variation in the angle of the inclined plate, thereby changing the compression ratio of the compressor.

If the above type of compressor is used in an automotive air conditioning system, torque shock based on clutch cycling is prevented since it is not required to control air temperature by clutch cycling. However, when a main switch of the air conditioning system is turned on, it is necessary to turn the clutch on and off, and thereby producing torque shock.

In consideration of the above problem, it is known to reduce torque shock by reducing the angle of the inclined plate with a cam spring at the time that the main switch is off. At that time, suction pressure in the compressor is high and the pressure difference between a crank chamber and a suction chamber is small. Accordingly, pressure in the crank chamber is high. But the pressures in the suction and crank chambers are reduced when the compressor is started, thereby providing a large compression capacity. Since the above situation exists for an instant when the air conditioning system is turned on, the compressor capacity of the compressor is then large, thereby producing extremely large torque shock.

It is one object of this invention to provide a wobble plate type compressor with a variable displacement mechanism which can reduce torque shock.

US-A-4606705 discloses a refrigerant compressor including a compressor housing having a cylinder block provided with a plurality of cylinders, a front end plate disposed on one end of the housing and enclosing a crank chamber within the housing; pistons slidably fitted within respective ones of the cylinders and reciprocable by a drive mechanism including a wobble plate, a rotor connected to a drive shaft, an adjustable slant plate having an inclined surface in close proximity to the wobble plate and adjustably connected to the rotor so as to have an adjustable slant angle, which changes in response to changes of pressure in the crank chamber to change the capacity of the compressor; the front end plate rotatably supporting the drive shaft in a hole therethrough; a rear end plate disposed on the end of the cylinder block remote from the crank chamber with a suction chamber and a discharge chamber therein; and a control means responsive to discharge and suction chamber pressures for controlling the opening and closing of a passageway between the suction chamber and the crank chamber; and, in accordance with the invention, such a compressor is characterised in that the control means includes a first control valve means controlling the opening and closing of one end of the passageway and responsive to pressure in the suction chamber or the crank chamber, and a second control valve means controlling the opening and closing of the other end of the passageway and responsive to a difference between the pressures in the suction and discharge chambers such that the other end of the passageway is opened when the pressure difference becomes equal to or greater than a predetermined value, the first and second control valve means being independently operable and acting in series between the suction and crank chambers.

In the accompanying drawings:

Figure 1 is a cross-sectional view of a wobble plate compressor with a variable displacement mechanism in accordance with one embodiment of this invention; and

Figure 2 is a cross-sectional view of a wobble plate compressor with a variable displacement mechanism in accordance with another embodiment of this invention.

With reference to Figure 1, a wobble plate compressor 10 in accordance with one embodiment of this invention has a cylindrical housing 20 including a cylinder block 21, a front end plate 23 at one end of the housing 20, a crank chamber 22 formed between the cylinder block 21 and the front end plate 23 and a rear end plate 24 attached to the other end of the cylinder block 21. The front end plate 23 is mounted on the housing forward (to the left in Figure 1) of the crank chamber 22 by a plurality of bolts 101. The rear end plate is mounted on the cylinder block 21 by a plurality of bolts 102. A valve plate 25 is located between the rear end plate 24 and the cylinder block 21. An opening 231 is centrally formed in the front end plate 23 for supporting a drive shaft 26 therethrough by a radial bearing 30 disposed therewithin. The inner end portion of the drive shaft 26 is rotatably supported by a radial bearing 31 disposed within a central bore 210 of the cylinder block 21. The bore 210 has a cylindrical chamber 211 rearward (to the right) of the end of the drive shaft 26 containing the valve control mechanism as discussed below.

A cam rotor 40 is fixed on the drive shaft 26 by a pin member 261 and rotates therewith. A thrust bearing 32 is disposed between the inner end surface of the front end plate 23 and the adjacent axial end surface of the cam rotor 40. The cam rotor 40 includes
an arm 41 having a pin 42 extending therefrom. An inclined plate 50 is adjacent to the cam rotor 40 and includes an opening 53 through which passes the drive shaft 26. The inclined plate 50 includes an arm 51 having a slot 52. The cam rotor 40 and inclined plate 50 are connected by the pin 42 which is inserted in the slot 52 to create a hinge mechanism. The pin 42 is slidable within the slot 52 to allow adjustment of the angular position of the inclined plate 50 with respect to the longitudinal axis of the drive shaft 26. A coil spring 27 is disposed on the outer surface of the drive shaft 26 between the cam rotor and the inclined plate 50 and urges the inclined plate 50 towards the cylinder block 21 so that the angle of inclination of the inclined plate 50 is to a plane perpendicular to the longitudinal axis of the drive shaft 26 is a minimum.

A wobble plate 60 is nutatably mounted on the inclined plate 50 through a thrust bearing 61 and a radial bearing 62. A fork shaped slider 63 is attached to the outer peripheral end of the wobble plate 60 and is slidable mounted on a guide bar 64 held between the front end plate 23 and the cylinder block 21. The slider 63 prevents rotation of the wobble plate 60 and the wobble plate 60 nutates along the guide bar 64 when the cam rotor 40 rotates. The cylinder block 21 includes a plurality of cylinders 70 which are equiangularly located therein. Pistons 71 are reciprocatably fitted within respective ones of the cylinders. Each piston 71 is coupled with the wobble plate through a corresponding rod 72.

The rear end plate 24 includes a peripherally located annular suction chamber 241 and a centrally located discharge chamber 251. A valve plate 25 is located between the cylinder block 21 and the rear end plate 24 and includes a plurality of suction ports 242 to communicate the suction chamber 241 with the cylinders 70. The valve plate 25 also includes a plurality of discharge ports 252 to communicate the discharge chamber 251 with the cylinders 70. The suction ports 242 and discharge ports 252 are provided with suitable reed valves on both end surfaces of the valve plate 25.

The suction chamber 241 includes an inlet port 241a which is connected to an evaporator of the external cooling circuit (not shown). The suction chamber 251 is provided with an outlet port 251a connected to a condenser of the cooling circuit (not shown). Gaskets 27 and 28 are located between the cylinder block 21 and the inner surface of valve plate 25, and the outer surface of the valve plate 25 and rear end plate 24 respectively, to seal the mating surfaces of the cylinder block 21, the valve plate 25 and the rear end plate 24.

A valve control mechanism 80 is disposed within the cylinder block 21 and includes a cylindrical casing 81, and an annular end plate 82, and is provided with a hole 821 at its one end, and a diaphragm 83 at its other end. A valve seat 84, which is provided with a hole 841, is fixed to the inner surface of the cylindrical casing 81. A pedestal 85, which is provided with a shank portion 851, is fixed on one end surface of the valve seat 84. The interior of the valve control mechanism 80 is divided by the valve seat 84 and the pedestal 85 into a first chamber 801, a second chamber 802 and a third chamber 803. Holes 852 are formed through the pedestal 85 to communicate the second chamber 802 with the third chamber 803.

A bellows 86 which is under vacuum in its interior is fixed at its one end on the outer end surface of the pedestal 85 and a valve portion 861 is fixed on the other end of the bellows 86. The valve 861 opens and closes the hole 821 of the annular end plate 82 in accordance with operation of the bellows 86.

A pin 831 is fixed on the inner end surface of the diaphragm 83 at its one end. The other end of the pin 831 extends axially to urge a ball 87, which is supported by a coil spring 88 within a hole 841 of the valve seat 84, in the axial direction in accordance with operation of a diaphragm 83.

A passageway 212 is formed within the cylinder block 21 to communicate the first chamber 801 with the suction chamber 241 through the valve plate 25 and the gaskets 27 and 18. A communication hole 252 is formed through the valve plate 25, and the gaskets 27 and 28, to communicate a fourth chamber 804, which is defined by the outer end surface of the diaphragm 83 and the inner end surface of the valve plate 25 within a cylinder chamber 211, with the discharge chamber 251.

The operation of the above compressor is as now described:

When rotational motion of an engine (not shown) is transmitted to the drive shaft 26, the cam rotor 40, which is fixed to the drive shaft 26, is rotated therewith. The rotational motion transmitted to the cam rotor 40 is transmitted to the wobble plate 60 through the inclined plate 50. At this time, since the slider 63 of the wobble plate 60 is sicialably disposed on the upper end surface of the side bar 64, the wobble plate 60 is prevented from rotating together with the cam rotor 40, and thereby the rotational motion which is transmitted from the cam rotor 40 to the wobble plate 60 is converted into nutating motion of the wobble plate 60. The pistons 71 receive nutating motion from the wobble plate 60 through the connecting rods 72 and reciprocate within the cylinders 70 in accordance with the nutating motion from the wobble plate 60. Accordingly, refrigerant gas, which is sucked from the suction chamber 241 into the cylinders 70 through the suction ports 242, is compressed in the cylinders 70 and discharged to the discharge chamber 251 through the discharge ports 252. The compressed gas in the discharge chamber 251 is fed to a refrigerant circuit through an outlet port 251a.

While the air conditioning system is off, the pressure in the suction chamber 241 is almost equal to that
In the discharge chamber 251, i.e., the pressure in the first chamber 801 is almost equal to that in the fourth chamber 804. Accordingly, the diaphragm 83 does not move in any directions, and thereby the ball 87 closes the hole 841 of the valve seat 84 under the recoil strength of the coil spring 88. When the air conditioning system is turned on, compressor 10 starts to rotate. At this time, the angle of the inclined plate 60 becomes the least since the inclined plate 60 is urged towards the right in Figure 1 by the coil spring 27.

The refrigerant gas, which is sucked into the cylinders 70 from the suction chamber 241 through the suction ports 242, is compressed in the cylinder 70, and discharged into the discharge chamber 251. Accordingly, the pressure in the discharge chamber 251 gradually increases, and the pressure difference between the suction and discharge chambers 241 and 251 also gradually increases. At this time, since the ball 87 closes the hole 841 of the valve seat 84, the pressure in the crank chamber 22 is maintained to be almost equal to that in the discharge chamber 251, and the angle of the inclined plate 50 is maintained at the least.

If the pressure difference between the suction and discharge chambers 241 and 251 becomes greater than a predetermined value ΔP, the diaphragm 83 is bent towards the left side in the Figure 1, and the pin 831 moves to the left against the recoil strength of the coil spring 88 and urges the ball 87 to the left. Accordingly, the hole 841 of the valve seat 84 is gradually opened. Refrigerant gas in the suction chamber 241 flows into the third chamber 803 through the passageway 212, the first chamber 801 and the second chamber 802, and the pressure in the third chamber 803 becomes equal to that in the suction chamber 241.

When the pressure in the suction chamber 241 is greater than the extending force of the bellows 86, the bellows 86 contracts, and thereby the valve 861 opens the hole 821 in the annular end plate 82. Accordingly, the crank chamber 22 is in communication with the suction chamber 241 and compressed gas in the crank chamber 22 flows to the suction chamber 241 through gaps in the radial bearing 31, the third chamber 803, the second chamber 802, the first chamber 801 and the passageway 212, and thereby the pressure in the crank chamber 22 reduces. The angle of the inclined plate 60 thus increases and the piston stroke increases. Therefore, the compression capacity of the compressor 10 becomes large. Thereafter, the compression capacity of the compressor 10 is controlled in response to the pressure in the suction chamber 241.

In the above construction, since the angle of the inclined plate 60 becomes the least by virtue of the pressure in the crank chamber 22 immediately after the compressor 10 is started, even although the coil spring 27 does not urge the inclined plate 60 to the right, the coil spring 27 can be removed.

Figure 2 shows a wobble plate type compressor with a variable displacement mechanism in accordance with another embodiment of this invention. The same numerals are accorded to the same parts as in the first embodiment and the corresponding description is omitted to simplify the specification. In the valve control mechanism 80, an annular end plate 85 is fixed on one end of the valve seat 84 to define the second chamber 802 therebetween. A bellows 90 is attached to one end surface of the pedestal 91, which is fixed to the cylindrical casing 81 at its one end and is provided with a valve portion 901. The valve portion 901 opens and closes the hole of the annular end plate 89 in accordance with operation of the bellows 90. Holes 811 are formed through the cylindrical casing 81 to communicate the crank chamber 22 with the third chamber 803.

As mentioned above, when the air conditioning system is off, the ball 87 is supported within the valve seat 84 under the recoil strength of the coil spring 88 and closes the hole 841 of the valve seat 84. When the compressor 10 is driven, compressed gas from the cylinders 70 leaks into the crank chamber 232 through gaps between the inner surfaces of the cylinders 70 and the outer surfaces of the pistons 71, and the pressure in the crank chamber 22 increases. Simultaneously, the pressure difference between the pressures in the suction and discharge chambers 241 and 251 also increases. When the pressure difference between in suction and discharge chambers 241 and 251 becomes greater than the predetermined value ΔP the diaphragm 831 is bent towards the left in Figure 2 and urges the ball 87 to open the hole 841 of the valve seat 84. On the other hand, compressed gas in the crank chamber 22 flows into the third chamber 803 through gaps between the inner surface of the radial bearing 31 and the outer surface of the drive shaft 26 and holes 811 if the cylindrical casing 81, i.e., the pressure in the third chamber 803 is maintained equal to that in the crank chamber 22. When the pressure in the crank chamber 22 become greater than the extending force of the bellows 90, the bellows 90 contracts, and thereby the valve portion 901 opens the hole 891 in the annular end plate 89. Then the crank chamber 22 communicates with the suction chamber 241 through the third chamber 803, the second chamber 802, the first chamber 801 and passageway 212, and thereby the pressure of the gas in the crank chamber 22 reduces. As a result of the above reduction of the pressure in the crank chamber 22, the angle of the inclined plate 60 increases, and the compression ratio of the compressor 10 also increases.

Claims

1. A refrigerant compressor including a compres-
sor housing (20) having a cylinder block (21) provided with a plurality of cylinders (70), a front end plate (23) disposed on one end of the housing block and enclosing a crank chamber (22) within the housing; pistons (71) slidably fitted within respective ones of the cylinders and reciprocable by a drive mechanism including a wobble plate (60), a rotor (40) connected to a drive shaft (25), an adjustable slant plate (50) having an inclined surface in close proximity to the wobble plate and adjustably connected to the rotor so as to have an adjustable slant angle, which changes in response to changes of pressure in the crank chamber to change the capacity of the compressor; the front end plate (23) rotatably supporting the drive shaft (25) in a hole (231) therethrough; a rear end plate (24) disposed on the end of the cylinder block remote from the crank chamber with a suction chamber (241) and a discharge chamber (251) therein; and a control means (80) responsive to discharge and suction chamber pressures for controlling the opening and closing of a passageway (212, 802, 803) between the suction chamber and the crank chamber, characterised in that the control means includes as first control valve means (86, 861, 90, 901) controlling the opening and closing of one end of the passageway and responsive to pressure in the suction chamber or the crank chamber, and a second control valve means (83, 87) controlling the opening and closing of the other end of the passageway and responsive to a difference between the pressures in the suction and discharge chambers such that the other end of the passageway is opened when the pressure difference becomes equal to a greater than a predetermined value, the first and second control valve means being independently operable and acting in series between the suction and crank chambers.

2. A compressor according to claim 1, wherein an urging means (27) urges the slant plate (5) in the axial direction so that the angle of the slant plate with respect to a plane perpendicular to an axis of the drive shaft (28) is reduced.

Patentansprüche


2. Kompressor nach Anspruch 1, bei dem eine drückende Vorrichtung (27) die Schrägplatte (5) in die axiale Richtung so drückt, daß der Winkel der Schrägplatte in Bezug auf eine Ebene senkrecht zu einer Achse der Antriebswelle (26) verringert wird.

Revendications

1. Compresseur de réfrigérant comprenant un carter de compresseur (20) comportant une culasse (21) munie d'un certain nombre de cylindres (70), une plaque d'extrémité avant (23) montée sur un extrémité du bloc de carter et enfermant une chambre de manivelle (22) à l'intérieur du carter ; des pistons (71) montés en glissement à l'intérieur des cylindres respectifs et pouvant effectuer un mouvement de va-et-vient sous l'action d'un mécanisme d'entraînement comprenant un plateau oscillant (60), un rotor (40) relié à un arbre d'entraînement (26), une plaque inclinée réglable (50) comportant une surface inclinée au voisinage immédiat du plateau oscillant et reliée de manière réglable au rotor de manière à présenter un angle d'inclinaison réglable changeant en réponse aux variations de pression dans la chambre de manivelle pour modifier la capacité du compresseur ; la plaque d'extrémité avant (23) supportant en rotation l'arbre d'entraînement (26) dans un trou (231) percé dans celle-ci ; une plaque d'extrémité arrière (24)
montée sur l'extrémité de la culasse opposée à la chambre de manivelle contenant une chambre d'aspiration (241) et une chambre de décharge (251) ; et un dispositif de commande (80) répondant aux pressions régnant dans la chambre de décharge et dans la chambre d'aspiration pour commander l'ouverture et la fermeture d'un passage (212, 802, 803) entre la chambre d'aspiration et la chambre de manivelle, compresseur caractérisé en ce que le dispositif de commande comprend un premier dispositif de soupape de commande (86, 861, 90, 901) commandant l'ouverture et la fermeture d'une extrémité du passage et répondant à la pression régnant dans la chambre d'aspiration ou dans la chambre de manivelle, et une second dispositif de soupape de commande (83, 87) commandant l'ouverture et la fermeture de l'autre extrémité du passage et répondant à une différence de pression entre la pression régnant dans la chambre d'aspiration et la pression régnant dans la chambre de décharge, de façon que l'autre extrémité du passage soit ouverte lorsque la différence de pression devient égale ou supérieure à une valeur prédéterminée, le premier et second dispositif de soupape de commande pouvant être manœuvrés indépendamment et agissant en série entre la chambre d'aspiration et la chambre de manivelle.

2. Compresseur selon la revendication 1, caractérisé en ce qu'un dispositif de poussée (27) pousse la plaque inclinée (9) dans la direction axiale de manière à réduire l'angle de cette plaque inclinée par rapport à un plan perpendiculaire à l'axe de l'arbre d' entraînement (28).