

TYD-F879

DESCRIPTION

Tammelschreiber
 SWASH PLATE TYPE COMPRESSOR

5

TECHNICAL FIELD

Tammelschreiber

The present invention relates to a swash plate type compressor and, more particularly, to a highly reliable swash plate type compressor provided with a swash plate finished by surface treatment and capable of functioning with improved performance. *in valveless function*

BACKGROUND ART

A double-headed swash plate type compressor applied to an automobile air conditioning system, for example, has a drive shaft, a pair of cylinder blocks supporting the drive shaft for rotation, and a swash plate fixedly supported on the drive shaft for rotation together with the drive shaft in a swash plate chamber formed in a region including the boundary between the pair of cylinder blocks. A plurality of cylinder bores are formed so as to extend in both the cylinder blocks and are arranged around the drive shaft. Double-headed pistons are fitted for axial movement in the cylinder bores, respectively. Each piston is operatively engaged with the swash plate via shoe elements. The rotary motion of the swash plate is converted into the linear motion of the pistons for the suction, compression and discharge of a refrigerant gas. *reciprocating*

A single-headed swash plate type compressor has a cylinder block, and a housing closing an inner end of the cylinder block and having a swash plate chamber or a crank chamber. A swash plate is mounted on a drive shaft in the swash plate chamber and is engaged with pistons by shoes. Further, in a variable-displacement swash plate type compressor, a swash plate is engaged with single-headed pistons fitted in a plurality of cylinder bores by shoes, and is mounted on a drive shaft so as to wobble on a supporting point. *Tammelschreiber* The inclination of the swash plate is changed according to pressure in the crank chamber so that gas pressures acting on

the opposite ends of the single-headed piston balance each other. Consequently, the stroke of the single-headed piston is adjusted to control the displacement of the compressor.

The demand for weight reduction in the afore-mentioned swash plate type compressors has progressively increased and the swash plate type compressors for automobile air conditioning or climate control systems, including the swash plates, the pistons, and the cylinder blocks are now made of aluminum alloys. Therefore, abrasion-resistant and seizing-preventive measures have been examined to protect surfaces exposed to severe, high-speed abrasive actions for a long time, such as the surfaces of the swash plate in sliding contact with the shoes, and the sliding contact surface of the piston in sliding contact with the surface of the bore. Such measures include the formation of a fluorocarbon resin film on the sliding contact surface of the piston and the formation of a film of a solid lubricant on the sliding contact surface of the swash plate.

The double-headed piston, however, is provided with a recess extending across the periphery of the swash plate, and interfering surfaces formed in the recess to prevent the piston from rotation about its own axis come into impulsive contact with the outer circumference of the swash plate to prevent the piston from rotation by a rotation moment acting on the piston. The single-headed piston is provided with a rotation-preventive interfering surface in its base end part, and the interfering surface comes into impulsive contact with the inner surface of the housing to restrain the piston from rotation. Accordingly, it is possible, under a substantially nonlubricated state which occurs at the start of the compressor, that seizing occurs between the interfering surface of the piston and the outer circumference of the swash plate, and attempts have been made to form a lubricating film over the interfering surface of the piston and the outer circumference of the swash plate. However, in formation of a lubricating film, when, for example, a spray coating process for coating the swash plate with a lubricating film is used,

the yield of formation of the coating material film is usually very low. Furthermore, since the strength of an adhesive bond of the lubricating film and the sliding contact surface is low, such a protective measure using the lubricating film is
5 not satisfactory in reliability as well as in its seizing-preventive effect.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide an improved swash plate type compressor capable of providing
10 improved functional reliability attained by employing an improved swash plate coated with an excellent film and capable of being manufactured with a high productivity.

Another object of the present invention is to provide a long-life swash plate type compressor capable of properly
15 functioning, over an extended period of use, when applied to an automobile air conditioning system and driven by the engine of a vehicle to compress a refrigerant.

In accordance with the present invention, there is provided a swash plate type compressor which comprises: a
20 cylinder block provided with a plurality of cylinder bores; pistons fitted in the cylinder bores; a drive shaft supported for rotation about its axis of rotation; and a swash plate supported for rotation together with the drive shaft, having at least sliding contact surfaces to be in sliding contact
25 with shoes and operatively engaged with the pistons via the shoes;

wherein the sliding contact surfaces of the swash plate in sliding contact with the shoes are coated with a film of at least one solid lubricant selected from molybdenum disulfide,
30 tungsten disulfide and graphite by a transfer method.

The film of the solid lubricant formed on the sliding contact surface of the swash plate in sliding contact with the shoes exercises excellent lubricating performance, and the transfer method of forming the film of the solid lubricant is
35 very advantageous from the viewpoint of economy and productivity in the yield of the coating material and the control of the thickness of the film.

If the swash plate has an outer circumference to be in impulsive contact with interfering surfaces formed respectively in the pistons, it is preferable that a film of the solid lubricant is formed on the outer circumference by a transfer method. Thus, the contact surface to be in impulsive contact with the piston, in addition to the sliding contact surface in sliding contact with the shoes, is able to secure a further satisfactory seizing-resistant property.

If the sliding contact surfaces of the swash plate on which the film is formed, i.e., base surfaces for the film, are subjected to a surface roughening process, a coating material for forming the film is forced to dig into minute irregularities formed by the plastic deformation of the base surfaces to provide an anchoring effect which enhances the strength of connection of the film to the base surfaces. If the sliding contact surface and the outer circumference of the swash plate are coated for surface preparation with a plated film of a material containing ^{Zinn}tin as a principal component, the plated film prevents the aluminum base of the swash plate from being exposed even if part of the plated film falls off, and serves as a lubricating layer. Therefore, the swash plate has excellent durability.

Preferably, the film formed on the sliding contact surface of the swash plate is finished by grinding to adjust the thickness of the film and finish the surface of the film in a high surface accuracy (flatness).

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages will become apparent from the ensuing description of the preferred embodiments taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a longitudinal sectional view of a double-headed swash plate type compressor in a preferred embodiment according to the present invention;

Fig. 2A is a perspective view of a double-headed piston employed in the compressor of Fig. 1;

Fig. 2B is a longitudinal sectional view taken on line 2B-

2B in Fig. 2A;

Fig. 3 is a longitudinal sectional view of a single-headed swash plate type compressor in another embodiment according to the present invention;

5 Fig. 4A is a front view of a single-headed piston employed in the compressor of Fig. 3;

Fig. 4B is a rear end view showing a rotation preventing interfering surface formed in the single-headed piston;

Fig. 5 is a typical view of a transfer apparatus for
10 processing the sliding contact surface of a swash plate;

Fig. 6A is a typical view of a transfer apparatus for processing the outer circumference of a swash plate; and

Fig. 6B is a typical development showing the relation between a workpiece for making a swash plate, and rollers.

15 BEST MODE OF CARRYING OUT THE INVENTION

Referring to Figs. 1, 2A and 2B, a double-headed swash plate type compressor has a front cylinder block 1A and a back cylinder block 1B, and a drive shaft 2 is supported for rotation about an axis of rotation on the cylinder blocks 1A and 1B. A swash plate chamber 4 is formed in a region around the joint of the cylinder blocks 1A and 1B in the cylinder blocks 1A and 1B. A swash plate 3 is contained in the swash plate chamber 4 and is combined with the drive shaft 2 for rotation together with the drive shaft 2. Bores of a
20 predetermined diameter are formed in the cylinder blocks 1A and 1B, and the cylinder blocks 1A and 1B are joined together with the respective axes of the corresponding bores aligned with each other so as to form a plurality of axial cylinder bores (hereinafter referred to simply as "bores") 5 arranged
25 around the drive shaft 2. Opposite end parts of double-headed pistons 6 are fitted in the bores 5, respectively, for axial sliding movement. Each piston 6 is linked to the sliding contact surfaces 3a of the swash plate 3 by shoes 7. A rotary motion of the swash plate 3 is converted into a linear motion
30 of the piston 6 for the suction, compression and discharge of a refrigerant gas.

In this embodiment, the shoes 7 are made of an iron based

material and the cylinder blocks 1a and 1B, the swash plate 3 and the double-headed pistons 6 are made of an aluminum alloy such as a hypereutectic aluminum-silicon alloy.

As best shown in Figs. 2A and 2B, the double-headed piston 5 6 has cylindrical sliding contact surfaces 6a of a predetermined length formed in the opposite end parts thereof and capable of being slidably fitted in the bores 5, and a recess 6b formed in a middle part thereof between the opposite end parts provided with the sliding contact surfaces 6a so as 10 to extend across the outer circumference of the swash plate 3. Semispherical seats 6c in which the shoes 7 are seated, respectively, are formed axially opposite to each other in the recess 6b. Interfering surfaces 6d for restraining the piston 6 from rotation are formed axis-symmetrically in the middle 15 part. The interfering surfaces 6d come into impulsive contact with the outer circumference 3b of the swash plate 3 to inhibit the rotation of the piston 6 about its axis by a rotation moment exerted by the shoes 7 on the piston 6.

Referring to Figs. 3, 4A and 4B, a variable-displacement 20 swash plate type compressor in another embodiment according to the present invention has a cylinder block 10 having opposite end surfaces, a front housing 11 connected to the cylinder block 10 so as to cover the front end of the cylinder block 10, a valve plate 12 placed on the rear end surface of the 25 cylinder block 10, and a rear housing 13 connected to the cylinder block 10 so as to cover the rear end of the cylinder block 10. The cylinder block 10, the front housing 11 and the rear housing 13 are firmly fastened together with through bolts so that the connecting portions thereof are tightly 30 sealed. In the compressor, the cylinder block 10 and the front housing 11 define a crank chamber 14, and a drive shaft 15 is extended axially in the crank chamber 14 and is supported for rotation in a pair of radial bearings held respectively on the cylinder block 10 and the front housing 35 11.

A plurality of cylinder bores (hereinafter referred to simply as "bores") 16 are formed around the drive shaft 15 in

the cylinder block 10, and single-headed pistons 17 are fitted for reciprocation in the bores 16, respectively.

In the crank chamber, a rotor 20 is fixedly mounted on the drive shaft 15 for rotation together with the drive shaft 15.

5 An axial load exerted on the rotor 20 is sustained, through a thrust bearing, by the front housing 11. A swash plate 18 is mounted on the drive shaft 15 at a position behind the rotor 20. The swash plate 18 is always biased backward by the resilience of a compression spring interposed between the
10 swash plate 18 and the rotor 20.

The swash plate 18 has a shape generally resembling a plate and is provided with flat sliding contact surfaces 18a formed on the opposite sides of a peripheral part thereof. Semispherical shoes 19 are put in contact with the sliding
15 contact surfaces 18a, respectively. The shoes 19 are in sliding contact with semispherical seats 17c formed in the piston 17. A hinge mechanism K is formed between the swash plate 18 and the rotor 20 to allow the swash plate 18 to move pivotally relative to the rotor 20.

20 The swash plate 18 is provided with a bent central hole 18b formed through a central part thereof. The drive shaft 15 is extended through the central hole 18b to support the swash plate 18 thereon. The inclination of the swash plate 18 is variable without varying the top dead center of each single-
25 headed piston 17 relative to the corresponding bore 16.

In this embodiment, the cylinder block 10, the swash plate 18 and the piston 17 are made of an aluminum alloy, such as a hypereutectic aluminum-silicon alloy. Each piston 17 is provided in its head part with a sliding contact surface 17a
30 of a predetermined length fitting the bore 16, in its tail end part with a recess 17b (Fig. 4A) extending across the swash plate 18, and on the back side of a part thereof forming the recess 17b with a curved interfering surface 17d of a large radius of curvature capable of coming into impulsive contact
35 with the inner surface 14a defining the crank chamber 14 to prevent the piston 17 from rotation about its own axis.

The surface treatment of the swash plate, which is a

feature of the present invention, will be described with reference to Figs. 5, 6A and 6B.

The swash plate 8 linked to the double-headed pistons 6 in the former embodiment and the swash plate 18 linked to the single-headed pistons 17 in the latter embodiment differ from each other in that the former swash plate 3 has the outer circumference 3b with which the interfering surfaces 6d of the pistons 6 come into impulsive contact, while the latter swash plate 18 has the outer circumference with which the pistons 17 do not come into direct contact. Therefore, the outer circumference of the swash plate 18 need not be subjected to a surface treatment process for providing the same with a lubricating property. However, the surface treatment of the sliding contact surfaces 3a of the swash plate 3 to be in contact with the shoes 7, and the surface treatment of the sliding contact surfaces 18a of the swash plate 18 are substantially the same and hence only the surface treatment of the swash plate 3 will be described.

Although not clearly shown in the drawings, the sliding contact surfaces 3a formed on a workpiece 3W, i.e., a swash plate 3 that is being manufactured, are selectively processed to finish the sliding contact surfaces 3a in a surface roughness of $0.4\text{ }\mu\text{m Rz}$ or above by a surface roughening process, such as a shot blasting process, for a pretreatment to enhance the strength of adhesion of a film of a solid lubricant to the sliding contact surfaces 3a.

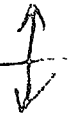
Both the sliding contact surfaces 3a (and the outer circumference 3b, if necessary) of the workpiece 3W are plated with a metal containing tin as a principal component for a selective pretreatment regardless of whether the sliding contact surfaces 3a are processed by a surface roughening process. The surface roughness of the sliding contact surfaces 3a processed by the surface roughening process is increased to a surface roughness on the order of $1.2\text{ }\mu\text{m Rz}$ by plating. Those base surfaces may be finished to a certain surface roughness by a cutting process, and these pretreatment processes may be omitted.

A transfer method (pad transfer method) for forming a film of a solid lubricant on the sliding contact surfaces 3a of the workpiece 3W thus pretreated will be described below. |

Referring to Fig. 5, a transfer apparatus 70 has a tank 71. The tank 71 contains a coating material C containing a solid lubricant, such as a mixture of molybdenum disulfide and graphite, and an unsolidified thermosetting resin, such as a polyimide resin. The tank 71 is installed on a slide table 72. The slide table 72 is in sliding contact with the lower open end of the tank 71 and moves horizontally in the directions of the arrows. An annular material holding groove 72a of a surface area substantially corresponding to that of the sliding contact surface 3a is engraved on the upper surface of the slide table 72. A cylindrical transfer pad 73 of a synthetic rubber is disposed at a waiting position at a predetermined distance in the direction of movement of the slide table 72 from the tank 71. The transfer pad 73 can vertically be moved. The stroke of the slide table 72 is determined so that the material holding grooves 72a reciprocate between the waiting position and the center of the tank 71.

The transfer pad 73 is formed so that its lower end surface 73b excluding a part in which a relief hole 73a for receiving the boss of the workpiece 3W therein bends slightly and fills up the material holding groove 72a. The transfer pad 73 can move horizontally between the waiting position and a transfer position, and can move vertically at the waiting position and the transfer position as indicated by the arrows. A support table 74 provided with a positioning recess 74 of a shape corresponding to that of the boss of the workpiece 3W is disposed under the transfer pad 73 as positioned at the transfer position. The support table 74 can be moved between the position shown in Fig. 5 and a drying apparatus, not shown.

The slide table 72 is moved to the left from the waiting position shown in Fig. 5 to locate the material holding groove 72a in alignment with the center of the tank 71, i.e., to



locate the material holding groove 72a so that a circle defining the outer boundary of the material holding groove 72a coincides with the edge of the lower open end of the tank 71 as indicated by alternate long and two short dashed lines.

5 Consequently, the material holding groove 72a is filled up automatically with the coating material C. Then, the slide table 72 is returned (is moved to the right) to the waiting position and the transfer pad 73 is lowered. Consequently, the lower end surface 73b is bent slightly and enters the
10 material holding groove 72a and the coating material C adheres to the lower end surface 73b of the transfer pad 73.

The transfer pad 73 thus wetted with the coating material C is raised, is moved to the right to the transfer position corresponding to the support table 74, is lowered to press the
15 lower end surface 73b against the sliding contact surface 3a of the workpiece 3W to transfer the coating material C from the lower end surface 73b to the sliding contact surface 3a, i.e., to coat the sliding contact surface 3a with the coating material C.

20 If necessary, the workpiece 3W having the sliding contact surface 3a thus coated with the coating material C is put in a drying apparatus for drying together with the support table 74, and the foregoing steps are repeated to adjust the thickness of the film. Similarly, the sliding contact surface
25 3a formed on the other side of the workpiece 3W is coated with the coating material C, and the films formed on the sliding contact surfaces 3a are made to adhere firmly to the sliding contact surfaces 3a by a baking process.

A transfer method (roller transfer method) for forming a
30 film of a solid lubricant on the outer circumference 3b of the workpiece 3W will be described below with reference to Figs. 6A and 6B.

A transfer apparatus 80 has a tank 82 containing a coating material C containing a solid lubricant, such as a mixture of
35 molybdenum disulfide and graphite, and an unsolidified thermosetting resin, such as a polyamidimide resin, a metal roller 83 partly dipped in the coating material C contained in

the tank 82, a comma roller 84 disposed near the metal roller 83 with a predetermined gap therebetween, a transfer roller 85 of a synthetic rubber having a coating part 85a of an increased diameter conforming to the locus of rotation of the outer circumference 3b of the workpiece 3W, and disposed with the coating part 85a in contact with the metal roller 83, a work holder 86 for rotatably holding the workpiece 3W, and a driving mechanism 81 for driving the rollers 83 and 85 for rotation in the directions of the arrows.

When the rollers 83 and 85 are rotated by the driving mechanism 81, the coating material C adheres to the circumference of the metal roller 83, the thickness of a layer of the coating material C on the metal roller 83 is adjusted by the comma roller 84, and the layer of the coating material C is transferred from the metal roller 83 to the coating part 85a of the transfer roller 85. When the rotating workpiece 3W is brought into contact with the transfer roller 85 by the work holder 86, the coating material C is applied (transferred) to the outer circumference 3b of the workpiece 3W from the transfer roller 85. Then the workpiece 3W is separated from the transfer roller 85 and is removed from the work holder 86. The workpiece 3W is subjected to a drying process to remove a solvent from the coating material C and is subjected to a baking process to form a film firmly adhering to the outer circumference 3b.

The representative processes of forming the films of the solid lubricant on the workpiece 3W illustrated in Figs. 5, 6A and 6B may be carried out in the following manner.

The sliding contact surfaces 3a and the outer circumference of 3b of the workpiece 3W may be roughened by shot blasting to a desirable surface roughness in the range of 2 to 12 $\mu\text{m Rz}$, and films of the solid lubricant may directly be formed on the sliding contact surfaces 3a and the outer circumference 3b without plating the sliding contact surfaces 3a and the outer circumference 3b of the workpiece 3W. It is obvious that the films of the solid lubricant can be formed by the transfer apparatus 70 shown in Fig. 5 or the transfer

apparatus 80 shown in Figs. 6A and 6B.

In another embodiment, sprayed layers of a copper-bearing metal may be formed by spraying on the sliding contact surfaces 3a and the outer circumference 3b of the workpiece 3W, and films of the solid lubricant may be formed on the sprayed layers. The surfaces of the sprayed layers may be roughened by shot blasting to a surface roughness in the range of 2 to 12 μm Rz, and then the films of the solid lubricant may be formed on the roughened sprayed layers.

It should be understood that shot peening, sand blasting or cutting by a tool may be used instead of shot blasting for surface roughening.

Naturally, the foregoing embodiments relating to the workpiece 3W are applicable also to the manufacture of the swash plate 18.

As is apparent from the foregoing description, according to the present invention, the swash plate included in the swash plate type compressor has sliding contact surfaces coated with the film of the solid lubricant, the film of the solid lubricant, provides an excellent lubricating performance, and the coating of the sliding contact surfaces with the film of the solid lubricant by the transfer method is very advantageous from the viewpoint of economy and productivity in the yield of the coating material and the control of the thickness of the film.

If the sliding contact surfaces of the swash plate on which the film is formed, i.e., the base surfaces for the film, are finished by a surface roughening process, the coating material is forced to dig into the irregularities formed to provide an anchoring effect which enhances the strength of adhesion of the film to the sliding contact surfaces. If the sliding contact surfaces and the outer circumference of the swash plate are coated for surface preparation with plated films of a material containing tin as a principal component, a further satisfactory durability will be guaranteed.

CLAIMS

1. A swash plate type compressor comprising:
a cylinder block^{14, 16} provided with a plurality of cylinder
5 bores⁽⁵⁾,
pistons⁶ fitted in said cylinder bores⁵, respectively;
a drive shaft² supported for rotation about its axis of
rotation; and
a swash plate³ supported for rotation together with
10 drive shaft², having at least sliding contact surfaces^{3a} in
sliding contact with shoes⁷ and operatively engaged with said
pistons⁶ by said shoes⁷;
wherein said sliding contact surfaces^{3a} of said swash plate³
in sliding contact with said shoes⁷ are coated with a film of a
15 solid lubricant containing at least one lubricating material
selected from molybdenum disulfide, tungsten disulfide and
graphite by a transfer method.
2. The swash plate type compressor according to claim 1,
wherein each of said pistons⁶ has an interfering surface^{6a} for
20 restraining said piston⁶ from rotation, said interfering
surface^{6a} of said piston⁶ comes into impulsive contact with said
outer circumference^{3b} of said swash plate³, and said outer
circumference^{3b} of said swash plate³ is coated with a film of
said solid lubricant by a transfer method.
- 25 3. The swash plate type compressor according to claim 1
or 2, wherein said sliding contact surfaces^{3a} of said swash
plate³ are finished by a surface roughening process, and said
film of said solid lubricant is formed on said sliding contact
surfaces finished by said surface roughening process.
- 30 4. The swash plate type compressor according to claim 3,
wherein said sliding contact surfaces^{3a} are finished by a
surface roughening process to a surface roughness in the range
of 2 to 12 $\mu\text{m Rz}$.
- ~~5. The swash plate type compressor according to claim 1~~
35 or 2, wherein a plated layer of a metal containing tin as a
principal component underlies said film of said solid
lubricant formed on said sliding contact surfaces^{3a} of said



swash plate.³

6. The swash plate type compressor according to claim 2 or 3, wherein a plated layer of a metal containing tin as a principal component underlies said films of said solid lubricant formed on said sliding contact surfaces^{3a} and said outer circumference^(3b) of said swash plate.³

7. The swash plate type compressor according to claim 1, wherein the accuracy of the surface of the film of the solid lubricant formed on the sliding contact surfaces^{3a} of the swash plate³ is adjusted by a grinding process.

8. The swash plate type compressor according to claim 1, wherein the aluminum alloy forming the swash plate is a hypereutectic aluminum-silicon alloy.