

TITLE OF THE INVENTION

SCREW COMPRESSOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a screw compressor.

2. Description of the Related Art

For example, in Japanese Patent Laid-Open Publication No. 2007-132243 there is disclosed a water-cooled type screw compressor wherein a lip seal is disposed within a bearing casing to prevent lubricating oil in a suction-side bearing from flowing out to a suction channel. In such a screw compressor, the gap between a rotor shaft and a partition wall which provides a partition between the suction channel and the bearing casing is set as small as possible, so that, even upon breakage of the lip seal, bearing lubricating oil may not immediately flow out to the suction channel and cause damage to the bearing.

Usually, the suction channel is held at a negative pressure with respect to the bearing casing, but, for example, at the instant of stop of operation, the internal pressure of the suction channel becomes higher than that of the bearing casing, and the gas to be compressed may flow into the bearing casing. At this time, there is a fear that the gas to be compressed may entrain dust, and the dust may get in between the lip seal and the partition wall. Since the gap between the partition wall and the rotor shaft is small, the dust which has once entered between the lip seal and the

partition wall stays there as it is, resulting in damage of the lip seal and shortening of the lip seal life.

There also has been a case where, at the time of assembling, a screw compressor dust gets in between a lip seal and a partition wall which partitions a suction channel, with consequent shortening of the lip seal life.

SUMMARY OF THE INVENTION

The present invention has been accomplished in view of the above-mentioned problem and it is an object of the invention to provide a screw compressor wherein the lip seal life is not shortened by dust.

For achieving the above-mentioned object, in a first aspect of the present invention, there is provided a screw compressor comprising a pair of male and female screw rotors meshing with each other; a rotor casing for accommodating the screw rotors; a suction channel for sucking gas to be compressed into the rotor casing; a bearing for supporting a suction-side rotor shaft of each of the screw rotors; a lip seal disposed between the suction channel and the bearing; and a partition wall formed between the suction channel and the lip seal, wherein a gap of not smaller than 0.5 mm is formed between the partition wall and the rotor shaft.

According to this structure, dust which enters a rotor-side space of the lip seal is discharged from the gap between the partition wall and the rotor shaft and hence the lip seal is not damaged.

In the screw compressor according to the first aspect of the present invention, the gap between the partition wall and the rotor shaft may be not larger than 1.5 mm.

Even if the gap between the partition wall and the rotor shaft is larger than 1.5 mm, there is no difference in the dust discharging action. As a countermeasure to damage of the lip seal, it is preferable that the gap in question be set small.

In a second aspect of the present invention, there is provided a screw compressor comprising a pair of male and female screw rotors meshing with each other; a rotor casing for accommodating the screw rotors; a suction channel for sucking gas to be compressed into the rotor casing; a bearing for supporting a suction-side rotor shaft of each of the screw rotors; a lip seal disposed between the suction channel and the bearing; and a partition wall formed between the suction channel and the lip seal, wherein a gap of not smaller than one-tenth of the height of the lip seal is formed between the partition wall and the rotor shaft. By "the height of the lip seal" as referred to herein is meant the size of the lip seal in a direction perpendicular to the rotor shaft. In the case where plural lip seals are present between the suction channel and the bearing, the size in question is of the lip seal positioned closest to the suction channel.

According to this structure, since dust which gets into a rotor-side space of the lip seal is discharged from the gap between the partition wall and the rotor shaft, the lip seal is not damaged.

In the screw compressor according to the second aspect of the present invention, the gap between the partition wall and the rotor shaft may be not larger than three-tenths of the height of the lip seal.

Even if the gap between the partition wall and the rotor shaft is larger than three-tenths of the height of the lip seal, there is no difference in

the dust discharging action. As a countermeasure to damage of the lip seal it is preferable that the gap between the partition wall and the rotor shaft be set small.

In the screw compressors according to the first and second aspects of the present invention, a lubrication space for introducing a lubricating fluid therein may be formed between the lip seal and the partition wall, and there also may be formed a lubrication channel for introducing the lubricating fluid into the lubrication space.

According to this structure, the lubricating fluid prevents the entry of dust into the lubrication space from the suction channel, and even if dust should get into the lubrication space, the lip seal is not damaged by the dust because the lubricating fluid discharges the dust into the suction channel.

In a third aspect of the present invention, there is provided a screw compressor comprising a pair of male and female screw rotors meshing with each other; a rotor casing for accommodating the screw rotors; a suction channel for sucking gas to be compressed into the rotor casing; a bearing for supporting a suction-side rotor shaft of each of the screw rotors; a bearing casing for holding the bearing; a partition wall for partitioning between the suction channel and the bearing casing, the rotor shaft extending through the partition wall; a lip seal disposed on the suction channel side with respect to the bearing within the bearing casing and dividing the interior of the bearing casing; and a lubrication channel for introducing a lubricating fluid, the lubrication channel being formed in a space within the bearing casing on the suction channel side with respect to the lip seal.

According to this structure, since a lubricating fluid flows constantly

from the space formed on the suction channel side with respect to the lip seal within the bearing casing toward the suction channel, there is no fear of dust getting into the bearing casing from the suction channel.

Thus, in the present invention, even in the event of entry of dust around the lip seal which isolates the bearing from the suction channel, it is possible to discharge the dust into the suction channel (the first and second aspects), or the screw compressor according to the present invention is structured so as to prevent the entry of dust from the suction channel around the lip seal which isolates the bearing from the suction channel (third aspect). According to the present invention, therefore, the life of the lip seal is not shortened.

Particularly, according to the present invention, in a water cooled type screw compressor wherein bearings are lubricated with lubricating oil, and a rotor casing is lubricated with water, it is possible to prevent shortening of the life of a lip seal which is for preventing the outflow of bearing lubricating oil.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a screw compressor according to a first embodiment of the present invention;

Fig. 2 is a graph showing a relation between the size of a gap formed between a partition wall and a rotor shaft and wear of a lip seal;

Fig. 3 illustrates a screw compressor according to a second embodiment of the present invention; and

Fig. 4 illustrates a screw compressor according to a third

embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described below with reference to the drawings.

Fig. 1 illustrates a screw compressor 1 according to a first embodiment of the present invention. The screw compressor 1 is an oil-free screw compressor wherein gas to be compressed (e.g., air or refrigerant) is compressed by a pair of male and female screw rotors 4 accommodated within a rotor casing 3 of a housing 2 and meshing with each other.

In the housing 2 there are formed a suction channel 5 for the supply of gas to be compressed into the rotor casing 3, a discharge channel 6 for discharging the gas compressed by the screw rotors 4 in the rotor casing 3, and shaft bearing/sealing casings 8 and 9 for installation therein of a structure which is for supporting and sealing rotor shafts 7 of the screw rotors 4 on both suction side and discharge side. The suction channel 5 and the shaft bearing/sealing casing 8 located on the suction side are partitioned from each other by a partition wall 10 which has an opening for passage therethrough of the rotor shafts 7.

The screw compressor 1 is a water-cooled type compressor structured in such a manner that cooling water is fed from a water supply path (not shown) into the rotor casing 3 through the suction channel 5 together with the gas to be compressed in order to lubricate and cool the interior of the rotor casing 3.

Each rotor shaft 7 is supported rotatably by a roller bearing 11

installed within the shaft bearing/sealing casing 8 located on the suction side and also by two ball bearings 12 installed within the shaft bearing/sealing casing 9 located on the discharge side. The rotor shaft 7 extends up to the exterior of the housing 2 through the suction-side shaft bearing/sealing casing 8 and is connected to a motor (not shown).

A lip seal 13 for preventing the entry of a foreign matter (lubricating oil or grease in the roller bearing 11) to the motor side is installed on the motor side of the roller bearing 11. On the screw rotor 4 side of the roller bearing 11 there are disposed a lip seal 14 for preventing the lubricating oil in the roller bearing 11 from flowing out toward the screw rotor 4, and a lip seal 15 for preventing the entry of cooling water from the suction channel 5 into the roller bearing 11.

In the discharge-side shaft bearing/sealing casing 9 located between the screw rotor 4 and the ball bearings 12, there are disposed a mechanical seal 16 and lip seals 17 and 18 in order from the screw rotor 4 side. The mechanical seal 16 is a known sealing device comprising a fixed stator fitted with an inner wall of the shaft bearing/sealing casing 9, and a rotor which is in airtight contact with the stator and fitted with the rotor shaft 7 to rotate together with the rotor shaft 7. The lip seal 17 is installed in a direction to prevent the entry of cooling water from the mechanical seal 16 side, while the lip seal 18 is installed in a direction to prevent the outflow of lubricating oil or grease from the ball bearings 12.

In the housing 2, there are formed an open channel 19 for communication of the shaft bearing/sealing casing 8 located between the lip seals 14 and 15 with the exterior, and a pressure reducing channel 20 for

communication of the shaft bearing/sealing casing 9 located between the mechanical seal 16 and the lip seal 17 with the suction channel 5.

In connection with the screw compressor 1, Fig. 2 shows a relation of a gap δ between the rotor shaft 7 and the partition wall 10 to the amount of wear of the lip seal 15 after 5000 hours' operation which is a normal life of the lip seal. When the gap δ between the rotor shaft 7 and the partition wall 10 was set at a value smaller than 0.5 mm, the lip seal 15 was damaged before the lapse of 5000 hours.

As shown in the drawing, a required life of the lip seal 15 can be ensured by setting the gap δ between the rotor shaft 7 and the partition wall 10 at 0.5 mm or more. This is because as a result of making large the gap δ between the rotor shaft 7 and the partition wall 10, the dust which enters the shaft bearing/sealing casing 8 from the gap δ is discharged to the suction channel 5 from the same gap, and thus the lip seal 15 becomes difficult to be damaged. Because the height of the lip seal 15 in this experiment is 5 mm, on the basis of the height of the lip seal 15, it is necessary that the gap δ between the rotor shaft 7 and the partition wall 10 be not less than one-tenth of the height of the lip seal 15. By the height of the lip seal 15 as referred to herein is meant the size of the lip seal 15 in the vertical direction in the drawing, i.e., in a direction perpendicular to the rotor shaft.

The wear of the lip seal 15 caused by dust decreases as the gap δ between the rotor shaft 7 and the partition wall 10 becomes larger. Taking a safety factor into account, it is preferable that the gap δ at a value of not smaller than 1.0 mm (two-tenths of the height of the lip seal 15).

However, even if the gap δ exceeds 1.5 mm (three-tenths of the height

of the lip seal 15), there is no difference in the wear reducing effect. Even in the event of damage of the lip seals 13 and 14, it is preferable that the gap δ between the rotor shaft 7 and the partition wall 10 be as small as possible in order to diminish the outflow of lubricating oil in the roller bearing 11. Therefore, the gap δ should be 1.5 mm (three-tenths of the height of the lip seal 15) or smaller.

Fig. 3 illustrates a screw compressor 1a according to a second embodiment of the present invention. In the following description, the same constituent elements as in the previous embodiment will be identified by the same reference numerals as in the previous embodiment and same descriptions will be omitted. Like the screw compressor 1 of the first embodiment, the screw compressor 1a is also a water-cooled type screw compressor wherein the rotor casing 3 is lubricated and cooled with cooling water.

In the screw compressor 1a, on the rotor casing 3 side of the lip seal 15, there is formed a lubrication space 21 between the lip seal 15 and the partition wall 10. Further, a lubrication channel 22 is formed in the housing 2 to supply cooling water (lubricating fluid) to the lubrication space 21. In the shaft bearing/sealing casing 9 on the discharge-side of the screw compressor 1a, there is disposed a non-contact type labyrinth seal 16a to seal the rotor-stator gap with cooling water.

The screw compressor 1a introduces the compressed gas discharge from the discharge channel 6 into a gas-liquid separator 23 to separate the cooling water and then supplies the gas to consumption equipment (not shown). The cooling water separated with the gas-liquid separator 23 is

freed from a foreign matter with a filter 24 and is then introduced into the lubrication space 21 through the lubrication channel 22. The cooling water thus introduced into the lubrication space 21 flows out into the suction channel through the gap between each rotor shaft 7 and the partition wall 10 and is sucked into the rotor casing 3 together with the gas to lubricate and cool the rotor casing 3 and the screw rotors 4.

In this embodiment, since cooling water is supplied to the lubrication space 21, a constant flow of the lubricating fluid is ensured from the lubrication space 21 toward the suction channel. Therefore, dust does not get into the shaft bearing/sealing casing 8 from the suction channel 5. Thus, it is possible to prevent abnormal wear of the lip seal 15 and hence the life of the lip seal 15 does not become short.

Fig. 4 illustrates a screw compressor 1b according to a third embodiment of the present invention. The screw compressor 1b is a water-cooled type screw compressor like that of the second embodiment, but the gap between each rotor shaft 7 and the partition wall 10 is small as in the conventional screw compressor. And the amount of cooling water leaking from the lubrication space 21 into the suction channel is consequently small, and cooling water is mainly supplied directly to the rotor casing 3. In this embodiment, for preventing the rise in pressure of the lubrication space 21, it is preferable to use a regulator or the like to restrict the flow rate and pressure of the cooling water fed to the lubrication channel 22.

In this embodiment, since there is ensured a constant flow of the lubricating fluid from the lubrication space 21 toward the suction channel,

there is no fear of dust getting into the lubrication space 21 from the suction channel.

What is claimed is:

1. A screw compressor comprising:
 - a pair of male and female screw rotors meshing with each other;
 - a rotor casing for accommodating said screw rotors;
 - a suction channel for sucking gas to be compressed into said rotor casing;
 - a bearing for supporting a suction-side rotor shaft of each of said screw rotors;
 - a lip seal disposed between said suction channel and said bearing;and
 - a partition wall formed between said suction channel and said lip seal,wherein a gap of not smaller than 0.5 mm is formed between said partition wall and said rotor shaft.
2. A screw compressor according to claim 1, wherein said gap between said partition wall and said rotor shaft is not larger than 1.5 mm.
3. A screw compressor comprising:
 - a pair of male and female screw rotors meshing with each other;
 - a rotor casing for accommodating said screw rotors;
 - a suction channel for sucking gas to be compressed into said rotor casing;
 - a bearing for supporting a suction-side rotor shaft of each of said screw rotors;
 - a lip seal disposed between said suction channel and said bearing;and

a partition wall formed between said suction channel and said lip seal,

wherein a gap of not smaller than one-tenth of a height of said lip seal is formed between said partition wall and said rotor shaft.

4. A screw compressor according to claim 3, wherein said gap between said partition wall and said rotor shaft is not larger than three-tenths of the height of said lip seal.

5. A screw compressor according to any of claims 1 to 4, wherein a lubrication space for introducing a lubricating fluid therein is formed between said lip seal and said partition wall, and there is formed a lubrication channel for introducing said lubricating fluid into said lubrication space.

6. A screw compressor according to claim 5, wherein said lubricating fluid is water.

7. A screw compressor comprising:

a pair of male and female screw rotors meshing with each other;

a rotor casing for accommodating said screw rotors;

a suction channel for sucking gas to be compressed into said rotor casing;

a bearing for supporting a suction-side rotor shaft of each of said screw rotors;

a bearing casing for holding said bearing;

a partition wall for partitioning between said suction channel and said bearing casing, said rotor shaft extending through said partition wall;

a lip seal disposed on said suction channel side with respect to said

bearing within said bearing casing and dividing an interior of said bearing casing; and

a lubrication channel for introducing a lubricating fluid, said lubrication channel being formed in a space within said bearing casing on said suction channel side with respect to said lip seal.

8. A screw compressor according to claim 7, wherein said lubricating fluid is water.