

Oil and Gas Sealing Device for Dry Vacuum Pumps and Rotary Machines

The present disclosure claims the priority of the Chinese patent application filed on March 29, 2023 before the CNIPA, China National Intellectual Property Administration with the application number of 202310322395.6 and the title of “Oil and Gas Sealing Device for Dry Vacuum Pumps and Rotary Machines”, which is incorporated herein in its entirety by reference.

Technical Field

The present disclosure relates to the technical field of vacuum pumps, and more particularly relates to an oil and gas sealing device for dry vacuum pumps and rotary machines.

Background Art

The function of a vacuum pump is to extract gas molecules from a vacuum chamber, thereby reducing gas pressure in the vacuum chamber to achieve the required vacuum degree. The vacuum pump is mainly applied in the industries such as pharmaceuticals and chemicals, vacuum coating, vacuum drying, surface treatment, vacuum smelting, ceramic manufacturing, food packaging, milking, and beverages.

Two axes of rotors of the vacuum pump are parallel to each other, the rotor is formed by combining impellers with a shaft, and there are tiny gaps between the impellers, as well as between the impeller and a casing and a wall plate to prevent mutual contact. The two rotors are driven by an electric motor through a pair of synchronous gears to rotate at the same speed in opposite directions. By means of mutual meshing of two impellers, an air inlet and an air outlet of a pump are not in direct communication, a closed basic volume is formed by the enclosure of the impellers, the casing and the wall plate, and with continuous rotation of the impellers, the basic volume is always in a cycle state of air suction, compression, transportation and air exhaust, so as to constantly exhaust air and dust in the chamber out of the pump to meet the process requirements.

A dry vacuum pump consists mainly of a rotor component and a stator component, and is divided into two chambers by a combined sealed oil and gas sealing structure, wherein one chamber is a working medium conveying chamber, namely, a process by-product chamber, and the other chamber is a cooling chamber for providing lubrication to bearing, gears, and the like, namely, a lubricating oil chamber. The media in the two chambers need be sealed against each other and must not be in communication with each other. If a process by-product leaks into the lubricating oil chamber, it is likely to cause contamination of lubricating oil and affect the service life of the pump; and if the lubricating oil leaks into the process by-product chamber, it is likely to cause

environmental pollution. Meanwhile, insufficient lubricating oil may also affect the service life of the pump. However, in order to balance the internal pressure of the process by-product chamber and the lubricating oil chamber, an air passage also needs to be maintained between the two chambers which cannot be completely isolated.

In the prior art, there are relatively few combined sealed oil and gas sealing products. Especially in the industry of dry vacuum pumps, the main technical problems of the existing sealing products include: poor sealing effects, specific requirements for the usage environment, complex sealing structures, large occupied space and high costs.

Therefore, how to overcome the deficiencies of the existing technical solutions mentioned above and provide a sealing system which is compact in structure, excellent in sealing effect, low in cost and applicable to the industry of vacuum pumps has become an urgent technical problem to be solved in this technical field.

Summary of the Invention

In order to overcome the deficiencies of the prior art mentioned above, the present disclosure provides an oil and gas sealing device for dry vacuum pumps and rotary machines. The following technical solutions are specifically adopted in the present disclosure.

An oil and gas sealing device for dry vacuum pumps and rotary machines, includes: an oil tank cover (1), an oil flinger (3), a lock nut (4), a bearing (5), a bearing fixed seat (6), a fixed plate (7), a shaft seal (8), an O-ring (9), a piston ring (10), a stator (11), and a rotor (13);

the oil tank cover (1), the oil flinger (3), the lock nut (4), the bearing (5), the bearing fixed seat (6), and one side of the fixed plate (7) adjacent to the bearing fixed seat (6) form a lubricating oil chamber (2);

the shaft seal (8), the O-ring (9), the piston ring (10), the stator (11), the rotor (13), and one side of the fixed plate (7) adjacent to the shaft seal (8) form a process by-product chamber (12); wherein the fixed plate (7) and the shaft seal (8) are sequentially sleeved on the rotor (13), the piston ring (10) is positioned between the fixed plate (7) and the rotor (13), and the O-ring (9) is positioned between the shaft seal (8) and the rotor (13) to respectively seal gas and oil for the lubricating oil chamber (2) and the process by-product chamber (12).

Optionally, a fixed plate step portion is provided on a surface of the rotor (13), and the fixed plate (7) is mounted on the fixed plate step portion; and

the fixed plate step portion or the fixed plate (7) is provided with a piston ring mounting groove, and the piston ring (10) is mounted in the piston ring mounting groove.

Optionally, the fixed plate (7) is provided with a high-pressure air inlet hole (21), and inner space of the high-pressure air inlet hole (21) is in communication with the surface of the rotor (13); and

the piston ring (10) is closely attached to a downstream end face of the piston ring mounting groove under the action of differential pressure between two sides.

Optionally, a plurality of piston rings (10) are provided, and the plurality of piston rings (10) are provided at intervals along a length direction of the rotor (13).

Optionally, the surface of the rotor (13) is provided with an oil seal step portion, and the shaft seal (8) is mounted on the oil seal step portion; and

the oil seal step portion or the shaft seal (8) is provided with an O-ring mounting groove, and the O-ring (9) is mounted in the O-ring mounting groove.

Optionally, wherein the bearing (5) is sleeved on one side of the rotor (13) away from the fixed plate (7), the bearing fixed seat (6) is sleeved on an outer side of the bearing (5), and the bearing fixed seat (6) is fixed on the fixed plate (7); and

the rotor (13) is positioned on a surface of one side of the lubricating oil chamber (2), external threads are provided near a position where the bearing (5) is mounted, and the lock nut (4) is sleeved on the external threads for fixing the bearing (5).

Optionally, anon-contact seal is adopted between the bearing fixed seat (6) and the shaft seal (8).

Optionally, the non-contact seal is a labyrinth sealing structure which enables a concave-convex combination with a small clearance between the shaft seal (8) and the bearing fixed seat (6).

Optionally, the oil tank cover (1) is fixedly connected to the fixed plate (7); and

the oil flinger (3) is positioned inside the lubricating oil chamber (2) and fixed on the rotor (13), and a surface on an inner side of the oil tank cover (1) is provided with an inclined plane for guiding lubricating oil flung out by the oil flinger (3) to the bearing (5).

Optionally, the stator (11) is of a hollow structure, and the rotor (13) is mounted inside the stator (11).

The oil and gas sealing device for dry vacuum pumps and rotary machines in the present disclosure has a good sealing effect and is applicable to dry vacuum pumps. Moreover, a sealing structure of the oil and gas sealing device is simple and easy to implement. The sealing design is carried out only on constituent parts, thereby occupying small space without additional components, and being easy to process and low in cost.

Brief Description of the Drawings

FIG. 1 is a schematic structural diagram of an oil and gas sealing device for dry vacuum pumps and rotary machines according to the present disclosure.

FIG. 2 is a schematic diagram of a gas sealing structure of the sealing device according to the present disclosure.

FIG. 3 is a schematic structural diagram of a piston ring of the sealing device according to the

present disclosure.

FIG. 4 is a schematic diagram of an oil sealing structure of the sealing device according to the present disclosure.

Detailed Description of the Invention

Hereinafter, the present disclosure will be further described with reference to the accompanying drawings. The example implementations described herein are only intended for illustrating the technical solutions of the present disclosure more clearly, not intended for limiting the scope of protection of the present disclosure. It is noted that, the detailed description is only exemplary, intended for further explaining the present disclosure.

Unless otherwise indicated, all technological and scientific terms referred to herein have same meanings as generally understood by a person of normal skill in the art. It is noted that, the terms referred to therein are only intended for describing specific implementations, not intended for limiting the example implementations of the present disclosure. unless otherwise explicitly indicated, a single form of a term referred to herein is also intended for covering its plural form. In addition, the terms “comprise” and/or “include” referred to herein indicate presence of features, steps, operations, devices, components and/or combinations thereof.

Referring to FIG. 1, a specific example of the present disclosure relates to an oil and gas sealing device for dry vacuum pumps and rotary machines, including: an oil tank cover 1, an oil flinger 3, a lock nut 4, a bearing 5, a bearing fixed seat 6, a fixed plate 7, a shaft seal 8, an O-ring 9, a piston ring 10, a stator 11, and a rotor 13.

The oil tank cover 1, the oil flinger 3, the lock nut 4, the bearing 5, the bearing fixed seat 6, and one side of the fixed plate 7 adjacent to the bearing fixed seat 6 form a lubricating oil chamber 2.

The shaft seal 8, the O-ring 9, the piston ring 10, the stator 11, the rotor 13, and one side of the fixed plate 7 adjacent to the shaft seal 8 form a process by-product chamber 12.

In the sealing device, the oil tank cover 1 is fixedly connected to the fixed plate 7.

The oil flinger 3 is positioned inside the lubricating oil chamber 2 and fixed on the rotor 13. A surface on an inner side of the oil tank cover 1 is provided with an inclined plane, and the inclined plane is positioned on one side facing the oil flinger 3 and used for guiding lubricating oil flung out by the oil flinger 3 to the bearing 5. It should be understood that this inclined plane is positioned above the oil flinger 3 and the bearing 5. When the lubricating oil is flung out, the lubricating oil flung out by the oil flinger 3 is guided to the bearing 5 and the bearing fixed seat 6 based on this inclined plane to achieve lubrication of the bearing 5. Meanwhile, the lubricating oil flung out to the bearing fixed seat 6 may further flow to the position of the shaft seal 8 positioned below the bearing fixed seat 6 to achieve lubrication of shaft seal 8.

Specifically, as shown in FIG. 4, a black area indicated at a position A in FIG. 4 represents that the lubricating oil flung out by the oil flinger 3 slides off to the bearing fixed seat 6 to further lubricate the bearing 5. An area indicated at a position B in FIG. 4 represents the lubricating oil flowing to the position of shaft seal 8 to lubricate the shaft seal 8.

The bearing 5 is sleeved on a surface of the rotor 13, the bearing fixed seat 6 is sleeved on an outer side of the bearing 5, the bearing fixed seat 6 is fixed on one side of the fixed plate 7 facing the lubricating oil chamber 2, the shaft seal 8 and the fixed plate 7 are sequentially sleeved on the rotor 13, and the shaft seal 8 is positioned between the bearing fixed seat 6 and the fixed plate 7.

The rotor 13 is positioned on a surface of one side of the lubricating oil chamber 2, external threads are provided near a position where the bearing 5 is mounted, and the lock nut 4 is sleeved on the external threads for fixing the bearing 5.

The stator 11 is of a hollow structure, and the rotor 13 is mounted inside the stator 11.

Further, based on the connection relationship of various structures mentioned above, as shown in FIG. 2 and FIG. 4, a fixed plate step portion 13a is provided on the surface of the rotor 13, the fixed plate 7 is mounted on the fixed plate step portion 13a, the fixed plate step portion 13a or the fixed plate 7 is provided with a piston ring mounting groove 10a, and the piston ring 10 is mounted in the piston ring mounting groove 10a. That is, the piston ring 10 is positioned between the fixed plate 7 and the rotor 13 to form a gas sealing structure. During working, this gas sealing structure may prevent a process by-product medium in the process by-product chamber 12 from entering the lubricating oil chamber through a gap to cause contamination of the lubricating oil.

It should be understood that the piston ring mounting groove mentioned above is an annular groove, and the annular groove is wound around an outer side of the rotor for mounting the piston ring. The position where the piston ring mounting groove is provided is not specifically limited, for example, the piston ring mounting groove may be provided in the fixed plate step portion on the rotor, and of course, may also be provided in one side of the fixed plate facing the rotor, as long as sealing between the rotor and the fixed plate is achieved.

In some preferred examples, as shown in FIG. 4, the piston ring mounting groove 10a is positioned in the fixed plate step portion 13a on an outer surface of the rotor 13.

Referring to FIG. 2, FIG. 2 is a schematic diagram of a gas sealing structure according to the present disclosure. The fixed plate 7 is provided with a high-pressure air inlet hole 21, and inner space of the high-pressure air inlet hole 21 is in communication with the surface of the rotor 13. Due to a gap 22 between the rotor 13 and the fixed plate 7, if there is no gas sealing, the process by-product medium in the process by-product chamber 12 may enter the lubricating oil chamber 2 through the gap 22 during working, thereby causing contamination of the lubricating oil. However, in order to balance the internal pressure of the process by-product chamber 12 and the lubricating

oil chamber 2, an air passage also needs to be maintained between the two chambers which cannot be completely isolated. Therefore, a piston ring 10 is used for gas sealing here. In order to ensure the sealing performance, the high-pressure air inlet hole 21 is reserved in the fixed plate 7.

Referring to FIG. 3, FIG. 3 is a schematic structural diagram of a piston ring 10 according to the present disclosure. According to the characteristics such as a working rotational speed and a working medium of this dry vacuum pump, a gas sealing device adopts the form of a piston ring seal. The piston ring seal is so named because a self-expanding sealing ring with a notch is used, and is a device which utilizes the principles of blocking and throttling for sealing. A plurality of piston rings are mounted into annular grooves with shaft shoulders processed, the piston rings are attached to inner holes of stator sealing seats by means of elastic forces thereof, and pre-tightening sealing is formed at excircle parts of the piston rings, so that a gas can only leak downstream through the gaps between the piston rings and the annular grooves. During working, the piston ring 10 is closely attached to a downstream end face of a piston ring groove under the action of differential pressure between two sides, and a high-pressure gas entering the gap from the high-pressure air inlet hole 21 fills back clearance space, thereby further strengthening the sealing between the excircle of the piston ring 10 and the inner hole of the stator sealing seat, and the remaining leakage passage is only the notch of the piston ring 10. Since the notch is very small, only a very small amount of gas can leak out, and the notch may balance the internal pressure of the two chambers in the pump simultaneously.

In order to enhance the airtightness, in some preferred examples, as shown in FIG. 2, a plurality of piston rings 10 may be provided in parallel, and the plurality of piston rings 10 are provided at intervals along a length direction of the rotor 13. In this way, after the sealing of several piston rings 10, the amount of gas which may leak out is smaller.

Of course, it should be understood that when a plurality of piston rings 10 are provided, a plurality of piston ring mounting grooves need to be provided in the fixed plate step portion on the surface of the rotor, and the plurality of piston rings are correspondingly provided in the plurality of piston ring mounting grooves. As shown in FIG. 4, two piston ring mounting grooves 10a are provided in the fixed plate step portion 13a, the corresponding piston rings 10 are respectively accommodated in the two piston ring mounting grooves 10a, the fixed plate 7 is provided with the high-pressure air inlet hole 21, and the high-pressure air inlet hole 21 is positioned between the two piston rings 10 to enhance the airtightness.

The piston ring 10 is made of a cast iron material, with high precision, the capability of automatic compensation after wear, and a long service life.

Further, referring to FIG. 4, FIG. 4 is a schematic diagram of an oil sealing structure according to the present disclosure. There are two lubricating oil seals in the present disclosure, wherein the

first one is the seal between the shaft seal 8 and the rotor 13, and the second one is the seal between the bearing fixed seat 6 and the shaft seal 8. Through the oil sealing structures at these two positions, the lubricating oil in the lubricating oil chamber may be prevented from leaking into the process by-product chamber, thereby avoiding environmental pollution while ensuring a sufficient usage amount of the lubricating oil.

As shown in FIG. 4, for the first seal between the shaft seal 8 and the rotor 13, since both the shaft seal 8 and the rotor 13 are rotating components and remain relatively stationary, a mode of a contact static seal is adopted for the seal between the two, namely, the gap between the shaft seal 8 and the rotor 13 is sealed by the O-ring 9.

Specifically, as shown in FIG. 4, the surface of the rotor 13 is provided with an oil seal step portion, the shaft seal 8 is mounted on the oil seal step portion of the rotor 13, the oil seal step portion or the shaft seal 8 is provided with an O-ring mounting groove, and the O-ring 9 is mounted in the O-ring mounting groove.

It should be understood that the above oil seal step portion abuts against the fixed plate step portion, and the oil seal step portion is positioned on one side close to the lubricating oil chamber for mounting the oil sealing structure, and the like. Similarly, the position where the O-ring mounting groove is provided is not specifically limited in this example, for example, the O-ring mounting groove may be provided in the oil seal step portion on the outer surface of the rotor 13, and may also be provided in one side of the shaft seal facing the rotor, as long as the sealing between the rotor and the shaft seal is achieved.

In some preferred examples, the O-ring mounting groove is provided in one side of the shaft seal 8 facing the rotor 13.

During mounting, firstly the O-ring 9 and the piston ring 10 are respectively fixed into the O-ring mounting groove and the piston ring mounting groove, then the rotor 13 is mounted inside the stator 11 and sealed into the process by-product chamber 12 through the fixed plate 7, next the shaft seal 8 is mounted on the rotor 13, the bearing fixed seat 6 is fastened on the fixed plate 7, afterwards the bearing 5 is mounted, the rotor 13 is locked and fixed through the lock nut 4, then the oil flinger 3 is fixed on the rotor 13, and the oil tank cover 1 is assembled on the fixed plate 7.

During working, the rotor 13 drives the oil flinger 3, the lock nut 4, the shaft seal 8 and the O-ring 9 to rotate under the action of the supporting of the bearing 5. The oil tank cover 1, the bearing fixed seat 6, the fixed plate 7, the piston ring 10 and the stator 11 are all fixed. The lubricating oil chamber 2 is filled with the lubricating oil, and the lubricating oil is flung onto the inclined plane of the oil tank cover 1 under the driving of the oil flinger 3, and guided to the bearing 5 and the bearing fixed seat 6 to lubricate the bearing 5 and the shaft seal 8.

For the second seal between the bearing fixed seat 6 and the shaft seal 8, a non-contact seal is

adopted, and a sealing device which is not in contact with the shaft and does not have a friction part is adopted. Specifically, a labyrinth sealing structure, including a structure such as an oil groove and a labyrinth, may be adopted to achieve the purpose of sealing by utilizing a centrifugal force and a small clearance.

The labyrinth seal in the present disclosure is a concave-convex combination sealing structure with a small clearance between the shaft seal 8 and the bearing fixed seat 6, which is especially applicable to the prevention of oil leakage from high-speed shafts.

The radial and axial data of the labyrinth seal clearance in the present disclosure are shown in Table 1 below.

Nominal diameter of shaft (mm)	Labyrinth seal clearance	
	Radial (mm)	Axial (mm)
Below 50	0.25-0.4	1-2
50-200	0.5-1.5	2-5

Table 1: Radial and axial labyrinth seal clearance

The foregoing is merely the preferred embodiments of the present disclosure. It should be pointed out that for those ordinarily skilled in the art, several improvements and variations may also be made without departing from the technical principles of the present disclosure, and these improvements and variations should also be regarded as falling within the protection scope of the present disclosure.

Claims

1. An oil and gas sealing device for dry vacuum pumps and rotary machines, comprising: an oil tank cover (1), an oil flinger (3), a lock nut (4), a bearing (5), a bearing fixed seat (6), a fixed plate (7), a shaft seal (8), an O-ring (9), a piston ring (10), a stator (11), and a rotor (13);
the oil tank cover (1), the oil flinger (3), the lock nut (4), the bearing (5), the bearing fixed seat (6), and one side of the fixed plate (7) adjacent to the bearing fixed seat (6) forming a lubricating oil chamber (2);
the shaft seal (8), the O-ring (9), the piston ring (10), the stator (11), the rotor (13), and one side of the fixed plate (7) adjacent to the shaft seal (8) forming a process by-product chamber (12);
wherein
the fixed plate (7) and the shaft seal (8) are sequentially sleeved on the rotor (13), the piston ring (10) is positioned between the fixed plate (7) and the rotor (13), and the O-ring (9) is positioned between the shaft seal (8) and the rotor (13) to respectively seal gas and oil for the lubricating oil chamber (2) and the process by-product chamber (12).
2. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 1, wherein a fixed plate step portion is provided on a surface of the rotor (13), and the fixed plate (7) is mounted on the fixed plate step portion; and
the fixed plate step portion or the fixed plate (7) is provided with a piston ring mounting groove, and the piston ring (10) is mounted in the piston ring mounting groove.
3. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 2, wherein the fixed plate (7) is provided with a high-pressure air inlet hole (21), and inner space of the high-pressure air inlet hole (21) is in communication with the surface of the rotor (13); and
the piston ring (10) is closely attached to a downstream end face of the piston ring mounting groove under the action of differential pressure between two sides.
4. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 2, wherein a plurality of piston rings (10) are provided, and the plurality of piston rings (10) are provided at intervals along a length direction of the rotor (13).
5. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 1, wherein the surface of the rotor (13) is provided with an oil seal step portion, and the shaft seal (8) is mounted on the oil seal step portion; and
the oil seal step portion or the shaft seal (8) is provided with an O-ring mounting groove, and the O-ring (9) is mounted in the O-ring mounting groove.
6. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 1, wherein the bearing (5) is sleeved on one side of the rotor (13) away from the fixed plate (7), the bearing fixed seat (6) is sleeved on an outer side of the bearing (5), and the bearing fixed seat (6)

is fixed on the fixed plate (7); and

the rotor (13) is positioned on a surface of one side of the lubricating oil chamber (2), external threads are provided near a position where the bearing (5) is mounted, and the lock nut (4) is sleeved on the external threads for fixing the bearing (5).

7. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 5, wherein a non-contact seal is adopted between the bearing fixed seat (6) and the shaft seal (8).

8. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 7, wherein the non-contact seal is a labyrinth sealing structure which enables a concave-convex combination with a small clearance between the shaft seal (8) and the bearing fixed seat (6).

9. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 1, wherein the oil tank cover (1) is fixedly connected to the fixed plate (7); and

the oil flinger (3) is positioned inside the lubricating oil chamber (2) and fixed on the rotor (13), and a surface on an inner side of the oil tank cover (1) is provided with an inclined plane for guiding lubricating oil flung out by the oil flinger (3) to the bearing (5).

10. The oil and gas sealing device for dry vacuum pumps and rotary machines according to claim 1, wherein the stator (11) is of a hollow structure, and the rotor (13) is mounted inside the stator (11).