A sealing arrangement is disclosed for a rotating shaft. A mechanical seal and a throttle bushing are mounted in a pump casing having a process fluid chamber and an end region. A shaft is rotatably mounted in the pump casing. The seal has a stationary portion mounted to the pump casing, and a rotatable portion mounted to the shaft. A throttle bushing surrounds the shaft and is connected to the casing. The throttle bushing has an inner surface that provides a fluid passageway between the inner surface of the throttle bushing and the shaft. The throttle bushing is spaced along the shaft at an axial distance from the mechanical seal, thus forming a barrier fluid space. The mechanical seal separates the barrier fluid space from the process fluid chamber. Barrier fluid migrates past the throttle bushing inner surface, lubricates the pump bearings and gears, and is collected for reuse.
PUMP SEALING SYSTEM WITH THROTTLE BUSHING

FIELD OF THE DISCLOSURE

[0001] The disclosure is generally related to the field of positive displacement pumps, and more particularly to an improved seal arrangement that improves the mean time between failures and reduces cost compared to known technologies.

BACKGROUND OF THE DISCLOSURE

[0002] There are a large number of different shaft sealing systems used with fluid handling pumps that are very satisfactory for normal operating conditions and for conventional pumps. In many applications, pumps are used to pump harsh fluids, the leakage of which may be undesirable. Leakage from such pumps can present hazardous situations if large scale leakage occurs within the pump casing, or if leakage outside the pump casing occurs. Some systems may have shaft seal systems that are designed to prevent all leakage. These seal systems require complex combinations of mechanical seals, which may require regular replacement. In most applications the seal replacement process interferes with the system operations, since the system often must be taken off line to complete the seal replacement process. The entire replacement process can take several hours or days.

[0003] When using mechanical seals, methods must be employed to ensure lubrication between mechanical seal faces. This can be accomplished by various methods, including using single and double mechanical seal arrangements, using gas seals, using a single mechanical seal and pressurizing the inside of the seal with a barrier fluid, and by using a single mechanical seal on the process side and lip seal and pumping ring on the atmospheric side.

[0004] All of these arrangements seek to prevent all leakage of the process fluid out of the pumping chamber. As such, they all suffer from problems associated with shorter than desired “mean time between failures.” Thus, it would be desirable to provide an improved pump seal that increases the associated mean time between failures, that is simple to install and operate, and which can be implemented in new pump applications as well as retrofit applications.

SUMMARY OF THE DISCLOSURE

[0005] A sealing arrangement is disclosed for use with a rotating shaft. The sealing arrangement may include a pump casing having a process fluid chamber and an end region. A shaft may be rotatably mounted with respect to the pump casing. A mechanical seal may have a stationary portion and a rotatable portion, the stationary portion associated with the pump casing and the rotatable portion associated with the shaft. A throttle bushing may include an outer surface coupled to the pump casing and an inner surface surrounding a portion of the shaft. The throttle bushing inner surface may be configured to provide a fluid passageway between the inner surface of the throttle bushing and an outer surface of the shaft. A barrier space may be formed between the mechanical seal, the throttle bushing, and an outer surface of the shaft. The barrier space may be coupled to a source of barrier fluid. The source of barrier fluid may be configured to maintain barrier fluid in the barrier space within a predetermined pressure range. The mechanical seal may separate the barrier fluid space from the process fluid chamber.

[0006] A sealing arrangement is disclosed for a rotating shaft. The sealing arrangement may include a pump casing having a process fluid chamber and an end region, a shaft rotatably mounted within the pump casing, and a mechanical seal having a stationary portion associated with the pump casing and a rotatable portion associated with the shaft. The sealing arrangement may further include a throttle bushing having an outer surface coupled to the pump casing and an inner surface configured to provide a fluid passageway between the inner surface of the throttle bushing and an outer surface of the shaft. A barrier space may be formed between the mechanical seal, the throttle bushing, and an outer surface of the shaft. The barrier space may be coupled to a source of barrier fluid. The source of barrier fluid may be configured to maintain barrier fluid in the barrier space within a predetermined pressure range. The mechanical seal may separate the barrier fluid space from the process fluid chamber.

[0007] By way of example, a specific embodiment of the disclosed device will now be described, with reference to the accompanying drawings:

[0008] FIG. 1 is a cross-section view of an exemplary embodiment of the disclosed seal arrangement;

[0009] FIG. 2 is a cross-section view of another embodiment of the disclosed seal arrangement;

[0010] FIG. 3 is an isometric view of an exemplary positive displacement pump incorporating the disclosed seal arrangement;

[0011] FIG. 4 is a cross-section view of the pump of FIG. 3 taken alone line 4-4;

[0012] FIG. 5 is a detail view of a portion of FIG. 4 illustrating the disclosed seal arrangement;

[0013] FIG. 6 is a partial cutaway view of the pump of FIG. 3; and

[0014] FIGS. 7A-7C are isometric, cross-section, and detail views, respectively, of an exemplary throttle bushing for use with the disclosed seal arrangement.

DETAILED DESCRIPTION

[0015] The disclosure describes an improved dual shaft seal for use in positive displacement pumps. These terminologies, as well as others in this disclosure, follow those used in American Petroleum Institute (API) standard 682. It will be appreciated that although the description will proceed in relation to sealing of positive displacement pump shafts, the disclosed seal arrangement is not so limited, and thus, it may be applied to a wide variety of rotating shaft sealing applications.

[0016] The disclosed seal arrangement addresses the aforementioned deficiencies in prior seal arrangements. In some embodiments the seal arrangement includes a throttle bushing in combination with a mechanical seal, and a barrier fluid disposed between the bushing and the mechanical seal. With the disclosed design, controlled leakage of barrier fluid past the throttle bushing is collected at the pump ends and reintroduced into the system. In some cases, this collected barrier fluid can function to lubricate one or more pump bearings and gears located at or near the pump ends.

[0017] FIG. 1 shows an exemplary implementation of the disclosed seal 1 in the context of a pump shaft sealing application. The pump shaft 2 may be rotatable about its longitudinal axis A-A, supported at least in part by a bearing 4 coupled directly or indirectly to a pump casing 6. The pump shaft 2 may have a mechanical seal 8 having a stationary portion 8a and a rotating portion 8b. One of the portions will
be coupled to the shaft 2, while the other portion will be coupled to the pump casing 6. The rotating portion 8b of the mechanical seal may be subject to process fluid "PF" (i.e., the fluid being pumped) on one side, while the stationary portion may be subject to a barrier fluid "BF," which in one non-limiting embodiment is lubricating oil. As will be appreciated, the barrier fluid "BF" may be provided at a desired pressure with respect to the pressure of the process fluid "PF." The barrier fluid pressure is adjusted so that it is higher than the pressure of the process fluid "PF," thus ensuring clean fluid between the seal faces.

It will be appreciated that the presence of liquid between the bearing surfaces of the mechanical seal portions 8a, 8b will serve to lubricate the portions to minimize wear. For embodiments in which the process fluid "PF" is held at a higher pressure than the barrier fluid "BF," the process fluid "PF" may migrate to the interface between the bearing surfaces of the stationary seal portion 8a and the rotating seal portion 8b. The presence of process fluid "PF" between these portions may not always serve to lubricate their respective bearing surfaces thereby reducing seal life. Alternatively, for embodiments in which the barrier fluid "BF" is held at a higher pressure than the process fluid "PF," the barrier fluid "BF" may migrate to the interface between the bearing surfaces of the seal 8 and serve to lubricate those surfaces with a clean fluid, increasing seal life.

The barrier fluid "BF" may be provided in a cavity 10 in the pump casing adjacent to the mechanical seal 8. A circumferential throttle bushing 12 may be positioned about the shaft 2 on a side of the cavity 10 opposite the mechanical seal 8. The throttle bushing 12 may be coupled directly or indirectly to the pump casing 6 so that the shaft rotates with respect to an inner surface of the throttle bushing. In the illustrated embodiment, a shaft sleeve 14 is provided between the shaft 2 and the mechanical seal 8 and between the shaft and the throttle bushing 12. It will be appreciated that this shaft sleeve 14 is not required, and the disclosed seal arrangement can be used equally well for shaft arrangements that do not include a sleeve.

In operation, the throttle bushing 12 may allow a small quantity of barrier fluid "BF" to migrate between the throttle bushing 12 and the shaft 2 (or between the throttle bushing 12 and the shaft sleeve 14, if one is used). In the illustrated embodiment barrier fluid flows past the throttle bushing in a direction indicated by arrows "B." Once past the throttle bushing 12, the migrated fluid "BF" can be collected at a suitable location, such as the pump end. In some embodiments the barrier fluid "BF" is lubricating oil, and thus the migrated barrier fluid can serve to lubricate one or more shaft bearings 4 located between the throttle bushing 12 and the pump end. Once collected, the barrier fluid "BF" may be reused. For example, the barrier fluid "BF" can be drained or pumped to an external lubricating oil tank (not shown). The collected barrier fluid "BF" may be cooled, filtered, and returned to the cavity 10 under pressure in the manner previously described.

In one embodiment, a fluid loop is provided to direct the collected barrier fluid "BF" to a lubricating oil tank, and then back to the cavity 10. A pressure regulator (not shown) can be provided in this fluid loop to ensure that the barrier fluid "BF" in the cavity 10 is maintained within a desired pressure range. The barrier fluid "BF" is maintained at a pressure that is about 25 pounds per square inch gauge (psig) higher than the pressure of the process fluid "PF." In a non-limiting example, the process fluid "PF" may be from about 0 psig to about 100 psig, while the barrier fluid "BF" may be from about 25 psig to about 125 psig. It will be appreciated that these pressure ranges are not critical, and that the disclosed seal arrangement can be used at other pressures.

FIG. 2 illustrates an embodiment of the disclosed seal in which the throttle bushing 12 allows for the controllable migration of barrier fluid "BF" between the shaft sleeve 14 and the bushing (again, in the direction of arrow "B"). In this embodiment the barrier fluid "BF" lubricates the bearing 4 within bearing housing 16, and is collected in the pump end, which is enclosed by an end cap 18. The fluid "BF" (which may be the same as the lubricating oil used to lubricate the components of the pump end) may then be directed to a return loop (in the direction of arrow "C") and reused in the manner described in relation to the embodiment of FIG. 1.

FIGS. 3-6 illustrate an exemplary application of the disclosed seal arrangement in a positive displacement pump 20. The illustrated pump 20 is a two-screw pump having a long shaft screw 22 and an intermeshing short shaft screw 24 which, when rotated, draw process fluid "PF" from suction 26 and discharge the pressurized process fluid via discharge 28. The pump 20 may have a casing 30 including a pump head 32 through which the long shaft screw 22 protrudes, and a gear housing 34 which helps support the screws 22, 24 at an end opposite that of the pump head 32.

The long and short shaft screws 22, 24 are supported in the casing 30 by a plurality of bearing sets 36a, 36b, 36c which, in the illustrated embodiment, are roller bearing sets. A pair of mechanical seals 38, 40 are provided for each of the shaft screws 22, 24 to seal the process fluid "PF" from bearing sets 36a and other internal portions of the pump 20. The mechanical seals 38, 40 may be of a variety of seal types.

Each of the shaft screws 22, 24 may be provided with a throttle bushing 42 positioned between each of the mechanical seals 38, 40 and the adjacent bearing sets 36a. The throttle bushings 42 may each have an inside diameter "ID" (FIG. 7B) for engaging an outer diameter of the respective shaft screw 22, 24. The throttle bushings 42 may also have an outside diameter "OD" with a recess 44 formed therein for receiving an o-ring 46. The o-ring may be formed of a polymer that is compatible the barrier fluid "BF," a non-limiting example of which is Viton. The o-ring may be sized so that its outer surface protrudes from the recess 44 so that it engages the front bearing assembly 46 to fix the throttle bushing 42 in place, and to prevent barrier fluid "BF" from passing through the interface between the bearing assembly and the "OD" of the throttle bushing. A similar throttle bushing 42 arrangement (including o-ring 46) is provided adjacent to the bearing sets 36b of the rear bearing assembly 48.

In the instant pump 20, process fluid "PF" is disposed in the chamber region 50, and is sealed off from the pump head 32 by the combination of the mechanical seals 38, 40 and the associated throttle bushings 42. Barrier fluid "BF" is supplied in the space between the mechanical seals 38, 40 and the throttle bushings 42 at a pressure that is higher than the pressure of the process fluid "PF," for the reasons previously described in relation to the embodiments of FIGS. 1 and 2.

The "ID" surfaces of the throttle bushings 42 may be carefully selected so that a controlled amount of fluid will pass between the bushings and the shafts at a particular differential pressure across the bushings. In one non-limiting exemplary embodiment, the "ID" surfaces of the throttle
bushings may comprise one or more grooves to improve sealing performance. In some embodiments these grooves may comprise labyrinth grooves. As such, during operation, a controlled amount of barrier fluid “BF” may be allowed to migrate between the shaft screws 22, 24 and the associated throttle bushings 42. As previously noted, this fluid may lubricate the adjacent bearing sets 36a, and may be collected in the pump head 32.

[0028] A similar arrangement may exist in relation to the gear housing 34. Barrier fluid “BF” is supplied to the chamber region 50 of the throttle bushings 42 associated with the shaft screws 22, 24. As shown in more detail in FIG. 5, the barrier fluid “BF” is supplied to the space 45 between the throttle bushings 42 and the mechanical seal 43 (a portion of which is shown in FIG. 5). During operation, barrier fluid “BF” migrates between the shaft screws 22, 24 and the associated throttle bushings 42 in a manner previously described, lubricating bearing sets 360. The fluid may then be collected in the gear housing 34. Although FIG. 5 shows this arrangement in relation to long shaft screw 22, it will be appreciated that a similar arrangement will exist for short shaft screw 24.

[0029] As can be seen in FIG. 6, tube connections 52, 54 are provided in the gear housing 34 and pump head 32, respectively to allow for the coupling of tubing (not shown) to draw away the barrier fluid “BF” collected in the pump head 32 and gear housing 34. The collected fluid may be recirculated to an exterior tank where it can be cooled, filtered, and reintroduced into the regions between the mechanical seals and the throttle bearings in the manner previously described. As previously noted, this recirculation scheme can include a pressure regulator (not shown) to regulate the pressure of the barrier fluid “BF” that is being reintroduced into the pump.

[0030] FIGS. 7A-C show an exemplary throttle bushing 42 for use in the disclosed seal arrangement. The throttle bushing may have an inside diameter “ID,” and outside diameter “OD,” and a recess 44 disposed about the outer perimeter of the bushing for receiving an appropriately sized o-ring or other sealing member to seal the bushing with respect to the pump casing. Leakage of the barrier fluid “BF” between the ID of the throttle bushing 42 and the outside diameter of the respective shaft 22, 24 can be controlled by adjusting the clearance between the two surfaces, as well as the length “BL” (FIG. 7C) of the bushing. The throttle bushing may be made from steel, bronze, and the like. In the illustrated embodiment a desired flow across the bushing is achieved through careful selection of the bushing “ID” in relation to the outer diameter of the associated pump shaft. In other embodiments, to increase the pressure drop across the bushing, the inner surface “IS” of the bushing 42 may include one or more grooves. In one embodiment, the grooves may comprise a labyrinth arrangement.

[0031] As will be appreciated, the disclosed seal arrangement may result in increased seal life and/or reduced cost as compared to prior seal designs. The disclosed seal arrangement may also occupy less space than current, more complex seal arrangements. The disclosed seal arrangement includes dual use of barrier and lubrication fluid instead of separate systems. As such, it does not waste, barrier fluid.

[0032] Based on the foregoing information, it will be readily understood by those persons skilled in the art that the present invention is susceptible of broad utility and application. Many embodiments and adaptations of the present invention other than those specifically described herein, as well as many variations, modifications, and equivalent arrangements, will be apparent from or reasonably suggested by the present invention and the foregoing descriptions thereof, without departing from the substance or scope of the present invention. Accordingly, while the present invention has been described herein in detail in relation to its preferred embodiment, it is to be understood that this disclosure is only illustrative and exemplary of the present invention and is made merely for the purpose of providing a full and enabling disclosure of the invention. The foregoing disclosure is not intended to be construed to limit the present invention or otherwise exclude any such other embodiments, adaptations, variations, modifications or equivalent arrangements; the present invention being limited only by the claims appended hereto and the equivalents thereof. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for the purpose of limitation.

What is claimed is:

1. A sealing arrangement for a rotating shaft, comprising:
   a pump casing having a process fluid chamber and an end region;
   a shaft rotatably mounted with respect to the pump casing;
   a mechanical seal having a stationary portion and a rotatable portion, the stationary portion associated with the pump casing and the rotatable portion associated with the shaft;
   a throttle bushing having an outer surface coupled to the pump casing and an inner surface surrounding a portion of the shaft, the throttle bushing inner surface configured to provide a fluid passageway between the inner surface of the throttle bushing and an outer surface of the shaft; wherein the throttle bushing is spaced along the shaft at an axial distance from the mechanical seal to form a barrier fluid space therebetween; and
   wherein the mechanical seal separates the barrier fluid space from the process fluid chamber.

2. The sealing arrangement of claim 1, wherein the barrier fluid space is coupled to a pressure regulator for maintaining a pressure of barrier fluid in the barrier fluid space within a predetermined pressure range.

3. The sealing arrangement of claim 2, wherein the predetermined pressure range is greater than a pressure of process fluid in the process fluid chamber so that barrier fluid passes through the mechanical seal into the process fluid space.

4. The sealing arrangement of claim 1, wherein the inner surface of the throttle bushing is configured to allow a predetermined amount of barrier fluid to pass from the barrier fluid space between the throttle bushing and the shaft during operation.

5. The sealing arrangement of claim 4, wherein the inner surface of the throttle bushing has no inner diameter groove.

6. The sealing arrangement of claim 5, wherein the at least one inner diameter groove is a labyrinth type seal.

7. The sealing arrangement of claim 1, further comprising a bearing assembly coupled to the shaft, the bearing assembly positioned between the throttle bushing and the end region of the pump so that barrier fluid passing through the fluid passageway between the inner surface and an outer surface of the shaft contacts the bearing assembly.

8. The sealing arrangement of claim 1, wherein the throttle bushing comprises an outer surface, the outer surface defining a groove for receiving a sealing element, the sealing element for sealing at least a portion of the outer surface of the throttle bushing to the pump casing.
9. The sealing arrangement of claim 8, wherein the sealing element is an elastomeric o-ring.

10. The sealing arrangement of claim 1, the barrier fluid space having a barrier fluid inlet for receiving barrier fluid from a barrier fluid source, the end region having a fluid outlet for discharging collected barrier fluid therefrom.

11. The sealing arrangement of claim 1, wherein the source of barrier fluid comprises a fluid loop coupled between the barrier space and the end region of the pump casing, the fluid loop further including a cooling element and a filter element for cooling and filtering barrier fluid collected from the end region.

12. The sealing arrangement of claim 11, wherein the fluid loop includes a pressure regulator.

13. The sealing arrangement of claim 12, wherein the stationary portion and the rotatable of the mechanical seal comprise respective seal faces, and wherein the pressure regulator is configured to maintain barrier fluid in the barrier fluid space at a pressure higher than a pressure of process fluid in the process fluid chamber.

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