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(54) **Centrifugal pump and a static seal thereof**

(57) The present invention relates to a centrifugal pump and a static seal of the dynamic sealing thereof. The invention especially relates to modifying the attachment of said static seal and a seal cover acting as a counter ring thereof in such a way that, for example, when the static seal wears, the clearance thereof can be adjusted without a need to stop the pump. A characteristic feature of a centrifugal pump in accordance with the invention, comprising, among other things, a pump housing (72), a shaft (12), an impeller arranged on the shaft and a dynamic seal (30, 32) arranged in connection with the shaft (12), and a static seal arranged in connection with the shaft (12) behind the dynamic seal as seen from the impeller, said static seal comprising a flexible seal means (50) on the shaft (12) and a stationary counter ring thereof, is that a seal cover (62) including a stationary counter ring (60) is adjustable in the axial direction of the pump.

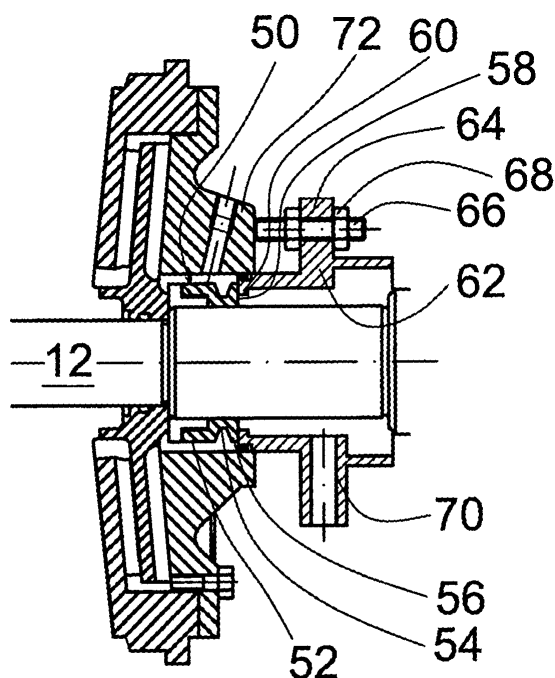


Fig. 2

Description

[0001] The present invention relates to a centrifugal pump and a static seal of dynamic sealing thereof. The invention especially relates to modifying the attachment of said static seal and a seal cover acting as a counter ring thereof in such a way that, for example, when the static seal wears, the clearance thereof can be adjusted without a need to stop the pump.

[0002] A dynamic sealing is a sealing arrangement, which is able to without any mechanical contact seal a centrifugal pump during its operation so that no liquid leaks along the shaft towards the bearings and the drive. Other sealing arrangements for the same purpose are, for example, braided packings and slide ring seals, which both require mechanical contact between the rotary and stationary surface. In other words, it is clear that the above-mentioned seal types based on continuous mechanical contact suffer at some point of their life cycle from wearing problems.

[0003] A dynamic sealing is located behind the pump volute in front of the pump bearing (seen from the suction duct) in an annular chamber arranged in connection with the rear wall of the pump. Said chamber is in direct flow connection with the pump volute, where the pump impeller rotates. A rotary disc attached on the pump shaft divides said chamber to an impeller side cavity and a pump bearing side cavity. Said disc is provided with vanes facing the bearing side cavity, whereby it can also be called a repeller, whereas the other side of the disc is even. Considering a case where said annular chamber contains liquid, the vanes on said disc tend to pump the liquid first radially outwards and then around the outer edge of the disc to the impeller side cavity of the chamber. However, now that the pump is in operation, the pressure generated in the pump volute by the impeller effects to the opposite direction, i.e. the impeller forces liquid towards the bearings. Thereby, an equilibrium can be found where a liquid ring rotated by the above mentioned repeller vanes compensates the pressure generated by the impeller and the pump is sealed in such a way that no liquid enters the shaft space of the chamber on the bearing side. However, when the pump is not running, the liquid to be pumped is allowed to flow freely around the edge of the repeller disc in the chamber to the shaft space and therethrough to the atmosphere, unless it is prevented in a suitable manner. This is carried out by a so-called static seal, of which there are a number of known types. Among others, WO-A1-03/040598 and CA-C-1,3173,29 relate to static seals. The following description, however, discusses two other basic types of a static seal, which can be considered the basis of the present invention. In one type, for example, the one illustrated in Fig. 1, a disc, which is manufactured of a flexible material and extends radially towards the pump shaft, is attached to the pump housing or to the cover thereof and has a ring attached on the shaft to act as counter member for the flexible disc. Said ring has been mounted on the shaft in such a

way that when the liquid flows from the pump to the shaft space, it presses the flexible disc against the ring on the shaft, or more precisely against the sealing surface of said ring. Another alternative, which is discussed below more in detail, is naturally to arrange a disc of flexible material on the shaft and its stationary counterpart to the pump housing or to the cover of the housing. The operating principle, however, remains the same in both cases.

[0004] A disadvantage with the static seal of a dynamic sealing described more in detail above having a flexible disc attached to the pump housing or to the cover of the housing is that when the pump stops, the centrifugal force pushes the liquid between the counter ring and the static seal. This possibly causes a leakage of the liquid to be pumped and wearing of the seals. One solution to the above mentioned problem has been disclosed in patent specification US 4,973,063, in which two seal rings, one flexible, the other inflexible, are located on the shaft to prevent the outflow of the liquid in connection with the dynamic sealing, while the pump is running. Both seals are rotary, and the purpose of the inflexible seal ring closer to the dynamic sealing is to prevent the liquid from flowing to the outer seal ring acting as the main seal, and therethrough, further out. Since both seals have been assembled on the shaft inside the pump housing the possible adjustment of the clearance is difficult and can be performed only by stopping the pump.

[0005] A static seal of the dynamic sealing typically used as the shaft seal of a centrifugal pump is, as described above, formed of a stationarily assembled, flexible disc, and a rotary counter ring attached with a locking screw to the shaft. Below, there is a list of a number of disadvantages of such a construction affecting the operation of the pump:

- When the pump stops running, the centrifugal force expedites the escape of the liquid and the particles entrained therewith between the rotary counter ring and the static seal causing leakage of the liquid to be pumped and wearing of the seal.
- When the static seal wears, the pump must be stopped, because the counter ring of the static seal is attached on the shaft. The locking screws typically used for the attachment of the counter ring must be loosened and thereafter the counter ring must be moved to a new position for the static seal. This kind of adjustment is a very time-consuming and cumbersome task.
- In a prior art solution, means for the collection of leakage splashes and a shaft cover are missing. If the structure were provided with a cover against splashes and contact with the shaft, it should be removed always before the adjustment of the counter ring clearance. The arrangement would be complicated, expensive and difficult to use.

[0006] According to the invention, by turning the above disclosed construction the other way round in such a way

that the flexible plate which acted as a static seal member in the prior art arrangement is made rotary, is designed to be applicable for the purpose, and by locating it in the shaft space and by manufacturing the counter ring, which rotated in the prior art arrangement, as a static seal member and by locating it in the axial direction further away from the impeller, for example, following advantages are achieved:

- When the pump is stopped, but is still rotating, the centrifugal force is made to transfer liquid to be pumped together with the particles possibly entrained therein away from the proximity of the sealing point of the static seal, whereby leakages of the liquid and wearing of the seals are reduced.
- When the static seal wears, it is possible to adjust the clearance thereof while the pump is running, because it is possible to arrange the adjustment in connection with a seal cover attached to the cover of the pump housing or to the housing, which seal cover operates as a counter member of the static seal. Thereby, the adjustment can be performed more quickly than in the conventional arrangement.
- According to a preferred embodiment of the invention, the shaft is protected from the liquid to be pumped and if the seal leaks, it is possible to collect the splashes to the seal cover and lead such in a controlled manner therefrom to a leakage collection system. The seal cover may also be designed such that the rotary shaft can be covered, whereby the shaft will neither be a risk in the adjustment of the seal clearance nor will it prevent from performing the adjustment, as was the case in the prior art solutions.

[0007] The present invention aims at eliminating at least some of the problems and disadvantages of the prior art centrifugal pumps by disclosing, for example, a static seal to be applied in a centrifugal pump. By using said static seal, it is possible, when the pump is stopped, but is still rotating, to make the centrifugal force to transfer liquid to be pumped together with the particles possibly entrained therewith away from the proximity of the sealing point of the static seal, whereby leakages of the liquid and wearing of the seals are reduced. It is a typical feature of a centrifugal pump in accordance with the invention and a static seal used in connection therewith that when the static seal wears, the clearance thereof may be adjusted, while the pump is still running.

[0008] Other characteristic features of a centrifugal pump and a static seal thereof in accordance with the present invention will become clear in the accompanying claims.

[0009] The centrifugal pump in accordance with the present invention and the static seal thereof are discussed more in detail below, by way of example, with reference to the accompanying drawings, in which

ance with the prior art, in connection with a centrifugal pump; and

Fig. 2 schematically illustrates a static seal in accordance with the present invention in connection with a centrifugal pump.

[0010] Fig. 1 schematically illustrates a conventional construction for a static seal of a dynamic sealing of a centrifugal pump in accordance with the prior art. An impeller (not shown in the drawing) of a centrifugal pump pumps liquid entering the pump from the left along a suction duct to a pressure opening of the pump volute. The impeller is attached to a pump shaft 12, which is mounted with bearings to the right, the part being already cut away, to the pump housing. The space in the pump behind the impeller is limited by a pump rear wall 20. A disc 30 attached to the pump shaft 12, located in an annular sealing chamber 32 arranged in connection with the rear wall 20 of the pump acts as dynamic sealing of the pump, and is called a repeller. The rotary disc 30 i.e. the repeller attached to the shaft 12 divides the chamber 32 to an impeller side cavity 34 and a pump bearing side cavity 36 in such a way that there is a flow connection between said cavities outside the outer edge of the rim of the disc 30. Said disc 30 is provided with vanes 38 on the side facing said bearing side cavity 36 substantially throughout the whole radial dimension of the disc, while the opposite side is even. The purpose of the repeller vanes 38 is to pump liquid in the bearing side cavity 36 outwards towards the impeller side cavity 34, which again is affected by the pressure generated by the impeller of the pump reduced by the counter pressure generated by the rear vanes of the impeller. In other words, the vanes 38 of the repeller generate a pressure affecting from cavity 36 to space 34 and towards the impeller of the pump, by means of which the pressure prevailing in the space behind the impeller is balanced.

[0011] A typically used static seal of the above described dynamic sealing of a centrifugal pump is a flexible static plate or disc 40 arranged behind the dynamic sealing as seen from the impeller, which static plate or disc is attached by means of a ring 46 and bolts or headless screws 48 to the pump housing or the cover of the housing, and which, when the pump stops, is pressed against a counter ring 42 of the rotary static seal 40 on the shaft 12 and prevents liquid from flowing out of the pump. In other words, the liquid entering from the direction of the impeller (from the left in the drawing), thus, presses the seal disc 40 against the counter ring 42. The counter ring 42 is attached on the shaft 12 with one or more screws. Problematic situations, such as those listed in the introductory part of the description occur, for example, when the pump is stopped, but is still running whereby the centrifugal force pushes the liquid entering a shaft space 44 on the side of the bearing after the dynamic sealing, between the static seal disc 40 and the rotary counter ring 42. The described seal is of such a construction that solid material that has entered the range of the surface of the

Fig. 1 schematically illustrates a static seal in accord-

rotary counter ring 42 tends to flow outwards along the surface due to the centrifugal force, whereby it enters the clearance between the rotary ring and the seal disc. While being therebetween, the solid material either erodes the surfaces, mostly the seal disc, or when the mutual movement between the surfaces stops, it leaves a gap between the surfaces, wherefrom liquid in the seal space is allowed to leak out.

[0012] Fig. 2 illustrates a seal arrangement in accordance with a preferred embodiment of the invention. According to the invention, the structure of the known static seal arrangement of Fig. 1 is changed opposite in such a way that the flexible plate 40 that acted as a static seal member is redesigned and made rotary and the rotary stationary counter ring 42 is now manufactured as a static seal member. A novel, flexible seal means 50 is located on the pump shaft behind the dynamic sealing and it, among other things, prevents, according to a preferred embodiment of the invention, the shaft 12 from coming into contact with the liquid to be pumped. A novel, static, i.e. stationary counter ring 60 in accordance with the invention is naturally located behind the flexible seal means 50 as seen from the impeller of the pump. As the flexible seal means 50 of the new static seal is rotary, it is possible, by means of centrifugal force, to keep liquid and particles possibly entrained therewith away from between the rotary seal means and the static seal means.

[0013] The flexible seal means 50 of the static seal is of its form, according to a preferred embodiment of the invention, a tubular cylinder having an even diameter at the part 52 facing the pump impeller, followed by a constricted part 54 which has a smaller diameter than the part 52, the purpose of which part 54 is to ensure the flexibility of the seal, and further followed by a lip 56 having a larger diameter and facing the stationary counter ring 60. The axial dimension of said seal lip 56 is less than that of the part 52. Further, the axial dimension of the lip 56 diminishes towards the radially outer tip of the lip. A sealing surface 58 of the flexible seal means 50, which is preferably substantially perpendicular to the shaft 12 and which is pressed against the end surface of the counter ring 60, may be either straight or at least partially inclined while the tip of the lip 56 is closer to the surface of the counter ring. When the sealing surface 58 is inclined by a suitable dimensioning, the tip of the lip tends to turn outwards, due to the centrifugal force, when the pump is started, and, at the same time, slightly away from the counter ring 60, in other words spaced apart from the counter ring 60, whereby wearing of the static seal can be reduced.

[0014] The counter ring 60 which is a part of an annular seal cover 62 attached to the cover of the pump housing or to the housing 72 acts as a counterpart of the flexible seal means 50 of the static seal. The seal cover 62 is attached to the pump housing or to the cover of the housing by means of a flange 64 extending from an otherwise substantially tubular seal cover 62. The flange 64 is provided with openings required for attachment bolts or

headless screws 66, by means of which the seal cover is attached to the pump housing 72 or the cover of the housing. There can be one or more, preferably however three, attachment points, for the seal cover 62 acting as a second part of this static seal. Thereby, it is possible to adjust the static seal by means of the headless screws 66 and the nuts 68 driven to them. The adjustment has been arranged in connection with the seal cover 62 attached to the cover of the pump housing or to the housing, whereby, when the static seal wears, the clearance thereof can be adjusted while the pump is running. Thereby, the adjustment can be performed more easily and quickly than with the conventional solution.

[0015] According to Fig. 2, the flexible seal means 50 of a static seal protects the shaft 12 from the liquid to be pumped. If the flexible seal means 50 is humidity-permeable or leaks towards the bearing, it is possible, according to a preferred embodiment of the invention, to collect the leakage to a seal cover 62 operating as a counterpart of the flexible seal means 50 and, further, remove therefrom in a controlled manner to a collection system 70. The seal cover 62 can be extended towards the pump bearing, as is tentatively disclosed in the drawing, so that the rotary shaft 12 may be covered with the seal cover, whereby there is no risk of touching the rotating shaft when adjusting the clearance of the static seal, nor does it prevent the adjustment of the clearance, as was the case in the prior art solutions.

[0016] It must be noted from the above description that the seal cover with its counter ring and flange and extension is illustrated as one unitary member. It is, of course, possible that the seal cover is made of several elements. It is, for example, possible that the counter ring is a separate part attached together with the flange and shaft cover when assembling the seal. In the similar way, also other modifications are possible. It is, for example, possible that the shaft cover is not an integrated part of the seal cover, but a separate part utilizing the attachment bolts and headless screws thereof in the attachment.

[0017] As can be seen from the above description, it has been possible to develop a static seal which is more versatile than the previous static seal arrangements, said arrangement enabling, for example, the adjustment of the seal clearance while the pump is running. While the invention has been herein described by way of examples in connection with what are at present considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations and/or modifications of its features and other applications within the scope of the invention as defined in the appended claims.

Claims

1. A centrifugal pump, comprising a pump housing (72), a shaft (12), an impeller attached on the shaft, and

- a dynamic sealing (30, 32) arranged in connection with the shaft (12), and a static seal arranged in connection with the shaft (12) behind the dynamic sealing as seen from the impeller, said static seal comprising a flexible seal means (50) on the shaft (12) and a stationary counter ring thereof, **characterized in that** a seal cover (62) including a stationary counter ring (60) is adjustable in the axial direction of the pump.
2. Centrifugal pump in accordance with claim 1, **characterized in that** the clearance of the static seal may be adjusted while the pump is running.
 3. Centrifugal pump in accordance with one of the preceding claims, **characterized in that** a seal cover (62) is attached to a pump housing (72) and/or to a cover of the housing by means of adjusting means (64, 66, 68).
 4. Centrifugal pump in accordance with one of the preceding claims, **characterized in that** said adjusting means comprise a flange (64) of the seal cover and the attachment bolts or headless screws (66) with nuts (68).
 5. Centrifugal pump in accordance with one of the preceding claims, **characterized in that** an extension of the seal cover (62) towards the pump bearing acts as shaft cover.
 6. Centrifugal pump in accordance with one of the preceding claims, **characterized in that** means for collecting liquid leaking from the static seal to the seal cover (62) and for leading such further to a leakage collection system (70).
 7. Centrifugal pump in accordance with one of the preceding claims, **characterized in that** the flexible seal means (50) of the static seal is located on the pump shaft, and is formed of a cylindrical portion (52), an annular constricted portion (54), and a lip (56).
 8. Centrifugal pump in accordance with one of the preceding claims, **characterized in that** said seal means (50) prevents the liquid to be pumped from getting into contact with the pump shaft (12).
 9. A static seal to be used in connection with a dynamic sealing of a centrifugal pump, said static seal comprising a flexible seal means (50) and a stationary counter ring thereof, **characterized in that** the counter ring (60) is a part of the seal cover (62) together with a flange (64), by means of which flange the clearance of the static seal is adjusted.
 10. Static seal in accordance with claim 9, **characterized in that** the flexible seal means (50) of a static seal to be assembled on the shaft is formed at its one end of a substantially cylindrical portion (52), of an annular constricted portion (54) and, at its other end, of a radially outwards extending lip (56) of the seal means (50), one side of which forms an end surface (58) of the seal means (50) and operates together with the counter ring (60).
 11. Static seal in accordance with claim 10, **characterized in that** said end surface (58) is substantially radial.
 12. Static seal in accordance with one of the preceding claims 9-11, **characterized in that** the end surface (58) of the seal means (50) is inclined either completely or partially.
 13. Static seal in accordance with one of the preceding claims 8-11, **characterized in that** said radially outermost part of the lip (56) forms the tip of the lip, which is in contact with the counter ring (60) when the seal is in operation.
 14. Static seal in accordance with one of the preceding claims 9-13, **characterized in that** said tip of the lip (56) extends axially further than the rest of the lip.
 15. Static seal in accordance with one of the preceding claims 9-14, **characterized in that** the seal cover (62) is substantially cylindrical of its form, forming a shaft cover.
 16. Static seal in accordance with one of the preceding claims 9-11, **characterized in that** the seal cover is provided with means for guiding the leakage liquid to a leakage collection system.

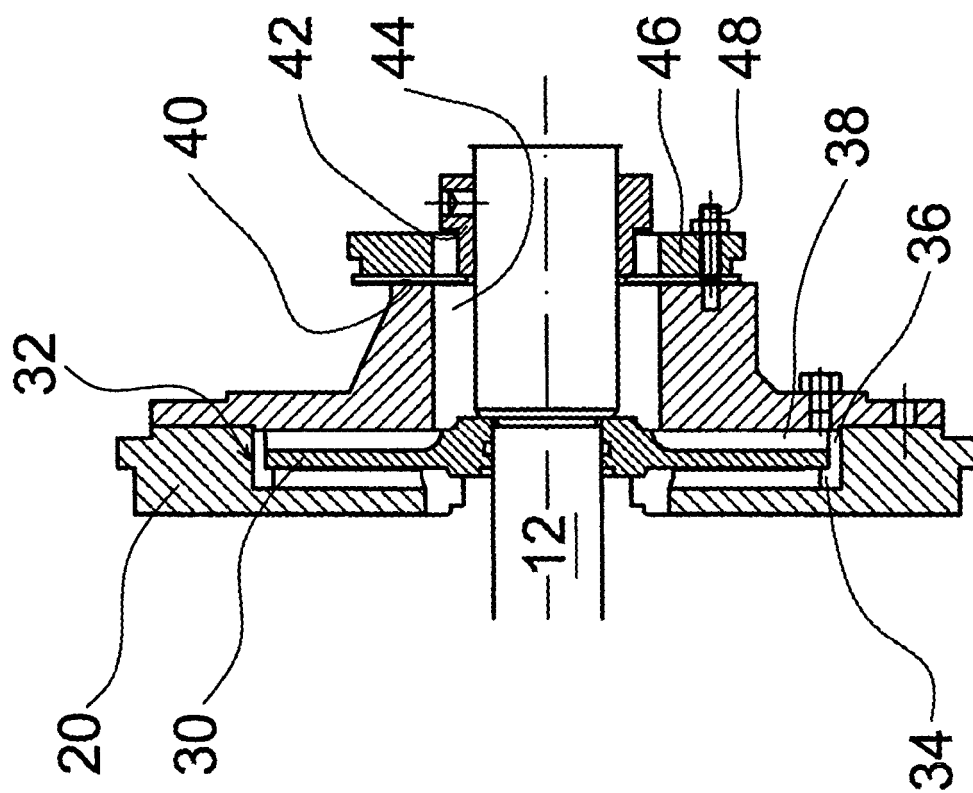


Fig. 1

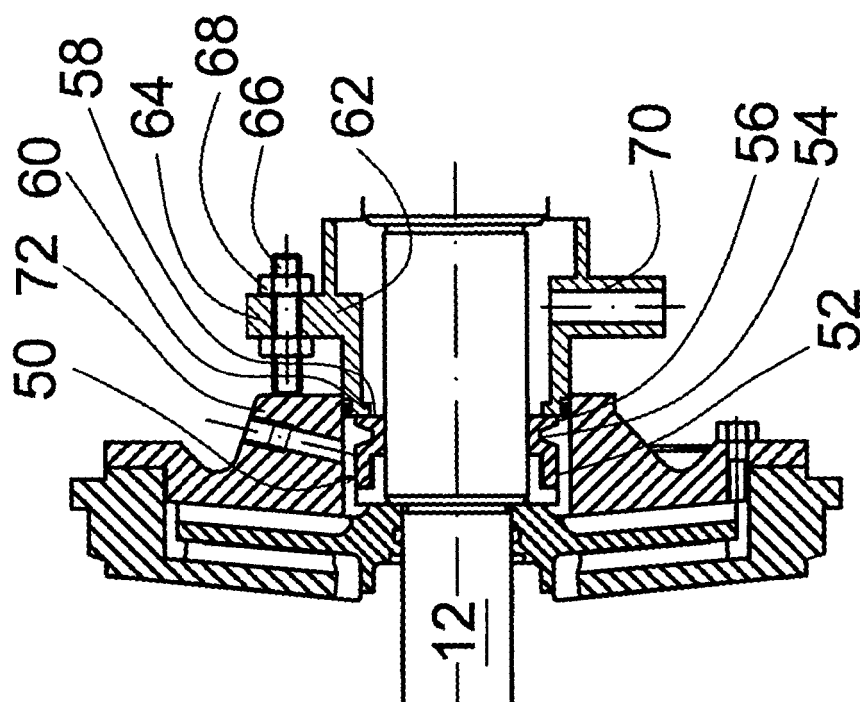


Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 03040598 A1 [0003]
- CA 1317329 C [0003]
- US 4973063 A [0004]