

May 31, 1966

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3,253,816

DE-AERATION OF SEALING FLUID IN AERATED ROTARY FLUID MACHINES

Filed March 12, 1965

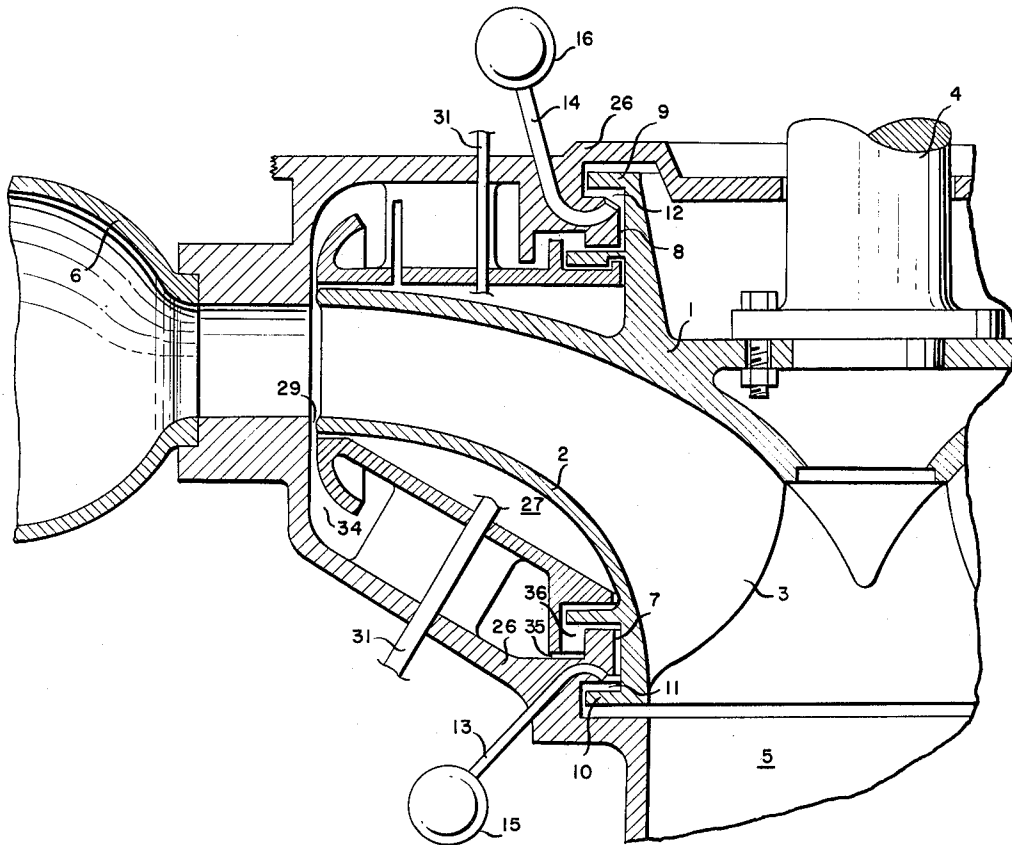


FIG. 1

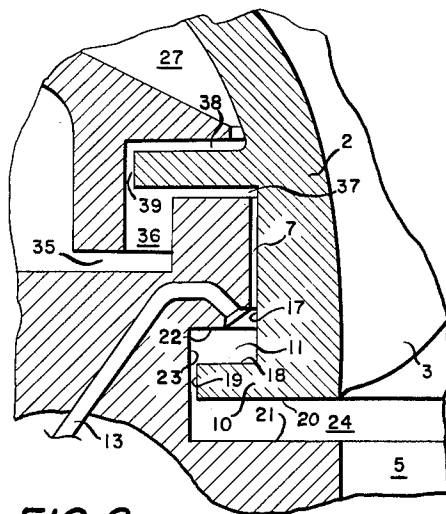


FIG. 2

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ROTARY FLUID MACHINESRobert S. Sproule, Montreal, Quebec, Canada, assignor
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Filed Mar. 12, 1965, Ser. No. 439,274

3 Claims. (Cl. 253-26)

The present invention relates to rotary fluid-machines, such as pumps and pump turbines of the type which have shrouded impellers, means to aerate the spaces surrounding the shrouds and means to prevent air from escaping into the impeller intake.

In rotary hydraulic machines it is customary to provide seals which prevent excessive quantities of working fluid from leaking past the impeller by way of the clearances between the impeller and the stationary structure. The working fluid which unavoidably leaks through these seals passes into the main stream of working fluid at some location adjacent to the intake side of the impeller. In machines which have aerated shroud spaces for reducing fluid friction, the fluid escaping through the seals can serve as a barrier to the unintentioned escape of air from the shroud spaces, in which case, any air which does escape from the shroud spaces, passes with the discharged seal water into the main stream of working fluid.

Air passing into the main stream of working fluid is of little consequence where the machine is operating as a turbine. However, if the machine is operating as a pump, the escaping air will enter the impeller and, if in excess, will seriously affect the operating efficiency of the machine.

There have been prior art methods, such as disclosed in German Patent 714,290, designed to cope with the problem of limiting the quantity of escaping air which reaches the impeller inlet. This patent discloses a leak-off chamber which is separated from the low pressure area adjacent to the impeller inlet by a space seal; this seal is supplied with working fluid under pressure. This method is not fully effective for the following reasons: Firstly, the air-water mixture in both the leak-off chamber and the space-seal is rotated due to the fluid friction drag from the rotating impeller shroud. This results in centrifugal separation of the air and water whereby the lighter component, i.e. air, is urged toward the axis of rotation of the machine. The air leakage path along the clearance of the space seal to the area of the impeller intake is such, that the air moves freely into the impeller intake, because at no point does the leakage path increase in radius to utilize the force of centrifugal separation to impede the escaping air rather than assist it to escape. A secondary defect is that separation of air and water occurs on the high pressure side of the runner seal so that the solubility of air in the water it contacts is high, hence the effectiveness of separation is considerably reduced by the large amount of air that the water retains in solution. The subsequent leakage of air-saturated water past the seal results in the release of a large quantity of air in the low pressure space at the impeller intake.

The disadvantages of prior art are overcome in the present invention by the provision of an air collection chamber on the low pressure side of the impeller seals, with an air removal system, in conjunction with a structure such that the leak-off path for air to the impeller intake offers considerably more resistance to any air flow than that offered by the designed removal path. This is achieved by making some part of the escape path from the collection chamber to the impeller intake on an increasing radius from the axis of rotation in order to utilize the directional separating effect of centrifugal action.

According to the present invention there is provided in a rotary fluid machine, which incorporates an aerated shrouded impeller, space seals supplied with working fluid under pressure together with radial extensions on the impeller shrouds, and air collection chambers for the removal of air. The air collection chambers are disposed between the low pressure side of the impeller seals and the impeller extensions. These radial extensions, acting in cooperating relationship with the stationary part of the machine, form passageways which offer considerably more resistance to the escape of air than to the escape of liquid because of the directional separating effect of centrifugal action.

In co-pending U.S. patent application Serial No. 357,448, filed April 6, 1964, there is described an aerated rotary fluid machine in which the escape path of any excess of air supplied to the shroud spaces is through the seals to the area adjacent to the impeller intake. The present invention will be described as incorporated in this type of machine but it will be readily understood that the incorporation of the teachings herein described to other types of aerated rotary fluid machines falls within the scope of the present invention.

The primary object of the present invention is to provide an economical means whereby air leakage from the shroud spaces of an aerated rotary fluid machine is prevented from entering the impeller intake in such quantity as to significantly affect the performance of the machine.

A further object of the present invention is to provide on both the band shroud and crown shroud of a rotary impeller at locations adjacent to the low pressure sides of the band and crown seals respectively, radial extensions which project outwards from the axis of rotation of the impeller into annular spaces provided in the stationary structure, such that the maximum diameter of these extensions is greater than the diameter at the exits of the fluid seals.

Other objects and many of the attendant advantages of the present invention will become more readily apparent upon consideration of the following detailed specification in connection with the accompanying drawings wherein:

FIG. 1 is a partial sectional view of an impeller and stationary casing embodying the present invention and;

FIG. 2 is an enlarged sectional view of a portion of the rotary machine shown in FIG. 1.

Referring now to the drawings and with particular reference to FIG. 1, when the machine is operated as a pump, a source of external power is applied to drive shaft 4 which is attached to the impeller assembly. The rotating assembly comprises crown shroud 1 and band shroud 2 which are connected to each other by a plurality of blades 3. In the operation of the rotating impeller assembly as a pump, water is pumped from a low pressure at the inlet shown generally at 5 and is discharged at a higher pressure into a volute casing 6. Conventional close clearance space seals are shown at 8 on crown shroud 1 and at 7 on band shroud 2. Extending from the axial peripheries on the crown and band shrouds 1 and 2, are radial extensions 9 and 10 respectively. These radial extensions are attached to and rotate with the impeller assembly in annular recessed portions 11 and 12 formed in the outer housing members 26. Leading from chambers 11 and 12 are a plurality of passageways 13 and 14 which function as bleed off lines and terminate in manifolds 15 and 16 respectively.

In FIG. 2 there is shown an enlarged partial sectional view of the band shroud seal. It will be understood that similar structures on the axial periphery of crown shroud 1 will perform similar functions. Chamber 11 is bounded by axial surface 17 which is an extension of the rotating

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element of band seal 7, by radial surface 18, by radial wall 22 and axial wall 23 of stationary structure 26.

Parallel surfaces 20 and 21 of shroud 2 of stationary structure 26 respectively, delineate a horizontal annular space 24 which is open to inlet 5.

When the machine is operated as a pump, shroud compartment 27 will be aerated by air supply pipe 31 according to the disclosure set forth in co-pending application Serial No. 357,448. There will be a continuous flow of water through peripheral gap 29 and through the passageways 34, 35, 36 and 37, to supply sealing water to seal 7. Excess of air, above that which is required for aeration of compartment 27, is discharged by way of annular pasageways 38 and 39 into chamber 36, where it is then conveyed by the sealing water by way of passageway 37 through seal 7, to chamber 11.

As the impeller assembly revolves, rotating surface 18 tends to cause the air-water mixture in chamber 11 to rotate, whereby centrifugal force will urge the lighter air portion of the mixture toward surface 17 where an escape path is provided by way of conduit 13 to manifold 15. Space 24 is bounded by the horizontal surface 20 of the impeller and rectangular faces 21 and 23 of stationary structure 26, while being accesible to the fluid present at 5 adjacent to the impeller intake. It is manifest that rotation of the impeller causes a drag and hence rotation, to be generated in the fluid space 24. Consequently there is a pressure build-up in the region of face 23 and rotating surface 19, imparted by the centrifugal force of the fluid. Necessarily, the pressure at face 23 is significantly higher than in region 5. This pressure build-up is conducive to the evacuation of the air-water mixture through conduit 13.

In the case of a single stage machine or the low pressure stage of a multi-stage machine, the air-water mixture in manifold 15 can be directed to a separator (not shown) from which the air is discharged to atmosphere and the water is recycled to the machine intake. In the case of high pressure stages of a multiple stage machine the air and water of the air-water mixture can be separated at such pressures that they are suitable for aeration and sealing operation respectively, for the lower pressure stages.

It can be seen that in accordance with the present invention there is provided a rotary fluid machine, having aerated impeller shrouds, with means for preventing the air from passing into the main stream of the working fluid. In the disclosed embodiment the means for achieving this result comprises radial extensions on both the band shroud and the crown shroud of the impeller which

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are so disposed that the air separated by centrifugal action tends to follow the path of least resistance to the leak-off chambers, rather than around the increased radius of the radial extensions and into the impeller intake.

While particular embodiments of the invention have been illustrated and described with reference to a hydraulic pump using water as the working fluid and air in the shroud chambers, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the spirit of the invention. For example, the present invention could be applied to a pump with a working fluid of crude oil, utilizing gases in the shroud compartment which must not contaminate the working fluid.

I claim:

1. In a rotary fluid machine comprising a stationary housing, a rotating member, said rotating member comprising axially spaced upper and lower shrouds having a plurality of blades secured therebetween and defining a fluid flow channel, said stationary housing forming shroud spaces between the said upper and lower shrouds and said housing, means for introducing air to the shroud spaces, radial extensions on the impeller shrouds for providing a path of flow from the shroud spaces to the impeller intake on an increasing radius, and means for withdrawing air and water mixture disposed adjacent the radial extensions, the radial extensions acting as a barrier to the flow of air into the impeller intake from the shroud spaces.

2. A rotary fluid machine according to claim 1 and further including fluid seal means comprising restricted passageways formed at each end of the shroud spaces to limit the inflow of fluid from the impeller passageway into the shroud spaces.

3. A rotary fluid machine according to claim 1 wherein the inlets for the air withdrawing means are disposed adjacent the area of least radius of the radial extensions whereby air escaping from the shroud spaces are mixing with the fluid tends to be separated from the fluid by centrifugal force and passes through the inlets of the air withdrawing means.

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