CLOSE-COUPLED CENTRIFUGAL PUMP

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ABSTRACT OF THE DISCLOSURE

A close-coupled centrifugal pump which includes a mounting plate having a centrifugal pump casing releasably sealed to the pump side of the plate and a motor encapsulated on the other side of the plate, and one of a plurality of fluid tight shaft seals preventing the passage of fluid from the pump side to the motor side of the mounting plate.

According to this invention, a close-coupled, immersible centrifugal pump is provided; and more particularly, a small sealed, close-coupled centrifugal pump is provided which is capable of being immersed in the liquid which is being pumped.

Considerable difficulty had previously been experienced in providing low maintenance, sealed centrifugal pumps of small proportions and with motors of fractional horsepowers. Also, the adaptability of previous pumps to different service conditions was severely restricted.

These and other disadvantages of the prior art have been overcome, according to the present invention, by the provision of a close-coupled centrifugal pump which comprises a mounting plate having a pump side and a motor side. A stationary volute casing is releasably sealed to the pump side of the mounting plate, and an impeller is mounted in the casing on a rotatable shaft. The shaft passes through a shaft seal at the mounting plate and extends on into a motor which is mounted adjacent to the motor side of the mounting plate. The rotor of the motor is mounted on the shaft. The shaft is journaled in bearings positioned on either side of the rotor. The rotor, the shaft, and the bearings are enclosed in a container which is impervious to viscous fluids. The motor and bearings are permanently encapsulated in an electrically nonconductive, thermally conductive, solidified in situ coating.

The shaft seal, which is mounted in sealing relationship with the mounting plate to prevent the passage of fluid along the shaft from the pump side to the motor side of the mounting plate, is selected from one of a plurality of available seals depending upon the service conditions to which the close-coupled pump will be subjected.

The shaft in the close-coupled centrifugal pump of this invention is mounted in self-centering bearings which are permanently lubricated by lubricant-saturated pads surrounding the self-centering bearings. The shaft seals are of such construction that they require no maintenance. The motor and the bearings are permanently encapsulated in an encapsulating agent which is cast in a fluid state and solidifies in situ to a hard coating. The motor and bearings are enclosed so that the viscous encapsulating agent does not penetrate into the bearings or into the space in which the rotor operates. The close-coupled pump is generally so arranged that everything on the motor side of the mounting plate is encapsulated along with the motor side of the mounting plate. The encapsulation is permanent, and the encapsulated unit may be immersed in an electrically conductive fluid while it is operating. The encapsulating agent is generally a thermosetting resin which is loaded with metallic particles. The proportion of metallic particles to resin is such that the particles are isolated from one another by a matrix of resin so that the coating is not electrically conductive. The metallic particles are, however, present in sufficient quantity to increase the thermal conductivity of the coating to a level where it will conduct away a sufficient amount of heat to permit the motor to operate continuously.

The stationary volute casing is releasably sealed to the pump side of the mounting plate. The rating of the pump may be changed as desired by removing the stationary volute casing and its matched impeller from the pump side of the mounting plate and replacing them with a casing and impeller of different characteristics. In the drawings:

FIG. 1 is a perspective view of the close-coupled, water immersible centrifugal pump of this invention;
FIG. 2 is a side elevation of the pump shown in FIG. 1;
FIG. 3 is a side elevation partially in cross section and in phantom lines of the pump shown in FIG. 1;
FIG. 4 is a planned view partially in cross section and in phantom of the pump shown in FIG. 1;
FIG. 5 is a cross-sectional view taken along lines 5—5 in FIG. 4;
FIG. 6 is a cross-sectional view taken along line 6—6 in FIG. 5;
FIG. 7 is a cross-sectional view of an impeller taken along line 7—7 in FIG. 6;
FIG. 8 is a cross-sectional view taken along line 8—8 in FIG. 5;
FIG. 9 is a partial cross-sectional view taken along line 9—9 in FIG. 8;
FIG. 10 is an exploded perspective view of the pump shown in FIG. 1;
FIG. 11 is a partial cross-sectional view of an additional embodiment of a shaft seal; and
FIG. 12 is a partial cross-sectional view of a further embodiment of a shaft seal.

With particular reference to FIGS. 5 and 10 there is illustrated a single stage, single suction centrifugal pump 10, a mounting plate 12, a stationary volute casing 18, an impeller 30, a shaft 32, a bearing bracket 40, a shaft seal 42, self-centering bearings 58 and 88, a shaded pole induction motor 76, and rotor bearing support 84 operatively associated with one another as is described and shown more particularly hereinafter.

Mounting plate 12 is provided with first side 14 and second side 16. A stationary volute casing 18 is mounted in fluid tight relationship to first side 14 of mounting plate 12. Stationary volute casing 18 is provided with suction port 20 and discharge port 22. A casing seal 24 is positioned between casing 18 and first side 14. Casing 18 is fastened to first side 14 by means of mounting screws 26, only one which is shown. The interior wall of casing 18 defines involute shaped impeller cavity 28. The involute shape of this cavity is emphasized by the dash circle drawn on the same center and shown in FIG. 6. Impeller 30 is shown particularly in FIGS. 5, 6, 7, and 10. The direction of rotation of impeller 30 is indicated by the arrow in FIG. 6. Impeller 30 is mounted on the first end 24 of shaft 32. First end 24 of shaft 32 is splined as shown in FIG. 7. The second end of shaft 32 is indicated at 36. An opening 38 is provided in mounting plate 12 to receive shaft seal 42. Bearing bracket 40 is adapted to hold shaft seal 42 and the self-centering bearing 58. Bearing bracket 40 is attached to mounting plate 12 by means of mounting screws 41, only one of which is shown.

Shaft seal 42, as shown particularly in FIGS. 5, 8, and 10, includes an annular seal plate 44 which is provided
with a centrally located upset sealing ring 45 which projects angularly towards and is biased into frictional engagement with shaft 32. Sealing ring 45 projects into the opening 38 from the plane plate 44. Seal plate 44 is constructively material which is resiliently deformable. The hole through which shaft 32 passes is of smaller diameter than the outside diameter of shaft 32 so that the sealing ring 45 is continuously biased into contact with shaft 32 by reason of its plastic memory, which allows to return plate 44 to a flat configuration. Rigid washer 46 is positioned against the inner diameter of seal plate 44. The inside diameter of rigid washer 46 is greater than the outside diameter of shaft 32 so that there is no contact between the two. Rigid washer 46 is provided with a conical depression at its center. Porous wick washer 48 is positioned in the central conical depression in rigid washer 46. Porous wick washer 48 is in physical contact with shaft 32. Washer 48 is loaded with a liquid lubricating agent. This liquid lubricating agent lubricates shaft seal 42. This lubricating agent also serves to emulsify any water which may pass from the pump side to the motor side of seal plate 44. The outer peripheries of seal plate 44 and rigid washer 46 are sealed with suitable sealant so as to prevent the passage of liquid along these peripheries.

A further embodiment of the shaft seal of this invention is shown particularly in FIG. 11. Shaft seal 50 is a dual lip seal which is provided with a rigid disc 52 having a flexible angularly projecting shaft engaging lip 54 which is in frictional engagement with shaft 32 and is biased towards shaft 32. A flexible conical membrane 56 projects angularly towards the second end of shaft 32 in the generally opposite direction from lip 54. Membrane 56 is in frictional engagement with and is biased towards shaft 32.

Self-centering bearings 58 and 88, shown particularly in FIGS. 5 and 11, include respectively, porous metallic sleeve bearings 60 and 90 which serve to lubricate and Journal shaft 32. Bearings 60 and 90 are mounted in bearing cages which permit some movement of these bearings so as to accomplish exact axial alignment between these bearings and shaft 32. Metallic sleeve bearings 60 and 90 are provided, respectively, with bearing retainer rings 68 and 98. These bearing retainer rings are moveable, frictional engagement with the respective metallic sleeve bearings. These bearing retainer rings permit movement of the metallic sleeve bearings but provide more resistance to such movement than the surfaces of revolution at the opposite ends of the respective metallic sleeve bearings. Bearing retainer rings 68 and 98, respectively, rest on and are pressed against porous deformable packings 70 and 100. Packings 70 and 100 are loaded with a lubricant which seeps through the porous sleeve bearings to provide lubrication between shaft 32 and the respective bearing surfaces. The position of retainer rings 68 and 98, respectively, may be shifted slightly against the deformable packings to facilitate alignment of the sleeve bearings and shaft 32. Self-centering bearings 60 and 90, respectively, are being retainer plates 72 and 102 which are secured in bearing bracket 40 and rotor bearing support 84, respectively. These retainer plates are spaced slightly from retainer rings 68 and 98 respectively, by suitable compression means which bear against the retainer rings to force them against the deformable packings.

A first spacer 74 is positioned around shaft 32 between bearing 58 and rotor 78, and second spacer 75 is positioned around shaft 32 between bearing 88 and rotor 78.

Shaded pole induction motor 76 includes rotor 78 which is mounted on shaft 32, stator 80, and field winding 82 which is wound on a leg of stator 80. Stator 80 is composed of flat plates secured together on the inside with opening for the rotor cut perpendicularly through this stack of metal plates. Induction motor 76 is mounted to bearing bracket 40 by means of mounting bolts 81 and mounting nuts and washers 83 (only one of which is shown). Rotor bearing support 84 encloses one end of rotor 78 and also provides a mounting support for bearing 88. Rotor bearing support 84 is attached to stator 80 and bearing bracket 40 by means of mounting screws 86 (only one mounting screw is shown) which pass through stator 80 and are threadably received in bearing bracket 40. Bearing bracket 40, stator 80, and rotor bearing support 84 form a compartment in which rotor 78 is housed. This compartment is filled with insulating fluid as viscous fluids are considered.

All of the elements on the second side of mounting plate 12 are permanently encapsulated within a coating 104 of electrically insulative, thermally conductive material which is cast around these elements and solidified in situ. The compartment containing rotor 78 is sufficiently fluid tight to prevent the viscous encapsulating agent from leaking into this compartment before it solidifies. In order to facilitate the transfer of heat from the vicinity of the rotor 78 and to support the pump, fins 106 (FIG. 2) are provided in the solidified in situ coating 104. Electrical current is provided for the operation of motor 76 by means of a three-wire electrical cord 108. Insulated cord 108 is liquid impervious, and its exposed ends are encapsulated in coating 104. Mounting plate 12 is provided with mounting brackets 110 by means of which the close-coupled centrifugal pump may be mounted to a suitable base, as shown particularly in FIG. 1. An ear 112, FIGS. 8 and 9, is provided on mounting plate 12 which is adapted to receive electrical cord 108 and retain it in the desired position during the encapsulating procedure. A retainer 114 is secured around electrical cord 108 and is spaced from ear 112 to prevent cord 108 from being bent over or pulled out of coating 104. In addition to locking cord 108 in coating 104, the collar on retainer 114 prevents liquid from entering coating 104 along cord 108.

Referencing particularly to FIG. 12, there is illustrated a mechanical seal in which snap ring 116 is snapped onto shaft 32. A rubber cushion 118 is positioned adjacent to snap ring 116 and in contact with shaft 32. Snap ring 116 and rubber cushion 118 rotate with shaft 32. Floating seat 120 is positioned axially adjacent to rubber cushion 118. Floating seat 120 rotates with shaft 32 and is provided with rotating mating surface 121. Mating surface 121 is in frictional and sealing engagement with stationary mating surface 123 of carbon seal ring 122. Carbon seal ring 122 is contained in spring adapter 124. Spring adapter 124 is urged forward, carrying carbon seal ring 122 with it, by spring 126. Spring 126 is confined between spring adapter 124 and case 130. Inside case 128 serves to prevent spring adapter 124 completely out of case 130 while the mechanical seal is being assembled before carbon seal ring 122 is in contact with floating seat 120. Floating seat 120 and case 130 are spaced concentrically with, but out of contact with, shaft 32. The passage of fluid along the inner surface of case 130 and the inside diameter of carbon seal ring 122, is prevented by the presence of O-ring 132. This mechanical seal is confined within opening 38 of mounting plate 12. This mechanical seal is particularly adopted
for use where the liquid which is being pumped on the pump side 14 of mounting plate 12 contains abrasives or is of a corrosive nature. The coating 104 is, for example, a thermostetting composition composed of eight fluid ounces of rigid polyester resin, thin fluid granules of fine metal powder, and four fluid ounces of powdered limestone, three fluid ounces of milled fiberglass, catalyzed by methyl ethyl ketone peroxide. The resin waterproofs the coating and surrounds the aluminum particles to insulate them electrically from each other. The aluminum particles are in sufficiently close proximity to one another to allow heat to be transferred from one to another to effect rapid dissipation of deleterious heat. The limestone and fiberglass act as a binder which increases the thermal stability and impact resistance of the coating 104.

The elements on the second side 16 of mounting plate 12 are provided with mating surfaces which facilitate the accurate alignment of the components when the close-coupled centrifugal pump 10 is assembled. An annular lip on bearing bracket 40 fits over the boss which surrounds and defines opening 38 on second side 16 of mounting plate 12 so as to provide accurate concentric alignment between the opening 38 and bearing bracket 40. The bosses on bearing bracket 40 which receive the mounting screws 41 which secure plate 12 to bearing bracket 40 are spaced radially outwardly some distance from the axis of self-centering bearing 58. These bosses which receive screws 41 bear directly against the second side 16 of mounting plate 12 so as to further insure accurate axial alignment between opening 38 and bearing bracket 40.

The mating surfaces between laminated stator 80 and bearing bracket 40 are distributed over a large area and bear against one another so as to insure concentric and axial alignment of the opening in stator 80 with the axis of bearing bracket 40. The mating surfaces between stator 80 and rotor bearing support 88 are distributed over a sufficiently broad area to enable the accurate and stable, concentric and axial alignment of rotor bearing support 84 with the opening in stator 80. Since each of the elements on second side 16 of mounting plate 12 is accurately aligned with and securely fixed to its adjacent elements, all of these elements are in accurate concentric and axial alignment with opening 38.

The bearing bracket 40 and rotor bearing support 84 are provided with relatively large openings to accommodate packings 70 and 100, respectively. These packings serve as reservoirs for the liquid lubricant which lubricates the bearings in which shaft 32 is mounted. The large size of these packings, which may conveniently be felt pads, insures a sufficient supply of lubricant throughout the life of the close-coupled pump.

During the manufacturing process, the rotor 78, winding 83, and stator 80 are preferably coated with varnish or other moisture proof material and oven-baked to moisture proof these components. The coil on stator 80 is impregnated under vacuum with varnish. The bearing bracket 40 and rotor bearing support 84 are of a moisture proof material, such as brass, plastic, zinc, aluminum alloy, or the like, which is treated, for example, by anodizing or dichromate to inhibit corrosion and moisture proof these elements. This treatment, which is preferred, enhances the inertness of these components to the encapsulating material while it is in the viscous liquid state and also serves as added protection in the event that the coating completely fails while a close-coupled pump is in service. Also, if the seal fails and water enters the rotor cavity, the pump will continue to operate because the coil and electrical contacts are electrically insulated from the rotor cavity by the waterproofing.

The opening 38 in mounting plate 12 is of such proportions that it is adapted to receive one of a plurality of seals. The proper seal is selected for the service conditions under which the pump will be operated. For clean liquids, which contain little or no grit, seals, as shown in FIG. 11 and FIG. 5, are very effective. Where the liquid to be pumped contains abrasive or corrosive materials, the mechanical seal, shown in FIG. 12, is generally preferred.

Impeller 30 is concentric to and rotates with shaft 32. The vanes on impeller 30 are arranged in a spiral design with an open space at the center of the impeller. The open space permits unimpeded entry of the fluid at the center of the impeller. The curved vanes pick up the fluid from the center of the impeller and spin it around under the urging of centrifugal force. The spiral arrangement of the vanes provides a greater radial thrust to the liquid than would be accomplished through the use of straight vanes. Also, the spiral configuration of the vanes allows the liquid to slide off of the vanes with greater ease than would be the case with straight vanes. This ease of stripped the liquid from the vanes reduces the resistance of the impellers to rotation which permits the impeller to maintain a greater velocity with a minimum of power. Suction port 20 is provided immediately above and concentrically with impeller 30. The suction port 20 is of substantially larger diameter than discharge port 22, and the inner wall of suction port 20 is smooth and furred into the top of the volute casing 18, thus insuring an adequate supply of liquid to the open central portion of the impeller 30 with a minimum of turbulence. The inner walls and top of the impeller cavity 28 are smooth and radially to follow the contour of the impeller vane profile so as to maintain constant pressures without undue turbulence.

The ribs (FIG. 8) on the second side 16 of mounting plate 12 provide rigidity to mounting plate 12 and insure that second side 16 is encapsulated so that no liquid can travel between coating 104 and second side 16.

In addition to a variety of interchangeable shaft seals, impellers and casings which may be employed according to this invention, it is possible to change the horsepower rating of the motor by increasing or decreasing the thickness of the stator 80. The horsepower of the motor is increased by increasing the thickness of the stator 80.

As will be understood by those skilled in the art, what has been described are preferred embodiments in which modifications and changes may be made without departing from the spirit and scope of the accompanying claims.

What is claimed is:

1. A close-coupled centrifugal pump comprising:
   a mounting plate having a pump side and a motor side, stationary volute casing having a releasably sealed connection to said pump side, an impeller mounted in said casing on a rotatable shaft, a shaft seal adjacent said plate having an aperture therethrough, a portion of said shaft extending through said aperture, said shaft seal comprising a resiliently deformable seal plate having an upset centrally located sealing ring which is biased into frictional engagement with said shaft, said seal plate being sealed to said mounting plate, said shaft seal being lubricated by a porous wick washer which is loaded with a lubricant and is positioned in contact with said shaft adjacent the motor side of said seal, a motor mounted adjacent said motor side having a rotor therein mounted on said seal, bearings on opposite sides of said rotor and forming journals for said shaft, a visous fluid tight container comprising an enclosure for said rotor, said shaft and said bearings, and a permanent electrically non-conductive, thermally conductive solidified in situ coating forming an encapsulating encasement for said motor.

2. The pump of claim 1 wherein said self-centering bearings comprise a porous metallic sleeve bearing movably mounted in a bearing cage, said porous bearing being in contact with a lubricant loaded washer.

3. A close-coupled centrifugal pump comprising:
a mounting plate having a pump side and a motor side, a stationary volute casing having an impeller cavity therein, an impeller, a rotatable shaft, a bearing bracket, a stator, a rotor and a rotor bearing support, said shaft passing through said plate, a shaft seal preventing the passage of fluid from the pump side to the motor side of said plate, said shaft extending from said shaft seal through and being journalined in a first self-centering bearing mounted in said bearing bracket, said shaft extending from said first bearing through a viscous fluid tight container into a second self-centering bearing mounted in said rotor bearing support, said rotor being mounted on said shaft in said fluid tight container between said first and second bearings, said stator carrying a winding and being positioned adjacent said rotor, and an electrically nonconductive, thermally conductive, solidified in situ coating of thermosetting resin loaded with metallic particles permanently encapsulating and being in direct contact with said motor side, bearing bracket, stator, winding, and rotor bearing support.

4. A close-coupled centrifugal pump comprising:
a mounting plate having a pump side, a motor side, and an opening passing through said plate;
a centrifugal pump assembly releasably sealed to said pump side;
a motor mounted adjacent the motor side of said plate, said motor and said motor side of said plate being in direct contact with and permanently encapsulated in an electrically nonconductive, thermally conductive, solidified in situ coating of thermosetting resin loaded with metallic particles;
a rotatably mounted shaft extending from said centrifugal pump through said opening to said motor, whereby said motor drives said pump; and
a shaft seal mounted in sealing relationship with said opening in said mounting plate, said shaft extending through said seal.

5. The centrifugal pump of claim 4 wherein said opening is adapted to receive and mount one of a plurality of shaft seals.

6. A close-coupled centrifugal pump comprising:
a mounting plate having a first side and a second side;
a stationary volute casing mounted in a fluid tight relationship to said first side, the interior walls of said casing defining an involute shaped impeller cavity;
a motor mounted adjacent said second side, the rotor of said motor being rotatably mounted within a viscous fluid tight container;
a shaft extending through said mounting plate from said motor into said impeller cavity, said shaft passing through a shaft seal, said shaft seal being operatively associated with said mounting plate to prevent the passage of fluid from said first side to said second side of said mounting plate;
an impeller attached to said shaft in said impeller cavity; and
said motor being permanently encapsulated in a solidified in situ, electrically nonconductive, thermally conductive, thermoset coating of thermosetting resin loaded with metallic particles, said coating being in direct contact with said container.

7. The pump of claim 6 wherein the volute casing and the impeller are selected from a plurality of casings and impellers.

8. A close-coupled centrifugal pump comprising:
a mounting plate having a pump side and a motor side;
a volute casing having an impeller cavity, said casing being releasably sealed to said pump side;
an impeller mounted in said cavity on one end of a rotatable shaft, said shaft extending through said mounting plate;
a shaft seal around said shaft, said seal preventing the passage of liquid from said pump side to said motor side of said mounting plate;
a plurality of elements on said motor side of said plate comprising:
a bearing bracket mounted on the motor side of said plate, said bracket containing a first self-centering bearing in which said shaft is journalined;
a stator mounted on said bracket;
a rotor bearing support mounted on said stator;
a second self-centering bearing mounted in said rotor bearing support, the other end of said shaft being journalined in said second bearing;
a rotor mounted on said shaft in operative association with said stator within a viscous fluid tight container defined by the combination of said bearing bracket, stator and rotor bearing support; and
said plurality of elements on said motor side being waterproofed and permanently encapsulated in an electrically nonconductive, thermally conductive, solidified in situ coating of thermosetting resin loaded with metallic particles, said coating being in direct contact with exteriors of each of said bearing bracket, stator and rotor bearing support.

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