Disclosed is a bottom-intake pumping system that includes a pump assembly and a motor that drives the pump assembly with a driveshaft assembly. The bottom-intake pumping system includes a first thrust bearing that supports the driveshaft assembly on a first side of the pump assembly and a second thrust bearing that supports the driveshaft assembly on a second side of the pump assembly. The bottom-intake pumping system also includes a shroud assembly and a discharge pipe. The shroud assembly has a lower shroud hanger configured for rigid attachment at a selected location on the pump assembly, a shroud body connectable to the lower shroud hanger and an upper shroud hanger connectable to the shroud body. The upper shroud hanger is configured for sliding engagement with a discharge pipe.
ENCAPSULATED BOTTOM INTAKE PUMPING SYSTEM

FIELD OF THE INVENTION

[0001] This invention relates generally to the field of downhole pumping systems, and more particularly to encapsulated bottom intake pumping systems.

BACKGROUND

[0002] Submersible pumping systems are often deployed into wells to recover petroleum fluids from subterranean reservoirs. Submersible pumping systems often include an electric motor coupled to a pump assembly. When driven by a motor, the pump assembly moves fluids from the reservoir to surface facilities through production tubing. In many installations, the discharge from the pump assembly is connected directly to the production tubing. In these installations, the motor is commonly placed below the pump assembly at the terminal end of the equipment string.

[0003] In other applications, however, it is desirable to place the pump assembly below the electric motor. Prior art “bottom intake” pumping systems are often used in combination with a shroud and an intake tailpipe to draw fluids from a lower well zone that has been isolated from the pump assembly by a packer. Although widely used, prior art bottom intake pumping systems are prone to mechanical failure. Furthermore, the shroud assemblies used to encapsulate bottom-intake pumping systems must be custom fabricated under strict tolerances for proper fit. There is therefore a need for a more robust and easier to manufacture bottom intake pumping system.

SUMMARY OF THE INVENTION

[0004] In a preferred embodiment, the present invention includes a bottom-intake pumping system having a pump assembly, a motor configured to drive the pump assembly and a driveshaft assembly for delivering power from the motor to the pump assembly. A first thrust bearing supports the driveshaft assembly on a first side of the pump assembly and a second thrust bearing supports the driveshaft assembly on a second side of the pump assembly.

[0005] In another aspect, the preferred embodiment includes a shroud assembly and a discharge pipe. The shroud assembly preferably includes a lower shroud hanger configured for rigid attachment at a selected location on the pump assembly, a shroud body connectable to the lower shroud hanger and an upper shroud hanger connectable to the shroud body. The upper shroud hanger is preferably configured for sliding engagement with the discharge pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a front view of a bottom-intake pumping system with a cross-sectional view of the shroud assembly constructed in accordance with a presently preferred embodiment.

[0007] FIG. 2 is a partial cross-section view of the bottom-intake pumping system of FIG. 1 depicting the internal components of the upper seal section, pump assembly and lower seal section of a preferred embodiment.

[0008] FIG. 3 is a partial cross-sectional view of the pump assembly and lower seal section.

[0009] FIG. 4 is a cross-sectional, exploded view of the shroud assembly of FIG. 1.

[0010] FIG. 5 is a cross-sectional view of the shroud assembly of FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] In accordance with a preferred embodiment of the present invention, FIG. 1 shows a front perspective view of a downhole pumping system 100 attached to production tubing 102. The downhole pumping system 100 and production tubing 102 are disposed in a wellbore 104, which is drilled for the production of a fluid such as water or petroleum. As used herein, the term “petroleum” refers broadly to all mineral hydrocarbons, such as crude oil, gas and combinations of oil and gas. Although the pumping system 100 is primarily designed to pump petroleum products, it will be understood that the present invention can also be used to move other fluids, which may be generically referred to as “wellbore fluids” while in the ground or “produced fluids” on the surface.

[0012] The production tubing 102 connects the pumping system 100 to a wellhead 106 located on the surface. The wellhead 106 is in turn connected to surface facilities for transporting, refining or storing the produced fluids. It will be understood that, although each of the components of the pumping system 100 are primarily disclosed in a submersible application, some or all of the components disclosed herein can also be used in surface pumping operations.

[0013] The pumping system 100 preferably includes some combination of a pump assembly 108, a motor assembly 110, an upper seal section 112 and a lower seal section 114. In a preferred embodiment, the motor assembly 110 is an electrical motor that receives its power from a surface-based source. Generally, the motor assembly 110 converts the electrical energy into mechanical energy, which is transmitted to the pump assembly 108 through a series of connected shafts that are collectively referred to as the driveshaft assembly 116 (not shown in FIG. 1).

[0014] The pump assembly 108 transfers a portion of this mechanical energy to fluids within the wellbore, causing the wellbore fluids to move through the production tubing 102 to the surface. In a particularly preferred embodiment, the pump assembly 108 is a turbomachine that uses one or more impellers and diffusers to convert mechanical energy into pressure head. In an alternative embodiment, the pump assembly 108 is a progressive cavity (PC) pump that moves wellbore fluids with one or more screws or pistons.

[0015] In the preferred embodiment, the pumping system 100 is configured as a shrouded bottom-intake pumping system in which the pump assembly 108 is located below the motor 110. The pump assembly 108 preferably includes an intake 118 and a discharge 120. The lower seal section 114 is preferably connected to the intake 118 at the terminal end of the pumping system 100. The upper seal section is preferably connected between the discharge 120 and the motor 110. In this way, the upper and lower seal sections 112, 114 are connected to a “discharge end” and an “intake end,” respectively, of the pump assembly 108.

[0016] The pumping system 100 also includes a shroud assembly 122, a discharge pipe 124 and a cross-over 126.
The discharge pipe 124 is preferably connected to the production tubing 102 and the cross-over 126. The cross-over 126 is preferably secured to the top of the motor 110. In this way, the shroud assembly 122 creates a substantially sealed fluid path between the discharge 120 and the cross-over 126 around the external surface of the upper seal section 112 and the motor 110. Fluids discharged from the pump assembly 108 are retained within the shroud assembly 122 and forced into the discharge pipe 124 through the cross-over 126. Forcing wellbore fluids through the shroud assembly 122 lowers the temperature of the internal motor lubricant and motor components. Lower operating temperatures result in improved motor life and reduced levels of scaling.

[0017] Turning now to FIG. 2, shown therein is a cross-sectional view of the upper seal section 112. The upper seal section 112 is designed to equalize the pressure inside the motor 110 with the pressure in the wellbore and to compensate for the expansion and contraction of motor lubricants due to changes in the temperature of the motor 110. In a presently preferred embodiment, the upper seal section 112 is configured as a labyrinth-type seal section that uses a tortuous fluid path and gravity separation to permit the expansion of motor lubricants while preventing contaminated wellbore fluids from reaching the motor 110. In an alternate embodiment, the upper seal section 112 includes one or more elastomeric bags in addition to, or in place of, the labyrinth-type seal. The elastomeric bags function as a positive barrier between the motor lubricant and corrosive well fluids. The upper seal section 112 preferably also includes an upper thrust bearing 128 that is designed to carry a portion of the axial thrust developed by the pump assembly 108. In a particularly preferred embodiment, the thrust bearing includes a rotating runner 130 bounded by first and second stationary thrust pads 132, 134.

[0018] Turning now to FIG. 3, shown therein is a cross-sectional depiction of the lower seal section 114. In the presently preferred embodiment, the lower seal section 114 is configured as a bag-type seal that includes an elastomeric bag 136. The elastomeric bag 136 prevents wellbore fluids from the pump assembly 108 from contacting other internal components within the lower seal section 114. Although a single elastomeric bag 136 is presently preferred, it will be understood that additional elastomeric bags 136 can be used. In an alternate preferred embodiment, the elastomeric bag 136 is replaced by, or used in conjunction with, a labyrinth-type seal mechanism.

[0019] The lower seal section 114 also includes a lower thrust bearing 138 that works in concert with the upper thrust bearing 128 to absorb mechanical shock induced in the driveshaft assembly 116 during operation. Like the upper thrust bearing 128, the lower thrust bearing 138 preferably includes a rotating runner 140 and first and second thrust pads 142, 144. The axial movement of the driveshaft assembly 116 is supported by upper and lower thrust bearings 128, 138, respectively, on opposing ends of the pumping system 100. Supporting the driveshaft assembly 116 on both ends of the pumping system 100 reduces the likelihood that the driveshaft assembly 116 will become pinned or sheared when subjected to excessive downthrust or torque.

[0020] Turning now to FIGS. 4 and 5, shown therein are exploded and assembled elevational views, respectively, of the shroud assembly 122 and the associated other portions of the pumping system 100. In the presently preferred embodiment, the shroud assembly 122 includes a lower shroud hanger 146, a shroud body 148 and an upper shroud hanger 150. The shroud body 148 is preferably configured for mating engagement between the lower shroud hanger 146 and the upper shroud hanger 150. In a particularly preferred embodiment, the shroud body 148, upper shroud hanger 150 and lower shroud hanger 148 include threaded portions that permit a secure engagement.

[0021] The lower shroud hanger 146 is preferably secured to the pump assembly 108 below the discharge 120. In the presently preferred embodiment, the lower shroud hanger 148 is preferably a conventional shroud hanger that rigidly secures the shroud assembly 122 to the pump assembly 108. The attachment of conventional shroud hangers is well known in the art. The shroud body 148 is preferably configured as an elongated cylinder having a length sufficient to extend above the crossover 126 when secured to the lower shroud hanger 146.

[0022] The upper shroud hanger 150 preferably includes a central bore 152, a plurality of central seals 154 and at least one penetrator assembly 156. The central bore 152 is preferably sized and configured to receive the discharge pipe 124. The central seals 154 are configured to engage the discharge pipe 124 to form a substantially sealed connection between the discharge pipe 124 and the upper shroud hanger 150. In a particularly preferred embodiment, the discharge pipe 124 is a polished, non-upset pup-joint connected between the cross-over 126 and the production tubing 102. In this particularly preferred embodiment, the central seals 154 are configured as “o-rings” with an inner diameter substantially equivalent to the outer diameter of the discharge pipe 124. The at least one penetrator assembly 156 permits the introduction of power or signal cables into the shroud assembly 122. During assembly, cables from the motor 110 can be fed through the upper shroud hanger 150 as it is lowered onto the discharge pipe 124. The upper shroud hanger 150 can then be moved down the discharge pipe 124 a desired extent to connect the components within the shroud assembly 122.

[0023] Thus, unlike prior art shroud assemblies that are constructed at specific lengths to be secured at specific locations on the pumping system, the shroud assembly 122 of the preferred embodiment can be constructed without requiring specific length and attachment points. With the sliding engagement of the upper shroud hanger 150 on the discharge pipe 124, a single shroud assembly 122 can be used to encapsulate a variety of pumping systems 100.

[0024] It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention have been set forth in the foregoing description, together with details of the structure and functions of various embodiments of the invention, this disclosure is illustrative only, and changes may be made in detail, especially in matters of structure and arrangement of parts within the principles of the present invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed. It will be appreciated by those skilled in the art that the teachings of
the present invention can be applied to other systems without departing from the scope and spirit of the present invention.

It is claimed:

1. A bottom-intake pumping system comprising:
   a pump assembly, wherein the pump assembly has an intake end and a discharge end;
   a motor;
   an upper seal section between the motor and the discharge end of the pump assembly;
   a lower seal section adjacent the intake end of the pump assembly; and,
   a shroud assembly.

2. The bottom-intake pumping system of claim 1, wherein the shroud assembly is configured to encapsulate the motor, the upper seal assembly and the discharge end of the pump assembly.

3. The bottom-intake pumping system of claim 2, wherein the shroud assembly further comprises:
   a lower shroud hanger;
   a shroud body; and
   an upper shroud hanger, wherein the upper shroud hanger includes a central bore that is configured to slidingly receive a discharge pipe.

4. The bottom-intake pumping system of claim 3, wherein the upper shroud hanger includes a plurality of O-rings coaxial with the central bore that are configured to engage the discharge pipe.

5. The bottom-intake pumping system of claim 3, wherein the upper shroud hanger includes at least one penetrator assembly.

6. The bottom-intake pumping system of claim 1, wherein the lower seal section includes a lower thrust bearing configured to oppose downthrust produced in a pumping operation.

7. The bottom-intake pumping system of claim 1, wherein the upper seal section includes an upper thrust bearing configured to oppose downthrust produced in a pumping operation.

8. The bottom-intake pumping system of claim 1, wherein the shroud assembly isolates the discharge end of the pump assembly from the wellbore.

9. A bottom-intake pumping system comprising:
   a pump assembly, wherein the pump assembly has an intake end and a discharge end;
   a motor;
   an upper seal section between the motor and the discharge end of the pump assembly; and
   a lower seal section adjacent the intake end of the pump assembly.

10. The bottom-intake pumping system of claim 9, wherein the lower seal section includes a lower thrust bearing configured to oppose downthrust produced in a pumping operation.

11. The bottom-intake pumping system of claim 10, wherein the upper seal section includes an upper thrust bearing configured to oppose downthrust produced in a pumping operation.

12. The bottom-intake pumping system of claim 9, further comprising a shroud assembly, wherein the shroud assembly is configured to encapsulate the motor, the upper seal assembly and the discharge end of the pump assembly.

13. The bottom-intake pumping system of claim 12, wherein the shroud assembly further comprises:
   a lower shroud hanger;
   a shroud body; and
   an upper shroud hanger, wherein the upper shroud hanger includes a central bore that is configured to slidingly receive a discharge pipe.

14. The bottom-intake pumping system of claim 13, wherein the upper shroud hanger includes a plurality of O-rings coaxial with the central bore that are configured to engage the discharge pipe.

15. The bottom-intake pumping system of claim 13, wherein the upper shroud hanger includes at least one penetrator assembly.

16. The bottom-intake pumping system of claim 1, wherein the shroud assembly isolates the discharge end of the pump assembly from the wellbore.

17. A bottom-intake pumping system comprising:
   a pump assembly;
   a motor configured to drive the pump assembly;
   a driveshaft assembly for delivering power from the motor to the pump assembly;
   a first thrust bearing that supports the driveshaft assembly above the pump assembly; and
   a second thrust bearing that supports the driveshaft assembly below the pump assembly.

18. A shroud assembly for use in a bottom-intake pumping system having a pump assembly and a discharge pipe, the shroud assembly comprising:
   a lower shroud hanger configured for rigid attachment at a selected location on the pump assembly;
   a shroud body connectable to the lower shroud hanger; and
   an upper shroud hanger connectable to the shroud body, wherein the upper shroud hanger is configured for sliding engagement with the discharge pipe.

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