ABSTRACT

Embellishments of the invention provide a pumping system having a pump and a motor. The motor includes a lubricating oil composition, and more particularly, a low ash, sulfur, and phosphorus lubricating oil composition. The pumping system may further include a grounding ring disposed in the frame that is in communication with the motor. The motor may also include a cord cap assembly having a cord cap and a quick disconnect power cord.
PUMP AND ELECTRIC INSULATING OIL
FOR USE THEREIN

CROSS REFERENCE TO RELATED
APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/939,552 filed on Feb. 13, 2014, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] A submersible pump is a pump designed to be utilized and submerged within the fluid and/or solids that are to be pumped. Submersible pumps are oftentimes utilized in a harsh and/or less than ideal environment with respect to operating conditions. To that end, numerous methods have been introduced to protect and extend the useful life of the pump and the motor. Some of the proposed solutions have included mechanical changes to the pump and motor including changing the materials, seals, and structure of the pump motor.

[0003] Submersible pumps typically include a housing having a motor that is sealed or otherwise manufactured to prevent leakage. Traditional pump motors utilize oil to, among other things, lubricate one or more parts (e.g., bearings) to reduce friction and wear, and to assist in cooling the motor using the thermal conductivity properties of the oil. These oils enhance the anti-wear and anti-oxidation properties of the motor and oftentimes include additives to further increase the benefits of the oil. For example, additives related to anti-wear, extreme pressure, friction reducers, dispersants, detergents, corrosion inhibitors, and viscosity adjustment are oftentimes included in the oil to provide one or more benefits.

[0004] However, unfortunately, there are numerous obstacles relating to the oil compositions used within the submersible pump motors. In some situations, adjusting one additive in the oil composition may enhance one property of the motor, while at the same time, decrease one or more other properties of the motor. For example, adding a viscosity adjuster may desirably decrease the viscosity of the oil while making the thermal conductivity properties of the oil unfavorable.

[0005] Other obstacles exist with respect to the manufacture of submersible pumps. For example, many submersible pumps use variable frequency drives to change the electrical frequency of the electrical power, which changes the speed of the pump motor. Use of a variable frequency drive optimizes the pump speed such that only the speed that is needed to match the required load is delivered. As such, using a variable frequency drive saves energy.

[0006] However, there are some drawbacks associated with the use of variable frequency drives with submersible pumps. For example, variable frequency drives induce high frequency voltages on the shaft of the motor. In many instances, the voltage bleeds off through the bearings and causes arcing in the bearing races and steel balls of the bearings. The arcing creates weld marks and eventually causes bearing damage and bearing failure.

[0007] Some attempts have been made to overcome the aforementioned drawback. In particular, some submersible pumps include a filter on the variable frequency drive. However, the filter is expensive and does not work properly if the sizing is incorrect. Another option is to include ceramic bearings in the motor that can withstand the arcing. However, the ceramic bearings are extremely expensive and only protect the bearing adjacent the static charge. Arcing is still present along the shaft of the motor and can discharge in other locations. A further option is to use conductive grease. However, drawbacks to using the grease include that the grease adds additional load to the motor, must be added frequently, and does not eliminate the static charge that may discharge in other locations causing damage. Finally, current diverter rings may be used on the outside of the motor. However, use of the diverter rings in a submersible wastewater pump causes the brushes to clog and sewage to penetrate the area between the ring and the shaft. As such, the use of current diverter rings is typically not recommended for external use in sewage applications.

[0008] Another obstacle associated with submersible pumps is the connection between the electrical cord and the pump. In particular, many existing submersible pumps, the electrical cord is integral with the pump. In these applications, the entire pump must be removed and/or replaced in the event of an electrical failure.

[0009] Therefore, it would be desirable to incorporate a low-cost, effective solution in submersible pumps used with variable frequency drives to eliminate the arcing problem associated therewith. It would further be desirable to include an oil composition in the pump motor that is defined by a lighter viscosity with increased thermal transfer as compared to traditional oils used in submersible pumps. It is also desirable to provide a submersible pump having an electrical cord that is easily disconnectable from the submersible pump in the event the pump loses power and/or the electrical cord must be changed.

SUMMARY

[0010] The invention relates generally to a pumping system, and more specifically to a submersible pumping system designed with a grounding ring suitable for use with variable frequency drives. The pumping system further includes a cord cap assembly having a cord cap and a quick disconnect power cord.

[0011] The pumping system of embodiments of the invention is designed to offer a lubricating oil composition suitable for use in the pumping system, and more particularly, to a low ash, sulfur, and phosphorous lubricating oil composition. The pumping system includes a motor and a pump disposed within a housing. The pumping system further includes a grounding ring disposed in the housing that is in communication with the motor.

[0012] Other embodiments of the pumping system include a submersible pump having a pump and a motor enclosed in a housing. The motor is in communication with the pump and includes a rotor in communication with a grounding ring. The motor further includes a cord cap assembly having a cord cap and a quick disconnect power cord.

[0013] In one embodiment of the invention, a submersible pumping system comprises a frame defining an intake opening and an outlet opening, and a pump in communication with a pump motor and the intake opening and the outlet opening. The pump and the pump motor are disposed within the frame. A grounding ring is also disposed within the frame and is in communication with the pump motor. The grounding ring includes conductive filaments extending therefrom to draw current away from bearings disposed within the frame.

[0014] In a different embodiment of the invention, a submersible pump system comprises a frame defining an intake
opening and an outlet opening. A pump is in communication with a pump motor and the intake opening and the outlet opening. The pump and the pump motor are disposed within the frame. A cord cap assembly extends upwardly from the frame and includes at least one quick disconnect cord coupled to a cord cap. The cord cap provides a connection between the pump motor and a power source.

These and other aspects of the invention will become apparent in light of the following detailed description.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of a pumping system having a motor and a pump, according to one embodiment of the invention;

FIG. 2 is a bottom plan view of the pump of FIG. 1;

FIG. 3 is a top isometric view of the pump of FIG. 1, with the motor removed for clarity;

FIG. 4 is a cross-sectional view of the pump of FIG. 3 taken generally along the line 4-4 of FIG. 3;

FIG. 5 is an isometric view of various internal components of the pump of FIG. 1;

FIG. 6 is a cross-sectional view of the internal components of the pump of FIG. 5 taken generally along the line 6-6 of FIG. 5;

FIG. 7 is an isometric view of the pump of FIG. 1 shown with a drive shaft assembly of the motor of FIG. 1;

FIG. 8 is a partial cross-sectional view of the pump of FIG. 5 taken generally along the line 8-8 of FIG. 4;

FIG. 9 is a front isometric view of the motor of FIG. 1 with portions of the motor removed therefrom for clarity;

FIG. 10 is a bottom isometric view of the motor of FIG. 1;

FIG. 11 is a front isometric view of the pump of FIG. 1 in communication with the motor of FIG. 1, wherein portions of the motor have been removed for clarity;

FIG. 12 is a cross-sectional view of the motor of FIG. 11 taken generally along the line 12-12 of FIG. 11;

FIG. 13 is an isometric view of a grounding ring for use in the motor of FIG. 1;

FIG. 14 is an isometric view of a terminal block for use in the motor of FIG. 1;

FIG. 15 is an isometric view of a cord cap assembly for use with the motor of FIG. 1; and

FIG. 16 is a schematic representation of the components of the pumping system.

DETAILED DESCRIPTION

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” or “having” and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms “mounted,” “connected,” “supported,” and “coupled” and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings.

The following discussion is presented to enable a person skilled in the art to make and use embodiments of the invention. Various modifications to the illustrated embodiments will be readily apparent to those skilled in the art, and the generic principles herein can be applied to other embodiments and applications without departing from embodiments of the invention. Thus, embodiments of the invention are not intended to be limited to embodiments shown, but are to be accorded the widest scope consistent with the principles and features disclosed herein. The following detailed description is to be read with reference to the figures, in which like elements in different figures have like reference numerals. The figures, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of embodiments of the invention. Skilled artisans will recognize the examples provided herein have many useful alternatives and fall within the scope of embodiments of the invention.

The submersible solids handling pump is designed to be at least partially submerged in fluid and to move fluid therethrough. The submersible pump can be used in many residential and commercial applications and settings including wastewater treatment, transfer, and lift, airports, hospitals, schools, subdivisions, universities, amusement parks, and the like.

FIG. 1 illustrates a pumping system 100, according to one embodiment, that is designed to act as a submersible solids handling wastewater pump. The pumping system 100 includes a pump 102 and a pump motor 104 both disposed within a frame 106. The pumping system 100 further includes a cord cap assembly 108 that extends upwardly from the frame 106. The pump 102 and pump motor 104 are in communication with a controller 110 (see FIG. 16) that is designed to control operation of the pumping system 100. The pumping system 100 is designed to accommodate different types of fluid and to be used in different applications, such as, for example applications involving sewage, wastewater processing, and effluent.

Although the terms “liquid” and “fluid” are used throughout, it should be understood that the pumping system 100 is designed to move liquid, solids, slurries, sewage, sludge, and the like. In some applications, the pumping system 100 can accommodate solids in the range of about 0% to about 3%. In other applications, the pumping system 100 can accommodate solids in the range of less than about 5%. In further applications, the pumping system 100 can accommodate solids in the range of about 1% to about 2%.

The pumping system 100 is designed to be at least partially submerged in the fluid that is to be pumped. In some instances, the pump 102 and pump motor 104 are disposed in the fluid to be pumped and one or more portions of the cord cap assembly 108 (e.g., the power cord) extend upwardly through the fluid until terminating at the controller 110. In other instances, one or more parts of the pumping system 100 may be fully submerged in the fluid to be pumped, or otherwise in communication with the fluid to be moved. For example, in one embodiment, the entire pumping system 100 may be submerged and in communication with the controller 110 (and/or a power source) via a wired, wireless, or other communications connection. One suitable pumping system
100 is the submersible solids handling pump that uses a Premium Efficient motor sold under the Hydromatic® brand by Pentair, Inc.

[0038] As shown in FIGS. 1 and 2, the frame 106 includes an upper section 120 designed to contain the motor 104 and a lower section 122 designed to retain the pump 102. The upper section 120 and lower section 122 are coupled to each other such that the pump 102 and motor 104 are in communication with each other, as described in more detail below. As best seen in FIG. 2, the frame 106 further includes an intake opening 124 disposed in a bottom surface 126 of the lower section 122 of the frame 106 and an outlet opening 128 that extends outwardly from the lower section 122 of the frame 106 via a cylindrical flange 130. The intake opening 124 is designed to receive fluid (not shown) into the pumping system 100 and the outlet opening 128 is designed to discharge fluid. The lower section 122 of the frame 106 optionally includes one or more legs 132 that are designed to support the frame 106 such that fluid can access the intake opening 124. The legs 132 may be any height, but should allow the pump 102 to be raised above the surface that is supporting the pump 102.

[0039] The pumping system 100 includes an overall height dimension H1 (see FIG. 1) of between about 115 centimeters to about 150 centimeters. The pumping system 100 further includes another height dimension H2 that excludes the cord cap assembly 108 (see FIG. 1). The height dimension H2 may be between about 87 centimeters to about 123 centimeters. The pumping system 100 further includes a length dimension L (see FIG. 2) of between about 32 centimeters to about 80 centimeters. The pumping system further includes a width dimension W (see FIG. 2) of between about 32 centimeters to about 55 centimeters. It should be recognized that the height dimensions H1, H2, length L, dimension, and width W dimension of the pumping system 100 may be adjusted as desired.

[0040] Now turning to FIGS. 3-8, the intake opening 124 of the pump 102 extends through the lower section 122 of the frame 106, which retains the pump 102. As shown in FIGS. 4 and 5, the pump 102 includes an impeller 140 that is in fluid communication with a volute chamber 142. As shown in FIG. 6, the impeller 140 is defined by a housing 144 having a circular shape 146 that is in communication with the intake opening 124 and a sidewall defined by a tapering spiral sidewall 148. In some embodiments, the impeller 140 can be made from ductile iron. However, any suitable metallic material may be used to make the impeller 140. The impeller 140 further includes a centrally disposed threaded bore 160 (see FIG. 6) in communication with a bolt 162 and an impeller key 164. The key 164 is designed to be in communication with a drive shaft assembly 166 (see FIG. 7) that extends from the motor 104. The key 164 may be shaped in a specific manner to correspond to the shape of the drive assembly 166 to ensure that the key 164 and drive assembly 166 remain in communication during the operation of the pump 102. More particularly, the key 164 may be provided with various ridges, protrusions, and/ or is shaped in a complementary manner with the drive assembly 166.

[0041] As depicted in FIG. 8, the internal components of the pump 102 are enclosed by a plate 168 and an O-ring 170 that circumscribes the plate 168. The O-ring 170 and the plate 168 form a substantially liquid-proof seal between the pump 102 and the motor 104. The plate 168 is substantially flat and includes a cylindrical pedestal 172 (see FIG. 7) extending upwardly from a central portion thereof. The pedestal 172 includes an opening 174 that is designed to receive a portion of the motor 104, as explained in more detail below.

[0042] In contrast to some traditional pumps, the pump 102 disclosed herein is designed to push fluid to the surface via the rotating impeller 140 as opposed to pulling the fluid through the pump 102, as shown in FIG. 4. As fluid enters the pump 102 through the intake opening 124, the rotating impeller 140 increases the pressure and flow rate of the liquid. After the fluid is accelerated by the impeller 140, the fluid flows radially outwardly into the volute chamber 142 and exits the pump 102 through the outlet opening 128. The fluid exiting the pump 102 travels through one or more outlet pipes (not shown) to the desired location.

[0043] In other embodiments, the pump 102 may be provided with a vortex type impeller (not shown) that uses a receded impeller to swirl the entering liquid. In these embodiments, the majority of the pumped liquid does not come in contact with the impeller blades, but rather is caught up in the mainstream of the pump casing and is discharged out through the pump exit using centrifugal force.

[0044] Now turning to FIGS. 9-15, drive force is provided to the pump 102 via the pump motor 104. The pump motor 104 is efficient in that it uses less energy, lowers operating costs of the pumping system, and contributes to a longer pump life. As shown in FIG. 10, the motor 104 includes a housing 200 defined by a bearing housing 202 in communication with a motor housing 204. The motor housing 204 and bearing housing 202 are designed to retain all of the components of the motor 104 and to protect the motor 104 from damage from fluids. The motor housing 204 and bearing housing 202 are joined to each other such that the housing 200 is substantially leak-proof. In some embodiments, the motor housing 204 and bearing housing 202 are made from cast iron. However, any suitable material may be used to make the motor housing 204 and bearing housing 202.

[0045] FIGS. 11 and 12 depict the housing 200 that includes a centrally disposed opening (not shown) to receive and support the drive shaft assembly 166 of the motor 104. In some embodiments, the drive shaft assembly 166 may be a stainless steel shaft. The drive shaft assembly 166 is defined by an elongate rotor 210 that extends longitudinally through the housing 200. The rotor 210 terminates at one end and is in communication with the pump 102. As best seen in FIG. 12, the rotor 210 includes an opening 212 that receives the impeller key 164.

[0046] Still referring to FIG. 12, the rotor 210 is held within the pump 102 adjacent the plate 168 and further includes a lower seal 214 and an upper seal 216 that are each designed to keep fluids from entering the housing 200 of the motor 104 via the pump 102. The lower seal 214 circumscribes the exterior surface of the rotor 210 and is retained interiorly under the raised pedestal 172 of the plate 168 adjacent the pump 102. The upper seal 216 circumscribes the rotor 210 and is disposed adjacent the exterior surface of the raised pedestal 172. In some embodiments, the upper and lower seals 216, 214 are provided as a single cartridge type seal (not shown). In these embodiments, the single cartridge may be removed without detaching the plate 168 or the use of special tools.

[0047] In some embodiments, the lower seal 214 may be a type 2 outboard seal adaptable to a wide range of surface conditions. The lower seal 214 can be made from silicon carbide, for example. Additionally, or alternatively, the lower seal 214 can be made from a tungsten carbide material. Simi-
larly, the upper seal 216 may be a type 2100 inboard seal made from silicon carbide, for example, to provide ease of installation and less drag. Additionally, or alternatively, the upper seal 216 can be made from tungsten carbide, for example.

[0048] As best seen in FIG. 12, the motor 104 further includes a stator 230 that surrounds the rotor 210. The stator 230 is stationary and may be electromagnetic, which energizes the rotor 210 and causes the rotor 210 to rotate. The stator 203 may be characterized by a maximum stator temperature rating of about 180°C.

[0049] As shown in FIG. 11, the motor 104 further includes a seal leak detection system 240 disposed in the bearing housing 202. The seal leak detection system 240 includes at least one seal failure probe 242 in communication with one or more sensor wires 244. The seal leak detection system 240 is designed to alert of liquid intrusion into the housing 200. The seal failure probe 242 is isolated electrically from the housing 200 by ceramic, epoxy, plastic, and/or other non-electrically conductive materials. One suitable failure probe 242 is provided by Fusiite Co. and sold under the model number 20-60959. The one or more sensor wires 244 provide communication between the seal leak detection system 240 and the controller 110. In some embodiments, a solid state relay (not shown) may be mounted to the controller 110 and configured to send a low voltage, low amperage signal to the probe 242, continuously monitoring the conductivity of the liquid in the housing 200. If the housing 200 of the motor 104 is breached by liquid, the seal failure probe 242 senses the increase in conductivity and transmits an electrical signal through the sensor wires 244 to the controller 110. The controller 110 triggers an alarm that the housing 200 has been breached. In some instances, the alarm is visual, audio, and/or other types of alerts. Other types of sensors may be included in the pump system 100 including heat sensors, pressure sensors, and the like.

[0050] The motor 104 also includes a plurality of ball bearings that are depicted in FIG. 12. Lower ball bearings 252 are provided on opposing sides of the rotor 210 in double rows. The lower ball bearings 252 provide over 50,000 hours of operation over the entire curve, and may be capable of absorbing thrust loads and reducing harmful thrust transfer upward to the motor stack. Thus, the mean time between service calls for the pump 102 may be reduced as well. One or more retaining rings 254 are provided adjacent the lower ball bearings 252. At least one retaining ring 254a is provided internal to the lower ball bearings 252 and a second retaining ring 254b is provided external to the lower ball bearings 252. Upper ball bearings 260 are also provided in the motor 104 at a distal end of the rotor 210. The upper ball bearings 260 may be a single row, permanently lubricated radial bearing that reduces bearing maintenance due to the continuous oil lubrication. In addition, the upper ball bearings 260 may replace conventional wavy washers and extend the pump 102 life over the entire curve.

[0051] A washer spring (not shown) and a screen 272 are provided adjacent the upper ball bearings 260. The spring is designed to keep the screen 272 from rubbing on the bearings 260 and the screen 262 is provided to keep material and debris out of the bearings 260.

[0052] As shown in FIGS. 9, 12, and 13, the motor 104 further includes a grounding ring 280 that is in communication with the rotor 210. The grounding ring 280 is provided in the form of a circular ring body 282 that defines a centrally disposed opening 284 (see FIG. 13). An interior wall 286 circumscribes the opening 284 and includes a plurality of carbon fiber brushes 286 extending outwardly therefrom. The carbon fiber brushes 286 may include conductive filaments to protect bearings from stray shaft currents by providing a low impedance path to ground, drawing the currents away from the bearings. The grounding ring 280 is disposed within the housing 200 and circumscribes an end of the rotor 210. The grounding ring 280 is provided to protect the motor 104 from damage caused by stray currents, which may be caused by a variable frequency drive.

[0053] Variable frequency drives often induce high frequency voltages on the shaft assembly 166 that seek a path to ground through the motor’s 104 bearings. When these voltages exceed the insulation breakdown of the lubricant, the voltages discharge through the bearings to ground leading to premature bearing failure in variable frequency drive driven motors. Even if the motor includes insulated bearings, shaft currents can travel to the coupled equipment, such as pumps, pillow blocks, gearboxes, and damage those bearings. Thus, the grounding ring 280 makes the submersible pump 102 compatible for use with variable frequency drives, while reducing bearing fusion caused by shaft currents.

[0054] In some embodiments, the grounding ring 280 is made of brass and includes one or more brushes 286. In other embodiments, the grounding ring 280 could be made from aluminum or any highly conductive material. The brushes 286 may be made from any strong fibrous material that conducts electricity and will not cause excessive wear to the shaft assembly 166 of motor 104.

[0055] Now turning to FIGS. 9, 11, 12 and 14, a terminal block 290 is provided adjacent the upper end of the rotor 210 and is designed to act as a connection point between the motor 104 and a power source 292 (see FIG. 16). The terminal block 290 is provided in the form of an elongate housing 294 with a plurality of openings 296. The openings 296 are designed to receive one or more wires 298. Use of the terminal block 290 in the motor 104 eliminates the use of a connection box, wire nuts, and crimp connectors, as used in typical motors.

[0056] As shown in FIG. 15, the motor 104 further includes the cord cap assembly 108 disposed adjacent the terminal block 290. The cord cap assembly 108 includes a cord cap 300 and a quick disconnect power cord 302. The cord cap 300 is in communication with the motor housing 204 and provides a connection between the motor 104 and the power source 292. The cord cap 302 may be positioned between 10.5 meters and about 30.5 meters in length and is attached to the cord cap 300 via the interaction between threads 304 disposed on an internal surface of the power cord 302 and the external surface of a raised member 306 extending from the cord cap 300. A secondary quick disconnect sensor cord 308 extends from the cord cap 300 and is designed to accommodate one or more sensor wires 244 from the seal failure probe 242, and/or other sensors and electrical components in the pump system 100. The power cord 302 and the sensor cord 308 can be easily disconnected from the cord cap 300 in the event that a problem occurs with the power cord 302 or sensor cord 308.

[0057] The power cord 302 and the sensor cord 308 are designed to be quick disconnect. Each cord 302, 308 is coupled to a fitting 310, 312 that each include a pin (not shown) and associated sockets (not shown). When one of the cords 302, 308 are to be disconnected, the fitting(s) 310, 312 are rotated via the threading, which causes the cords 302, 308 to become disconnected. Advantageously, the quick disconnect of the fittings 310, 312 allows for servicing the pump 102.
in the field without compromising federal motor carrier safety administration (FMCSA) listings. In addition, the power cord 302 and/or the sensor cord 308 can be replaced without rewiring the pump 102. In some embodiments, the cord fittings 310, 312 include a dual seal epoxy potted cord cap that attaches to the quick caps to provide a positive seal to eliminate wicking if the power cord 302 or sensor cord 308 is cut.

[0058] The motor 104 is also provided with oil disposed in internal components thereof. Having an oil filled motor 104 allows for increased cooling compared to air-filled motors. Oil filled motors 104 may also involve lower operating temperatures, provide moisture protection, and self-lubricating bearings. In addition, oil filled motors may be less susceptible to early bearing failure because the motor is supplied with windings rated for 180°C. Thus, the motor 104 can operate in the Class A temperature range (i.e., less than 105°C) at about 68°C. For each 10°C that a motor operates below its maximum design operating temperatures, life expectancy is approximately doubled. Conversely, for each 10°C a motor is operated beyond its designed operating temperature, its life expectancy is cut in half.

[0059] The oil is non-toxic and non-conductive and is designed to be lighter than traditional oils used in submersible pumps. The oil is a mixture of a base oil stock and a synthetic base stock.

[0060] The synthetic base stock may include hydrocarbon oils as well as non-hydrocarbon oils. The synthetic base stock can be derived from a variety of processes including, for example, chemical combination (e.g., polymerization, oligomerization, condensation, alkylation, acylation), where materials consisting of smaller species are synthesized into more complex molecular species. The synthetic base stock may also include hydrocarbon oils such as polyolefins and interpolymerized olefins (polybutylene, polypropylene, propylene isobutylene copolymers, ethylene-olefin copolymers, and ethylene-alphaolefin copolymers, for example). Other oils useful in the synthetic base stock may include polyol esters, diesters, liquid esters of phosphorus-containing acids (e.g., tricresyl phosphate, triethyl phosphate, and the diethyl ester of decane phosphonic acid), or polymeric tetrahydrofurans. The synthetic base stock may be produced by Fischer-Tropsch reactions and typically may be hydroisomerised Fischer-Tropsch hydrocarbons or waxes.

[0061] The oil is generally paraffinic and meets the requirements of the electrical industry in accordance with ASTM D3487. By “paraffinic,” it is meant that the oil may include any saturated hydrocarbons, such as alkanes, linear alkanes, branched alkanes (iso-paraffins), cycloalkanes (cycloparaffins; mono-ring and/or multi-ring), and branched cycloalkanes.

[0062] The oil further includes a variety of components provided in the form of a mixture of anti-wear and anti-oxidant additives. The anti-wear and anti-oxidant additives are employed in the range of about 0.005 wt. % to about 20 wt. % based on the total weight of the oil. Examples of suitable anti-wear agents include phosphate esters, sulphurised olefins, sulphur-containing anti-wear additives including metal dihydrocarbodiilithiophosphates (such as zinc dialkylthiodiphosphates or molybdenum dialkyldithiophosphates), thio-carbamate-containing compounds including, thio-carbamate esters, alkylene-coupled thio-carbamates, and bis(8-alkyldithiocarbamyl)disulphides. Additional suitable anti-wear agents include long chain fatty acid derivatives of amines, fatty esters, fatty epoxides, fatty imidazolines such as condensation products of carboxylic acids and polyalkylenepolyamines, amine salts of alkylphosphoric acids, fatty alkyl tartrates, fatty alkyl tarreramides, or fatty alkyl tarramides.

[0063] In one embodiment, the anti-wear agent comprises an ashless antiwear agent (i.e., the antiwear agent is metal-free). In some instances, the ashless antiwear agent may be provided in the form of an amine salt of a phosphorus-containing antiwear agent. For example, the ashless antiwear agent may comprise phosphoric acid esters, or an amine salt thereof, or salts of dialkyldithiophosphoric acid esters. The amine may be primary, secondary, tertiary, and/or mixtures thereof.

[0064] In other embodiments, the antiwear agent may also encompass materials such as sulphurised fatty compounds and olefins, molybdenum dialkyldithiophosphates, molybdenum dithiocarbamates, sunflower oil or monooester of a polyol and an aliphatic carboxylic acid. In one embodiment, the antiwear agent may be a long chain fatty acid derivative of amines, esters, or epoxides, fatty alkyl tartrates, fatty alkyl tartramides, and fatty alkyl tarramides.

[0065] The oil may include other additives known in the art such as dispersants, demulsifies, metal deactivators, detergents, friction modifiers, extreme pressure agents, corrosion inhibitors, dispersant viscosity modifiers, foam inhibitors, pour point depressants, seal swelling agents, viscosity modifiers, and/or mixtures thereof.

[0066] The oil is defined by a specific gravity of about 0.8 at 15.5°C, and an API gravity of about 36 at 15.5°C. Using ASTM D1298. The oil is also characterized by a viscosity of about 40 SUS at 37.8°C using ASTM D445, a viscosity of about 4.7 cSt at 4.4°C using ASTM D445, and a viscosity of about 1.6 cSt at 37.8°C using ASTM D445. The oil may also be characterized by a flash point of about 154°C (PMCC) and a pour point of about -45.5°C determined using ASTM D97.

[0067] The oil described above provides an improvement of efficiency of the motor 104 described herein. For example, the oil described herein provides less scarring by the ball bearings as determined using a four ball wear test (15 kg load/1200 rpm/60 minutes). In this test, there was only about 0.46 mm of wear scar and a kinematic viscosity of 40 at SUS at 37.8°C, as tested using the motor 104 described herein.

[0068] Now turning to FIG. 16, the pump 102 and motor 104 are in communication with the controller 110, which provides control over the pumping system 100. In one embodiment, the controller 110 includes a variable frequency drive 350 that provides for the infinitely variable control of the pump motor 104 (i.e., varies the speed of the pump motor). By way of example, within the operation of the variable frequency drive 350, a single phase AC current from a source power supply is converted (e.g., broken) into a three-phase AC current. Any suitable technique and associated construction/configuration may be used to provide the three-phase AC current. The variable frequency drive 350 supplies the AC electric power at a changeable frequency to drive the pump motor 104.

[0069] In use, a user interface 360 may be provided to input operating parameters of the pump 102 into the controller 110. Buttons, knobs, and the like may be used to specify the operating parameters. In many instances, the user interface 360, the controller 110, and/or the power source 292 will be disposed remote from the pump 102 and motor 104 due to the submersible location of the pump 102.

[0070] It will be appreciated by those skilled in the art that while the invention has been described above in connection
with particular embodiments and examples, the invention is not necessarily so limited, and that numerous other embodiments, examples, uses, modifications and departures from the embodiments, examples and uses are intended to be encompassed by the claims attached hereto. The entire disclosure of each patent and publication cited herein is incorporated by reference, as if each such patent or publication were individually incorporated by reference herein. Various features and advantages of the invention are set forth in the following claims.

1. A submersible pump system, comprising:
a pump in communication with a pump motor;
a frame designed to substantially enclose the pump and pump motor; and
a grounding ring disposed within the frame and in communication with the pump motor, the grounding ring including conductive filaments extending therefrom to draw currents away from bearings disposed within the frame.

2. The submersible pump system of claim 1 further comprising a drive shaft assembly coupled to the pump motor, the drive shaft assembly defined by a rotor extending through the frame and circumscribed by the grounding ring at a first end.

3. The submersible pump system of claim 1, wherein the grounding ring includes a circular ring body that defines a centrally disposed opening circumscribed by an interior wall from which the conductive filaments outwardly extend.

4. The submersible pump system of claim 1, wherein the conductive filaments include carbon fiber brushes for protecting the pump motor from damage caused by stray currents.

5. The submersible pump system of claim 1 further comprising a cord cap assembly extending upwardly from the frame, the cord cap assembly including at least one quick disconnect cord coupled to a cord cap, wherein the cord cap provides a connection between the pump motor and a power source.

6. The submersible pump system of claim 5, wherein the at least one quick disconnect cord includes a power cord and a sensor cord.

7. The submersible pump system of claim 1 further comprising a controller in communication with the pump and the pump motor to control operation of the submersible pumping system.

8. The submersible pump system of claim 7 further comprising a seal leak detection system disposed within the frame, the seal leak detection system including at least one seal failure probe adapted to detect liquid intrusion into the frame and transmit an electrical signal to the controller to trigger at least one of a visual alarm and an audio alarm.

9. The submersible pump system of claim 1 further comprising a lubricating oil suitable for use in the pump and pump motor, wherein the lubricating oil includes a low ash, sulfur and phosphorous composition.

10. The submersible pump system of claim 9, wherein the lubricating oil is characterized by a flash point of about 154°C.

11. A submersible pump system, comprising:
a frame defining an intake opening and an outlet opening;
a pump in communication with a pump motor and the intake opening and the outlet opening, the pump and the pump motor disposed within the frame; and
a cord cap assembly extending from the frame and including at least one quick disconnect cord coupled to a cord cap, wherein the cord cap provides a connection between the pump motor and a power source.

12. The submersible pump system of claim 11, further comprising a grounding ring disposed within the frame and in communication with the pump motor, the grounding ring including conductive filaments extending therefrom to draw currents away from bearings disposed within the frame.

13. The submersible pump system of claim 12, wherein the grounding ring includes a ring body that defines a centrally disposed opening circumscribed by an interior wall from which three conductive filaments outwardly extend.

14. The submersible pump system of claim 13, wherein the conductive filaments include carbon fiber brushes for protecting the pump motor from damage caused by stray currents.

15. The submersible pump system of claim 11, wherein the at least one quick disconnect cord includes at least one of a power cord or a sensor cord.

16. The submersible pump system of claim 11 further including a controller having a variable frequency drive.

17. The submersible pump system of claim 11, wherein the quick disconnect cord is coupled to a fitting that includes a pin.

18. The submersible pump system of claim 11, wherein the quick disconnect cord is threaded to the cord cap.

19. A submersible pump system, comprising:
a pump in communication with a pump motor;
a cord cap assembly extending from the pump motor and including at least one quick disconnect cord coupled to a cord cap, wherein the cord cap provides a connection between the pump motor and a power source; and
a grounding ring disposed in communication with the pump motor, the grounding ring designed to draw currents away from bearings associated with the pump motor.

* * * * *