A pump includes a drive shaft linked to a motor. The drive shaft passes through a seal assembly before passing into the pump chamber. The seal includes an outer seal housing that accommodates a lip seal. A portion of the drive shaft that passes through the seal assembly is coated with PTFE to prolong the working life of the seal assembly.
PUMPS WITH IMPROVED DRIVE SHAFT/CASING SEALS

TECHNICAL FIELD

[0001] This disclosure relates to improved pumps, drive shafts and seal assemblies for pumps intended to pump liquids that prematurely degrade conventional seals disposed between the drive shaft and the casing. The disclosed drive shafts and pump designs provide improved wear characteristics for the seal assemblies and therefore require less maintenance and longer operating times between servicing and seal replacements than existing pumps.

BACKGROUND

[0002] Gear pumps are positive displacement pumps, meaning that they pump a constant amount of fluid per revolution. Gear pumps use dual meshing gears, to pump the fluid and include two basic types: internal gear pumps and external gear pumps. External gear pumps typically include a rotor gear mounted on a drive shaft or drive shaft that passes through the casing and into the pump chamber. The rotor gear is in mesh with and consequently rotates an idler gear disposed within the casing and next to the rotor gear (i.e., external to the rotor gear). The idler gear is also mounted on a shaft or pin that is rotatably mounted to, but does not need to pass through the casing. Typically, the idler pin is mounted to the head plate that encloses the pump chamber. In contrast, internal gear pumps also include a rotor mounted on a drive shaft that passes through the casing and into the pump chamber. The rotor also drives an idler gear, but the idler gear is disposed within the rotor (i.e., internal to the rotor). Either way, the drive shaft of a gear pump must pass through the casing without permitting the fluid being pumped from leaking from the pump chamber and outside of the casing. To prevent this occurrence, a seal assembly between the drive shaft and casing is required. However, certain fluids that may be pumped with gear pumps can cause premature failure of the drive shaft/casing seal assembly. For example, non-trans fat oils, certain unsaturated hydrocarbons, components of glue and adhesives and various other liquids and slurries that are sticky or tacky may cause premature failure of the drive shaft/casing seal assembly.

[0003] For example, trans-fat is the common name for a type of unsaturated fat with trans-isomer fatty acid(s). Trans-fats may be monounsaturated or polyunsaturated. Most trans-fats consumed today are created industrially through partial hydrogenation of plant oils through a process developed in the early 1900s. The goal of partial hydrogenation is to add hydrogen atoms to unsaturated fats, making them more saturated, i.e. fewer double bonds between carbon atoms. These more saturated fats have a higher melting point, which makes them attractive for baking and, importantly, the reduction in double bonds between carbon atoms extends the shelf-life of the resulting product. For example, hydrogenated vegetable oil or trans-fat can be used to replace the natural peanut oil in peanut butter, which provides shelf stable peanut butters that can be stored without refrigeration and without the trans-fat separating from the other components of the peanut butter. In contrast, natural peanut butters have shorter shelf lives and the peanut oil naturally separates from the heavier components of peanut butter.

[0004] Unlike other dietary fats, trans-fats are neither essential nor even nutritious. In fact, the consumption of trans-fats increases the risk of coronary heart disease by raising levels of “bad” LDL cholesterol and lowering levels of “good” HDL cholesterol. In sum, trans-fats from partially hydrogenated oils are widely regarded as being less healthy than naturally occurring oils.

[0005] Chemically, trans-fats are made of the same building blocks as non-trans-fats, but have a different arrangement. In trans-fatty acid molecules, the hydrogen atoms bonded to pairs of double-bonded carbon atoms (characteristic of all unsaturated fats) are in the trans rather than the cis molecular arrangement. This results in a straight, rather than kinked, shape for the carbon chain, more like the straight chain of a fully saturated fat. The trans and cis versions of a fatty acid having the same chemical formula have different chemical and physical properties owing to the slightly different bond configuration. Notably, the trans-fat has a much higher melting point, due to the ability of the trans molecules to pack more tightly, forming a solid that is more difficult to break apart and that it is a solid at human body temperatures.

[0006] According to the FDA, the average American consumes 5.8 grams of trans-fats per day or about 2.6% of an average calorie intake. To date, the FDA has not generated a recommended daily amount (DV%) for trans-fats. However, health authorities worldwide recommend that consumption of trans-fat be reduced to trace amounts. Some U.S. cities are independently acting to reduce consumption of trans-fats with public education campaigns and requests to restaurant owners to voluntarily eliminate trans-fat from their offerings.

[0007] Therefore, pressure from consumers and public health advocates to convert from cooking oils containing trans-fats to cooking oils free of trans-fats is present now and will only increase in the future. It is anticipated that corn, soybean and canola oils will be the primary substitutes for trans-fat oils.

[0008] Deep fryers are a necessity of the food service industry and particularly for the fast food service industry. Deep fryers use a substantial amount of shortening or oil during the cooking process. During the cooking process, some of the oil is absorbed by a food product, resulting in loss of oil volume. The remaining oil can become filled with food debris due to constant use. As a result, commercial hot oil fryers may include a pump and filter system to remove the debris and replenish the oil in the fryer. Further, as more expensive oils that are free of trans-fats are being used, there is even a greater need to extend the usable life of the unabsorbed oil and to keep the unused oil clean during the cooking process.

[0009] With respect to hot oil or “deep” fryers, improved pump designs are needed as manufactures replace trans-fat oils with zero trans-fat oils. Specifically, a typical deep fryer requires at least two pumps: first, a filter/return pump for drawing used cooking oil from the cooking vat through a filter system and then pumping the filtered oil back into the cooking vat; and second, a supply pump for “topping-off” the cooking vat with clean or fresh oil as the oil level in the vat decreases.

[0010] Currently available pumps, used in food manufacturing and in food preparation, are prone to frequent seal failure when used to pump natural, unsaturated and trans-fat-free oils such as corn, soybean and canola oils. During the transition between trans-fat oils and zero trans-fat oils, it has been found that failure of the seal between the rotor drive shaft and the casing has become commonplace. This seal is critical because it contains the cooking oil within the pump chamber and prevents the oil from leaking outside the pump.
Accordingly, an improved seal arrangement for pumps intended for pumping hot trans-fat-free oils is needed and/or a seal arrangement that either avoids a reliance on the use of the currently employed seal material—fluoropolymer elastomers or fluoroelastomers or a modified seal system is needed.

Fluoroelastomers are commonly used in O-rings and other molded or extruded goods. Fluoroelastomers are part of a family comprising copolymers of hexafluoropropylene (HFP) and vinylidene fluoride (VDF) or VDF-terpolymers of tetrafluoroethylene (TFE), vinylidene fluoride (VDF) and hexafluoropropylene (HFP) as well as perfluoromethylvinylether (PMVE) containing specialties. The fluoride content of the most common fluoroelastomers varies between 66 and 70%. As noted above, the failure rate of fluoroelastomer seals in pumps used to pump zero trans-fat oils is unacceptably high. Other fluids which can make fluoroelastomer seals susceptible to premature failure include certain components of glues or adhesives and other materials such as gasoline and methanol, especially at low temperatures. Further, it has been found that exposure to sticky or tacky fluids, slurries and mixtures may often adversely impact the working life of a fluoroelastomer seal.

Fluoroelastomer lip seals may fail in a timeframe as little as six months when used with zero trans-fat oils and other materials, some of which are noted above. Therefore, new pumps and new seal mechanisms for use in pumps are needed for reliably pumping fluids which can prematurely degrade fluoroelastomers and therefore shorten the useful life of fluoroelastomer seal assemblies.

SUMMARY OF THE DISCLOSURE

In satisfaction of the aforesaid needs, an improved pump is disclosed. The pump includes a casing that accommodates a seal assembly and a drive shaft. The drive shaft passes through the casing and through the seal assembly. The seal assembly includes a resilient annular seal member that sealingly engages the drive shaft. Further, at least a portion of the drive shaft that passes through the seal assembly is coated with polytetrafluoroethylene (PTFE).

In a refinement, the PTFE coating on the drive shaft has a thickness ranging from about 0.45 to about 0.75 mils.

In a refinement, the portion of the drive shaft that is coated with PTFE extends across the sealing region of the shaft or the portion of the shaft that passes through the seal assembly.

In another refinement, the seal assembly may further include an annular seal casing and a resilient annular lip seal that engages the PTFE coating on the drive shaft.

In another refinement of this concept, the resilient annular seal member may be fabricated from a material selected from the group consisting of a copolymer of hexafluoropropylene (HFP) and vinylidene fluoride; a terpolymer of tetrafluoroethylene (TFE), vinylidene fluoride (VDF) and hexafluoropropylene (HFP); perfluoromethylvinylether (PMVE); a nitrile rubber, a polyethylene propylene, a fluoro rubber, a silicone rubber, a urethane rubber, a natural rubber, ethylene-tetrafluoroethylene (ETFE), a polyamide and a perfluoroelastomer.

In yet another refinement, the coating on the drive shaft is fabricated from PTFE and the resilient annular seal member is fabricated from a fluoroelastomer.

In a refinement, the resilient annular seal member may be a lip seal. The lip seal may include two or three lip members that engage the PTFE on the drive shaft.

An improved input shaft or drive shaft for a pump is also disclosed. The drive shaft includes an inboard end (or dry end) and an outboard end (or wet end). At least a portion of the shaft disposed between the inboard and outboard ends passes through a seal assembly. The seal assembly prevents leakage of the fluid being pumped, which may cause damage to the pump motor leading to malfunctioning of the pump and associated components. At least a portion of the outer surface of the drive shaft that passes through the seal assembly may be coated with PTFE to inhibit wear and tear on the seal assembly.

In another refinement, a method for pumping trans-fat free cooking oils is disclosed. The method may include providing a pump including a casing that accommodates a seal assembly and a drive shaft. The drive shaft may pass through the casing and through the seal assembly before being coupled to a rotor. The rotor may be an idler. The seal assembly may include a resilient annular seal member, and at least a portion of the drive shaft that passes through the seal assembly may be coated with PTFE. The method may further include engaging the portion of the drive shaft that is coated with PTFE with the resilient annular seal member and, rotating the drive shaft and PTFE as the PTFE engages the resilient annular seal member.

Other advantages and features will be apparent from the following detailed description when read in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the disclosed methods and apparatuses, reference should be made to the embodiments illustrated in greater detail in the accompanying drawings, wherein:

FIG. 1 is a plan view of an improved drive shaft made in accordance with this disclosure;

FIG. 2 is a left end view of the shaft shown in FIG. 1;

FIG. 3 is a sectional view of an improved lip seal and lip seal case made in accordance with this disclosure;

FIG. 4 is a sectional view of an alternative case for the lip seal shown in FIG. 3;

FIG. 5 is a sectional view taken substantially along line 5-5 of FIG. 8 illustrating a pump incorporating the lip seal and lip seal case shown in FIG. 3;

FIG. 6 is a side plan view of the pump shown in FIG. 5;

FIG. 7 is a front plan view of the pump shown in FIGS. 5-6; and

FIG. 8 is a rear plan view of the pump shown in FIGS. 5-7.

It should be understood that the drawings are not necessarily to scale and that the disclosed embodiments are sometimes illustrated diagrammatically and in partial views. In certain instances, details which are not necessary for an understanding of the disclosed methods and apparatuses or which render other details difficult to perceive may have been omitted. It should be understood, of course, that this disclosure is not limited to the particular embodiments illustrated herein.
DETAILED DESCRIPTION

[0034] An improved rotor shaft or drive shaft 50 is illustrated in FIGS. 1 and 2. The drive shaft 50 includes an inboard end 51 and an outboard end 52. An axially extending tang 53 couples the drive shaft 50 to a motor or other drive mechanism (not shown). The drive shaft 50 also includes an outer surface 54 that may include an uncoated portion 55 and a coated portion 56. The coated portion 56 may be coated with PTFE at a thickness that may vary, depending upon the size of the pump and the particular application. In one embodiment, the PTFE coating on the coated portion 56 of the outer surface 54 of the drive shaft 50 may range from about 0.45 to about 0.75 mils. The coated portion 56 of the outer surface 54 of the drive shaft 50 passes through a seal assembly 60 which is illustrated in FIGS. 3-4.

[0035] FIG. 3 illustrates an improved seal assembly 60 that includes a housing 61 that comprises an outer case member 62 and an inner case member 63. Sandwiched between the inner and outer housing members 62, 63 is a seal member 64, which is preferably a lip seal as shown in FIG. 3. The seal member 64, which may be a lip seal as shown in FIG. 3, may be fabricated from a fluoroelastomer such as, but not limited to: a copolymer of hexafluoropropylene (HFP) and vinylidene fluoride; a terpolymer of tetrafluoroethylene (TFE), vinylidene fluoride (VDF) and hexafluoropropylene (HFP); perfluoromethylvinylmethylether (PMVE); a nitrite rubber; a polyethylene propylene; a fluoro rubber; a silicone rubber; a urethane rubber; a natural rubber; ethylene-tetrafluoroethylene (ETFE); a polyamide; and a perfluoroelastomer.

[0036] Water and water-containing substances like most foods do not wet PTFE, therefore adhesion to PTFE surfaces is inhibited. Due to this property, PTFE is used as a non-stick coating for pans and other cookware. PTFE is very non-reactive, and so it is often used in containers and pipe work for reactive and corrosive chemicals. Where used as a lubricant, PTFE reduces friction, wear and energy consumption of machinery. However, PTFE has not been heretofore used extensively as a coating for pump drive shafts or pump input shafts.

[0037] The seal member 64 may comprise one, two or three lip members as shown at 65, 66 and 67 in FIG. 3. The third lip member 67 or the middle lip member 67, shown phantom in FIG. 3, if utilized, preferably falls to one side or towards one of the outer lip members 65, 66. Alternatively, the middle lip member 67, if utilized, may be more robust than the outer lip members 65, 66 and may maintain a neutral position between the outer lip members 65, 66.

[0038] The inner and outer case members 62, 63 as shown in FIG. 3 are primarily L-shaped. In contrast, the casing 70 of FIG. 4 includes a sturdier, more robust design with inner and outer leg members 71, 72 disposed on either side of a top panel 73. A reinforcing inner leg member 74 is also shown that helps define a middle cavity 75 for receiving and holding a seal member 64 (not shown in FIG. 4). In contrast, the housing 61 as shown in FIG. 3 is slimmer and more compact and is therefore may be preferred in certain applications.

[0039] FIG. 5 illustrates a pump 80 that includes a drive shaft 50 that includes a motor (not shown) at its inboard end 51. The drive or drive shaft 50 passes through the seal assembly 60. As shown in FIG. 5, lip members 65, 66 engage an outer surface 54 of the drive shaft 50 and the housing 61 holds the seal assembly 60 in place within the cavity 81 in the front casing 82. The drive or drive shaft 50 passes through an input or rotor gear 83 that is engaged with an output or idler gear 84 through which an output or idler shaft 85 passes. The pump chamber 86 is disposed within the rear casing 87 which is sealably connected to the front casing 82. The seal 88 prevents fluid from leaking outward from the pump chamber 86 and between the front casing 82 and rear casing 87. As shown in FIGS. 7-8, the front casing 82 includes a pair of mounting slots 91. The tang 53 that couples the inboard end 51 of the drive shaft 50 to a motor (not shown) or other means for rotating the drive shaft 50 is also shown in FIG. 7.

[0040] Pumps with input or drive shafts coated with PTFE, and equipped with a seal assembly made in accordance with this disclosure were tested for 28,500 cycles (=15 years) and 19,000 cycles (=10 years) without a seal failure. This is a surprising result, given the current expected lifetime for many fluoroelastomer seal assemblies, which can be as short as six months, depending on the fluid being pumped and the operational temperatures.

[0041] While only certain embodiments have been set forth, alternatives and modifications will be apparent from the above description to those skilled in the art. These and other alternatives are considered equivalents and within the spirit and scope of this disclosure and the appended claims.

What is claimed is:

1. A pump comprising:
   a casing accommodating a seal assembly and a drive shaft; the drive shaft passing through the casing and through the seal assembly; the seal assembly includes a resilient annular seal member that sealingly engages the drive shaft; and at least a portion of the drive shaft that passes through the seal assembly being coated with PTFE.

2. The pump of claim 1 wherein the PTFE coating has a thickness ranging from about 0.45 to about 0.75 mils.

3. The pump of claim 1 wherein the seal assembly further includes an annular seal casing that surrounds the resilient annular seal member that engages the PTFE coating on the drive shaft.

4. The pump of claim 3 wherein the resilient annular seal member is a lip seal.

5. The pump of claim 1 wherein the resilient annular seal member is fabricated from a material selected from the group consisting of:
   a copolymer of hexafluoropropylene (HFP) and vinylidene fluoride; a terpolymer of tetrafluoroethylene (TFE), vinylidene fluoride (VDF) and hexafluoropropylene (HFP); perfluoromethylvinylmethylether (PMVE); a nitrie rubber; a polyethylene propylene, a fluoro rubber, a silicone rubber, a urethane rubber, a natural rubber, ethylendtetrafluoroethylene (ETFE), a polyamide and a perfluoroelastomer.

6. The pump of claim 1 wherein the seal assembly comprises an annular seal casing that surrounds the resilient annular seal member that engages the PTFE coating on the drive shaft, the resilient annular seal member being fabricated from at least one fluoroelastomer.

7. The pump of claim 1 wherein the resilient annular seal member is a lip seal.

8. The pump of claim 7 wherein the lip seal includes two lip members.

9. The pump of claim 7 wherein the lip seal includes three lip members.

10. A drive shaft for a pump, comprising:
    a shaft body having an inboard end, an outboard end and an outer surface;
11. The drive shaft of claim 10 wherein the portion of the drive shaft that is coated with PTFE extends from the inboard end of the drive shaft partially towards the outboard end of the drive shaft.

12. The drive shaft of claim 10 wherein the PTFE coating has a thickness ranging from about 0.45 to about 0.75 mils.

13. A method for pumping trans-fat free cooking oils, the method comprising:

   providing a pump including a casing that accommodates a seal assembly and a drive shaft, the drive shaft passing through the casing and through the seal assembly before being coupled to a rotor, the rotor being enmeshed with an idler, the seal assembly including a resilient annular seal member, and at least a portion of the drive shaft that passes through the seal assembly being coated with PTFE;

   engaging the portion of the drive shaft that is coated with PTFE with the resilient annular seal member; and

   rotating the drive shaft and PTFE as the PTFE engages the resilient annular seal member.

14. The method of claim 13 wherein the PTFE coating has a thickness ranging from about 0.45 to about 0.75 mils.

15. The method of claim 13 wherein the resilient annular seal member is fabricated from a material selected from the group consisting of:

   a copolymer of hexafluoropropylene (HFP) and vinylidene fluoride; a terpolymer of tetrafluoroethylene (TFE), vinylidene fluoride (VDF) and hexafluoropropylene (HFP); perfluoromethylvinylether (PMVE); a nitrile rubber, a polyethylene propylene, a fluoro rubber, a silicone rubber, a urethane rubber, a natural rubber, ethylenetetrafluoroethylene (ETFE), a polyamide and a perfluoroelastomer.

16. The method of claim 13 wherein the seal assembly comprises an annular seal casing the surrounds the resilient annular seal member.

17. The method of claim 13 wherein the resilient annular seal member is fabricated from at least one fluorooelastomer.

18. The method of claim 13 wherein the resilient annular seal member is a lip seal.

19. The method of claim 18 wherein the lip seal includes two lip members.

20. The method of claim 18 wherein the lip seal includes three lip members.