

DRIVE SYSTEM AND DRIVE SUB-ASSEMBLY FOR DRIVING A SHAFT

Technical Field

[0001] The present invention relates generally to apparatuses and methods that provide bearing support to a driven shaft that may include an impeller or other device for agitating fluid and may be employed in a mixer or mixing system.

Background

[0002] In material processing equipment such as mixers or mixing systems, it is common that a rotatable shaft assembly is supported by spherical and/or tapered bearing assemblies. This support is commonly accomplished by placing the bearing assemblies at various axial locations along the rotatable shaft. In particular, a mixing system may include an output impeller drive shaft that extends into a mixing vessel to drive an impeller and a hollow shaft that may encircle a portion of the output shaft. The hollow shaft may be rotationally coupled to the output shaft, and have a gear that is driven to transmit rotational motion to the hollow shaft. A first bearing or bearing set may be employed to support the output shaft, while a second bearing or bearing set may be utilized to support the hollow shaft.

[0003] The output shaft may be subject to high load and bending forces due to various mixing conditions during operation of a mixing system. These conditions may include, for example, shaft speed, physical properties of materials to be mixed, and shaft length. These forces may translate into bending forces that may cause the output shaft to deflect radially. The first and second bearings or bearing sets may isolate the hollow shaft from the output shaft and the associated bending loads the output shaft experiences. This may prevent the likelihood of the hollow shaft from transmitting undesirable loads to other components of the mixing system.

[0004] However, the second bearing or bearing set may be separated radially and/or axially from the gear by a portion of, or a separate component attached to a portion of, the hollow shaft which is surrounded by the second bearing or bearing set. As such, the rotation of the gear which is transferred to the hollow shaft and thereby the output shaft, is not directly supported by either of the first or second bearings or bearing sets. In addition, each of the first and second bearings or bearing sets may require a respective type of lubricant, for example oil for one

bearing and grease for another bearing, to operate. This may require multiple lubricant sources and delivery mechanisms.

[0005] The mixing system may also include a frame assembly and bearing housings (e.g. bearing caps) mounted on the frame assembly which house each of the first and second bearings or bearing sets. The bearing housings include multiple components and may be mounted in such a way that bearing bores of respective bearings are not accurately aligned with one another. This can result in misalignment between the output shaft and the hollow shaft.

[0006] In view of the foregoing, there is a need for an apparatus and a method that improves bearing accuracy and performance while reducing a total number of parts required to transmit motion of a gear to a driven shaft. In addition, there is a need for an arrangement of bearings which permits for multiple bearings to be lubricated by the same lubricant.

[0007] These and other needs are addressed by the present disclosure.

Summary

[0008] According to an aspect of the present disclosure a drive sub-assembly is provided and may include a hub extending from a first end face to a second end face along a longitudinal axis. The hub may have an outer circumferential surface and inner circumferential surface. The drive sub-assembly may further include at least a first inner race and first rollers of a first bearing assembly, and a gear attached to the second end face of the hub. The gear may have a second inner circumferential surface that may be arranged to engage a second bearing assembly. According to an aspect of the present disclosure, the outer circumferential surface may define a first recess proximate to the first end face, and a shoulder between the first recess and the second end face along the longitudinal axis. The first inner race and the first rollers may be mounted on the shoulder, and the first inner circumferential surface may define a second recess proximate to the second end face.

[0009] According to another aspect of the present disclosure a drive system for a mixing apparatus may transmit a rotational movement of an input shaft to an output shaft of the mixing apparatus and include a housing having a first housing configured to receive the input shaft and a second housing, the second housing including a cylindrical wall extending from the second housing towards the first housing and arranged to receive the output shaft. The drive system

may further include a hub mounted on the cylindrical wall, a gear attached to the hub and configured to transmit the rotational movement of the input shaft to the hub, a first bearing assembly operatively positioned between the hub and the first housing, and a second bearing assembly operatively positioned on the cylindrical wall and the gear. In addition, the drive sub-assembly may include a plurality of seals positioned between the housing and the hub such that a same fluid lubricates the first bearing assembly and the second bearing assembly and is prevented from contacting the output shaft.

[0010] According to still another aspect of the present disclosure, a method for driving an output shaft may include applying a force to a gear causing a rotational movement of a hub, and engaging the output shaft with the hub causing a rotational movement of the output shaft corresponding to the rotational movement of the hub. According to an aspect of the present disclosure the hub may include an outer circumferential surface that defines a first recess and a shoulder, an inner circumferential surface that defines a second recess, and at least a first inner race and first rollers of a first bearing assembly mounted on the shoulder. Further, the gear may be attached to the hub and engage second rollers of a second bearing assembly positioned below the second recess along a longitudinal axis.

Brief Description of the Drawings

[0011] FIG. 1 illustrates a motor and a cross-sectional view of a drive system of a mixing apparatus, according to an aspect of the present disclosure.

[0012] FIG. 2 is an enlarged view of a portion of FIG. 1 including a drive sub-assembly, according to an aspect of the present disclosure.

[0013] FIG. 3 illustrates a perspective view of a second housing for a housing assembly, according to an aspect of the present disclosure.

[0014] FIG. 4A illustrates a front perspective view of a drive sub-assembly, according to an aspect of the present disclosure.

[0015] FIG. 4B illustrates an overhead perspective view of a drive sub-assembly, according to an aspect of the present disclosure.

[0016] FIG. 5 illustrates an exploded view of a drive sub-assembly and a portion of a housing assembly, according to an aspect of the present disclosure.

[0017] FIG. 6 illustrates a partial cross-sectional view of a housing assembly, according to an aspect of the present disclosure.

Detailed Description

[0018] It is noted that as used herein the specification and the appending claims the singular forms “a,” “an,” and “the” can include plural references unless the context clearly dictates otherwise. Further, unless specified otherwise, the terms “substantial” or “substantially” as used herein mean “considerable in extent,” or “largely but not necessarily wholly that which is specified.” Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context.

[0019]

[0020] Aspects of the disclosure will now be described in detail with reference to the drawings, wherein like reference numbers refer to like elements throughout, unless specified otherwise.

[0021] FIG. 1 illustrates a motor 10 and a cross-sectional view of a drive system 100 of a mixing apparatus 1, according to an aspect of the present disclosure. The drive system 100 transmits the rotational movement of an input shaft 12 driven by the motor 10 to an output shaft 102 of the drive system 100. The output shaft 102 may extend through a housing assembly 104 of the drive system 100 and into a container or other vessel (not shown). An impeller, blade, or other component (not shown) may be fixedly attached to at an end of the output shaft and configured to mix fluids within the container with the rotation of the output shaft 102.

[0022] The housing assembly 104 includes a first housing 104a mounted on and attached to a second housing 104b, and a flange 104c which extends from the first housing 104a to support the motor 10. The flange 104c receives the input shaft 12. The first housing 104a may be removably attached to the second housing 104b by a plurality of bolts secured by nuts or received in threaded bores formed around a periphery of the first housing 104a and the second

housing 104b, or other fasteners known in the art. An operating chamber 106 is defined between the first housing 104a and second housing 104b and receives an input pinion shaft 108 that is engaged with the input shaft 12 and extends through a portion of the flange 104c of the first housing 104a.

[0023] The input pinion shaft 108 is engaged with a first intermediate gear 110 that is fixedly attached to an end of a first intermediate pinion shaft 112. The first intermediate pinion shaft 112 is aligned and supported for rotation by first intermediate bearing assemblies 114. The first bearing assemblies 114 may include a combination of ball bearings, needle roller bearings, or the like. Rotation of the first intermediate pinion shaft 112 causes rotation of a second intermediate gear 116 engaged with the first intermediate pinion shaft 112 and fixedly attached to an end of a second intermediate pinion shaft 118. The second intermediate pinion shaft 118 is aligned and supported for rotation by second intermediate bearing assemblies 120. The second bearing assemblies 114 may include a combination of ball bearings, needle roller bearings, or the like.

[0024] The first intermediate pinion shaft 112 and the first bearing assemblies 114 are positioned within a first wall 122a of an intermediate housing 122. The second intermediate pinion shaft 118 and the second bearing assemblies 120 are positioned within a second wall 122a of the intermediate housing 122. The second wall 122a includes a longitudinal opening 122c through which the second intermediate pinion shaft 118 engages a drive sub-assembly 150 described in more detail below with reference to FIGS. 2, 4A, and 4B.

[0025] The drive sub-assembly 150 is positioned between a first shaft housing 124 and a second shaft housing 126 of the drive system 100. Each of the first shaft housing 124 and the second shaft housing 126 defines a cylindrical wall that surrounds a portion of the output shaft 102 when installed in the drive system 100. The first shaft housing 124 is a tubular housing formed in and extending from the first housing 104a, and is closed by a cover 128 that includes a sensor 130 that detects a speed of the output shaft 102. In addition, the sensor 130 may detect a position (axial position) of the output shaft 102 with the first shaft housing 124. A thrust plate 132 for limiting axial movement of the output shaft 102 is attached to an end of the output shaft 102 positioned within the first shaft housing 124 proximate to the sensor 130.

[0026] The second shaft housing 126 may include a first outer surface 126a, a second outer surface 126b, and a third outer surface 126c. The first outer surface 126a may have an outer

diameter less than an outer diameter of the second outer surface 126b, which may be less than outer diameter of the third outer surface 126c of the second shaft housing 126. As illustrated in FIG. 1, the output shaft 102 extends through the second shaft housing 126 and out of the second housing 104a through bore 134 defined in a wall of the second housing 104a.

[0027] FIG. 2 is an enlarged view of a portion of FIG. 1 including the drive sub-assembly 150, according to an aspect of the present disclosure. The drive sub-assembly 150 includes an output gear 200 and a hub 202. As illustrated in FIG. 2, the second intermediate pinion shaft 118 is engaged with the output gear 200 which includes a mounting surface 200a on which the hub 202 is attached. The hub 202 includes a base 202a, which defines a flange for receiving fasteners 201 for fixedly attaching the hub 202 to the gear 200. The fasteners 201 may include bolts, screws, or other types of fasteners known in the art capable of joining separate components.

[0028] The hub 202 includes a body extending from the base 202a and having an outer circumferential surface which includes a first outer circumferential surface 202b (hereafter referred to as “first hub outer surface 202b”) and a second outer circumferential surface 202c (hereafter referred to as “second hub outer surface 202c”). As illustrated in FIG. 2, the first outer hub surface 202b extends from the base 202a, and the second outer hub surface 202c extends from the first hub outer surface 202b. A diameter of the first hub outer surface 202b is greater than a diameter of the second hub outer surface 202c so as to form a shoulder 202d on which a first output bearing assembly 204 may be mounted. The first output bearing assembly 204 may be a ball bearing, needle roller bearing, or equivalent bearing assembly. According to an aspect of the present disclosure, the first output bearing assembly 204 includes a first inner race 204a, first rollers 204b, and a first outer race 204c. The first inner race 204a and first rollers 204b may be mounted and attached to the hub 202 such that the first rollers 204b engage the first outer race 204c when the drive sub-assembly 150 is positioned in the housing 104. The first outer race 204c being attached to the first shaft housing 124. Alternatively, the entire first output bearing assembly 204 may be mounted and attached to the hub 202 such that during installation of the driving assembly 150 in to the housing 104, the first outer race 204c is tightly fitted (e.g. friction fitted) or adhered to an inner surface of a portion of the first shaft housing 124.

[0029] A hub outer recess 202e may be formed in the first hub outer surface 202b proximate to (e.g. at or near) a first end face 202f of the hub 202 corresponding to the end of the output shaft 102 including the thrust plate 130. The first end face 202f is provided on an end of the hub positioned within the first shaft housing 124. A first seal 206 may be positioned in the hub outer recess 202e to form a seal between the first shaft housing 124 and the hub 202. The first seal 206 separates a first lubricant buffer zone 208 from a sub-chamber 210 in which the thrust plate 132 and a portion of the sensor 130 extending into the housing 104 are positioned. Accordingly, the first seal 206 prevents lubricating fluid (hereafter referred to as “lubricant”) provided in the operating chamber 106 for lubricating the first output bearing assembly 204 from entering into the sub-chamber 210 and contacting the output shaft 102.

[0030] A second end face 202g provided on an end of the hub 202 that surrounds the second shaft housing 126. The second end face 202g of the hub 202 may include a stepped portion 202h that may be shaped to receive a portion of the output gear 200 that surrounds a second output bearing assembly 212, as illustrated in FIG. 2. The second output bearing assembly 212 may be a ball bearing, needle roller bearing, or equivalent bearing assembly. According to an aspect of the present disclosure, the second output bearing assembly 212 includes a second inner race 212a, second rollers 204b, and a second outer race 212c. The second inner race 212a and second rollers 212b may be mounted and attached to the second shaft housing 126, and the second outer race 212c may be mounted and attached to the gear inner surface 200b. The second rollers 212b may engage the second outer race 212c when the drive sub-assembly 150 is positioned in the housing 104. Alternatively, the entire second output bearing assembly 212 may be mounted and attached to the gear inner surface 200b of the output gear 200 such that the second inner race 212a is tightly fitted (e.g. friction fitted) or adhered on to the third outer surface 126c of the second shaft housing 126 when the drive sub-assembly 150 is positioned on the second shaft housing 126.

[0031] An inner hub recess 202i may be formed in a first inner circumferential surface of the drive sub-assembly 150 that is defined by an inner surface of the hub 202 (hereafter “inner hub surface 202j”), proximate to (e.g. at or near) the second end face 202g of the hub 202. The inner hub recess 202i may include a series of stepped portions in which a second seal 214 is positioned between a second lubricant buffer zone 216 and a gap 218 defined by the inner hub recess 202i

and the first and second outer surfaces 126a, 126b of the second shaft housing 126. The second seal 214, the gap 218, and interface between the inner hub surface 202h and the first outer surface 126 of the second shaft housing 126 provide a sealed area (e.g. a drywell) within the operating chamber 106 which may be filled or substantially filled with the lubricant. According to one aspect of the present disclosure the first or second bearing assemblies 204, 212 may be lubricated directly through conduits or other mechanisms dedicated to delivering the lubricant locally.

[0032] The second seal 214 may be positioned above a spacer 220 (e.g. a shim or packing) located between the second output bearing assembly 212 and the second end face 202g of the hub. According to an aspect of the present disclosure the spacer 220 may be formed in the shape of a flat ring and positioned to have a surface of the flat ring be in abutment with the second seal 214. The spacer 220 may prevent movement of the second seal 214 or one or more components of the of the second output bearing assembly 212 along a longitudinal axis A of the hub 202, and prevent or minimize damage or wear to the second seal 214. As illustrated in FIG. 2, with the output shaft 102, the longitudinal axis A of the hub 202 coincides with a longitudinal axis (not designated) of the output shaft 102.

[0033] The second seal 214 may be positioned in the inner hub recess 202i to form a seal between the second shaft housing 124 and the hub 202. The second seal 214 separates the gap 218 from the second lubricant buffer zone 216 to prevent lubricant in the operating chamber 106 from moving into an interface between the inner hub surface 202j and the first outer surface 126a of the second shaft housing 126. More importantly for applications of the mixing apparatus 1 to food products, the second seal 214 prevents the lubricant from contacting the output shaft 102 in an area of the second shaft housing 126.

[0034] The arrangement of the first seal 206 relative to the hub 202 and the first shaft housing 124, in combination with the arrangement of the second seal 212 relative to the hub 202 and the second shaft housing 124, facilitates lubrication of the first and second output bearing assemblies 204, 212 by the same lubricant (e.g. oil) provided within the operating chamber 106. Thus, different lubricants and different sources of lubricant do not need to be respectively employed within the drive system 100 to lubricate the first and second output bearing assemblies 204, 212. The drive sub-assembly 150 enables the first and second output bearing assemblies

204, 212 to be lubricated by the same type of lubricant, from the same lubricant source, while ensuring the lubricant does not come in contact with the output shaft 102. Each of the first and second seals 206, 214 may be an O-ring, packing, labyrinth seal, gasket, or other sealing mechanism known in the art. The first and second seals 206, 214 may be formed from elastomeric materials (e.g. thermosets, thermoplastics, etc.), soft metals, or other materials known in the art for forming seals.

[0035] The output gear 200 of the drive sub-assembly 150 sets the second output bearing assembly 212. Thus, the output gear 200 limits/allows there to be an amount of axial clearance between bearing rollers and races, and/or limits/allows an amount of axial interference (preload) between bearing rollers and races; or more generally limits/allows an amount of axial movement permitted by the bearing rollers. The output gear 200 rotates and effects a rotation of the output shaft 102, a rotation which is supported by the second output bearing assembly 212. Setting the second output bearing assembly 212 with the output gear 200 may provide improved performance and accuracy in the operation of the second output bearing assembly 212, and thus the output shaft 102, as compared to a bearing assembly that is set by a bearing cap. It will also be understood that the first shaft housing 124 limits the axial movement of first rollers 204b and the first outer race 204c via the attachment/engagement of the first outer race 204c and an inner surface of the first shaft housing 124, and via the engagement of the first outer race 204c with the first rollers 204a. Accordingly, the output gear 200 and the first shaft housing 124 each perform a similar function as, and therefore eliminate a need for, a bearing cap that could be used to set either of the first or second output bearing assemblies 204, 212. Further, the positioning of the output gear 200 with the hub 202 attached so that the output gear 200 engages with the second intermediate pinion shaft 118 effectively aligns both of the first output bearing assembly 204 and the second output bearing assembly 212 radially within the housing assembly 104.

[0036] According to an aspect of the present disclosure, the drive sub-assembly 150 includes a second inner circumferential surface defined by an inner surface of the output gear 200 (hereafter referred to as “gear inner surface 200b”). The gear inner surface 200b provides a bearing bore which accommodates the second output bearing assembly 212. As a result, the output gear 200 minimizes a number of interfaces between components that facilitate support of the rotational movement of the output gear 200 by the second output bearing assembly 212.

More specifically, according to an aspect of the present disclosure, the output gear 200 may be directly engaged with/mounted on the second output bearing assembly 212. Thus, the motion of the output gear 200 is supported by the second output bearing assembly 212 without an additional component operatively positioned between the output gear 200 and the second output bearing assembly 212. The arrangement of the drive sub-assembly 150 including the output gear 200 directly engaged with the second output bearing assembly 212 improves accuracy and performance of the drive system 100 with respect to the rotation of the output shaft 102. In addition, arranging the output gear 200 to be directly attached to the hub 202 and directly engaged with the second output bearing assembly 212 reduces a total number of parts needed for the drive system 100. The reduced number of parts may improve time and ease of assembly for the drive system 100.

[0037] FIGS. 4A and 4B respectively illustrate front and overhead perspective views of the drive sub-assembly 150, according to aspects of the present disclosure. The drive sub-assembly 150 may be assembled into a single part that may be installed in the drive system 100, as well as removed from the drive system 100 and replaced. As illustrated FIGS. 4A and 4B, the drive sub-assembly 150 may include the gear 200, the hub 202, and the first inner race 204a and first rollers 204b of the first output bearing assembly 204 assembled into the single part to be installed in the drive system 100, according to an aspect of the present disclosure. The first output bearing assembly 204 includes a first cage or separator 400 which holds the first rollers 204b.

[0038] As illustrated in FIG. 4B, a key recess 402 may be formed in portions of the inner hub surface 202j along the longitudinal axis A corresponding to the second outer hub surface 202c and the hub outer recess 202e. According to an aspect of the present disclosure, the key recess 402 may extend to the first end face 202f of the hub 202. The key recess 402 may correspond to a shape of a keyed portion (not shown) of the output shaft 102. The keyed portion of the output shaft 102 may fit into the key recess 402 and operatively engage (e.g. lock) the hub 202 with the output shaft 102 so that rotational movement of the output gear 200 and the hub 202 is transmitted to the output shaft 102 (i.e. torque is transferred to output shaft and drives the rotational movement). It will be understood that various configurations including a key recess and a keyed portion may be used with a keyed recess formed in an outer surface of the output shaft 102 and a keyed portion extending from the inner hub surface 202j. It will also be

understood that other arrangements and mechanisms may be employed to operatively engage the hub 202 with the output shaft 102 without increasing the potential for lubricant to contact the output shaft 102. For example, other arrangements and mechanisms may include multiple keyed recesses and keyed portions, splines, locking pins (preferably positioned above the first seal 206), set screws, and the like, or friction fit arrangements.

[0039] According to another aspect of the present disclosure, the drive sub-assembly 150 of FIGS. 4A and 4B may include one more components not shown including the second seal 214, the spacer 220, and one or more components of the second output bearing assembly 206. With reference to FIG. 2, the drive sub-assembly 150 of FIGS. 4A and 4B as the single assembled part may include the second seal 214 positioned within inner hub recess 202i, and the spacer 220 positioned between second end face 202g and the second outer race 212c which is fixed to the inner gear surface 200b. As illustrated in FIG. 2, the inner gear surface 200b may overlap at least a portion the second end face 202g, the second outer race 212c, and the spacer 220 along the longitudinal axis A.

[0040] It will be understood that spacers of different annular dimensions may be provided for the spacer 220 according the present disclosure. As a result, the spacer 220 as applied in the drive sub-assembly 150 of FIGS. 4A and 4B may cover all or a portion of a radial space between the inner gear surface 200b and the second outer surface 126b of the second shaft housing 126. According to an aspect of the present disclosure, the spacer 220 may cover all of the radial space discussed above, and hold the second seal 214 within the inner hub recess 202i when the drive sub-assembly is not installed in the drive system 100.

[0041] FIG. 5 illustrates an exploded view of the drive sub-assembly 150 and a portion of the housing assembly 104 including the second shaft housing 126, according to an aspect of the present disclosure. According to an aspect of the present disclosure, in providing the drive system 100, the second seal 214 may be placed in the inner hub recess 202i and the spacer 220 may be placed inwardly of the mounting surface 200a and between at least the second outer race 212c and the second end face 202g (FIG. 2) of the hub 202. The hub 202 may be attached to the output gear 200 by the fasteners 201 which extend through first bores 500 formed in the hub 202 and second bores 502 formed in the gear 200. Where the fasteners 201 are threaded, at least the second bores 502 may include corresponding threaded surfaces to receive and secure the

fasteners 201 in order to secure the gear 200 to the hub 202. Prior to or after the gear 200 being attached to the hub 202, at least the first inner race 204a, first rollers 204b, and first cage or separator 400 may be mounted and attached to the second hub outer surface 202c/shoulder 202d.

[0042] As can be seen from FIG. 5, the second inner race 212a, the second rollers 212b, and a second cage or separator 504 which holds the second rollers 212b, may be mounted and attached to the first outer surface 126a of the second shaft housing 126. The assembled drive sub-assembly 150 including the output gear 200 and the hub 202 may be mounted on the second shaft housing 126 such that the second rollers 212b engage the second outer race 212c located on the gear inner surface 200b. It will be understood that the first inner race 204a, the first rollers 204b, and first cage or separator 400 may be positioned on the hub 200 before or after a sub-assembly of the hub 202 and the output gear 200 (including at least the second outer race 212c) is positioned on the second shaft housing 126, which may then be followed by the placement of the first seal 206 around the hub outer recess 202e.

[0043] Further aspects of the drive system 100 will be described with reference to FIGS. 1-4. Following a positioning of the first seal 206, the first housing 104a may be mounted on the second housing 104b by aligning an opening defined by the first shaft housing 124 with the hub 202 of the drive sub-assembly 150 as illustrated in FIGS. 1 and 2. As the first housing 104a is located on to the second housing 104b, the first outer race 204c of the first output bearing assembly 204 will engage the first rollers 204b, and the first seal 206 will engage an inner surface of the first shaft housing 124 as illustrated in FIG. 2. The output shaft 102 may be inserted through the bore 134 and passage defined by the second shaft housing 126 and the inner hub surface 202j, thereby engaging the key recess 402 of the hub 202 illustrated in FIG. 4B. The thrust plate 132 illustrated in FIGS. 1 and 2, may be secured to the end of the output shaft 102 via bolts or other fasteners causing the output shaft 102 to be held in place within the drive system 100. Subsequent to the securement of the thrust plate 132, the cover 128 may be fixed on to the first shaft housing 124.

[0044] It will be appreciated that the foregoing description provides examples of the disclosed system and technique. However, it is contemplated that other implementations of the disclosure may differ in detail from the foregoing examples. All references to the disclosure or examples thereof are intended to reference the particular example being discussed at that point

and are not intended to imply any limitation as to the scope of the disclosure more generally. All language of distinction and disparagement with respect to certain features is intended to indicate a lack of preference for those features, but not to exclude such from the scope of the disclosure entirely unless otherwise indicated.

CLAIMS:

We claim:

1. A drive sub-assembly for driving a shaft, the drive sub-assembly comprising:
a hub extending from a first end face to a second end face along a longitudinal axis, the hub having an outer circumferential surface and inner circumferential surface;
at least a first inner race and first rollers of a first bearing assembly; and
a gear attached to the second end face of the hub, the gear having a second inner circumferential surface that is arranged to engage a second bearing assembly,
wherein the outer circumferential surface defines:
a first recess proximate to the first end face, and
a shoulder between the first recess and the second end face along the longitudinal axis,
wherein the first inner race and the first rollers are mounted on the shoulder, and
wherein the first inner circumferential surface defines a second recess proximate to the second end face.
2. The drive sub-assembly of claim 1, further comprising:
a first seal positioned in the first recess; and
a second seal positioned in the second recess.
3. The drive sub-assembly of claim 1,
wherein the second end face is formed on a base of the hub that is positioned on a mounting surface of the gear and defines at least a first bore and a second bore,
wherein the gear defines at least a third bore corresponding to the first bore and a fourth bore corresponding to the second bore, and
wherein the first bore, the second bore, the third bore, and the fourth bore receive fasteners to fixedly attach the gear to the hub.
4. The assembly of claim 1,

wherein the first rollers are arranged to engage a first outer race of the first bearing assembly, and

wherein the drive sub-assembly includes a second outer race of the second bearing assembly, the second outer race being mounted and attached to the second inner circumferential surface.

5. The drive sub-assembly of claim 4, further comprising:
a first seal positioned in the first recess; and
a second seal positioned in the second recess.
6. The drive sub-assembly of claim 5,
further comprising a spacer positioned between the second outer race and the second end face along the longitudinal axis,
wherein the second seal is positioned between the spacer and the second recess along the longitudinal axis in abutment with the spacer.
7. The drive sub-assembly of claim 6,
wherein the second inner circumferential surface extends along the longitudinal axis, and
wherein the second inner circumferential surface overlaps at least a portion of each of the second end face, the spacer, and the second outer race along the longitudinal axis.
8. The drive sub-assembly of claim 6,
wherein the second end face is formed on a base of the hub that is positioned on a mounting surface of the gear and defines at least a first bore and a second bore,
wherein the gear defines at least a third bore corresponding to the first bore and a fourth bore corresponding to the second bore, and
wherein the first bore, the second bore, the third bore, and the fourth bore receive fasteners to fixedly attach the gear to the hub.
9. A drive system for a mixing apparatus that transmits a rotational movement of an input shaft to an output shaft of the mixing apparatus, the drive system comprising:

a housing having a first housing configured to receive the input shaft and a second housing, the second housing including a cylindrical wall extending from the second housing towards the first housing and arranged to receive the output shaft;

a hub mounted on the cylindrical wall;

a gear attached to the hub and configured to transmit the rotational movement of the input shaft to the hub;

a first bearing assembly operatively positioned between the hub and the first housing;

a second bearing assembly operatively positioned on the cylindrical wall and the gear;
and

a plurality of seals positioned between the housing and the hub such that a same fluid lubricates the first bearing assembly and the second bearing assembly and is prevented from contacting the output shaft.

10. The assembly of claim 9,
wherein the gear sets the second bearing assembly relative to a longitudinal axis of the hub.

11. The assembly of claim 10,
wherein an outer race of the second bearing assembly is attached to an inner circumferential surface of the gear, and
wherein an inner race and rollers of the second bearing assembly are attached to the cylindrical wall.

12. The assembly of claim 9,
wherein the hub is mounted on an end of the cylindrical wall within the housing,
wherein the gear is attached to an end of the hub that surrounds the cylindrical wall,
wherein a first seal of the plurality of seals is positioned in an inner circumferential surface of the hub in sealing contact with the cylindrical wall, and
wherein the first seal is positioned along a longitudinal axis of the hub between the end of the cylindrical wall and the second bearing assembly.

13. The assembly of claim 12,
wherein the inner circumferential surface of the hub and an outer surface of the cylindrical wall define a gap there between, and
wherein the first seal separates the gap from a lubricant buffer zone that is defined by the end of the hub and is adjacent to the second bearing assembly along the longitudinal axis.
14. The assembly of claim 12,
wherein a second seal of the plurality of seals is positioned in an outer circumferential surface of the hub in sealing contact with the first housing, and
wherein the second seal is positioned along the longitudinal axis between the first bearing assembly and a cover mounted on the first housing.
15. The assembly of claim 12,
wherein the gear sets the second bearing assembly relative to the longitudinal axis.
16. The assembly of claim 9,
further comprising a pinion shaft operatively engaged with the input shaft and the gear,
wherein the pinion shaft is positioned in an intermediate housing that extends from the second housing towards the first housing, and
wherein the gear operatively engages the pinions shaft through a longitudinal opening defined by a wall of the intermediate housing.
17. A method for driving an output shaft, the method comprising:
applying a force to a gear causing a rotational movement of a hub; and
engaging the output shaft with the hub causing a rotational movement of the output shaft corresponding to the rotational movement of the hub;
wherein the hub includes:
an outer circumferential surface that defines a first recess and a shoulder,
an inner circumferential surface that defines a second recess, and

at least a first inner race and first rollers of a first bearing assembly mounted on the shoulder, and

wherein the gear is attached to the hub and engages second rollers of a second bearing assembly positioned below the second recess along a longitudinal axis.

18. The method of Claim 17, further comprising:

limiting an axial movement of the second bearing assembly with the gear during rotational movement of the output shaft.

19. The method of Claim 17,

wherein a base of the hub is positioned on a mounting surface of the gear and defines at a first bore and a second bore,

wherein the gear defines at least a third bore corresponding to the first bore and a fourth bore corresponding to the second bore,

wherein the first bore, the second bore, the third bore, and the fourth bore receive fasteners to fixedly attach the gear to the hub.

20. The method of Claim 17, further comprising:

lubricating the first bearing assembly and the second bearing assembly with a same fluid provided within an operating chamber,

wherein the first bearing assembly and the second bearing assembly are positioned within the operating chamber on opposite sides of a base of the hub along the longitudinal axis.