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Inventor(s)	Waldhoer; Timo et al.

POWER END OF RECIPROCATING PUMP WITH FASTENER ASSEMBLY

Abstract

A power end frame includes a plurality of rings cooperatively defining an interior of the power end frame configured to enclose a portion of a crankshaft of a power end of the reciprocating pump and a rod extending through each ring of the plurality of rings to couple each ring with an adjacent ring of the plurality of rings.

Inventors: **Waldhoer; Timo (Tahlequah, OK), Hall, JR.; Randall Turner (Claremore, OK)**

Applicant: **GD Energy Products, LLC** (Tulsa, OK)

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to the field of high pressure reciprocating pumps and, in particular, to a power end of high pressure reciprocating pumps.

BACKGROUND

[0002] High pressure reciprocating pumps are often used to deliver high pressure fluids during earth drilling operations. Generally, a reciprocating pump includes a power end and a fluid end. The power end can generate forces sufficient to cause the fluid end to deliver high pressure fluids to earth drilling operations. For example, the power end includes a crankshaft that drives a plurality of reciprocating plungers or pistons near or within the fluid end to pump fluid at high pressure. The power end also includes a frame that supports and encloses components of the power end, such as the crank shaft. The frame is arranged to withstand stress (e.g., a mechanically induced stress, a hydraulically induced stress) being produced during operation of the reciprocating pump to enable desirable performance of the reciprocating pump.

SUMMARY

[0003] The present application relates to a power end frame of a reciprocating pump. The techniques discussed herein may be embodied as a power end frame, a method for assembling a reciprocating pump, and a reciprocating pump.

[0004] More specifically, in accordance with at least one embodiment, the present application is directed to a power end frame of a reciprocating pump. The power end frame includes a plurality of rings cooperatively defining an interior of the power end frame configured to enclose a portion of a crankshaft of a power end of the reciprocating pump and a rod extending through each ring of the plurality of rings to couple each ring with an adjacent ring of the plurality of rings.

[0005] In accordance with another embodiment, the present application is directed to a method. The method includes aligning a plurality of rings with one another to define an interior of the power end frame configured to enclose a portion of a crankshaft of a power end of the reciprocating pump, inserting a rod through the plurality of rings, and securing the plurality of rings together with the rod.

[0006] In accordance with yet another embodiment, the present application is directed to a reciprocating pump. The reciprocating pump includes a fluid end configured to enclose a reciprocating element configured to receive and discharge fluid and a power end configured to enclose a portion of a crankshaft configured to operate the reciprocating element. The power end includes a plurality of rings, each ring of the plurality rings having a base and a flange extending from the base, as well as a rod extending through the flange of each ring of the plurality of rings.

[0007] The foregoing advantages and features will become evident in view of the drawings and detailed description.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] To complete the description and in order to provide for a better understanding of the present application, a set of drawings is provided. The drawings form an integral part of the description and illustrate embodiments of the present application, which should not be interpreted as restricting the scope of the disclosure, but just as examples. The drawings comprise the following figures:

[0009] FIG. **1** is a front perspective view of a prior art reciprocating pump including a fluid end and a power end.

[0010] FIG. **2**A is a side cross-sectional view of the prior art reciprocating pump of FIG. **1**.

[0011] FIG. **2**B is a front perspective view of a prior art power end.

[0012] FIG. **3**A is a rear perspective view of a power end frame of a reciprocating pump having a fastener assembly, according to an example embodiment of the present application.

[0013] FIG. **3**B is a rear perspective view the power end frame of FIG. **3**A illustrating a cross-section of the fastener assembly.

[0014] FIG. **4** is a rear perspective view of another power end frame of a reciprocating pump having a fastener assembly, according to an example embodiment of the present application.

[0015] FIG. **5** is a rear perspective view of a ring of a power end frame of a reciprocating pump, according to an example embodiment of the present application.
[0016] FIG. **6** is a rear perspective view of yet another power end frame of a reciprocating pump having a fastener assembly, according to an example embodiment of the present application.
[0017] FIG. **7** is a rear perspective view of a ring of the power end frame of FIG. **6**.
[0018] FIG. **8** is a rear perspective view of still another power end frame of a reciprocating pump having a fastener assembly, according to an example embodiment of the present application.
[0019] FIG. **9** is a rear perspective view of a ring of the power end frame of FIG. **8**.
[0020] FIG. **10** is a flowchart of a method of manufacture of a power end frame of a reciprocating pump, according to an example embodiment of the present application.
[0021] Like reference numerals have been used to identify like elements throughout this disclosure.

DETAILED DESCRIPTION

[0022] The following description is not to be taken in a limiting sense but is given solely for the purpose of describing the broad principles of the disclosure. Embodiments of the disclosure will be described by way of example, with reference to the above-mentioned drawings showing elements and results according to the present disclosure.
[0023] Generally, the present application is directed to a power end frame of a reciprocating pump. The power end frame includes rings that are coupled to one another via a fastener assembly to define an interior and an exterior of the power end frame. The fastener assembly includes a rod that extends through the rings and locks that are coupled to the rod to compress the rings toward one another to couple the rings to one another. By way of example, the locks include nuts that are threaded onto the ends of the rod and abut the rings to compress the rings toward one another. In some embodiments, the fastener assembly supplements other components, such as welds, that couple the rings together. The fastener assembly provides additional structural support that reduces deflection of the power end frame. For example, the fastener assembly may increase a stiffness of a portion of the ring to block deformation that otherwise may occur during operation of the reciprocating pump (e.g., caused by a force imparted onto the portion of the ring). As such, the fastener assembly may help maintain a structural integrity of the power end frame to increase a useful lifespan of the power end frame.
[0024] Referring to FIG. **1**, a prior art reciprocating pump **100** is illustrated. The reciprocating pump **100** includes a power end **102** and a fluid end **104**. The power end **102** includes a crankshaft that drives a plurality of reciprocating plungers or pistons (generally referred to as “reciprocating elements”) enclosed within the fluid end **104** to pump fluid at high pressure (e.g., to cause the fluid end **104** to deliver high pressure fluids to earth drilling operations). For example, the power end **102** may be configured to support hydraulic fracturing (i.e., fracking) operations, where fracking liquid (e.g., a mixture of water, chemicals, and/or sand) is injected into rock formations at high pressures to allow natural oil and gas to be extracted from the rock formations. However, to be clear, this example is not intended to be limiting, and the present application may be applicable to both fracking and drilling operations, as well as any other suitable operations.
[0025] In any case, often, the reciprocating pump **100** may be quite large and may, for example, be supported by a semi-tractor truck (“semi”) that can move the reciprocating pump **100** to and from a well. Specifically, in some instances, a semi may move the reciprocating pump **100** off a well to perform maintenance on the reciprocating pump **100**. However, a reciprocating pump **100** is typically moved off a well only when a replacement pump (and an associated semi) is available to move into place at the well, which may be rare. Thus, often, the reciprocating pump **100** is taken offline at a well and maintenance is performed while the reciprocating pump **100** remains on the well. If not for this maintenance, the reciprocating pump **100** could operate continuously to extract natural oil and gas (or conduct any other operation). Consequently, any improvements that extend the lifespan of components of the reciprocating pump **100**, extend the time between maintenance operations (i.e., between downtime), and/or minimize the time to complete maintenance operations

(minimizing downtime) are highly desirable.
[0026] Still referring to FIG. **1**, but now in combination with FIG. **2**A, the reciprocating pump **100** pumps fluid into and out of pumping chambers **208**. FIG. **2**A shows a side, cross-sectional view of reciprocating pump **100** taken along a central axis **209** of one of the reciprocating elements **202** included in reciprocating pump **100**. Thus, FIG. **2**A depicts a single pumping chamber **208**. However, it should be understood that a fluid end **104** can include multiple pumping chambers **208** arranged side-by-side. In fact, in at least some embodiments (e.g., the embodiment of FIG. **1**), a casing **206** of the fluid end **104** forms a plurality of pumping chambers **208**, and each pumping chamber **208** includes a reciprocating element **202** that reciprocates within the casing **206**. However, side-by-side pumping chambers **208** need not be defined by a single casing **206**. For example, in some embodiments, the fluid end **104** may be modular, and different casing segments may house one or more pumping chambers **208**. In any case, the one or more pumping chambers **208** are arranged side-by-side so that corresponding conduits are positioned adjacent to each other and generate substantially parallel pumping action. Specifically, with each stroke of the reciprocating element **202**, low pressure fluid is drawn into the pumping chamber **208** and high pressure fluid is discharged. During these operations, movement of the crankshaft **103**, movement of the reciprocating element **202**, and/or flow of fluid, as well as other moving parts, components, and/or flows, may generate stress at the power end **102**. The stress can affect a structural integrity of the power end **102**. Therefore, maintenance operations (e.g., inspection, replacement, repair) may be performed with respect to the power end **102** to ensure continued operation of the reciprocating pump **100**.
[0027] In various embodiments, the fluid end **104** may be shaped differently and/or have different features, but may still generally perform the same functions, define similar structures, and house similar components. For example, while the fluid end **104** includes a first bore **204** that intersects an inlet bore **212** and an outlet bore **222** at skewed angles, other fluid ends may include any number of bores arranged along any desired angle or angles, for example, to intersect the first bore **204** (and/or an access bore) substantially orthogonally and/or so that two or more bores are substantially coaxial. Generally, the bores **212** and **222**, as well as any other bores (i.e., segments, conduits, etc.), may intersect to form a pumping chamber **208**, may be cylindrical or non-cylindrical, and may define openings at an external surface **210** of the casing **206**. Additionally, the bores **212** and **222**, as well as any other bores (i.e., segments, conduits, etc.), may receive various components or structures, such as sealing assemblies or components thereof.
[0028] In the depicted embodiment, the inlet bore **212** defines a fluid path through the fluid end **104** that connects the pumping chamber **208** to a piping system **106** delivering fluid to the fluid end **104**. Meanwhile, the outlet bore **222** allows compressed fluid to exit the fluid end **104**. Thus, in operation, the bores **212** and **222** may include valve components **51** and **52**, respectively, (e.g., one-way valves) that allow the bores **212** and **222** to selectively open and deliver a fluid through the fluid end **104**. Typically, valve components **51** in the inlet bore **212** may be secured therein by a piping system **106** (see FIG. **1**). Meanwhile, valve components **52** in outlet bore **222** may be secured therein by a closure assembly **53** that, in the prior art example illustrated in FIG. **2**A, is removably coupled to the fluid end **104** via threads.
[0029] In operation, fluid may enter fluid end **104** via outer openings of inlet bores **212** and exit fluid end **104** via outer openings of outlet bores **222**. More specifically, fluid may enter inlet bores **212** via pipes of piping system **106**, flow through the pumping chamber **208** (due to reciprocation of a reciprocating elements **202**), and then through the outlet bores **222** into a channel **108** (see FIG. **1**). However, the piping system **106** and the channel **108** are merely example conduits and, in various embodiments, the fluid end **104** may receive and discharge fluid via any number of pipes and/or conduits, along pathways of any desirable size or shape.
[0030] Meanwhile, each of the first bores **204** defines, at least in part, a cylinder for reciprocating elements **202** and/or connects the casing **206** to a cylinder for reciprocating elements **202**. More

specifically, in the illustrated embodiment, a casing segment **207** houses a packing assembly **36** configured to seal against a reciprocating element **202** disposed interiorly of the packing assembly **36**. Reciprocation of a reciprocating element **202** in or adjacent to the first bore **204**, which may be referred to as a reciprocation bore (or, for fracking applications, a plunger bore), draws fluid into the pumping chamber **208** via the inlet bore **212** and pumps the fluid out of the pumping chamber **208** via the outlet bore **222**. To help provide access to these parts and/or the pumping chamber **208**, such as for performing maintenance operations, some fluid ends **104** have access bores that are often aligned with (and sometimes coaxial with) the first bore **204**. Other fluid ends **104** need not include an access bore and, thus, such an access bore is not illustrated in FIGS. **1** and **2**A.

[0031] Regardless of whether the fluid end **104** includes an access bore, the packing assembly **36** typically is to be replaced from an outer opening of the first bore **204** (i.e., a side of the first bore **204** aligned with the external surface **210** of the casing **206**). At the same time, to operate properly, the fluid end **104** is to be securely and stably coupled to the power end **102**. Thus, often, with prior art reciprocating pumps like the reciprocating pump **100**, the fluid end **104** is directly coupled to the power end **102** with relatively short couplers **175**, and at least a portion of the reciprocating pump **100** is to be disassembled to access the first bore **204**, e.g., to replace packing assembly **36**.

[0032] Now turning to FIGS. **2**A and **2**B, in the depicted prior art reciprocating pump **100**, couplers **175** (e.g., tie rods, which are sometimes referred to as stay rods) are threaded to a nose plate **172** of a crosshead assembly **170** of the power end **102** to position the fluid end **104** in close proximity to the power end **102**. More specifically, with the prior art power end **102**, the locations at which a fluid end **104** may be coupled to the power end **102** are fixed and/or preset by a set of receptacles **1730**. In this particular prior art power end **102**, the nose plate **172** defines the locations of receptacles **1730** for the power end **102** (which is positioned at and/or generally defines a front of the power end **102**). However, in other embodiments, receptacles **1730** could be included in any part or portion of a power end. That is, the power end **102** may include a frame **368** that extends from a front **369** to a back **367**, and the receptacles **1730** may generally be included in the front **369** of frame **368**. Receptacles **1730** can be seen in FIG. **2**B, which shows the power end **102** disconnected from the fluid end **104**, e.g., during maintenance of the packing assembly **36** included in the fluid end **104**. FIG. **2**B also shows how, in this particular embodiment, the nose plate **172** extends from a first end **1726** to a second end **1728** and also extends from a back surface **1720** to a front surface **1722**.

[0033] In the depicted embodiment, the receptacles **1730** extend into the nose plate **172** from the front surface **1722** and are generally disposed around pony rod holes **1740**. However, in other embodiments, the receptacles **1730** need not be positioned as such. In any case, the receptacles **1730** may be threaded so that a threaded coupler **175** can be secured directly therein. Still further, in some instances, the receptacles **1730** need not extend through back surface **1720**, which may prevent the couplers **175** from extending into the crosshead assembly **170** and interfering with operations of the crosshead assembly **170** and/or allowing contaminants into the crosshead assembly **170**. However, other embodiments might include receptacles that are through holes.

[0034] Still referring to FIGS. **2**A and **2**B, in the prior art reciprocating pump **100**—and in most high pressure reciprocating pumps—a crosshead frame **174** is a part of a crosshead assembly **170** that converts rotational motion of the crankshaft **103** into linear, reciprocating motion of a pony rod **185**. More specifically, the crosshead assembly **170** includes a connecting rod **171**, a crosshead **173**, and a pony rod **185**. The crosshead **173** includes a connector **176** disposed within a crosshead frame **174**, and the connecting rod **171** extends from the crankshaft **103** to the connector **176**. The connector **176** is configured to move linearly within the crosshead frame **174**, and opposite ends of the connecting rod **171** are configured to travel with the crankshaft **103** and the connector **176**.

[0035] Thus, as the connecting rod **171** rotates with the crankshaft **103**, the connecting rod **171** reciprocates the connector **176** within the crosshead frame **174**. The connector **176** is also connected to a back side **186** of the pony rod **185** so that the pony rod **185** reciprocates with the

connector **176**. Meanwhile, a front side **187** of the pony rod **185** can be coupled to a reciprocating element **202** (e.g., a plunger), such as via a clamp, to drive reciprocating motion of the reciprocating element **202** that pumps fluid through the fluid end **104**. Notably, during this action, the pony rod **185** and/or the crosshead **173** exert forces on the frame **368**. These forces stress the frame **368** (and potentially the crosshead frame **174**). Such forces may affect a structural integrity of the frame **368**. For this reason, forces imparted onto the frame **368** may wear out (e.g., decrease a useful lifespan of) the frame **368** and/or cause downtime of the power end **102**, such as to enable performance of a maintenance operation with respect to the frame **368**, thereby reducing effective operation of the reciprocating pump **100**.

[0036] FIG. **3**A is a rear perspective view of a power end frame **400** of a power end of a reciprocating pump in an assembled configuration. The power end frame **400** is configured to enclose another component of the reciprocating pump, such as a portion of a crankshaft configured to operate a reciprocating element, in the assembled configuration. For visualization purposes, certain components, such as a crankshaft, a crosshead assembly, a nose plate, and rods, are not shown in FIG. **3**A. The power end frame **400** is composed of multiple rings **402** coupled to one another. For instance, each ring **402** may include a base **404**, and the base **404** of adjacent rings **402** abut one another. Each base **404** defines a respective opening **406** (e.g., a crankshaft bore) in which components (e.g., a crankshaft) of the power end may be positioned. Additionally, each ring **402** includes a stand **408** configured to support and stabilize placement of the rings **402**, e.g., on a skid (not shown). As an example, the stands **408** may help balance and maintain a position of the rings **402**, as well as support a weight of the power end frame **400**. A fluid end (e.g., the fluid end **104**) may be coupled to the power end frame **400**, such as via a nose plate (not shown) configured to extend across a surface **409** of each ring **402**.

[0037] The rings **402** cooperatively form an interior **412** of the power end frame **400**. For example, the opening **406** of each ring **402** may align with one another. Additionally, portions of the bases **404** of adjacent rings **402** are offset from one another to form a compartment **414** (e.g., a gap, a space) therebetween. To this end, the bases **404** include lips **415** configured to abut one another to form the compartments **414**. The openings **406** and the compartments **414** cooperatively form the interior **412**. As such, certain components of the power end may be positioned within the openings **406** and/or within the compartments **414**.

[0038] A fastener assembly **416** is configured to couple the rings **402** to one another. As an example, each ring **402** may include a flange **418** extending from the base **404** away from the interior **412**. A rod or bolt (not shown) of the fastener assembly **416** extends through each flange **418** at an exterior of the power end frame **400**. Locks **420** are coupled to ends of the rod and abut against the flange **418** of end rings **402**A positioned at opposite ends of the power end frame **400**. For example, the locks **420** may include nuts configured to threadedly engage the ends of the rod. Abutment of the locks **420** against the flanges **418** of the end rings **402**A compresses the rings **402** against one another to restrict movement of the rings **402** relative to one another, thereby securing the rings **402** together. In some embodiments, a space **422** spans between the flanges **418** of adjacent rings **402**. In such embodiments, sleeves or spacers **424** are positioned within the space **422** between adjacent rings **402** to block unwanted deformation of the flanges **418** during compression of the rings **402** to one another. That is, the flanges **418** of the rings **402** abut against the sleeves **424** to prevent or at least discourage further deflection and movement of the flanges **418** during compression. Consequently, the sleeves **424** restrict movement of the rings **402** relative to one another to help secure the rings **402** together. The rod extends through each of the sleeves **424** to secure the sleeves within the space **422**. In additional or alternative embodiments, the rod may not extend through the sleeves positioned within the space **422**.

[0039] The fastener assembly **416** provides support at and between the rings **402** to stiffen the power end frame **400**. As an example, the fastener assembly **416** may block relative movement of the rings **402** at and adjacent to the flanges **418** (e.g., via compression of the flanges **418** to one

another). Thus, deflection at such portions of the rings **402**, which otherwise may occur during operation of the reciprocating pump as a result of produced forces imparted on the rings **402**, may be prevented or at least discouraged. Indeed, the fastener assembly **416** may absorb such forces imparted on the portions of the ring **402**. As such, the fastener assembly **416** may reduce or limit additional stress that, for instance, may be imparted on the flanges **418**. Additionally, by limiting deformation of the rings **402**, the fastener assembly **416** may also reduce or limit additional stress that may otherwise be produced as a result of deformation of the rings **402**, such as of the flanges **418** (e.g., to affect engagement with an adjacent ring **402**). Accordingly, the fastener assembly **416** may reduce fatigue of the rings **402** to help maintain a structural integrity of the power end frame **400**.

[0040] By way of example, the flange **418** may extend from a surface **410**, opposite of the surface **409** configured to couple to the fluid end. Thus, the flange **418** may extend away from the surface **409** and the fluid end. Implementation of the fastener assembly **416** at the flange **418** extending from the surface **410** may be particularly beneficial for limiting an excessive amount of forces from being imparted on the power end frame **400** that could otherwise deform the rings **402**. However, an additional or alternative fastener assembly may be implemented at another portion of the power end frame **400**, such as at the surface **409** and/or adjacent to the stands **408**.

[0041] Moreover, the fastener assembly **416** may provide greater stability as compared to another type of coupling technique, such as a weld. For example, the fastener assembly **416** may be configured to absorb a greater amount of force without reducing coupling of the rings **402** to one another. Thus, the fastener assembly **416** may more effectively increase the stiffness of the power end frame **400** and reduce potential fatigue at the rings **402**, which otherwise may occur by coupling the rings **402** to one another using welds alone. Thus, the fastener assembly **416** may provide sufficient structural securement of the rings **402** to one another without usage of welds. Alternatively, in certain embodiments, the fastener assembly **416** may supplement another coupling technique used to couple the rings **402** to one another. For instance, welds may be applied at the bases **404** (e.g., at the lips **415**) to couple the bases **404** to one another, and the fastener assembly **416** may be implemented to couple the flanges **418** to one another. It should be noted, however, that the fastener assembly **416** may reduce a quantity or amount of welds used to couple the rings **402** to one another, which may in turn reduce a cost associated with manufacture of the power end frame **400**.

[0042] Further still, the fastener assembly **416** enables sufficient accessibility within the power end frame **400**. As an example, the positioning of the fastener assembly **416** at an exterior of the power end frame **400** may avoid blocking the interior **412** of the power end frame **400**. As another example, the fastener assembly **416** may be readily removable (e.g., by removing the rod) to enable the rings **402** to be separated from one another for access to the interior **412** of the power end frame **400**. Thus, the fastener assembly **416** increases flexibility of adjusting a configuration of the fastener assembly **416**, such as for performing an inspection, a maintenance, and/or a modification of the power end frame **400**.

[0043] FIG. **3**B is a rear perspective view of the power end frame **400** illustrating a cross-section of the fastener assembly **416**. The illustrated embodiment includes a rod or bolt **450** (e.g., a tie rod, a tie bolt) extending through the flanges **418** of each ring **402** and through the sleeves **424** positioned between the flanges **418**. Ends **452** of the rod **450** extend beyond a lateral boundary of the rings **402** and are therefore exposed to enable the locks **420** to be coupled to (e.g., threaded on) the ends **452**.

[0044] In the illustrated embodiment, the rings **402** are positioned (e.g., stacked) next to one another along an axis **454**, and the rod **450** extends along the axis **454** through the flanges **418** and sleeves **424**. In other words, the rod **450** extends in generally the same direction along which the rings **402** are positioned adjacent to one another. However, in additional or alternative embodiments, the rod **450** may extend in a different direction along which the rings **402** are

positioned adjacent to one another. Furthermore, although a single rod **450** extending through the rings **402** is shown, in additional or alternative embodiments, the power end frame **400** may include multiple rods. As an example, each of the rods may extend through all of the rings **402**. As another example, each rod may extend through different rings **402**. For instance, a first rod may extend through a subset of the rings **402**, and a second rod may extend through a remainder of the rings **402**. Indeed, any suitable arrangement of rods may be utilized to secure the rings **402** to one another.

[0045] FIG. **4** is a rear perspective view of a power end frame **500**. The power end frame **500** includes rings **502** that have a base **504** defining a respective opening **506**. In addition, plates **508** are positioned between and abut adjacent rings **502**. The positioning of the plates **508** between the rings **502** provide compartments **510** between the bases **504**. That is, the rings **502** do not directly contact one another in the power end frame **500** and are offset by the compartments **510**. As such, the rings **502** and the bases **504** cooperatively form an interior **512** of the power end frame **500**.

[0046] A fastener assembly **516** is configured to couple the rings **502** to one another. To this end, each ring **502** includes a flange **518** extending from the base **504** away from the interior **512** and away from the plates **508**, and a rod or bolt (not shown) of the fastener assembly **516** extends through each flange **518**. For example, the rod may extend along an axis **520** along which the rings **502** are positioned adjacent to one another, an end of the rod may extend laterally beyond the rings **502** along the axis **520**, and locks **522** may couple to (e.g., threadedly engage) the ends to compress the flanges **518** and therefore the rings **502** against one another. Sleeves **524** are positioned between spaces **526** spanning between the flanges **518** of adjacent rings **502** to block deformation of the flanges **518** during compression of the rings **502** to one another. Thus, each sleeve **524** extends in overlap with a corresponding plate **508** between adjacent rings **502**.

[0047] In some embodiments, the fastener assembly **516** supplements another coupling technique. By way of example, welds may be applied at the bases **504** and/or at the plates **508** to couple the rings **502** and plates **508** to one another. However, in alternative embodiments, the fastener assembly **516** couples the rings **502** and plates **508** to one another without usage of welds or another coupling technique.

[0048] FIG. **5** is a rear perspective view of a ring **550**, such as one of the rings **402** and/or one of the rings **502**, of a power end frame. The ring **550** includes a base **552** and a flange **554** extending from the base **552**. The flange **554** includes a hole **556** configured to receive a rod of a fastening assembly for coupling the ring **550** to an adjacent ring **550** or an adjacent plate of the power end frame. The flange **554** has a triangular shape extending from the base **552** in the illustrated embodiment to provide a rounded corner of the ring **550**, but the flange **554** may have any suitable shape in additional or alternative embodiments.

[0049] Furthermore, the base **552** includes a lip **558** that extends and is configured to abut an adjacent ring **550** or an adjacent plate to form a compartment. The lip **558** also creates a recess **560** that offsets a corner **562** from the adjacent ring **550** or the adjacent plate. As such, the corner **562** is positioned away from the abutment with the adjacent ring **550** or with the adjacent plate. Thus, stress imparted on the corner **562** (e.g., stress concentrating at the corner due to a geometric discontinuity of the corner **562**) is away from the interface between the ring **550** and the adjacent ring **550** or the adjacent plate. Consequently, the effect of such stress on the coupling of the ring **550** to the adjacent ring **550** or to the adjacent plate may be reduced. As such, the coupling of the ring **550** to the adjacent ring **550** or to the adjacent plate may be maintained. For this reason, the lip **558** may increase structural rigidity of the power end frame.

[0050] FIG. **6** is a rear perspective view of a power end frame **600**. The power end frame **600** includes rings **602** that are coupled to one another. Each ring **602** includes a base **604** and a flange **606** extending from the base **604**. For example, the base **604** may have a circular shape, and the flange **606** may extend radially from the base **604**. Thus, the flange **606** may surround (e.g., circumferentially surround) at least a portion of a perimeter of the base **604**. The bases **604** of

adjacent rings **602** abut one another in the illustrated embodiment. However, in additional or alternative embodiments, the power end frame **600** may include plates positioned between adjacent rings **602** such that adjacent rings **602** are not in direct contact with one another.

[0051] A fastener assembly **608** is configured to couple the rings **602** to one another. For example, because the flange **606** of each ring **602** surrounds a perimeter of the base **604**, each flange **606** may accommodate multiple rods or bolts (not shown) of the fastener assembly **608** inserted therethrough. That is, rods may extend through different portions of the flange **606** to secure the rings **602** to one another. Sleeves **610** are positioned between the flanges **606** of adjacent rings **602** to block deformation of the flanges **606** and facilitate coupling of the rings **602** to one another. Additionally, ends of each rod extend beyond a lateral boundary of the rings **602** (e.g., along an axis **612** along which the rings **602** are positioned adjacent to one another), and locks **614** couple to the ends of the rod to compress the flanges **606** of the rings **602** to one another, thereby securing the rings **602** together.

[0052] In some embodiments, the fastener assembly **608** having rods extending through different portions of the flanges **606** may sufficiently couple the rings **602** to one another without having to use an additional coupling technique, such as welds. Indeed, by distributing the rods about the rings **602**, movement (e.g., deformation) of different parts of the rings **602** relative to one another may be blocked. However, in additional or alternative embodiments, the fastener assembly **608** may supplement another coupling technique.

[0053] FIG. **7** is a rear perspective view of the ring **602** of the power end frame **600**. The base **604** of the ring **602** defines an opening **650**, and the opening **650** cooperatively defines an interior of the power end frame **600** with openings **650** of other rings **602** in an assembled configuration. Holes **652** are distributed about the flange **606**. The holes **652** are configured to align with corresponding holes **652** of an adjacent ring **602** to enable a rod of the fastener assembly **608** to extend through the aligned holes **652** and couple the ring **602** and the adjacent ring **602** to one another.

[0054] The base **604** includes a lip **654** that extends and is configured to abut an adjacent ring **602** or an adjacent plate. The lip **654** creates a recess **656** that offsets a corner **658** from the adjacent ring **602** or the adjacent plate. Thus, the corner **658** is positioned away from the abutment with the adjacent ring **602** or with the adjacent plate to reduce an amount of stress imparted at the interface between the ring **602** and the adjacent ring **602** or the adjacent plate, thereby maintaining the coupling of the ring **602** to the adjacent ring **602** or to the adjacent plate to increase structural rigidity of the power end frame **600**.

[0055] FIG. **8** is a rear perspective view of a power end frame **700**. The power end frame **700** includes rings **702** and plates **704** positioned between adjacent rings **702**. Thus, the plates **704** offset the rings **702** from one another to create compartments **705**. However, in additional or alternative embodiments, the rings **702** (e.g., bases **706** of the rings **702**) may directly abut one another.

[0056] Each ring **702** also includes a flange **708** extending from the base **706**, as well as extensions **710** extending from the flange **708**. The extensions **710** of adjacent rings **702** are configured to abut one another. For instance, the plate **704** offsets the adjacent rings **702** from one another to form a space **712** between the flanges **708**, and the extensions **710** cooperatively span the space **712**. The extensions **710** and flanges **708** accommodate a fastener assembly **714** for securing the rings **702** and the plates **704** to one another. Specifically, FIG. **8** illustrates a cross- section of the fastener assembly **714** to show a rod or bolt **716** extending through the extensions **710** and the flanges **708** of each ring **702**. Ends **718** of the rod **716** extend beyond a lateral boundary of the rings **702** (e.g., along an axis **720** along which the rings **702** are positioned adjacent to one another), and locks **722** are coupled to the ends **718** to compress the flanges **708** to one another, which may cause the extensions **710** of adjacent rings **702** to abut one another. Thus, the extensions **710** block further deformation of the flanges **708** and enable the fastener assembly **714** to secure the rings **702** to one another without having to position sleeves between the flanges **708**. Therefore, the extensions **710**

may facilitate an case of manufacture of the power end frame **700** and/or reduce a cost associated with manufacture of the power end frame **700** (e.g., by reducing a quantity of components to be manufactured).

[0057] The fastener assembly **714** may be used as the only coupling technique or may supplement an additional coupling technique, such as welds, to couple the rings **702** to one another. Additionally, in certain embodiments, the flanges **708** may accommodate extension of multiple rods **716** therethrough. By way of example, the flanges **708** may surround a perimeter of the base **706**, and the extensions **710** may extend from different portions of each flange **708**. The rod **716** may be inserted through each extension **710** at the different portions. Thus, the fastener assembly **714** may be distributed around the rings **702** to provide greater securement of the rings **702** together.

[0058] FIG. **9** is a perspective view of one of the rings **702** of the power end frame **700**. The base **706** of the ring **702** defines an opening **750**, and the opening **750** cooperatively defines an interior of the power end frame **700** with openings **750** of other rings **702** in an assembled configuration. Holes **752** extend through the extensions **710** and the flange **708** to enable insertion of the rod **716** therethrough. Although the extensions **710** are cylindrical in the illustrated embodiment, the extensions **710** can have any suitable shape in additional or alternative embodiments.

[0059] The ring **702** includes a lip **754** that extends and is configured to abut an adjacent ring **702** or an adjacent plate **704**. The lip **754** creates a recess **756** that offsets a corner **758** from the adjacent ring **702** or the adjacent plate **704** to reduce an amount of stress imparted at the interface between the ring **702** and the adjacent ring **702** or the adjacent plate **704**. Thus, coupling of the ring **702** to the adjacent ring **702** or to the adjacent plate **704** is maintained to increase structural rigidity of the power end frame **700**.

[0060] It should be noted that other embodiments of power end frames having rings that are coupled to one another using a fastener assembly may be provided. By way of example, the rings may have flanges that are directly in contact with one another. In other words, there is no substantial space formed between the flanges of adjacent rings. In such embodiments, a rod of the fastener assembly may be inserted through each flange to compress the flanges to one another without usage of a sleeve positioned between the flanges and/or extensions that extend between the flanges.

[0061] FIG. **10** is a flowchart of a method **800** of manufacture of a power end frame, such as any of the power end frame **400**, **500**, **600**, **700** discussed herein. It should be noted that the method **800** may be performed differently in additional or alternative embodiments. For example, an additional operation may be performed, and/or any of the operations of the method **800** may be performed differently, performed in a different order, or not performed.

[0062] At block **802**, rings of the power end frame are aligned with one another. For instance, each ring includes a base that defines an opening, and the openings of the rings are concentrically aligned with one another. Moreover, each ring includes a flange that extends from the base, and each flange has a hole. Alignment of the rings with one another concentrically aligns the holes with one another.

[0063] Alignment of the rings positions the rings adjacent to one another along an axis. In some embodiments, the power end frame includes plate positioned between adjacent rings. In such embodiments, the plates offset the rings from one another such that the rings are not in direct contact with one another. In additional or alternative embodiments, the power end frame does not include plates, and the rings directly contact one another.

[0064] In either case, the flanges of adjacent rings may be offset from one another to create a space therebetween. In certain embodiments, sleeves are positioned within the space. Each sleeve includes a hole, and the sleeves are positioned to align the holes concentrically with the holes of the flanges. Additionally or alternatively, extensions extend from each flange, and the extensions of adjacent rings cooperatively span the space between the flanges of the adjacent rings. Each

extension includes a hole that is concentrically aligned with one another.

[0065] At block **804**, a rod or bolt is inserted through the holes of the flanges of the rings. Thus, the rod extends through each ring of the power end frame, such as along the axis along which the rings are positioned adjacent to one another. In embodiments in which sleeves are positioned between the flanges of adjacent rings, the rod is also inserted through the holes of the sleeves. In embodiments in which extensions span the space between the flanges of adjacent rings, the rod is inserted through the holes of the extensions.

[0066] At block **806**, the rings are secured together with the rod. By way of example, insertion of the rod through the rings may position ends of the rings beyond a lateral boundary of the rings, and locks may be coupled to (e.g., threadedly engage) the rod. The locks may abut end rings and impart a force to place the rod under tension and to compress the flanges of the rings to one another to secure the rings together. The sleeves positioned between the flanges of adjacent rings and/or extensions extending between the flanges of adjacent rings block excessive deflection of the flanges to enable securement of the rings to one another.

[0067] In some embodiments, the locks are coupled to provide a target amount of compressive force (e.g., a clamp load) to maintain a desirable stiffness of the power end frame. For example, the target amount of compressive force may enable the rod to absorb forces (e.g., during operation of the power end frame) that otherwise may cause the rings to deflect. Thus, the locks may be selectively coupled to secure the rings to one another in a desirable manner.

[0068] In certain embodiments, an additional coupling technique, such as welding, is used to secure the rings to one another. In such embodiments, the rod may be inserted before, after, or during implementation of the additional coupling technique. Furthermore, certain operations of the method **800** may be repeated. For example, multiple rods may be implemented by inserting multiple rods through the rings (e.g., at different portions of the flanges) and securing the rings together with each rod. Thus, different parts of the rings may be secured to one another and further increase structural rigidity of the power end frame.

[0069] While the disclosure has been illustrated and described in detail and with reference to specific embodiments thereof, it is nevertheless not intended to be limited to the details shown, since it will be apparent that various modifications and structural changes may be made therein without departing from the scope and within the scope and range of equivalents of the claims. In addition, various features from one of the embodiments may be incorporated into another of the embodiments. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the disclosure as set forth in the following claims.

[0070] Similarly, it is intended that the present disclosure cover the modifications and variations of this disclosure that come within the scope of the appended claims and their equivalents. For example, it is to be understood that terms such as “left,” “right,” “top,” “bottom,” “front,” “rear,” “side,” “height,” “length,” “width,” “upper,” “lower,” “interior,” “exterior,” “inner,” “outer” and the like as may be used herein, merely describe points of reference and do not limit the present disclosure to any particular orientation or configuration. Further, the term “exemplary” is used herein to describe an example or illustration. Any embodiment described herein as exemplary is not to be construed as a preferred or advantageous embodiment, but rather as one example or illustration of a possible embodiment of the disclosure.

[0071] Finally, when used herein, the term “comprises” and its derivations (such as “comprising”, etc.) should not be understood in an excluding sense, that is, these terms should not be interpreted as excluding the possibility that what is described and defined may include further elements, steps, etc. Meanwhile, when used herein, the term “approximately” and terms of its family (such as “approximate,” etc.) should be understood as indicating values very near to those which accompany the aforementioned term. That is to say, a deviation within reasonable limits from an exact value should be accepted, because a skilled person in the art will understand that such a

deviation from the values indicated is inevitable due to measurement inaccuracies, etc. The same applies to the terms “about” and “around” and “substantially.”

Claims

1. A power end frame of a reciprocating pump, comprising: a plurality of rings cooperatively defining an interior of the power end frame configured to enclose a portion of a crankshaft of a power end of the reciprocating pump; and a rod extending through each ring of the plurality of rings to couple each ring with an adjacent ring of the plurality of rings.
2. The power end frame of claim 1, wherein each ring of the plurality of rings comprises a base and a flange extending from the base, and the rod extends through the flange of each ring of the plurality of rings.
3. The power end frame of claim 2, comprising a plurality of sleeves, wherein each sleeve of the plurality of sleeves is positioned between adjacent flanges of adjacent rings of the plurality of rings, and the rod extends through each sleeve of the plurality of sleeves.
4. The power end frame of claim 2, wherein each ring of the plurality of rings comprises an extension, respective extensions of adjacent rings of the plurality of rings abut one another, and the rod extends through each extension.
5. The power end frame of claim 1 comprising a plurality of plates, wherein each plate of the plurality of plates is positioned between adjacent rings of the plurality of rings to cooperatively define the interior of the power end frame.
6. The power end frame of claim 1, wherein the rod is positioned at an exterior of the power end frame.
7. The power end frame of claim 1, wherein the power end frame does not include a weld that couples the plurality of rings to one another.
8. The power end frame of claim 1, wherein an end of the rod extends beyond a lateral boundary of the plurality of rings, and the power end frame comprises a lock coupled to the end to secure the rod within the plurality of rings.
9. The power end frame of claim 8, wherein the lock comprises a nut configured to threadedly engage the rod and abut against an end ring of the plurality of rings to secure the rod within the plurality of rings.
10. A method of manufacture of a power end frame of a reciprocating pump, comprising: aligning a plurality of rings with one another to define an interior of the power end frame configured to enclose a portion of a crankshaft of a power end of the reciprocating pump; inserting a rod through the plurality of rings; and securing the plurality of rings together with the rod.
11. The method of claim 10, wherein securing the plurality of rings comprises coupling a lock to an end of the rod, the end of the rod extending beyond a lateral boundary of the plurality of rings.
12. The method of claim 10, wherein aligning the plurality of rings with one another comprises aligning a respective hole formed through each ring of the plurality of rings with one another, and inserting the rod through the plurality of rings comprises inserting the rod through each respective hole formed through each ring of the plurality of rings.
13. The method of claim 10, comprising positioning sleeves between adjacent rings of the plurality of rings and inserting the rod through the plurality of rings and the sleeves.
14. The method of claim 10, comprising positioning plates between adjacent rings of the plurality of rings.
15. The method of claim 10, wherein each ring of the plurality of rings comprises a flange and an extension extending from the flange, aligning the plurality of rings with one another comprises abutting extensions of adjacent rings of the plurality of rings to one another, and inserting the rod through the plurality of rings comprises inserting the rod through each extension of the plurality of rings.

16. A reciprocating pump, comprising: a fluid end configured to enclose a reciprocating element configured to receive and discharge fluid; and a power end configured to enclose a portion of a crankshaft configured to operate the reciprocating element, wherein the power end comprises: a plurality of rings, wherein each ring of the plurality of rings comprises a base and a flange extending from the base; and a rod extending through the flange of each ring of the plurality of rings.

17. The reciprocating pump of claim 16, wherein each ring of the plurality of rings comprises a surface configured to couple to the fluid end, and the flange extends away from the surface.

18. The reciprocating pump of claim 16, comprising an additional rod extending through the flange of each ring of the plurality of rings.

19. The reciprocating pump of claim 16, wherein each ring of the plurality of rings is positioned adjacent to one another along an axis, and the rod extends through the flange of each ring of the plurality of rings along the axis.

20. The reciprocating pump of claim 16, wherein each ring of the plurality of rings comprises an opening, openings of the plurality of rings cooperatively define an interior of the power end, and the flange of each ring of the plurality of rings extends away from the interior of the power end.