METHOD OF AND APPARATUS FOR CONSTRUCTING A FLUID END OF A RECIPROCATING PUMP

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This invention relates to mud pumps and more particularly to the construction of the fluid end of a mud pump. With the advent of deeper and faster drilling into the earth stratum for oil and gas, the necessity for utilizing higher mud pressure for circulating drilling fluid into and through the bore hole of the well being drilled has increased.

Hereinafore, pumps of the character used for pumping mud into the bore hole of a well being drilled, usually utilized a fluid end constructed of either cast iron or cast steel. The castings of iron or steel, even under the most modern conditions, often have imperfections therein, become fractured or yield under high pressure to render the fluid end element of the mud pump inoperative. Since repair is often time-consuming, costly, and laborious, said element of equipment, or a portion thereof, often has to be discarded and a new piece of equipment or element installed.

In the construction of the present fluid end for mud pumps, the elements which are subjected to pressure are made of high density forged steel and are so shaped, bored, and counterbored that the various elements may be assembled together with high pressure sealing rings therebetweem. While these elements are being held together by pressure, such as by screw bolt pressure or the like, they are welded to form a unified fluid end.

A primary object of the invention is to provide a fluid end for a reciprocating mud pump for a rotary drilling rig, which fluid end is assembled from forged metal elements, which elements will resist fracturing caused by fatigue at high pressure.

Another object of the present invention is to provide an assembled unit of forged metal which may be assembled together into a fluid tight unit and the component parts thereof welded together to make a unitary construction.

A further object of this invention is to provide a metallic sealing ring element to be interposed within complementarily shaped orifices, and to provide a forged valve pot, so that when the valve pot and cylinder are joined by welding, the ring will prevent leakage even though the weld joining the two parts might be imperfect with respect to forming a fluid seal therebetweem.

Another object of the invention is to provide a pump of welded unitary construction which is so constructed that an element may be removed, by the use of a welding torch, and another part installed without the necessity of discarding the entire fluid end unit.

Still another object of the invention is to provide bolt clump means to hold a forged steel cylinder and a forged steel valve pot in clamped, complementary relation on a sealing ring so that hot weld metal, when used to join the adjacent portions, upon which weld will draw the forged steel faces into closer unitary relation.

A further object of the invention is to provide a forged steel cylinder and a forged steel valve pot having adjacent complementary faces, in which complementary grooves are formed to complementally receive metallic sealing rings therein to prevent leakage between the welded parts.

A final object of the invention is to provide a weld between forged steel having similar, annular grooves in the adjacent faces thereof, each which pair of adjacent grooves receives a metallic sealing ring therein, which sealing rings serve to align the forged steel valve pots with the respective portions of the forged steel cylinders.

With these objects in view and others which will become manifest as the description proceeds, reference is to be had to the accompanying drawings in which like reference characters designate like parts in the several views thereof, in which:

FIG. 1 is a fragmentary elevational view of a mud pump, showing the fluid end thereof;
FIG. 2 is an elevational view of a cylinder portion of the fluid end of the mud pump, with parts broken away and with parts shown in section to bring out the details of construction;
FIG. 3 is an enlarged sectional view taken on line 3—3 of FIG. 1, looking in the direction indicated by the arrows;
FIG. 4 is an enlarged fragmentary perspective view of a metallic, oval, cross section sealing ring, with parts shown in section to bring out the details of construction;
FIG. 5 is an exploded elevational view in cross section of the component parts that make up one end of one fluid cylinder;
FIG. 6 is a cross sectional view through the forged steel cylinder and the forged steel valve pot, showing the clamp bolt means and jig means for bringing the forged steel discharge valve pot and forged steel cylinder into binding engagement with the annular metallic sealing ring prior to welding;
FIG. 7 is a view similar to FIG. 6, showing a transverse sectional view through a forged steel cylinder and the forged steel inlet valve pot to show the manner of assembling and holding the forged steel inlet valve pot, the annular metallic sealing ring and the forged steel cylinder together with a clamp bolt and jig means prior to welding; and
FIG. 8 is a fragmentary sectional view showing a portion of the discharge cylinder, and showing the discharge pipe leading therefrom welded thereeto.

With more detailed reference to the drawings, the numeral 1 designates generally a fluid end assembly of the pumping unit, which pumping unit is designated generally by the numeral 2, which pump is used for circulating drilling mud through the drill stem and drill bit and up through the bore hole during the drilling of a bore hole by the rotary drilling method. The present pump utilizes a mechanism for operating the pump, which mechanism is similar in construction to that shown in my patent issued May 6, 1962, Patent Number 3,013,124, Mud Pumps.

The present fluid end assembly for mud pumps embodies one or more cylinders 4, the number being two, which cylinders each have an intake valve pot assembly 6 and a discharge valve pot assembly 8 thereon, each of which assemblies has the respective valves 10 and 12 therein together with the complementary elements necessary for the correct functioning of the valves. No detailed explanation will be made as to the operation of the valves and mechanism in the pump, as this is shown and described in the above mentioned patent.

The exterior contour of the intake valve pot 6 is best shown in FIG. 1 and the cross sectional contour of the intake valve pot 6 is best shown in FIG. 3. Intake valve pot 6 is bored from a solid bar of forged steel to form a longitudinal passage 14 therethrough, which bore is machined to a sufficient diameter to receive the valve element 10 and the various complementary elements associated therewith. The intake valve pot 6 is transversely bored, as indicated at 16, FIGS. 3 and 5. The side face 18 of intake valve pot 6 is machined to form a plane surface to complementarily fit a plane face 20 near each end.
of each fluid cylinder 4. Each intake valve pot 6 has an annular, angularly faced groove 22 formed within the plane face 18 thereof, which annular groove is evenly spaced from the cylindrical transverse bore 16 in each valve pot 6. The sides of the respective annular grooves form an acute angle, with the bottom of each groove being flat.

A similar groove 24 is formed in the side of each plane face 20 of each of the cylinders 4. Each pair of grooves 22 and 24 are complementary and receive a circular ring 26, which ring is elliptical in cross section so that when a ring 26 is placed within the grooves 22 and 24, they form a sealed joint with the sides of the respective annular grooves before the plane faces 18 and 20 are brought into contact relation and before the smaller end of the elliptical cross section of the sealing ring touches the bottom of the respective grooves. With the ring 26 so placed, pressure is applied by a screw bolt or the like, to the intake valve pot 6 and the cylinder 4 to bring the plane faces thereof into close relation, whereby the sealing rings form a fluid tight seal to prevent leakage of fluid therethrough.

With the parts held together in this manner, a weld 28 is used to join the intake valve pot 6 to the cylinder 4 in unitary relation, as will best be seen in FIG. 3.

Each cylinder 4 is made of high density forged steel and each cylinder 4 has a bore 30 therethrough to receive a pump liner therein. Each end of each cylinder 4 is faced, as indicated at 32. Each cylinder 4 has lateral bores 34 and 36 near each end thereof, which bores 34 and 36 are preferably at right angles to each other. Each exterior side of each cylinder 4, through which the respective lateral bores 34 and 36 pass, has a plane face, as indicated at 20 and 38 respectively, with an annular groove formed in the respective plane faces 38 on each end of each cylinder, one of which grooves 40 surrounds each of the lateral bores 36. Each of the grooves 40 are similar in construction to grooves 24.

Each discharge valve pot 8 has an axial bore 42 therethrough. Each discharge valve pot 8 is counterbored to receive therein a valve 12 and other elements associated therewith. Each discharge valve pot 8 has a plane face 44 on the lower end thereof with an annular groove 46 formed in each plane face 44 thereof. The annular groove 46 are similar in construction to the annular grooves 22. A sealing ring 48, elliptical in cross section, is fitted within the annular grooves 40 and 46 so that the annular faces of the grooves 40 and 46 will form a contact seal with elliptical sealing ring 48 when the discharge valve pot 8 is fitted thereon. However, the oval sealing ring 48 is of such dimension that the sides of the oval sealing ring 48 are larger than the annular grooves before the plane faces 38 and 44 come into contact. Upon application of pressure, as by a press, screw bolt, or the like, each cylinder 4 and each discharge valve pot 8 is urged together so that the plane faces 38 and 44 are brought into close relation to cause the arcuate sides of oval sealing ring 48 to become seated in fluid tight sealing relation. When each discharge valve pot 8 is seated in this manner, a weld 50, such as an arc weld, is applied to each cylinder 4 and to each discharge valve pot 8 to hold these elements in this relation. However, as the weld cools, shrinkage occurs within the metal to draw the plane faces 38 and 44 into closer relation. The plane faces 38 and 44 so maintained to prevent the "washing-out" of the joint between each cylinder 4 and each discharge valve pot 8.

Each of the discharge valve pots 8 has discharge line 52 welded thereto to conduct the drilling mud outward therefrom into central discharge pipe 54. The discharge lines 52 form an opposed manifold when fitted in place and welded, or otherwise secured together. These manifolds are strengthened by their interconnection with the discharge valve pots 8 and there is little likelihood of breakage of the weld.
be seen in FIG. 3. As the arc weld metal 50 cools, the adjacent plane faces 44 and 38 of the valve pot 8 and the cylinder 4, respectively, will be drawn into binding engagement, as shown in FIG. 3 and the sealing ring 48 will be deformed into the discharge valve pot 8 and the cylinder 4 to make a completely tight seal.

The high pressure seal formed by four lines of contact between elliptical or oval sealing ring and the walls of the respective grooves and with the weld 50 will resist leakage at extremely high pressures, even above eight thousand pounds per square inch. The weld 50 holds these elements together while the sealing ring 48 forms the primary fluid tight seal.

While the forged steel intake valve pot 6 has been indicated as being clamped and welded to the cylinder 45 first, and then the forged steel discharge valve pot 8 being clamped and welded onto the cylinder 4, secondly, the procedure may be reversed and the discharge valve pot 8 clamped and welded onto the cylinder 4, first and the intake valve pot 6 clamped and welded onto the cylinder 4 secondly, as each cylinder has two forged steel intake valve pots and two forged steel discharge valve pots which will assume the relation as shown in FIGS. 1 and 8, when in final assemblage form.

While the plane faces between the respective valve 25 pots and the plane faces 38 and 44 on the cylinder have been indicated as being drawn into approximately 0.0015 to .0020 of an inch space therebetween before welding, it is to be understood that this may be varied according to the size of the valve pot and the size of the cylinder 30 being worked on, as larger cylinders and larger valve pots will require more weld metal and become hotter while being welded, therefore, there is required than when welding smaller valve pots to smaller cylinders. Having thus clearly shown and described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A fluid end for a reciprocating mud pump, which fluid end comprises:
   (a) a pair of longitudinal, forged steel cylinders,
      (1) each said longitudinal, forged steel cylinder having an inlet opening formed in a side near each end thereof,
      (2) each said longitudinal, forged steel cylinder having a discharge opening formed in a side 45 near end thereof,
      (3) each longitudinal, forged steel cylinder having a plane face, adjacent to, and surrounding each inlet opening and each discharge opening,
      (4) each plane face of each of the respective longitudinal, forged steel cylinders having an annular groove formed therein and surrounding the respective openings in the sides thereof,
   (b) forged steel inlet valve pots, each having an inlet opening and a discharge opening formed therein,
      (1) a plane face surrounding said discharge opening of each forged steel inlet valve pot,
      (2) the discharge openings of which forged steel inlet valve pots register with the respective inlet openings in each end of each of said longitudinal, forged steel cylinders,
   (c) forged steel discharge valve pots, each having an inlet opening and a discharge opening formed therein,
      (1) a plane surface surrounding each said inlet opening of each forged steel discharge valve pot,
      (2) the inlet openings of which forged steel discharge valve pots register with the respective discharge openings in each end of each of said longitudinal, forged steel cylinders,
   (d) each plane face of each forged steel inlet valve pot adjacent the respective openings in the longitudinal, forged steel cylinders having an annular groove formed therein, each of which grooves surrounds each said opening and is spaced therefrom and is in complementary to the grooves in the adjacent face of the respective longitudinal, forged steel cylinders,
   (e) each plane face of each forged steel discharge valve pot adjacent the respective openings in the longitudinal, forged steel cylinders having an annular groove formed therein, each of which grooves surrounds each said opening and is spaced therefrom and in complementary to the respective grooves in the adjacent faces of the respective longitudinal, forged steel cylinders,
   (f) an annular ring fit within each adjacent pair of complementary grooves, so when the sides of the grooves within the forged steel valve pots and within the longitudinal, forged steel cylinders are brought into binding engagement with said annular ring, a fluid tight seal will be formed between each annular ring and each pair of complementary annular grooves,
   (1) said respective annual rings adapted to hold said adjacent plane faces of said valve pots and said cylinder a spaced distance apart before said respective valve pots and the respective cylinders are joined by welding,
   (g) welding means securing the respective forged steel valve pots to the corresponding portions of said longitudinal, forged steel cylinders,
   (b) a conduit, one of which branches is connected to the inlet opening of the respective inlet valve pots to supply fluid thereto, and
   (i) a branched discharge conduit, one of which branches is connected to the said discharge opening of the respective forged steel discharge valve pots.

2. A fluid end for a reciprocating mud pump, which fluid end comprises:
   (a) a pair of longitudinal, forged steel cylinders,
      (1) each said longitudinal, forged steel cylinder having an inlet opening formed in a side near each end thereof,
      (2) each said longitudinal, forged steel cylinder having a discharge opening formed in a side near each end thereof,
      (3) each longitudinal, forged steel cylinder having a plane face, adjacent to, and surrounding each inlet opening and each discharge opening,
      (4) each plane face of each of the respective longitudinal, forged steel cylinders having an annular groove formed therein and surrounding the respective openings in the sides thereof,
   (b) forged steel inlet valve pots, each having an inlet opening and a discharge opening formed therein,
      (1) a plane surface surrounding each said discharge opening of each forged steel inlet valve pot,
      (2) the discharge openings of which forged steel inlet valve pots register with the respective inlet openings in each end of each of said longitudinal, forged steel cylinders,
   (c) forged steel discharge valve pots, each having an inlet opening and a discharge opening formed therein,
      (1) a plane surface surrounding each said inlet opening of each forged steel discharge valve pot,
      (2) the inlet openings of which forged steel discharge valve pots register with the respective discharge openings in each end of each of said longitudinal, forged steel cylinders,
   (d) each plane face of each forged steel inlet valve pot adjacent the respective openings in the longitudinal, forged steel cylinders having an annular groove formed therein, each of which grooves surrounds each said opening and is spaced therefrom and is in complementary to the grooves in the adjacent face of the respective longitudinal, forged steel cylinders,
   (1) said annular grooves in the respective forged
steel valve pots each having acute, angulated sides,

each plane face of each forged steel discharge valve pot adjacent the respective openings in the logitudinal, forged steel cylinders having an annular groove formed therein, each of which grooves surrounds each said opening and is spaced therefrom and is in complementary relation to the respective grooves in the adjacent faces of the respective longitudinal forged steel cylinders,

(1) said annular grooves in the plane faces of the respective forged steel discharge valve pots each having acute, angulated sides,

(f) an annular ring, which is oval in cross-section, fitted within each adjacent pair of complementary grooves, so when the angulated sides of the grooves within the forged steel valve pots and within the longitudinal, forged steel cylinders are brought into binding engagement with said annular rings, a fluid tight seal will be formed between each annular ring and each pair of complementary annular grooves,

(1) said respective annular rings adapted to hold said adjacent plane faces of said valve pots and said cylinder a spaced distance apart before said respective positions and the respective cylinders are joined by welding,

(g) welding means securing the respective forged steel valve pots to the corresponding portions of said longitudinal, forged steel cylinders,

(h) a branched conduit, one of which branches is connected to the inlet opening of the respective intake valve pot to supply fluid there to, and

(i) a branched discharge conduit, one of which branches is connected to the said discharge opening of the respective forged steel discharge valve pots.

3. A method of assembling forged steel valve pots, each having a bore formed therein, on a forged steel cylinder having a longitudinal bore formed therein and a plurality of radial bores formed therein with the radial bores being in fluid communication with the longitudinal bore, which method comprises the steps of:

(a) forming a plane face on each cylinder to surround the radial bore thereof,

(b) forming an annular groove in each plane face on said cylinder, which grooves surrounds the respective radial bores,

(c) forming a complementary annular groove in a plane face of a steel valve pot to be complementally fitted adjacent said flattened plane face of said cylinder having said annular groove therein so the bore in said valve pot will be in fluid communication with the radial bores in said cylinder,

(d) clamping of said valve pot to said cylinder so the radial bores in said valve pot will be in fluid communication with a bore of said valve pot until the sides of said grooves are brought into sealing engagement with said annular sealing ring,

(e) leaving a space between the plane faces of said valve pot and said cylinder,

(f) applying weld metal to within said last mentioned groove at welding heat to said valve pot and said cylinder so the weld will surround the valve pot and secure said valve pot to said cylinder,

(1) of shrink fitting said valve pot into binding engagement with said annular metal ring and with said cylinder, and

(i) releasing the clamp from said valve pot and said cylinder.

4. A method of assembling steel valve pots, each hav-
temperature to permit a heat shrinkage to draw said plane faces of said forged steel valve pot and said forged steel cylinder into binding engagement upon cooling of the weld metal,

(1) said shrinkage exerting a compressive strain to further seat said annular ring into fluid tight, sealing relation with said annular grooves in said forged steel valve pot and said forged steel cylinder, and

(i) releasing the clamp from said forged steel valve pot and said forged steel cylinder.

6. A method of assembling a plurality of forged steel valve pots, each having a bore formed therein, and a forged steel cylinder having a longitudinal bore and a plurality of radial bores formed therein, which radial bores are in fluid communication with the longitudinal bore in said forged steel cylinder, and which radial bores are adapted to register with the bores in the respective forged steel valve pots, which method comprises the steps of:

(a) forming a plane face on a forged steel cylinder to surround each radial bore therein,

(b) forming an annular groove in each said plane face on said forged steel cylinder to surround said respective radial bores,

(c) fitting an annular ring within said respective annular grooves to wedgingly engage within said respective grooves,

(d) forming a plane face on each said forged steel valve pot, around the bore therein, for complementary engagement with each plane face on said forged steel cylinder,

(e) forming a complementary annular groove in each plane face of said forged steel valve pot so each said annular ring will wedgingly engage within said annular groove so that the bore in each said forged steel valve pot will be in fluid communication with a respective radial bore in said forged steel cylinder,

(f) clamping each forged steel valve pot to said forged steel cylinder so each annular ring in the complementary annular grooves will be in fluid tight, wedging engagement with said forged steel cylinder and said forged steel valve pot and with the plane faces thereof being spaced apart,

(g) of applying weld metal at welding heat to each said forged steel valve pot and to said forged steel cylinder surrounding each said annular ring so as to secure each said forged steel valve pot to said forged steel cylinder in a heated condition,

(h) of permitting the weld metal, each of the forged steel valve pots and the forged steel cylinder to cool to a normal temperature to permit heat shrinkage to draw said plane faces of said forged steel valve pots and said forged steel cylinder into binding engagement.

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