HYDRAULIC PUMP JACK SYSTEM FOR RECIPROCATING OIL WELL SUCKER RODS

Inventor: T. Leon Brown, Amarillo, TX (US)

Correspondence Address:
GABLE & GOTWALS
100 WEST FIFTH STREET, 10TH FLOOR
TULSA, OK 74103 (US)

Publication Classification

Int. Cl.
F04B 17/00 (2006.01)

U.S. Cl. ............................................ 417/390; 417/398

ABSTRACT

A pumping system for vertical reciprocation of a string of sucker rods within oil well tubing having a positive displacement pump at the bottom thereof, includes a vertically positioned elongated hydraulic cylinder supported above the tubing and in alignment therewith, the cylinder having a vertically displaceable piston therein. A pump rod is affixed to the piston and extends beyond the bottom end of the cylinder. A seal member affixed to the lower end of the cylinder scalably and reciprocally receives the piston rod. A Tee fitting is secured between the tubing and the cylinder bottom end and reciprocally receives the piston rod. A controlled hydraulic power system provides fluid pressure to the cylinder to vertically reciprocate the piston and thereby the piston rod and tubing string to pump crude oil upwardly in the tubing, the crude oil flowing under pressure into the Tee fitting and out through a side opening.
HYDRAULIC PUMP JACK SYSTEM FOR RECIPROCATING OIL WELL Sucker RODS

REFERENCE TO PENDING APPLICATIONS

[0001] This application is based on Provisional Patent Application 60/562,207 filed April 13, 2004 entitled PUMP APPARATUS AND METHOD FOR OIL WELL PRODUCTION.

REFERENCE TO MICROFICHE APPENDIX

[0002] This application is not referenced in any microfiche appendix.

FIELD OF THE INVENTION

[0003] This invention relates to a system for reciprocating an oil well pump located in the bottom portion of a string of tubing in which the pump is reciprocated by sucker rods extending from the pump to the earth's surface.

BACKGROUND OF THE INVENTION

[0004] Oil wells typically vary in depth from a few hundred feet to several thousand feet. In many wells there is insufficient subterranean pressure to force the oil to the earth's surface. For this reason some system must be devised for pumping the crude oil from the producing formation to the earth's surface. The most common system for pumping an oil well is by the installation of a pumping unit at the earth's surface that vertically reciprocates a string of sucker rods extending within tubing to a subsurface pump.

[0005] Traditionally sucker rod strings have been reciprocated by a device known as a pump jack which operates by the rotation of an eccentric crank driven by a prime mover which may be an engine or an electric motor. Such mechanical drive mechanism has been utilized extensively in oil production industry for decades and continues to be a primary method for extracting oil from a well. However, such mechanical systems suffer from a number of inherent disadvantages or inefficiencies that include their substantial size and weight that makes them expensive to produce, difficult to transport and expensive to install. The mass of such units also requires significant structural support elements at the wellhead which adds to the complexity and expense of the overall drive mechanism. Furthermore, mechanical drive systems have components that are physically linked or connected in some form by way of connecting rods, cams and gear boxes. For a variety of different reasons it often becomes necessary to adjust the travel of the pump rod. Mechanical linkages, as have been previously used, present difficulties in adjusting the travel or displacement of the pumping units. With most mechanical pumping systems in present use adjusting the rod displacement or pumping speed requires the drive system to be shut down, wasting valuable production time and increasing labor costs.

[0006] To combat these limitations in mechanical pump jack drive systems, others have provided a variety of different pneumatic and hydraulic drive mechanisms that have met varying degrees of success. Most hydraulic drive systems in use today are mounted above a stuffing box through which a polished rod extends. Below the stuffing box is a T-fitting so that produced oil is diverted from upward flow within the well tubing to a gathering line that connects to the stuffing box. Stuffing boxes require frequent lubrication. If not constantly lubricated, the packing in stuffing boxes soon wear out resulting in leakage that can spread crude oil to the environment. The invention herein provides an improved hydraulic operated pumping unit that, among other advantages, eliminates the need for a stuffing box.

[0007] For additional information relating to pumping units employed in the oil industry for reciprocating sucker rod strings, reference may be had to the following previously issued U.S. patents.

<table>
<thead>
<tr>
<th>Pat. No.</th>
<th>Inventor</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,645,900</td>
<td>Hutchinson</td>
<td>Hydraulic Type Fluid Transmission</td>
</tr>
<tr>
<td>2,651,914</td>
<td>Joy</td>
<td>Pumping Head and Operating Mechanism For Wells</td>
</tr>
<tr>
<td>2,699,154</td>
<td>Smith</td>
<td>Oil Well Pumping Apparatus</td>
</tr>
<tr>
<td>2,729,942</td>
<td>Billings et al.</td>
<td>Manually Controllable Pumping Jack</td>
</tr>
<tr>
<td>2,838,910</td>
<td>Bocchi</td>
<td>Hydraulic Pumping Jack</td>
</tr>
<tr>
<td>2,983,100</td>
<td>Sinclair</td>
<td>Pumping Unit</td>
</tr>
<tr>
<td>4,320,799</td>
<td>Gilbertson</td>
<td>Oil Well Pump Driving Unit</td>
</tr>
<tr>
<td>4,448,110</td>
<td>Pelak et al.</td>
<td>Hydraulic Pump</td>
</tr>
<tr>
<td>4,486,685</td>
<td>Gilbertson</td>
<td>Oil Well Pump Driving Unit</td>
</tr>
<tr>
<td>4,490,097</td>
<td>Gilbertson</td>
<td>Hydraulic Pump Driving Unit For Oil Wells</td>
</tr>
<tr>
<td>4,637,459</td>
<td>Roussel</td>
<td>Anti Rotational Device For Down Hole</td>
</tr>
<tr>
<td>4,646,517</td>
<td>Wright</td>
<td>Hydraulic Pumping Unit</td>
</tr>
<tr>
<td>5,906,688</td>
<td>Schultz et al.</td>
<td>Hydraulic Pump Jack Drive System For Reciprocating An Oil Well Pump Rod</td>
</tr>
</tbody>
</table>

BRIEF SUMMARY OF THE INVENTION

[0008] The hydraulic pump jack drive system for reciprocating a down hole oil well pump by means of a sucker rod string, that is the subject of this invention, includes a vertically positioned hydraulic cylinder having a reciprocated piston therein. A cylindrical, polished, piston rod extends from a lower end of the piston and through a bottom seal that closes the lower end of the hydraulic cylinder. The hydraulic cylinder preferably sits above a wellhead that has the lower end thereof connected to a tubing string that extends from the earth's surface downward to a subterranean oil producing formation. The wellhead has an upper end that is connected to the lower end of the hydraulic cylinder. Further the wellhead includes at least one side orifice that is adapted to be connected to a collection line by which crude oil produced by the well can be conveyed to a collection system. This arrangement eliminates the expense of providing a stuffing box that is typically employed with the systems currently used by the oil industry for pumping reciprocated bottom hole pumps. Not only does the system herein eliminate the stuffing box but eliminates the time and expense encountered in keeping a stuffing box properly lubricated and the packing replaced.

[0009] The invention herein provides a hydraulic system in which the stroke action can be significantly varied. By controlling the application of hydraulic fluid pressure the sucker rod strings can be raised at a selected rate from a lower to an upper position. At the upper positions the sucker rod strings may be held briefly in a steady state so that if the bottom hole pump is of the type designed to release gas
trapped within the pump, ample opportunity is given for the gas release. Thereafter, the hydraulic system may be controlled so that sucker rod string is dropped rapidly to recharge the bottom hole pump and to restart the pumping cycle.

The present invention addresses and solves many of the problems involved in fluid extraction from oil and gas wells with current art pumping systems. The loss of pump capacity due to rod stretch is eliminated. Full stroke of the pump plunger on each stroke prevents debris accumulating in the normally unused upper section of the pump barrel and therefore allows the pump to be unseated without sticking the plunger in the pump barrel. The repair of pumps is reduced when the plunger and barrel can be reus ed. Well pulling costs are reduced when the pump can be unseated and the tubing flushed without sticking the plunger in the pump barrel. Well pulling rig costs are reduced due to the ability of the invention to long stroke the pump. When needed the rods can be dropped at a velocity equal to a method only possible in current art pumping systems when a pulling rig is used. The present invention makes possible full control of the reciprocating action of the pump including the ability to stop at the peak of the stroke or any position in the cycle. The present invention can prevent pipeline damage by adjusting or stopping the rate of the sucker rod fall on the down stroke cycle.

In many wells, and stripper wells in particular, the walking beam pumping system cannot run at a slow enough rate. Well pulling and well tubing, rod and pump repair expense is reduced by slowing the rate to four strokes per minute or less in most wells. Electrical power use and maintenance is reduced. Horse power demand is less and is only needed on the upstroke of the pump. Elimination of the cyclic load created by a walking beam pumping unit on the electric motor results in reduced power factor penalties from electrical utility companies. In stripper wells in particular which produce ten barrels or less per day, the cost of daily operations are reduced. Reduced risk of pipe line leaks, the elimination of stuffing boxes leaks and no mechanical maintenance reduces the cost of field equipment and employees required to operate wells.

The present invention provides a pumping system which is easily installed on existing wells and is cheaper to operate and maintain. The productive life of all oil and gas wells depend on the economics involved in extracting and delivering the well bore fluids. The apparatus of the present invention includes (a) a hydraulic cylinder connected to the pumping tee; (b) a pump spacing adaptor attached to the cylinder rod; (c) a sucker rod string attached to the spacing adaptor; (d) a hydraulic pump of pre-determined pressure and rate to raise the rod string and load the down hole pump; (e) a means to control the hydraulic flow at the top of the upstroke of the down hole pump; (f) a means to hold the pump at the top of the stroke for a pre-determined time; (g) a means to release fluid back to the hydraulic reservoir and allow the gravity fall of the sucker rod string; (h) a means to regulate the speed of the gravity fall of the sucker rod string on the down stroke; and (i) a means to restart the pumping cycle at a pre-determined time.

The method of the present invention is an improved method using the above described apparatus for oil and gas well fluid extraction, which comprises, hydraulic fluid pumped into the hydraulic drive cylinder at sufficient pressure to raise the cylinder rod and sucker rod to load the down hole pump. When the pull rod of the down hole pump reaches the maximum stroke length of the pump barrel, pressure increases above what is required to lift the rods. An adjustable pressure switch stops the flow of drive fluid at a pre-determined pressure above the string weight, but less than the pressure required to unseat the pump. This insures full stroke of the pump regardless of the rod stretch. The gas venting pump is held at the peak of the up stroke for a pre-determined time to vent gas out of the fluid chamber and facilitate maximum fluid pump efficiency. After a pre-determined time an adjustable delay opens a solenoid valve and fluid is allowed to flow from the drive cylinder back to the hydraulic reservoir. Gravity and fluid column pressure in the well tubing allow the rods and pump to return to the down stroke position. A variable orifice valve adjusts the speed of the down stroke by holding back pressure on the drive cylinder. The pressure on the drive cylinder is adjusted to remain above the well tubing pressure with an adjustable back pressure valve. This insures that well fluids cannot dilute hydraulic drive fluid. An adjustable electric time delay restarts the hydraulic pump for the next cycle at a pre-determined time.

Another important advantage of the present invention is the provision of a unique system for adjusting the length of the sucker rod string for more efficient actuation of the bottom hole pump.

A better understanding of the invention will be obtained from the following detailed description of the preferred embodiments taken in conjunction with the drawings and the attached claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational diagrammatic view of a pumping unit according to this invention showing a system for producing hydraulic fluid pressure flow for the actuation of a piston within a cylinder.

FIG. 2 is an elevational view of the hydraulic cylinder with a piston rod extending therefrom.

FIG. 3 is an elevational view of the components of the system used to adjust the length of the sucker rod string to more effectively accommodate a bottom hole pump.

FIG. 4 is an elevational, partial cross-sectional view showing diagrammatically the components making up the system of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

It is to be understood that the invention that is now to be described is not limited in its application to the details of the construction and arrangement of the parts illustrated in the accompanying drawings. The invention is capable of other embodiments and of being practiced or carried out in a variety of ways. The phraseology and terminology employed herein are for purposes of description and not limitation.

Elements shown by the drawings are identified by the following numbers:

10 wellhead
12 tubing
14 earth’s surface
16 Tee fitting
[0026] 18 top of 16
[0027] 20 hydraulic cylinder
[0028] 22 top end
[0029] 24 bottom end
[0030] 26 piston
[0031] 28 internal cylinder wall
[0032] 30 downward extending piston rod
[0033] 32 seal member
[0034] 34 closure member
[0035] 36 air vent
[0036] 38 hydraulic fluid pump
[0037] 40 pipe
[0038] 42 inlet opening
[0039] 44 return pipe
[0040] 46 prime mover
[0041] 48 battery
[0042] 50 hydraulic controls
[0043] 52 string of sucker rods
[0044] 54 bottom hole pump
[0045] 56 side opening
[0046] 58 upwardly extending piston rod
[0047] 60 upper seal member
[0048] 62 tubular adjustment member
[0049] 64 reduced diameter lower end
[0050] 66 adjustment rod
[0051] 68 adjustment nut
[0052] 70 coupling

[0053] Referring to the drawings and first to FIG. 1, the basic elements making up a system that can be used to practice the invention are illustrated. A wellhead 10 of the type that is typically secured to the upper end of oil well casings is illustrated. Extending upwardly from wellhead 10 is the upper end portion of tubing 12. Tubing 12 is typically supported by slips within the wellhead 10, the tubing 12 hanging downwardly in the wellhead and extending downward to a producing formation in the earth which may be from several hundred to several thousand feet below the earth’s surface 14.

[0054] Affixed to the upper end of tubing 12 is a Tee fitting 16 that has a vertical passageway therethrough. Supported on the top 18 of the Tee fitting is a vertically positioned elongated hydraulic cylinder 20. Cylinder 20 has a top end 22 and a bottom end 24.

[0055] FIG. 4 shows hydraulic cylinder 20 in cross-sectional view and shows a piston 26 that is vertically and slidably displaceable within the internal cylindrical wall 28 of hydraulic cylinder 20. Affixed to piston 26 is a vertical, downwardly extending piston rod 30. Piston rod 30 is shown in dotted outline in FIG. 1.

[0056] Closing the bottom end 24 of hydraulic cylinder 20 is a seal member 32 that slidably and sealably receives piston rod 30.

[0057] The top end 22 of hydraulic cylinder 20 receives a closure member 34 and in the embodiments of FIGS. 1 and 4 closure member 34 has an air vent 36 therein.

[0058] As seen in FIG. 1, a hydraulic fluid pump 38 has a high pressure fluid outlet that is connected by pipe 40 to an inlet opening 42 in the cylindrical wall of hydraulic cylinder 20. Also illustrated in FIG. 1 is an optional return pipe 44 that in the embodiments of FIGS. 1 and 2 connects to an outlet opening 45 in the sidewall of cylinder 20. This permits top member 34 to be closed so that air above piston 26 can be circulated back and forth by the hydraulic fluid pump system 38. However, return pipe 44 is optional since it may be eliminated if closure member 34 has an air vent 36 as illustrated in FIGS. 1 and 2. In an alternate embodiment, as will be discussed with reference to FIG. 4, return pipe 44 connects outlet opening 45 in hydraulic cylinder 20 back to the hydraulic fluid pump 38.

[0059] The hydraulic system of FIG. 1 includes a prime mover 46, such as an engine or electric motor, by which pump 38 is powered. If prime mover 46 is a motor, energy may be supplied by way of a battery 48 that is representative of any other kind of electrical energy source. In addition, the hydraulic system includes hydraulic control 50 by which the force of hydraulic fluid applied to move piston 26 (as seen in FIG. 4) is controlled. The importance of the hydraulic control 50 will be described subsequently.

[0060] Piston rod 30 extending through seal member 32 is attached to the upper end of a string of sucker rods, generally represented by the numeral 52 in FIG. 4. The lower end of the sucker rod string 52 is secured to a bottom hole pump generally indicated by the numeral 54 in FIG. 4. Sucker rod reciprocated bottom hole pumps are well known in the industry and are used for lifting fluid from a subterranean formation upwardly within tubing 12 to the earth’s surface. As the fluid is pumped upwardly from the subterranean formation within tubing 12, it enters into internal passageway within Tee fitting 16. A side opening 56 in the Tee fitting provides a way of channeling the pumped crude oil to a collection line (not shown) by which the produced crude oil may be conveyed to a storage tank or other use passed to systems whereby it is ultimately delivered to a refinery for production of diesel fuel, gasoline, lubricating oils and other derivatives.

[0061] The seal member 32 at the lower end of hydraulic cylinder 20 confines the produced crude oil to the interior of Tee fitting 16 and thereby eliminates the requirement for a stuffing box. That is, there is no provision needed to seal around piston rod 30 exterior of the hydraulic cylinder 20.

[0062] FIG. 2 shows a different embodiment of the invention in which the hydraulic cylinder 20 has a piston therein (not seen in FIG. 2) that has extending downwardly from it piston rod 30 as has been described with reference to FIGS. 1 and 4 and in addition, there is an upwardly extending piston rod 58. That is, in FIG. 2 the piston has a double extending piston rod arrangement—one extending upwardly and one extending downwardly. In this arrangement, an upper seal member 60 is used at the upper end 22 of hydraulic cylinder 20. In the embodiment of FIG. 2 member
that closes the upper end 22 of the hydraulic cylinder 20 is a seal member that slidably and sealably receives an upper extending piston rod 58. When the embodiment of FIG. 2 is employed, hydraulic fluid pressure exists within the cylinder above the piston and therefore a return pipe 44 is required. The double rod piston arrangement of FIG. 2 that includes, in addition to the downward extending piston rod 30, the upwardly extending piston rod 58 is important in a closed hydraulic system since the quantity of hydraulic fluid remains constant during the up and down strokes of the piston.

It is important that the length of the sucker rod string 52 as seen in FIG. 4 be adjustable for the accurate positioning of bottom hole pump 54. FIG. 3 illustrates a system for adjusting the length of sucker rod string 52.

FIG. 3 shows a vertical tubular adjustment member 62 secured to the lower end of piston rod 30. The tubular adjustment member 62 has a reduced internal diameter open lower end 64 that receives an externally threaded adjustment rod 66. Within tubular adjustment member 62 is an internally threaded adjustment nut 68. By the threaded position of adjustment nut 68 on adjustment rod 66, the effective length of the sucker rod string 52 can be varied. A coupling 70 is threadably attached at the lower end of adjustment rod 62 and to the upper end of sucker rod string 52.

As previously stated, the pumping system of FIG. 1 includes a hydraulic control system 50. This enables the pumping unit to be operated in a manner to make most effective use of the down hole pump 54 that is being employed. For instance, down hole pump 54 may be of a gas release type in which case the hydraulic control system 50 will be regulated so that hydraulic fluid is supplied from hydraulic pump 38 by way of pipe 40 to the lower surface of piston 26 in such a way that the piston is raised at a predetermined rate of speed which can be relatively constant. The upward movement of piston 26 lifts piston rod 30 and thereby sucker rod string 52 and a plunger (not shown) in bottom hole pump 54, all in an upper direction. When piston 26 reaches the upper end of its stroke as seen in FIG. 4, the hydraulic control system 52 may be regulated such that the piston movement pauses after a downward stroke is commenced. The length of this pause can be adjusted by the system 50. Further, the hydraulic system may be programmed so that the downward movement of piston 26 occurs at a much faster rate than the upward movement. The downward movement rate can be as fast as the fall rate of the sucker rod strings. After the sucker rod string, piston rod and piston have reached their lower downward limit then the upward cycle can begin with or without a delay. Thus, in a preferred way, the pumping cycle applied to bottom hole pump 54 can be carefully regulated to match the requirements of the pump.

Thus, it can be seen that the pumping system herein is more economical than the typical hydraulic pumping system used for reciprocating sucker rod strings in that the need for a stuffing box is eliminated and the need for the constant repair and lubrication of the typical stuffing box is eliminated. Further, the pumping system includes provision for regulating the length of the sucker rod to accurately position the down hole pump in a well and the pumping cycle of the system can be regulated to match the characteristics of the particular down hole pump being employed.

While the invention has been described with a certain degree of particularity, it is manifest that many changes may be made in the details of construction and the arrangement of components without departing from the spirit and scope of this disclosure. It is understood that the invention is not limited to the embodiments set forth herein for purposes of exemplification, but is to be limited only by the scope of the attached claims, including the full range of equivalency to which each element thereof is entitled.

What is claimed is:

1. A pumping system for vertical reciprocation of a string of sucker rods in oil well tubing having a positive displacement pump at the bottom thereof, comprising:

   a vertically positioned elongated hydraulic cylinder having a top and bottom end and supported above said tubing and in alignment therewith;

   a vertically displaceable piston within said cylinder;

   a pump rod affixed to said piston and extending beyond said cylinder bottom end;

   a seal member affixed to said lower end of said cylinder for sealably and reciprocally receiving said piston rod;

   a Tee fitting having a vertical passageway therethrough, having a lower open end secured to said tubing, an upper open end secured to said cylinder bottom end and a side opening communicating with said passageway that reciprocally receives said piston rod; and

   a controlled hydraulic power system providing fluid pressure to said cylinder to vertically reciprocate said piston and thereby said piston rod and rod string to pump crude oil upwardly in the tubing, the crude oil flowing under pressure into said Tee fitting passageway and out through said side opening.

2. A pumping system according to claim 1 wherein said cylinder top end is vented to the atmosphere.

3. A pumping system according to claim 1 including:

   a top seal affixed to said upper end of said cylinder;

   an upper piston rod affixed to said piston and extending beyond said cylinder top end and sealably and reciprocally received by said top seal; and

   wherein said hydraulic power system provides controlled fluid flow to said cylinder above and below said piston.

4. A pumping system according to claim 1 wherein said hydraulic power system is programmable permitting separate selectable upward and downward sucker rod acceleration rates.

5. A pumping system according to claim 4 wherein said hydraulic power system includes a program providing selectable delays at the top and/or bottom of sucker rod reciprocations.

6. A pumping system according to claim 1 including a sucker rod length adjustment mechanism between said pump rod and said sucker rod string.

7. A pumping system according to claim 6 including:

   a vertical tubular adjustment member affixed at an upper end to said plumb rod and having a reduced internal diameter open lower end;
an externally threaded adjustment rod having an upper end portion received within said tubular adjustment member and a lower end affixed to the sucker rod string; and

an internally threaded adjustment nut threadably received on said adjustment rod within said adjustment tubular member, the length of the sucker rod string being adjustable by the rotational position of said adjustment bolt.

* * * * *