The present invention relates to a top hold-down pump having a barrel drain operatively connected to the pump beneath a seating nipple. The design of the pump provides specific advantages over past systems by improving the efficiency of re-setting the barrel drain and the required work over costs after the drain has been activated.
TOP HOLD DOWN ROD PUMP WITH HYDRAULICALLY ACTIVATED DRAIN AND METHOD OF USE

FIELD OF THE INVENTION

[0001] The present invention relates to top hold-down pump systems having a barrel drain operatively connected to the pump positioned beneath a pump seating nipple. The design of the pump provides specific advantages over past systems by improving the efficiency of re-setting the barrel drain and the required work over costs after the drain has been activated.

BACKGROUND OF THE INVENTION

[0002] As is well known, oil is often pumped from a production well using various designs of reciprocating pump and pump jack. Generally, the pump jack includes a reciprocating rod (i.e. a polish rod) that passes through the wellhead that is connected to a series of sucker rods which provides the reciprocating pumping action to draw oil from the well. The downhole pump is seated within a tubing string in the production zone of the well. The pump includes a pump barrel through which a pump piston operates to lift oil to the surface through the production tubing. This general style of pump has been in operation for over 100 years.

[0003] More specifically, the primary components of this type of pump consist of a pump barrel, a plunger and two valves; a traveling valve and a standing valve. Sucker rods which reciprocate within the tubing string of the well are connected to the plunger such that fluids are brought to the surface.

[0004] Over time, as various designs of pump have evolved, two hold down positions of rod pumps have been utilized; namely, the top hold down rod pump and the bottom hold down rod pump both of which are seated within a seating nipple within the production tubing. The top hold down rod pump (where the pump is below the seating nipple) is more commonly used as it is resistant to sand sticking and is typically easier to remove from the well when removal is required. The bottom hold down rod pump (where the pump is above the seating nipple) is less commonly used.

[0005] Similarly, top hold down insert progressive cavity pumps (PCPs) are becoming more available worldwide. A PCP includes a rotor and a stator and, as with reciprocating rod pumps, a pump barrel or stator is operatively seated within a seating nipple secured to the production tubing. A rotor rotates within the stator within a helical chamber so as to positively lift fluids from the lower end of the stator into the production tubing.

[0006] For both top and bottom hold down rod pumps and top hold down PCPs, when problems arise in the wellbore and the hydrostatic pressure above the pump is desired to be released for reasons such as to assist in killing a well or to avoid pulling a wet tubing string to the surface if the pump cannot be unseated, engineers may choose to incorporate a tubing drain. As a part of the tubing string, the tubing drain is located towards the bottom of the production tubing and slightly spaced above the pump seating nipple. The tubing drain will open at a threshold pressure and cause the discharged fluid above the pump to drain to the wellbore. As such, the pressure differential between the inside of the production tubing and the annulus between the well bore and production tubing will equalize. The pressure equalization may then enable the tubing string to be withdrawn without the trapped fluid within the production tubing or alternatively may enable the pump to be unseated and withdrawn from within the production tubing to surface. Additionally, the tubing drain can be used as a safety feature to protect the production system from over-pressuring while in operation.

[0007] If the tubing drain (which in the past has always been located on the production tubing string above the pump) is opened, regardless of the problem being solved or for the reason the tubing drain was opened, the opened drain requires that the production tubing string be returned to the surface in order to reset the tubing drain. Self-resetting tubing drains have not been employed due to the difficulty in automatically resetting such systems in the very dirty downhole environment. Withdrawing the entire tubing string to the surface is expensive and inefficient if the problem being solved does not relate to the tubing string.

[0008] More specifically, as the tubing drain is located slightly above the hold down seating nipple in the production tubing this means that when opened, the tubing drain allows the discharge fluid to drain to the annulus between the wellbore and the production tubing (usually by hydraulic over-pressure).

[0009] In summary therefore, there are many reasons for including a tubing drain as part of the production tubing with the top hold down rod pump. These include:

[0010] 1) The tubing drain is a safety feature for preventing over-pressuring of all equipment downstream of the pump discharge;

[0011] 2) The activation of the tubing drain can be invoked intentionally to assist in releasing a rod pump from the hold down seating nipple by removing both the fluid within the production tubing and its hydrostatic head; or to avoid pulling a wet tubing string if the pump will not release from the seating nipple;

[0012] 3) A tubing drain can also be activated in an effort to kill the surface pressure on a wellhead by pumping kill fluid down the tubing and entering the wellbore from the bottom of the production string via the tubing drain and cycling to the top.

[0013] However, in each case when the tubing drain of these past systems is activated, the production tubing must be removed from the wellbore to replace/reset the opened tubing drain and then returned downhole in order to resume production. This will result in significant cost increases, as service equipment and time is required to complete the work over.

[0014] Accordingly, there has been a need for a pump system that does not require that the production tubing be removed from the well in the event that it is required that the hydrostatic pressure within the production tubing is released.

[0015] A review of the prior art reveals that while limited hydraulic drain systems and various mechanically operated drains have been incorporated into various downhole pump designs, no such solution has been provided to a top hold down rod pump.

[0016] For example, U.S. Pat. No. 3,994,338 discloses a hydrostatic pressure release for bottom hold down rod pumps. This system provides a sub-joint having a release port that will drain oil from the production tubing into the borehole. The sub-joint is located between the standing valve and bottom hold down seal assembly on the pump. This system is limited by virtue of the bottom hold down drain being located in an area where sand commonly bridges off in the static fluid area adjacent the exterior of the pump barrel. As a result, the
normal settling of sand in many wells would make this drain inoperable in many wells. Moreover, trapped sand commonly causes the pump to become stuck in the pump seating nipple.

In a further embodiment, the barrel drain includes at least one barrel drain port and a barrel sleeve operatively retaining a drain sleeve between a closed position where the at least one barrel drain port is closed and an open position where the at least one barrel drain port is open, the drain sleeve and barrel sleeve retaining a shear pin for holding the drain sleeve in the closed position wherein an increase in hydraulic pressure on the interior of the barrel drain will cause the shear pin to shear at a threshold pressure causing the drain sleeve to move to the open position.

In another embodiment, the barrel drain includes at least one barrel drain port for operatively retaining a corresponding rupture disk for sealing the at least one drain port and rupturing at a threshold pressure to open the at least one barrel drain port.

In yet another embodiment, the barrel drain includes a precision slot having a specific thickness that will rupture at a threshold pressure.

In another aspect, the invention provides a method of releasing hydrostatic pressure in production tubing in a well having a top hold-down pump having a barrel drain, comprising the step of: applying a hydraulic pressure to the interior of the production tubing at sufficient pressure to open the barrel drain to permit fluid within the production tubing to flow to an annular space between the barrel and production tubing beneath the seating nipple.

In another aspect of the invention, the invention provides a top hold-down pump for operative connection to a top hold-down pump barrel secured within a hold-down seating nipple within production tubing, the top hold-down pump drain for operative connection to the pump barrel between the hold-down seating nipple and positive displacement pumping equipment retained within the pump barrel, the top hold-down pump drain for releasing hydrostatic fluid pressure from the production tubing and interior of the pump barrel to the exterior of the pump barrel beneath the hold-down seating nipple.

In a further embodiment, the invention provides a top hold-down pump system comprising:

- a barrel having a top section for sealing engagement with a seating nipple within the production tubing and a bottom section operatively retaining positive displacement pumping equipment;
- a barrel drain operatively connected to the barrel between the top section and the bottom section for releasing hydrostatic fluid pressure from the production tubing to the exterior of the barrel beneath the seating nipple;
- at least one production tubing opening operatively connected to the production tubing beneath the seating nipple and adjacent the barrel drain for allowing fluid flow from the annular space between the barrel and the exterior of the production tubing.

BRIEF DESCRIPTION OF THE FIGURES

The invention is described with reference to the accompanying figures in which:

FIG. 1 is a cross-sectional view of a top hold-down rod pump having a hydraulic drain in accordance with the prior art.
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Fig. 2A is a cross-sectional view of a top hold-down rod pump having a hydraulic drain in accordance with the invention;

Fig. 2B is a cross-sectional view of a top hold-down rod pump having a hydraulic drain in accordance with the invention and a secondary check valve;

Fig. 3A is a side and cross-sectional view of a hydraulic drain in accordance with one embodiment of the invention;

Fig. 3B is a side and cross-sectional view of a hydraulic drain in accordance with one embodiment of the invention;

Fig. 3C is a side and cross-sectional view of a hydraulic drain in accordance with one embodiment of the invention;

Fig. 4 is a cross-sectional view of a secondary check valve in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

With reference to the Figures, top hold-down pumps are described to include a hydraulic drain within a pump barrel. The design of the system promotes the efficiency of maintenance in the event that the hydraulic drain has been activated in that the system does not require that the production tubing string be withdrawn from the well to re-set the hydraulic drain.

With reference to FIG. 1, a typical top hold-down rod pump 10 in accordance with the prior art is described. The pump is set within a wellbore 12 having casing 13 and casing perforations 13a adjacent to or near the bottom of production tubing 14. The production tubing includes a seating nipple 16 for receiving a seating mandrel 18, seating cup 18a and seating cup ring 18b on the pump and for securing the pump at its upper end within the production tubing 14. The pump 10 is connected to the surface via sucker rod 20.

The pump 10 further includes a barrel 22 and plunger/piston 24 together with traveling valve 26 and standing valve 28. The traveling valve 26 is secured within the plunger 24 whereas the standing valve 28 is secured to the lower end of the barrel 22.

In operation, the sucker rod 20 is made to reciprocate such that the plunger 24 moves up and down within the barrel. Upward motion of the plunger causes the traveling valve 24 to close causing fluid above the plunger to be displaced upwardly. This fluid passes through the seating mandrel 18 wherein it is expelled to the interior 14a of the production tubing 14 towards the surface. At the same time, the standing valve 28 will open allowing fluid to enter the lower region of the barrel 22 to fill the volume 22a created by the upwardly moving plunger.

Subsequent downward motion of the plunger 24 causes the traveling valve 26 to open and the standing valve 28 to close such that the plunger 24 moves downwardly through the barrel 22 so as to retain hydrostatic pressure within the production tubing 14.

As well known, repetition of the cycle enables fluid to be drawn from the well.

Fig. 1 also shows the location of a tubing drain 30 in accordance with the prior art above the seating nipple 16 in the production tubing 14. As is known, in the event of the need to relieve the hydrostatic pressure in the production tubing (for all reasons including production, maintenance and safety), by increasing the hydraulic pressure within the production tubing 14a will cause tubing drain 30 to open allowing the fluid within the production tubing 14a to flow into the annular space 32 between the casing 13 and production tubing 14. Once opened, this system then requires that the entire tubing string 14 be removed from the well to replace the tubing drain 30.

As known to those skilled in the art, the pump 10 may be assembled in sections so as to facilitate maintenance of the various sub-components of a pump.

As shown in FIGS. 2A and 2B and in accordance with the invention, a barrel drain 52 is configured to the pump beneath the pump seating nipple 16 as a section of the barrel 22 and above the traveling 26 and standing valves 28. As such, in the event that the hydrostatic pressure within the production tubing 14 must be relieved, an increase in hydraulic pressure within the production tubing 14 will cause the barrel drain 52 to open. In the subject design, as the barrel drain 52 is located beneath the seating nipple 16 and in the barrel 22, hydrostatic pressure will equalize between the production tubing volume 14a and annular space 32 through micro-annular space 32a and the bottom of the production tubing 14. Importantly, this design will not require that the production tubing 14 be withdrawn from the well to reset the system but rather only requires that the pump 50 be returned to surface to be reset. In a further embodiment, the production tubing beneath the seating nipple 16 may also be provided with one or more slots 56 adjacent the barrel drain 52 such that in the event that the barrel drain 52 is opened, the fluid within the production will more rapidly flow into the well bore as fluid drag through the micro-annular space would be reduced. This may be especially advantageous in the event that surface pressure must be quickly killed within the well.

As readily understood by those skilled in the art, removal of the pump 50 is considerably more cost efficient than removing both the pump 50 and production tubing 14.

In a further embodiment, as shown in FIG. 2B and FIG. 4, a secondary check valve 54 may be incorporated beneath the barrel drain 52 to replace any secondary check valve above the seating mandrel on select pump configurations. The secondary check valve is used to assist in opening the travelling valve when the plunger moves downward as the check valve relieves the travelling valve of the weight of the hydrostatic head. As shown the secondary check valve 54 includes a valve sleeve 54a that is engaged around valve rod 16a between retaining cage 54b and check valve seat 54c. The secondary check valve does not interfere with the normal operation of the plunger and standing and travelling valves.

FIGS. 3A, 3B, and 3C show different embodiments of a barrel drain. In FIG. 3A, a barrel drain 70 includes a drain sleeve 72 around drain mandrel 74 having drain ports 75. Seal rings 76a and 76b provide a seal between the interior of the drain mandrel 74 and the exterior. Drain sleeve 72 is retained in a closed position as shown in the Figure by shear pin 78. In operation, by increasing the hydraulic pressure within the drain mandrel 74 will, at a desired pressure threshold, cause the shear pin 78 to shear thereby creating the drain sleeve to move to an open position where the drain ports 75 are opened. The barrel drain 70 may be configured to the pump barrel by an appropriate connection system such as threads.

In FIG. 3B, a barrel drain 80 is similar to the barrel drain 70 shown in FIG. 3A with respect to a barrel sleeve 82 and a drain port 84. The drain port 84 is fitted with a rupture plug 86 designed to rupture at a desired pressure threshold.
In FIG. 3C a barrel drain 90 includes a precision slot vertically milled into the joint. An increase in pressure above a threshold causes the precision slot to rupture at the precision slot based on the specific thickness of the slot material.

The technology may be similarly applied to a top hold-down insertable progressive cavity pump (PCP) which could use any of the barrel drains described above. In a progressive cavity pump system, the barrel drain would be configured to an upper section of a PCP stator beneath a top hold-down seating nipple and above the PCP rotor.

Although the present invention has been described and illustrated with respect to preferred embodiments and preferred uses thereof, it is not to be so limited since modifications and changes can be made therein which are within the full, intended scope of the invention.

I claim:

1) A top hold-down pump for pumping fluids from a well to the surface through production tubing, the top hold-down pump having an upper end for sealing engagement with a seating nipple within the production tubing and a positive displacement pumping system operatively retained within a barrel for allowing fluid within the barrel to be displaced to the surface by a reciprocating or rotating rod operatively connected to the positive displacement pumping system, the improvement comprising a barrel drain between the upper end and the lower end for draining fluid from the production tubing to the exterior of the barrel beneath the seating nipple.

2) A top hold-down pump comprising:
   a barrel having a top section for sealing engagement with a seating nipple within the production tubing and a bottom section operatively retaining positive displacement pumping equipment;
   a barrel drain operatively connected to the barrel between the top section and the bottom section for releasing hydrostatic fluid pressure from the production tubing to the exterior of the barrel beneath the seating nipple.

3) A top hold-down pump as in claim 2 wherein the barrel drain includes at least one barrel drain port and a barrel sleeve operatively retaining a drain sleeve between a closed position where the at least one barrel drain port is closed and an open position where the at least one barrel drain port is open, the drain sleeve and barrel sleeve retaining a shear pin for holding the drain sleeve in the closed position wherein an increase in hydraulic pressure on the interior of the barrel drain will cause the shear pin to shear at a threshold pressure causing the drain sleeve to move to the open position.

4) A top hold-down pump as in claim 2 wherein the barrel drain includes at least one barrel drain port for operatively retaining a corresponding rupture disk for scaling the at least one drain port and rupturing at a threshold pressure to open the at least one barrel drain port.

5) A top hold-down pump as in claim 2 wherein the barrel drain includes a precision slot having a specific thickness.

6) A top hold-down pump as in claim 2 where the top hold-down pump is a reciprocating rod pump.

7) A top hold-down pump as in claim 2 where the top hold-down pump is a progressive cavity pump.

8) A top hold-down pump as in claim 2 further comprising a secondary check valve operatively connected to the barrel between the barrel drain and the bottom section.

9) A method of releasing hydrostatic pressure in production tubing in a well having a top hold-down pump as described in claim 2, comprising the step of:
   applying a hydraulic pressure to the interior of the production tubing at sufficient pressure to open the barrel drain to permit fluid within the production tubing to flow to an annular space between the barrel and production tubing beneath the seating nipple.

10) A top hold-down pump drain for operative connection to a top hold-down pump barrel secured within a top hold-down seating nipple within production tubing, the top hold-down pump drain for operative connection to the pump barrel between the hold-down seating nipple and positive displacement pumping equipment retained within the pump barrel, the top hold-down pump drain for releasing hydrostatic fluid pressure from the production tubing and interior of the pump barrel to the exterior of the pump barrel beneath the hold-down seating nipple.

11) A top hold-down pump system comprising:
   a barrel having a top section for sealing engagement with a seating nipple within the production tubing and a bottom section operatively retaining positive displacement pumping equipment;
   a barrel drain operatively connected to the barrel between the top section and the bottom section for releasing hydrostatic fluid pressure from the production tubing to the exterior of the barrel beneath the seating nipple;
   a barrel drain operatively connected to the barrel between the top section and the bottom section for releasing hydrostatic fluid pressure from the production tubing to the exterior of the barrel beneath the seating nipple above a threshold pressure; and,
   at least one production tubing opening operatively connected to the production tubing beneath the seating nipple and adjacent the barrel drain for allowing fluid flow between the annular space between the barrel and production tubing.

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