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Hydraulic lift systems with piston type pump

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A R T I C L E I N F O

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A B S T R A C T

More difficult conditions of oil production process in recent years impose the necessity of finding out new technical solutions that will provide reliable and efficient lifting of reservoir fluid to the surface.
Technical solution presented in this paper, hydraulically driven piston pump, is one of the attempts in the field of artificial exploitation methods, to find a solution that will work effectively in different well types (vertical, horizontal and directional) and at depths that are greater than those achieved until today.
The task of this paper is to show the innovation in the pump construction. Innovations are made in the coiled tubing construction, one pipeline instead two or three; double acting type pump with reservoir fluid repression, towards the surface, through a channel drilled in the piston.
The new technical solution, laboratory prototype, has been tested and the results are presented in tables and on graphs in this paper. The aim is that after testing the laboratory prototype comes to the data that will be used for the design of industrial product.

1. Introduction

The need to ensure effective transmission of power from the engine, on the surface, down to the pump, at the well bottom hole, imposes the hydraulic transmission as one of the most desirable solutions. Hydraulically driven pumps have been in use for several decades now (Čičerov, 1983; Perrin et al., 1999).These systems provide extraordinary installation and operation flexibility, which facilitates fit-for purpose solutions to maximize production and lifting economy (Weatherford, 2008). The existing hydraulic lift systems have a range of operating depth from 1500 to 5200 m and flow rate of 8.0–2500 m^3/day.

Hydraulically driven pump use the fluid to power the subsurface pump which lift well fluids to the surface. Power fluid can be both well fluids or water (Barton, 1966). There are two technical solutions that use hydraulic energy for crude oil lifting (Čičerov, 1983), (Weath erford, 2008): (1) by moving the hydraulically driven piston into the cylinder or (2) by transfer energy into the jet pump.

Depending on the type of the working fluid circulation equipment, with hydraulically driven pump, can be with: open fluid circulation, Fig. 1-a, and with closed fluid circulation, Fig. 1-b (Čičerov, 1983).

In the first case, open fluid circulation, crude oil, cleaned out from water and mechanical ingredients, is brought under pressure by means of the pipeline (3) from the surface pump (1) to the hydraulic motor (4) which is directly connected to the piston of the deep well piston pump (5). The pump (5) takes in the fluid, and by discharge piping (6) sends it to the surface. Part of fluid goes to the facilities for processing and preparation of a new energy conversion cycle, while the rest goes to the collectors.

In the second case, the working fluid returns to the surface through the pipeline (7) into the cleaner (8). Only a small portion (1–2%) of the reservoir fluid is brought to the cleaner (8) through the pipeline (10), with an aim of compensating for the work fluid losses.

For open fluid circulation system two pipelines are needed at the well bottom hole: one to feed the hydro motor with fluid under pressure and the other for fluid to be delivered to the surface. At the end of the working cycle, the working fluid, in the hydraulic motor of the well pump, is being discharged at the well bottom hole and extracted to the surface by the well pump.

Advantage is simplicity of well competition. Disadvantage is the constant necessity for cleaning the new working fluid which makes construction more complex, and thus has an effect on operating costs (Čičerov, 1983).

Pumps with closed flow circulation require a third pipeline. By this line, the used fluid, in the hydraulic motor, flows back to the surface, i.e. to the plant for the cleaning of the work fluid. In case of the slim hole well, this makes the procedure of well competition more complicated. The advantages are: minimum losses of the work fluid, less preparation and pumping fluid costs. The lack is the complex system of pipelines that needs to be put down at the well bottom hole.

The increasing need for pumps that can operate in most difficult crude oil exploitation conditions, as well as those of water, and dewatering gas well processes, poses a reason for intensive work on the improvement of the existing and development of new pump constructions (Falk et al., 2002). Here in particular, we emphasize the constructive and technological characteristics of the two

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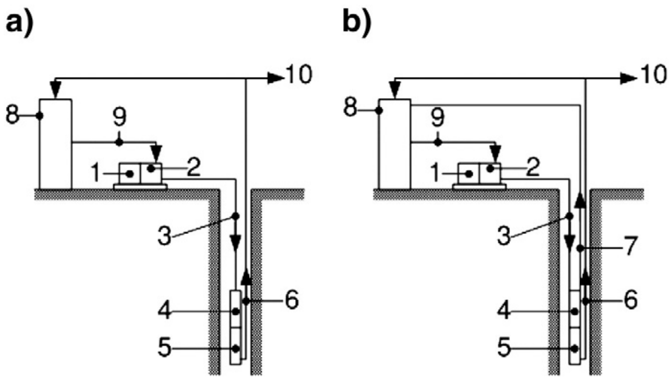

Fig. 1. Hydraulic lift systems. a) Open fluid circulation. b) Closed fluid circulation. 1. Motor, 2. Pump, 3. Pressure pipe, 4. Hydro motor, 5. Well pump, 6. Discharge pipe, 7. Return pipe, 8. Cleaner, 9. Suction pipe, 10 Pipeline.

technical solutions that are similar to the solution that we propose in this paper.

Coiled tubing (CT)-conveyed hydraulic pump for dewatering gas wells can be deployed through tubing or through casing (Lee and Wikler, 2010). In the trough tubing (TT) system, the hydraulic pump is run on CT through the production tubing and is seated in a seating nipple at the bottom of the tubing. The CT is filled with hydraulic fluid to operate the pump. Water (oil) is pumped up the CT-tubing annulus, allowing gas to flow up the tubing casing annulus.

In the through-casing system the hydraulic pump is run on a FLAT-pack umbilical package composed of two CT strings. One CT string is filled with hydraulic fluid and water is pumped up the other CT-string, allowing gas to flow up the umbilical package-casing annulus.

The hydraulic power unit (HPU) at the surface applies hydraulic pressure to the down hole pump, pushing the power piston up. The HPU then releases the hydraulic fluid to drain back to the tank. The difference in fluid density between the pumped water and the hydraulic fluid provides the restoring force that pushes the power piston down.

The Hygr. Fluid System is a surface-powered down hole pumping technology that uses a down hole transfer piston with specific hydraulic principles to supply theoretical pump efficiencies in excess of 95% for wells as deep as 1.000 m and producing 3.2–32.0 m^3/day (Lee and Wikler, 2010).

The hydraulically driven pumps, i.e. the existing solutions, are appropriate for placing into directional or horizontal wells. Both, the existing and the new technical solutions, can be successfully used in oil exploitation, but in dewatering gas wells and water production as well.

The hydraulic motor for deep well piston pump is a more desirable solution than the electric drive, especially concerning work safety. Pumps (single acting and double acting) have good pressure-flow characteristics, i.e., they can achieve high operating pressures with high volume capacity.

A serious disadvantage is the fact that they are sensitive to the sand present in the reservoir fluid being transported, and due to the narrow flow channels, they are also sensitive to the presence of paraffin. As such, they cannot be used for heavy oil production. Construction of hydraulically driven piston pumps is complex, so their purchase and maintenance price is high. This type of pumps is mostly used in the oil fields with larger number of wells and with a centralized feeding system (Molcanov, 1988; Weatherford, 2008). The problem with this kind of drive is that when it comes to a halt on the central drive device, practically all wells in the field come to a halt as well.

2. Hydraulically driven pumps — the new technical solution

By analyzing the existing technical solutions (Molcanov, 1988; Perrin et al., 1999; Weatherford, 2008) and the new tendencies in the development of these pumps (Falk et al., 2002) the authors have realized a new technical solution, Fig. 2, (Batalović, 2002; Batalović and Bizjak, 2002; Batalović, 2006; Batalovic and Danilovic, 2006) that is presented in this paper.

The main goal of the effort made while designing the new technical solution, was to create a pump that would be of a simple construction, low energy consumption and possibilities of application in heavy production conditions.

The originality of the prototype of hydraulically driven piston pump construction primarily reflects in the manner of power transmission from the engine located on the surface, to the hydraulic motor at the well bottom hole, as well as in the construction of the piston pump (double acting piston with the fluid flow through a channel drilled in the body of the piston).

The essence of the innovative solution lies in the torque transformation, resulting from the motor, into the pressure, using the surface pump (1), Fig. 2-a, Fig. 3.

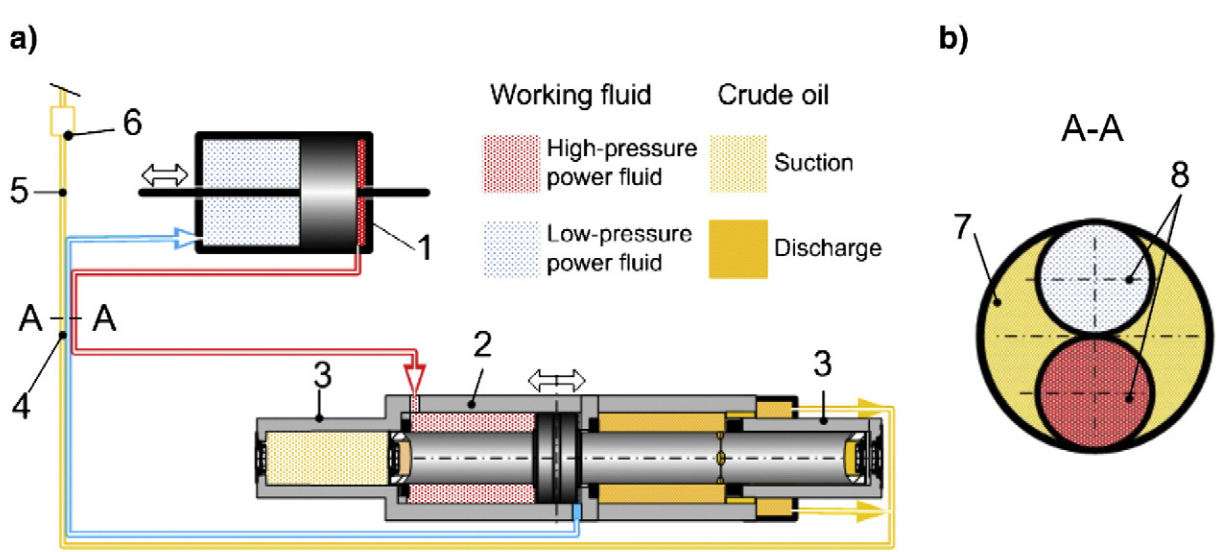

Fig. 2. Prototype of deep well piston pump, Scheme. a) 1. Surface pump, 2. Hydraulic motor, 3. Piston pump, 4. Complex tubing, 5. Discharge pipe, 6. Pipeline connection. b) 7. Main pipeline for crude oil, 8. Low- and high-pressure pipelines.