



SPE 104314-PP

Economic Pumping Technology for Coal Bed Methane (CBM), Stripper Oil and Shallow Gas Well Deliquification.

Michael W. Dickey, SmithLift LLC

Copyright 2006, Society of Petroleum Engineers

This paper was prepared for presentation at the 2006 SPE Eastern Regional Meeting held in Canton, Ohio, U.S.A., 11–13 October 2006.

This paper was selected for presentation by an SPE Program Committee following review of information contained in an abstract submitted by the author(s). Contents of the paper, as presented, have not been reviewed by the Society of Petroleum Engineers and are subject to correction by the author(s). The material, as presented, does not necessarily reflect any position of the Society of Petroleum Engineers, its officers, or members. Papers presented at SPE meetings are subject to publication review by Editorial Committees of the Society of Petroleum Engineers. Electronic reproduction, distribution, or storage of any part of this paper for commercial purposes without the written consent of the Society of Petroleum Engineers is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of where and by whom the paper was presented. Write Librarian, SPE, P.O. Box 833836, Richardson, TX 75083-3836 U.S.A., fax 01-972-952-9435.

Abstract

Operators of shallow, low flow oil and gas wells have commonly relied on conventional beam pump and other artificial lift methods to produce these types of wells. Often, the use of these pumping systems results in inefficiencies, short run-life and environmental challenges that affect the overall economics of the operation.

A hybrid artificial lift system has been developed to allow operators of shallow, low flow oil and gas wells the opportunity to produce the wells in a much more economical fashion than beam lift or other conventional methods. This paper introduces the technical aspects of the system, its operation and deployment techniques, and the power savings it realizes in comparison to beam lift and other traditional lift systems.

The Hydraulic Diaphragm Electric Submersible Pump (HDESP) uses a technology that offers a number of benefits to operators. The system's hybrid design advantageously combines the beneficial features of both electric submersible pumps (ESP) and hydraulic diaphragm pumps (HDP). Both of these types of systems are widely accepted in their respective industries.

Laboratory tests and deployment of the HDESP in producing wells confirm the systems capabilities in vertical wells up to 2500 feet in depth with production rates less than 200 BFPD. Ongoing design engineering has objectives of greater depths and higher volumes. Heat issues commonly associated with electric submersible motors are also being addressed.

Abrasives and gas handling comparisons are made between ESPs and beam pumps. Procedures optimizing HDESP reliability within adverse wellbores are also described.

Power cost studies indicate that the HDESP can reduce electrical cost by as much as 50% compared to beam pumps and water-well type ESPs. The net positive suction head

(NPSH) requirement is considerably less, allowing an operator to drawdown fluid levels very close to the pump intake. This offers potentially significant production benefits to the producer.

At the conclusion of the paper, readers will have a thorough understanding of the function of the HDESP system, its performance successes and failures, suitable target applications, deployment techniques, and the overall potential for economic benefit the system brings.

HDESP System Description

The HDESP is a positive displacement pump that comprises two main components: 1) an oil filled submersible electric motor and, 2) twin acting diaphragm tubes. The entire system contains hydraulic oil and is sealed against intrusion by well fluids. The stainless steel construction makes it resistant to corrosion. Figure 1 illustrates the internal components.

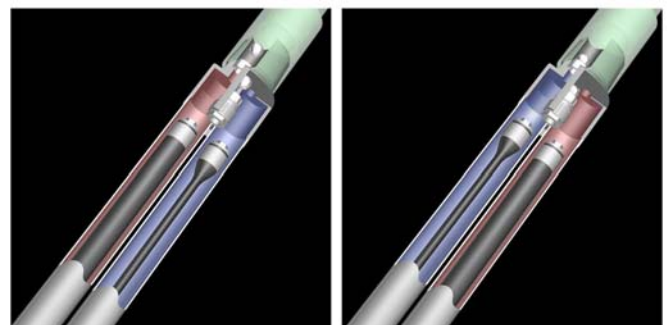


Figure 1

The electric motor is supplied with 3 phase, 460 volt power by a submersible power cable that is banded to the production tubing and sealed at the wellhead. Since the assembly is suspended by the tubing string and the prime mover is now located downhole, rod strings are eliminated and mechanical losses minimized. Rod wear is no longer an issue.

Hydraulic diaphragm pumps have excellent solids handling capabilities and the twin acting diaphragm tubes provide increased pumping efficiency even in the presence of produced gas.

Surface controls monitor and protect the motor against voltage fluctuations, phase loss, and ground faults. The pump-off control is built-in to the surface control panel. Variable speed drives can be utilized however, these devices are typically used to convert single phase to three phase power rather than speed control for the HDESP motor.

As environmental concerns increase for the operator, the HDESP offers a small surface profile installation that prevents fluid leakage from stuffing boxes and packing glands. Overhead irrigation concerns are not an issue, and since the system is downhole, noise pollution and unsightly pump jacks in sensitive areas are eliminated. By utilizing an electric submersible motor and hydraulic diaphragm pump, the HDESP represents a “true hybrid” system of two widely accepted forms of pumping fluid.

HDESP Pump Function

After an HDESP pump is installed and all the electrical connections are complete, power is supplied to the electric motor via the starter panel or variable speed drive. The motor is directly coupled to an internal pump that moves the hydraulic oil from one diaphragm to another so as to alternately expand and contract them. Two intakes, each dedicated to their own diaphragm tube, allow well fluid to enter into the chamber with the collapsed diaphragm. As one diaphragm is collapsed, the other is expanded thereby causing the discharge of contained production fluid from the pump into the tubing. Viewed as a process, the alternately expanding and contracting diaphragms provide flow continuity. Surface controls monitor downhole parameters and take the unit off line in the event of pump-off. This eliminates the need for downhole pressure sensors and fluid level gauges.

Since internal components are not in contact with the well fluid and since there are no rotating parts, the HDESP is far less susceptible to abrasive wear or gas locking than rod pumps and ESPs during low flow conditions and at pump-off.

Deployment Mechanisms

The 3.75 inch OD HDESP allows it to be deployed in 4.50” and larger casing. The system can be landed below the perforations. In such cases, a flow shroud may be necessary to increase fluid velocities by the motor shell for cooling purposes. Dimensionally, the HDESP is very easy to handle. Its length is approximately 7 feet and weight about 90 pounds. The pump can be deployed on conventional steel tubulars or coiled tubing. As a benefit of small system dimensions, recent deployments have been on one inch thermo-plastic tubing. Since coal bed methane (CBM) and shallow oil and gas wells commonly contain formation solids and frac sand, and usually produce at low flow rates, small diameter tubing results in relatively high fluid velocities. These are usually sufficient to ensure reliable solids transportation to the surface. This feature of small diameter tubing minimizes the potential for “solids settling” at the pump discharge or check valve. See Table 1.

Thermo-plastic tubing is corrosion resistant and can be installed in a matter of a few hours without need for a workover rig. The elimination of conventional tubing and rod

Comparison of Fixed Flow Rates and Resulting Velocities			
In 1.99” and 0.61” OD Pipes			
Flow Rate (B/D)	2 3/8”OD (1.99”ID) Velocity	1.0” OD (0.61” ID) Velocity	Percent Increase
100	0.3 ft/sec	3.2 ft/sec	1067%
150	0.5 ft/sec	4.8 ft/sec	960%

Table 1

strings, and their handling, is advantageous to HDESP installation economics. Figure 2 illustrates the deployment of an HDESP on thermoplastic tubing.



Figure 2

Field Performance Results

As with most new technologies, early field testing of prototype HDESPs did not meet all design goals. A number of test installations experienced short run failures. These were shown to primarily be the result of deployment in wells with inappropriate application windows. At the same time, field testing found a number of ways in which to improve prototype engineering designs. Initial field testing played an important role in establishing a sound production product design. An operator in Kentucky has been using the product since its early design stage. This operator uses the pump in shallow (1200 feet or less) oil stripper applications. Production is typically less than 25 BPD. The company had previously used rod pumps and had experienced failures primarily caused by wear from abrasives in their production fluid. The HDESPs

achieved a six-fold increase relative to prior beam pumps in realized run time. This operator produces from within environmentally sensitive areas and considers the cleaner well locations associated with the HDESP an important product bonus.

Several operators in the Powder River Basin in Wyoming have reported improvement in their CBM operations as a result of the HDESP installations. One well was experiencing an 18 day run average for water well type ESPs that were installed. Five of these pumps had been replaced within 90 days because of failures caused by gas locking and abrasive wear due to solids in the production fluid. The HDESP replacement system had achieved a cumulative run for 136 days. During this period, an increase in gas production from 60MCF to 110MCF was realized. The operator grossed an additional \$29,500 with the increased performance. An additional savings in pulling costs was also realized.

Since the application window for production HDESP systems has been clearly defined and because of engineering enhancements, the performance of the HDESP has, today, exceeded the initial performance goals.

Comparison to Other Lift Systems

The unique design of the HDESP offers several benefits that address common problems associated with rod pumps and ESPs.

In comparison to typical rod pump installations for shallow, low production wells, the HDESP eliminates the use of rods and mechanical wear on the tubing is eliminated. Since there are no rotating or moving parts in contact with the well fluid, abrasive wear to the pump is minimized. At pump-off conditions, gas locking has never been observed in HDESP units in the field. Packing glands and stuffing boxes are eliminated. The potential for leakage at the wellhead is essentially eliminated. The low surface profile of the HDESP eliminates concerns with over-head irrigation. Lastly, studies have indicated a substantial decrease in power consumption favoring the HDESP in comparison to rod pumps. The low power consumption of the HDESP is an even greater advantage when compared with ESPs.

Power Consumption Comparison

When oil prices are depressed, operators tend to place more emphasis on electricity costs for their artificial lift systems. It seems, during times of higher oil prices, that emphasis is shifted to other areas of concern although these costs still exist and can even become a larger percentage of production costs. The HDESP is a positive displacement pump. Typically these types of systems result in higher pumping efficiencies (60%-80%). A power cost study was performed at the Rocky Mountain Oilfield Test Center (RMOTC) to verify the HDESP's power consumption versus rod pumps and water-well type ESPs. A revenue grade power meter was installed on similar wells with the three different forms of lift. The data was analyzed and a formula of KW/bbl/1000' was applied. The results of those findings are summarized in Figure 3.

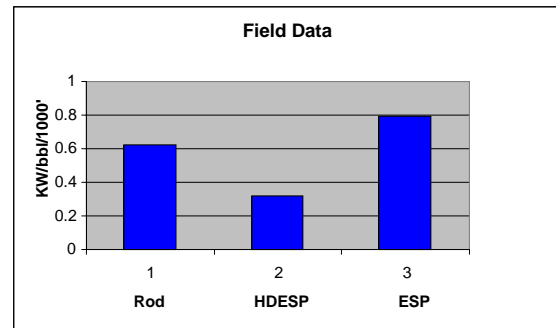


Figure 3

Based on these results, if one was to look at the case of a well lifting 200BPD from 2000 feet at \$0.10 per KWH, the results indicate a 55% savings versus a rod pump and a 74% savings versus an ESP. The resulting yearly power costs are illustrated in Figure 4.

A second study was performed with the operator from Kentucky. The results indicated the rod pump consumed 228% more electricity than the HDESP. This data supported the initial findings at RMOTC.

Power consumption testing is currently being performed to determine how the HDESP compares with other methods of artificial lift, such as progressive cavity pumps (PCPs).

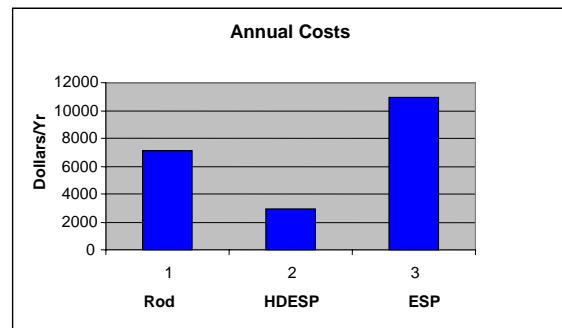


Figure 4

Conclusion

The HDESP is an advantageous alternative to conventional artificial lift systems. It is specifically designed for shallow, low volume fluid withdrawal. With its superior solids and gas handling capabilities, increased reliability is achieved. It can be deployed without a workover rig, thereby reducing deployment costs and downtime. Since there are no rod strings, mechanical wear is virtually eliminated. The pumping efficiency (60%-80%) of the system provides the operator with a reduction in electrical consumption. Finally, the low profile surface equipment provides a leak free, aesthetic completion for the operator.

References

Traylor, Leland; "Comparison of the Energy Efficiency of Various Types of Artificial Lift Systems for CBM Well Applications", presented at the "Gas Well Deliquification Symposium", Denver, CO March 2006.