Final Technical Report- “A method for using the production pump to continuously clean stripper wells”

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Final Report

Leland Traylor

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Pumping Solutions Incorporated
11510 Ranchitos Ave NE
Albuquerque NM 87122

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Abstract
Cable Suspended Pump (CSP) works! This low cost system, which was used to deploy submersible pumps on continuous, flexible production strings completed first installation from a small trailer at RMOTC in December 2002. The flexible production string consists of three elements, the suspension cable composed of wire rope, electrical cable and plastic reinforced tubing. All three elements are deployed from the trailer from powered spools and joined about every 30 feet. The completed string has a wet weight of 500 pounds/1000 feet, and costs less than $2.00/foot. The most dramatic result was the improvement in installation speed and the reduction in cost due to the use of the relatively lightweight trailer. Installations were completed in less than 2 hours/1000 feet, with a one or two person crew using a rig that was towed behind a F-250 Ford truck.

The first installation went smoothly in a Shannon formation well in the teapot dome field in Wyoming. The purpose of this installation was to shake down the trailer, so the pump was installed to a depth of 600 feet, and the next day, removed from the well to determine if fixtures and procedures needed to be changed. As expected, further improvements in the hardware and installation techniques were made after this initial shakedown.

The second installation was made a few weeks later into the same well, and the pump was set at the bottom of the well, at approximately 650'. The pump was run for two months and then pulled. A significant design problem was discovered when we attempted to pull the pump. The clamping system used did not adequately prevent the tubing from "bunching up" at the top of the pump, and the design of the bottom adaptor caused the pump to pull to one side, tending to cause it to lodge against the casing and catch on downhole obstacles such as gyp rings.

Winter and a traffic accident stopped testing until April 27th-30th 2003, when two runs were made to 1000' into the same well on consecutive days. This well is still in production on CSP and will be serviced by PSI when needed in the future.

Five additional test installations were completed as called for in the plan. These tests were or will be completed on conventional tubing as called for by the plan. These installations will be compared head to head with similar rod pumping installations under company funding.

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Introduction

Over the past year, Pumping Solutions Incorporated, has been performing tests on a novel, low cost production system that is used in conjunction with submersible pumps. This deployment system has the potential to replace more expensive 2 3/8" production tubing commonly used today. This patent pending system uses three strands deployed from powered reels at the surface. The first strand is the production cable, typically steel wire rope, the second strand is plastic insulated electrical cable, and the third is fabric reinforced polyethylene plastic tubing. The reels are mounted to a portable trailer that can be towed by a normal oil field truck and operated by one person. The purpose of the project was to deploy submersible pumps using this system to determine if it is useful and cost effective for stripper wells.

Executive Summary

This project produced significant results that far exceeded expectations. For the first time ever, a cable suspended pump was successfully deployed into a stripper well. Under the scope of the project, a completely new CSP trailer was designed, built and deployed. A new type of plastic high pressure, fabric reinforced hose was designed and built. Fittings needed to adapt the flexible string to the existing wellhead and to the submersible pump were developed. Finally, the submersible hydraulic diaphragm submersible pump itself received extensive test and run time as part of this project, including a head to head comparison that is just started and will continue well past the duration of this project under company funding.

The pumping system was deployed a total of four times after the trailer was completed in November 2002, and as a result, improvements were made that have resulted in a completely usable system for relatively shallow wells using submersible pumps. Another five installations using conventional installation techniques are planned or have been completed. The future installations will use equipment purchased using SWC funding, and will be deployed with company funds. The company plans to extend, under it's own funding, the technology to deeper wells, and other production situations such as Coal Bed Methane. Although not tested, system has been adapted to be used for conventional submersible centrifugal pumps, and for other types of wells, such as water wells.

The testing of the hydraulic diaphragm electrical submersible pumps (HDESP) was also significantly advanced by this project. Results from CSP and conventional installations have proven some remarkable characteristics of this technology. HDESPs have the ability to pump up to 1.5% sand, will pump off with no damage, provide mixed flow (gas and liquid) pumping allowing higher production rates and have reduced power consumption up to 66%. This performance is from an all stainless steel and rubber pumps that weighs about 100 pounds and is 3 _ " in diameter, and costs less than half of a conventional pump. With an expected life of one to three years continuous operation, the technology is estimated to reduce artificial lift costs by 50% for a typical low volume installation. As a result of this proof of concept, a major pump company has partnered with PSI and will offer this pump and related products such as CSP as part of a major new branch of artificial lift technology.

Experimental

The experimental results are in two parts, the first section for CSP deployments and the second for conventional.

CSP Deployments

The trailer and string has been deployed four times at RMOTC, the first time was a dry run where the pump was placed and pulled on the same day to determine if the system works, and what changes are needed. The second run was "for real" into the same well after appropriate hardware changes were made in the field. The second time the pump was placed and remained in well for three months until it failed and was pulled with the trailer. The next two deployments followed the same basic plan after major renovations were made after the first pump was retrieved. The dry run was on April 24, 2003, when the pump was deployed and then retrieved to determine that the new hardware would not get stuck downhole. The second deployment was on April 29, 2003, and is still in operation as of the time of this report.

The first test was completed in mid November 2002, at the RMOTC in teapot dome Wyoming. A pump was placed by the trailer to a depth of 600' and then removed. All proceeded without incident, and a few design changes were identified for the first "for real" run. A few weeks later, in mid-December, with the design changes in place, the first run was made. The first run followed an unfortunate incident where our field man, Paul, was involved in a single car accident on an icy road in Southern Wyoming. The _ ton F-250 superduty truck pulling the CSP trailer rolled down an embankment after hitting an icy patch. Everyone was OK except the truck.

Truck and trailer prior to crash

The trailer was undamaged, and Paul proceeded to RMOTC to complete the installation. The second installation went smoothly, and the pump was placed in a Shannon well at 650' depth. Again, several design changes were identified as a result of this run. The plan was to leave the trailer at the location and remove the pump in a few months time to determine if the system was working properly. In early February, a record breaking cold snap occurred in the Wyoming area, and froze a large percentage of the wellheads in the RMOTC field, including the test wellhead. When the pump was started, fluid could not flow, and the tubing burst at the pump end of the string. The pump was undamaged.

CSP Wellhead

We returned to RMOTC in late February to retrieve the pump from the well using the trailer. Several difficulties were encountered trying to pull the pump, which we later learned were the result of small but correctable problems with the design of the adaptors used for the test. When the pump was pulled, the pump became stuck downhole, 10's of feet above the original location. After much effort, the suspension cable was snapped in two in an attempt to retireve the pump by the suspension cable. An attempt was made to retrieve the pump by pulling the tubing. Fortunately, this succeeded in retrieving the pump and the electrical cable.

After the pump was removed and the remains examined, two problems came to light. First, the wire rope cable connection to the adaptor had come off center because of poor design assumptions. This off center pull cause the top of the adaptor to dig into and slide along one side of the casing, rather than in the center. The corner of the adaptor soon encountered gypsum deposits which caught on the end of the adaptor. This was enough resistance to arrest the upward movement of the assembly regardless of how hard we pulled. After the cable broke, the suspension was switched to the fluid tubing, which was on center, and released the stuck pump from the grips of the casing.

The second problem encountered was that the tubing and electrical cable were not attached firmly enough to the suspension cable, causing it to slip and become piled up at the top of the pump when we were moving the pump up and down to free it from the casing.

Two corrective actions were identified. First, the adaptors were redesigned to achieve an on center pull, and all flat surfaces facing upward have been removed. The shape of the adaptor was changed from a "can" shape to a "football" shape to facilitate the adaptor's movement up the casing. The second corrective action is to improve the connection between the tubing, electrical cable, and suspension cable by providing a layer of tape between the elements before the clamp is applied. The tape fills in the gaps and achieves a tighter fit at the clamp.

Also, as a result of this experience, the trailer was damaged, as the drives for the tubing were never designed to take the load applied to remove the pump from the well. The operator also suggested that we change from constant speed drives to constant force drives to simplify the operation of the trailer, and that a guard be added to make the trailer easier to set up.

Several interesting results came about after the tubing used in the test was examined at the surface. First, no degradation was suffered by the tubing in any way. The plastic and reinforcement layers were 100% intact. The inside surface of the tubing was completely clean, with no evidence of any mineral or paraffin buildup. The approximate velocity of the fluid in the tubing, when the pump was running, was 2 ft/sec. We also observed that the inside of the tubing was very smooth, and this may have also contributed to the lack of build up. Although the diameter of the tubing was relatively small, the tubing showed no signs of constriction. Although paraffins were found in the metal sections (adaptors, surface piping etc), significantly, no build-up was observed in the tubing itself.

CSP being installed

Tests number three and four were completed after extensive modification of both the trailer and the fittings. Test number three, which was a temporary installation to determine that the new fittings were not going to become stuck downhole, was conducted on April 24th 2003 at RMOTC into a Shannon formation well at 900 feet. The pump was successfully deployed and retrieved on the same day with no incident.

The following week, the fourth deployment was completed on April 29,2003 into the same Shannon formation well. The installation was made and completed in less than 4 hours, including final hook-up and pump up. The improvements over the previous installations were an improved adaptor with an on center pull and no sharp corners and improvements to the clamps, including the use of tape to improve the fit, and tape to cover the clamp "tags" to make sure they do not catch on the well coming up. This pump is currently in operation, and when required will be pulled with company funding.

Conventional Installations

Over thirty HDESP installations have been made in the past 24 months to various stripper and gas wells to determine the performance of and improve the design of the submersible diaphragm pump. To date, the average run time has been about 4 months, with the run time improving constantly with design changes. The HDESP is currently awaiting the arrival of a vastly improved diaphragm that has been in the works for the past 6 months. This change is the final step in the design evolution of the HDESP. Even without the new diaphragm, the pump has been proven as a result of the test program.

The PI had hoped to be able to conduct some of the final CSP and conventional installations with the new diaphragm, but this will not be possible within the time constraints of the SWC. We have recently deployed to the field three pumps as part of the conventional installation program that was approved as part of this project. Two pumps have been shipped and will be deployed to Bretagne G.P. in Kentucky as part of a side by side comparison between rod and HDESPs over the next year. Two more pumps will be sent to Betagne once the first two are installed, and the hope is that the new pumps will have the vastly improved diaphragms. Another pumps has been shipped to QuickSilver resources for use in stripper service in Michigan. The three pumps that have shipped are equipped with conventional diaphragms. The later two, plus any replacements required, will have the new diaphragm. Additionally, once reliable pumps with new diaphragms are available, more pumps will be sent to Geopetro, Quick Silver, Nobel (in Oklahoma) and Chatachwa energy, as well as other sites selected from SWC membership. All of the hardware shipped plus the two additional pumps use hardware that is part of this SWC program. The company will pay any additional expenses for hardware or deployment that occurs after this project is terminated.

Results and Discussion

Because of the successful development and deployment of this system, many more tests are planned, leading to full commercial deployment of both the HDESP and the CSP deployment system. A new DOE funded CSP test field is being put in place in the Red Mountain field in Western New Mexico this summer to show deployment on a wider scale. Approximately 30 deployments are ultimately planned for that project using exclusively CSP technology. A major pump company is also planning to test the system this summer in submersible centrifugal produced coal bed methane wells in Wyoming with the hope of deploying CSP centrifugal pumps this summer.

CSP Trailer at RMOTC

The goals as stated in the original proposal were as follows:

- Determine what tubing types will work with submersible pumps under real well conditions
- Design and build a prototype pull and run system to install pumps and tubing in wells
- Test the system under realistic test well and field conditions

In addition, SWC increased funding to provide for five additional deployments of the HDESP pump. This and a head to head comparison of this lifting technology vs conventional rod pumps will be accomplished as part of this project. It can be safely said that the project accomplished in one short year the stated goals and more.

A very usable, commercial cable deployed pumping system has been developed and tested under this program; the first CSP system ever used for low volume stripper wells. In addition the PSI Hydraulic Diaphragm

Electrical Submersible Pump is well on the way to being a commercially available product. We are partnering with a large, international artificial lift supplier that has committed to put significant resources into the final development engineering and ramp up to production required to make this product generally available.

Conclusion

The SWC can take pride in it's support of this technology development in the earlier stages that was needed to bring it to the point of general application. The model we have followed of innovation, development, testing and finally partnering with an existing, large company appears to be very efficient in moving technology from the lab to market. The benefits outlined in the original application are now closer to reality as a result of this process. PSI will continue to innovate and support pumps and related equipment, concentrating on deployment systems (like CSP) and innovative application solutions such as on site power generation equipment and specially pump applications.

HDESP pumps will become a significant new technology for lifting fluids from stripper oil and gas wells, as a result of this project and other development activities. With the new partnership between PSI and a major artificial lift company, we predict that these pumps will become generally available within the next year. CSP is a significant enhancement to the usability of this pump technology and has been and will continue to be developed as a result of this project. PSI is encouraged with the results so far, and expects that CSP will be generally available soon after the HDESP pump comes on the market.