WIRELINE RETRIEVABLE PROGRESSING CAVITY ELECTRIC SUBMERGIBLE PUMPING SYSTEM FIELD TRIAL

Jay Mann, Irfan Ali & Marvin Keller
REDA, A Camco International Company

INTRODUCTION

Development of the REDA PC progressing cavity electric submersible pumping system began in 1991. The primary driving force behind this product development was the problem of accelerated wear of sucker rods and production tubing in deviated and horizontal wells when using surface driven progressing cavity pump systems. Many producers were replacing sucker rod and production tubing strings multiple times per year. This was severely affecting the economic viability of the oil wells. Since May 1994, REDA PC units have been installed in over 60 oilwells. The main cause of pulling the pumping system has been pump life. The harsh downhole conditions reduce the pump's ability to produce fluid while the REDA PC drive system is normally unaffected. As a result, a customer requested that a system be designed that would allow the pump to be pulled and replaced while leaving the bottom drive system undisturbed. This paper will describe the tubing deployed REDA PC system and explain the wireline retrievable configuration, the in-well testing to date, and the future developments for the system.

THE REDA PC TUBING DEPLOYED SYSTEM

The REDA Progressing Cavity submergible pumping system consists of an electric submergible motor driving a progressing cavity pump. A flexdrive gearbox is used to reduce the speed of the motor and translate the oscillating motion of the pump rotor into concentric rotation. Fig. 1 shows the equipment configuration.

The gearbox uses a planetary reduction system. A thrust section has been incorporated to carry the thrust load of the pump. The gearboxes are available in 4:1 and 16:1 gear ratios.
A protector is mounted between the submergible motor and gearbox for sealing and pressure equalisation. Due to the specialised requirements of the motor and gearbox, each contain different fluids. These fluids are separated by the protector and allowed to equalise with the well pressure. An advantage of keeping the fluid separate is that if there is a failure in the gearbox or motor, the contaminated fluid will not migrate into the other component and cause further damage.

A 1700 rpm (60 Hz) electric submergible motor is used to drive the gearbox. Using a 1700 rpm input speed reduces the complexity of the gearbox, requiring only one reduction set to achieve the 425 rpm output speed at 60 Hz.

As shown in Figure 1., the progressing cavity pump is attached to the production tubing, the stator of the pump is connected to the intake housing of the gearbox using an adapter. This adapter is threaded to the stator and bolted to the intake. This eliminates the need to tighten the high torque joint during installation.

The REDA **PC** Wireline Retrievable system uses the same electric submersible motor, protector and gearbox as the tubing deployed version. The flexcoupling and intake are modified to receive the rotor adapter via the wireline. In the tubing deployed system the pump stator is rigidly attached to the intake section. For the Wireline Retrievable configuration, a stator anti rotation device is connected to the top of the intake. Above this is the pump canister. The pump canister houses the pc pump. At the top of the canister is an 'X' landing nipple. This nipple is threaded onto the bottom of the production tubing. This entire assembly is installed on the production tubing string, with the power cable banded to the outside of the tubing.

The pump assembly consists of the mating part of the stator anti-rotation device, which is threaded to the bottom of the stator, the rotor with its rotor adapter and the upper stator adapter. This assembly is threaded to the 'X' equalisation sub, which is in turn threaded to the 'X' locking mandrel.

For commercial installations, the pump assembly will be installed in the pump canister prior to the first installation. In the tests, the pump assembly was installed in one wireline run after the other equipment had been landed.

4 ½" TUBING FIELD TRIAL

The first well test of the wireline retrievable system was started in March, 1997. The drive assembly was installed on 4 ½" casing which had been used as production tubing in the 7" casing.

The drive system included a 40 HP 540 series 4-pole motor, a BSBSB-PC protector, a 5.25 in. dia., 4:1 flexdrive gearbox, a 4" i.d. pump canister and a 3.83 landing nipple. This equipment was landed on March 11, 1997. The depth was 3802' KB, 2800' TVD, at approximately 45 deg. from vertical.

On March 14 the wireline truck and a crane to support the lubricator were spotted on location. The line used was 3/16" braided slickline. A check run of the production tubing was made using a stiff string and ring gage. The PC pump assembly which consisted of a BMW Pump 100-6000 attached to the X locking mandrel and equalisation sub, was connected to the running tool which was in turn threaded onto the tool string. The tool string incorporated a spang, weight bars, skates, flexjoints and a hydraulic jar. Due to the length of this string, an 85' lubricator was required. The string was run in with no problems even though it had to pass through a 57 deg. transition zone. Once the string was on bottom, the spang was used to shear the X lock pins and the wireline string was removed from the well. A check set tool was run in to ensure that the X lock was properly latched. The check set tool was surfaced and indicated that the tool was properly latched. The well head was reassembled and the unit was started.

After 17 hours of running, the pump was producing a test rate of 429 BFPD, compared to a 425 BFPD design rate. The unit was shut off. A GS pulling tool with an equalisation prong was threaded onto the wireline tool string and run into the well. When the tool reached bottom, the spang was used to push the prong into the equalisation sub and shift it to open. Once the tool sting was latched onto the lock, the well was allowed to equalise. The hydraulic jar was used to try to unseat the locking mandrel and pump assembly. This was unsuccessful. It was apparent that the well had not equalised as expected. Water was pumped down the casing to fill it. Once the well was equalised, the jars were activated a few times and the pump assembly was successfully unseated and surfaced.

An inspection of the equipment showed that the X locking mandrel had been damaged by the excessive hammering and jarring that was performed while trying to unseat it when the well was not equalised. As a result, the job was suspended until a new X lock was obtained. The equalisation sub was tested on surface, where it worked properly. The reason for its non-action downhole was not determined. It is important to note that both the equalisation sub and the locking mandrel were installed as supplied and unmodified.

Once the replacement X lock was delivered, the pump and wireline string was reassembled and run in to the well. This time a check set run was not done, instead the unit was started as soon as the well was ready. Fluid was surfaced in a reasonably short time. Once the well was drawing down, the servicing equipment was removed and the well was put on production.

It was decided to pull the pump on June 27, 1997, inspect it and rerun it. The unit was shut off and the wireline truck and crane were spotted on location. It was suspected that the cause of the failure of the equalisation prong during the previous run might have been interference between the GS pulling tool and the locking mandrel. So an extension was added to the prong. The retrieval string with the GS pulling tool and extended equalisation prong were reassembled and run into the well. The spang hammer was used to try to get the equalisation sub to shift to open. This was unsuccessful. The string was surfaced and the equalisation prong was removed. The pulling tool was run in and latched to the mandrel. The casing was filled with water and the unit was quickly unseated using the hydraulic jars. Once the unit was surfaced, the pump assembly was inspected. It did not show any signs of wear or damage. The equalisation sub was tested on surface and appeared to work perfectly. The insertion string was reassembled and the pump was installed without incident. No check set run was performed, the unit was started and as soon as the well was drawing down the wireline truck and crane were removed. Up to this point a crane had been required to support the 85' lubricator. The wireline operator suggested that a slight change in the string configuration would allow the use of a much shorter lubricator, which did not require the crane. Design work was started immediately to get the required hardware built as soon as possible.

The pump failed to produce fluid to surface on July 5. A new pump was ordered and on July 24 the equipment was ready for the pump replacement. The wireline truck was the only equipment required for this operation. The pulling string was inserted into the lubricator, the lubricator was connected to the well head. Since the two previous attempts to shift the equaliser were unsuccessful, the GS puling tool was run in without the equalisation prong. The casing was filled with water and the pump was surfaced and replaced. The run in using the short lubricator was performed without incident. The unit was started and is running at the time of writing.

3 ½" TUBING FIELD TRIAL

Since the success of the first field trial, a 3 ½" tubing system has been developed. A 2.75" X lock system is used to locate the downhole equipment. The casing size is 7", the drive system consists of the same 540 series equipment as the 4 ½" system. The smaller system is restricted to a maximum flow rate of 500 BPD using a multi-lobe pump. The limiting factor is the size of pc pumps that are available in this diameter.

The drive system for the 3 ½" wireline retrievable system was installed in early February, 1998. The pump installation was started on February 18. A 44 ft. lubricator was used. During the assembly of the unit on surface a bolt was broken. This part was quickly repaired. An interference between the equalising prong and the pump adapter prevented the proper assembly of the pump string. The job was delayed until the next day while the components were remachined.

The job was resumed on February 19 at 8:00 am. The pump was landed at 3925 ft. TVD and the running string removed from the well by 10:30 am. The BOP was removed, the wellhead reassembled and the unit was started. Fluid was surfaced in 20 minutes.

On March 4, 1998 the GS pulling tool with equalising prong was run in the well. The pulling tool would not latch to the pump. Upon surfacing the tool, it was found that the shear pin was sheared. The tool was rerun without the equalising prong and latched to the pump assembly. The X lock acted as if the well was not equalising. The casing was filled with water to equalise the well, the pump assembly unlatched and was surfaced. The equalising prong had shifted downhole, it is assumed that the viscous well fluid flowed very slowly through the holes in the device. The X lock was replaced and the pump string was run into the well without incident. The unit is running at the time of writing.

CONCLUSIONS

The equalisation sub assembly requires further investigation for improved flow, even so, the REDA PC Wireline Retrievable System has been shown to be a feasible concept. The pump can be changed using only a wireline truck with a slickline spool and a lubricator. The ease of changing the pump, with a minimal rig up and running time, using a lubricator which eliminates the need to kill the well and risk formation damage can have significant effects on the economics of a well. Since the pump can be changed very easily, the operator can use an old or different sized pump for initial well clean out and simply replace it with an optimised pump when required. The steady run time of the test unit indicates that the reliability of the downhole system is not affected by the wireline modifications.

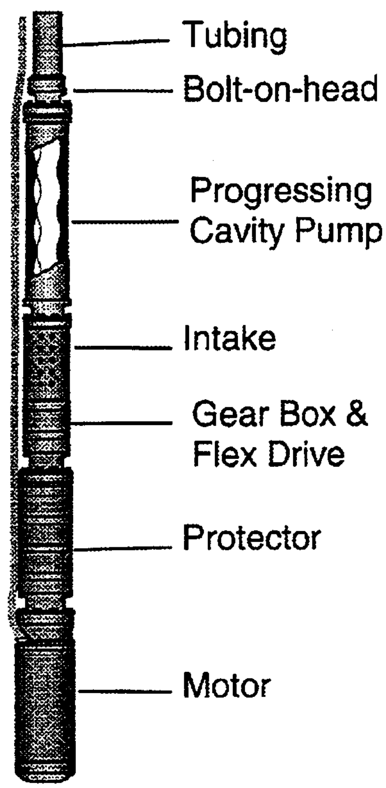

Figure 1 - Tubing Deployed REDA PC

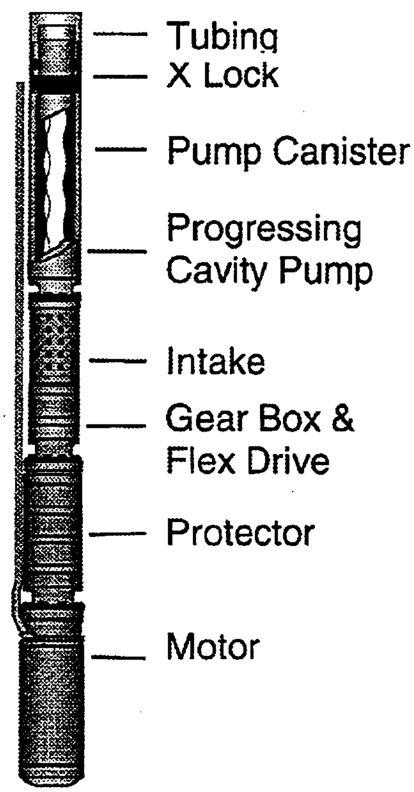

Figure 2 - Wireline Retrievable REDA PC