THE ESPCP™ PROJECT

Kent Cozzens, John Beardon & Steve Tetzlaff
Centrilift, A Baker Hughes Company

In 1992 the US market began to focus on the efficiency and solids handling capabilities of the Conventional Progressive Cavity Pump System (PCP). The Canadian Market, during this time frame, had already installed approximately 4000 of these units replacing conventional rod pump units. Because of the simple design and commonalties with the Rod pump, conversions were made easy. (Please see figure 1.1)

As the PCP's volume capabilities improved, the Electric Submersible Pump Industry (ESP) began to share their lower volume wells with the PCP. It was found that the PCP pump design would handle the thicker fluids with considerably less horsepower than the ESP.

The PCP market share is still expanding rapidly. We estimate their population today to be around 20,000 world wide. Canadian estimates for this system are about 9600 operating and growing. The US market uses about 1500 PCPs mostly in Coalbed Methane de-watering applications. Some 8900 units are scattered around the world in South American Countries, Asia and the CIS.

Although the PCPs growth has been exceptional, the industry continues to have problems in the following areas:

1) Stuffing Box leaks at the well head
2) Units uncontrollably back spinning when shut down due to release of energy from twisted Rods
3) Rod and tubing wear in deviated wells
4) Up-sizing current tubing size to accommodate flow by the Rods and guides
5) Frictional drag created by the Rods and guides.

Because most of the problems with this system are related to the sucker rods used to drive them, our Company was prompted to engineer a "rodless" system using as many common ESP components as possible. To replace the rods, we had to develop the following:

1) A flex shaft assembly to remove the eccentric motion inherent to the PCP design
2) Reduce the speed from our 3600 rpm submersible motor to 500 rpm or less by means of gear reduction

After several failures using "off the shelf" components to satisfy the above requirements, it became apparent that a totally new design would be required. Our company chose to use an engineering firm that had collegiate and Aerospace industry ties to build a completely new system. This approach ensured that we incorporated the best design groups available with state of the art ideas.

Having completed the design work and in house testing, our first production unit was installed in 1993. The unit was pulled for inspection 110 days later with no signs of wear. We then deployed a total of 9 additional test units in Canada and the US. Currently, Customers are operating several more production ESPCP systems with very encouraging results.

Almost all of the ESPCP units have been installed in problem wells where conventional PCPs were plagued with short runs due to excessive rod and tubing failures and in ESP applications experiencing short runs due to sand and scale. In some cases, the ESPCP has extended the run life in these wells by 400%.

(Please see figure 1.2)

Starting at the bottom, our system uses a standard 2-pole /3600 rpm motor. Although we have used 4-pole/1800 and 6-pole/1200 rpm motors in special applications, the standard 2-pole motor is the most efficient and least costly.

The next component is our Gear Reduction Unit (GRU). Displayed on figure 1.3, you can see the multiple speeds available by combining varying motor poles with the present gear ratios available. Most of the applications operating today are using the 9:1 gear ratio and 2-pole/3600 rpm motors. (Figure 1.3 allows for the actual operating speed of the motors under a loaded condition)

Due to the lower output speed of the motor through the GRU, the torque is now multiplied by the gear ratio used. An example of this would be: Using a 9:1 GRU and assuming the output torque of a 60 horsepower 2-pole motor to be 150 foot pounds, the actual torque capability of the unit is now 1350 foot pounds. This exceeds the torque capability of most sucker rods.

We chose to place the GRU between the motor and seal to eliminate the need for an additional set of mechanical seals and porting that would be required to balance the internal oil pressure with that of the well bore. This design also eliminates the need for additional reservoir capacity for oil expansion when heat is introduced and the potential of mixing a low dielectric strength lube oil with the high dielectric strength oil necessary for submersible motors.

Progressing up the assembly is our seal section. Within this component we balance the internal oil with the well bore pressures, protect the oil that is to be shared with the motor and install thrust bearings to protect the GRU and motor from the unusually high thrust loads of the PCP.

Because the seal section is located above the GRU, its speed is reduced enabling the use of a variety of bearings to handle the thrust loading. The speed reduction also minimizes the amount of cycles on mechanical seals in the assembly adding life to the system. Only slight modifications have been made to our seal section to accommodate the PCP load in most cases. With the introduction of our extreme high load bearings, we are now capable of even greater depths and larger pumps.

Our Flex shaft assembly is a simple design that has proven itself in multiple runs. We have made minor adjustments in this area over the past two years but basically have stayed with the same unique design. Several other methods of converting the PCPs eccentric motions are now under consideration and may be tested in the up-coming months.

We have adapted 5 separate vendor's PCPs to our system. In most applications, our Customers have decided what PCP company to use based on past experience and success. Our company has presently chosen to remain neutral in the PCP vendor selection process but will give assistance when requested.

Our units have been operating for a combined 5800 days. Using this experience we have had the opportunity to evaluate and improve our system in over 30 evaluations. The information gathered in these evaluations has led us to develop a stronger system for 7" casing (500 series) with even greater torque capabilities and more reliability. We have installed a number of these advanced units and are awaiting their return to do further enhancements if needed.

The 5 1/2" casing unit (400 series) has been successfully operating for over 300 days. As is evident on figure 1.4, its capabilities are much lower than the 7" casing (500 series) equipment. We will be doing additional development of this series and increasing its capabilities. We do not expect to obtain the same performance as the 500 series equipment.

Test Results

We have picked 2 wells to show as examples of how the ESPCP system has performed. Both of these wells are currently producing. (Please see Figures 1.5 & 1.6 for well details)

The first well (Figure 1.5) was experiencing 60 to 70 day runs while operating on ESP. This was due to light sands and CO_2 present in the produced gas. Our Customer installed a conventional PCP and increased their run life to an average 90 days. The failures on the PCP were all related to rod and tubing wear.

We then installed an ESPCP. The first attempt with this system increased the run life to 108 days failing due to CO_2 breaking down the ESP cable insulation and causing a short.

The next ESPCP we ran in this well was installed with a lead sheathed cable, high chrome content tubing, a special coating on the external parts of the assembly and a PCP stator with a 3/4" wall thickness. This assembly ran for 364 days failing due to an exposed area on our seal section created by dragging against the casing during installation. This exposed area allowed water into the motor causing a short.

The second well we chose (Figure 1.6) had no particular problem with run life. It was installed to verify the longevity of the system in the Customers field. Although we did not expect to learn allot from this installation, two important surprises occurred.

The first surprise was the actual horsepower required to operate the ESPCP versus an ESP in a neighboring well with almost exact requirements. As you can see on Figure 1.6, the actual production of this well is about 250 BOFD. From the depths indicated, we measured a horsepower usage of 18 3/4 for the ESPCP. TheESP well was drawing 36 horsepower with due to *the thick fluid and viscosity*.

Our next surprise was the amount of gas handled by the ESPCP. This well is monitored religiously and we have seen the GOR as high a 1200 SCF. The PCP is now operating at 50% volumetric efficiency and we are estimating the actual horsepower draw to be 14 while producing 180 BOFD. It is still maintaining the required fluid over the pump and producing the well with a much lower power requirement than it's sister well.

In conclusion, we feel the ESPCP will steadily increase in population over the next few years. As confidence in the system grows and PCP capabilities increase, the system will find a niche in the market that will help our Industry produce wells more economically.

Our company plans to continue our part in the development of the ESPCP and maximize it's capabilities through R&D and practical field applications. Because we can use a majority of the standard ESP components with our ESPCP in most cases, costs will be held down on new installations and enable us provide for low cost conversions of existing ESPs where applicable.

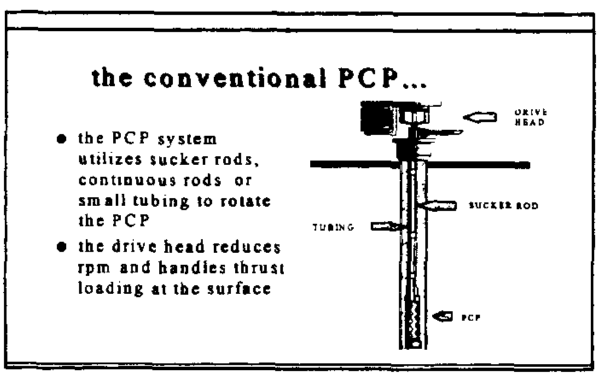

Figure 1.1

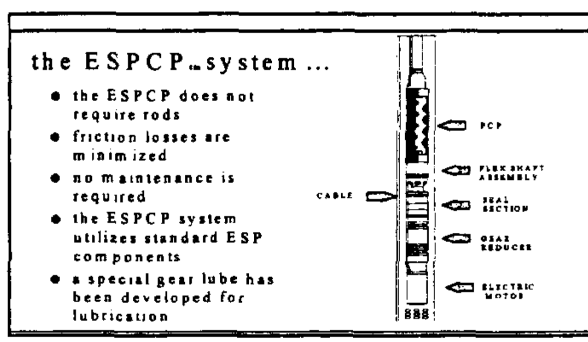

Figure 1.2

ESPCP SPEEDS WITH VARIOUS GRU/MOTOR COMBINATIONS: ACTUAL OPERATING SPEEDS WERE USED FOR THE 3600, 1800 & 1200 RPM MOTORS 60 Hz				
MOTOR POLES	MOTOR RPM OPER. SPEED	GEAR RATIO 3:1	GEAR RATIO 9:1	GEAR RATIO 15.5:1
2	3500	1167	389	226
4	1700	567	189	110
6	1100	367	122	71

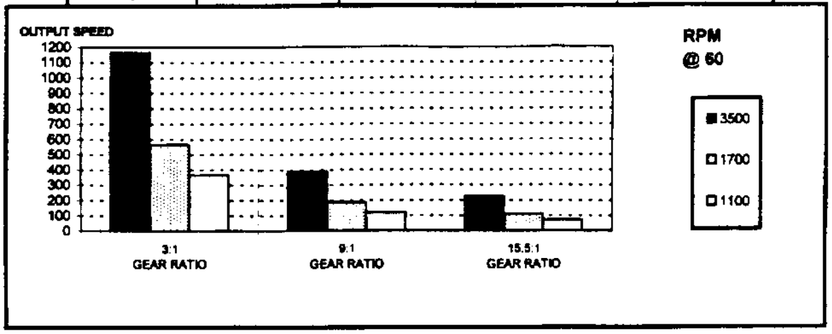

Figure 1.3

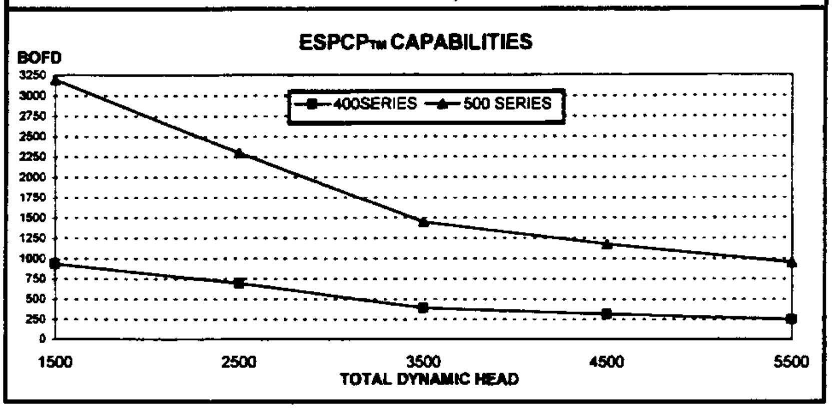

Figure 1.4

WELL VERTICAL DEPTH	1527'	DESIGNED BOFD	1598
WELL MEASURED DEPTH	1885'	ACTUAL BOFD	1537
API GRAVITY	20	PERCENT OF SAND IN FLUID	1%
GAS TO OIL RATIO	250	TUBING SIZE	2 7/8"
BOTTOM HOLE TEMPERATURE	130 F	DYNAMIC FLUID OVER PUMP	300'
HORSEPOWER REQUIRED	35	PERCENT OF WATER	91%
PERFORATIONS	635'/1476'	EQUIPMENT SIZE	500 SERIES

Figure 1.5

WELL VERTICAL DEPTH	3707	DESIGNED BOFD	250
WELL MEASURED DEPTH	5435	ACTUAL BOFD	180
API GRAVITY	19	PERCENT OF SAND IN FLUID	0.80%
GAS TO OIL RATIO	1200	TUBING SIZE	2 7/8"
BOTTOM HOLE TEMPERATURE	80	DYNAMIC FLUID OVER PUMP	1491'
HORSEPOWER REQUIRED	18 3/4	PERCENT OF WATER	2%
PERFORATIONS	5000'-5435'	EQUIPMENT SIZE	500 SERIES

Figure 1.6