ESPCP Application in Morichal District, Venezuela Results in Heavy oil Production Increase

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ARSTRACT

With oil prices at an all time low, production companies are making every effort to reduce operating expenses. Much of this reduction is not entirely on cutting production output, but in utilizing available new artificial list technology. Once such technology is ESPCPs; or Electric Submersible Progressing Cavity Pumps. By combining the technologies of both ESPs and PCPs, the operator can reduce their operating costs while increasing the lift system efficiency often resulting in an increase in production. By eliminating the sucker rods used in a conventional PCP application, the frictional losses can be reduced. In the case of heavy oil production, these losses can be substantial and if eliminated, can result in higher system efficiencies and increased production. When compared to a conventional ESP, the overall system efficiency is higher by the pure nature of the pumping technology (centrifugal vs. positive displacement).

A prime example can be seen in the ESPCP installation in MPG-202 in the Morichal District in Eastern Venezuela. The producing formation is the Morichal-7. Production is around 1100 BFPD (22% H_20) of 9° API gravity oil and the pump setting depth is 3259 feet. The well has a producing GOR of 625 SCF/STB. Prior to its installation on February 5, 1998, a conventional ESP system had been operating. Overall efficiencies of this system were extremely low as a result of the fluid viscosity and free gas at the pump intake. The decision was made to try an ESPCP system as an alternative lift method to see if the production rate could be increased without causing more problems from additional free gas at the pump intake.

Once installed, the production rate increased as a result of the increased efficiency of the ESPCP system in viscous fluids. One additional advantage of the ESPCP system is the pump's ability to handle the free gas at the pump intake. Calculations done for intake conditions showed the percentage of free gas at the pump intake to be 45%.

This paper will elaborate on the production advantages of installing the ESPCP system in this Eastern Venezuelan heavy oil well.

INTRODUCTION

In the Morichal District, 26%, of the wells use Progressing Cavity Pumps (PCPs) as the primary method of artificial lift. From PDVSA's standpoint, PCPs posses a larger capacity to handle the gas produced in this area (<800 scf/stb) as well as the sand produced (0.1-0.15%) in comparison to conventional sucker rod pumps and electric submersible pumps (ESPs).

In view of the demand to explore new technologies and variations to conventional lift systems, the evaluation of the ESPCP (Electric Submersible Progressing Cavity Pump) was appropriate. The system offers the following advantages:

- Reduction of power requirements
- High volumetric efficiency
- Handling of solids and abrasive particles
- Handling viscous fluids
- Does not create emulsions
- Reduces "Gas Locking" problems

Additionally, it provides the following improvements that are unique to the ESPCP system:

- Elimination of rod and tubing problems
- Eliminates stuffing box leakage
- High torque capacity
- Reverse flow capability at low speeds to flush sand
- Reduction of Bottom Hole viscosity due to exchange of heat from the downhole motor to the fluid

Apart from these characteristics, we can predict the dependability and adaptability of this system is high in wells having productivity indices (<1.5 bpd/psi) that allow the attainment of the desired production rate.

This paper will show the feasibility and evaluation of the ***Centrilift*** ESPCP system installed in MPG-202. The paper will discuss both the advantages and disadvantages of the system with regard to the conventional PCP system used.

The components of the ESPCP system installed in MPG-202 are shown in **Fig. 1.0**.

WELL DATA

MPG-202 was completed in the Morichal-7 formation with the producing interval from 3823' – 3961'. Initially the well was to be produced by conventional sucker rod pump. In 1993, this well was chosen to be re-completed with a horizontal section of 2147' (TVD 3870') with a 4 ½" liner.

The well conditions into which the ESPCP was installed are shown below.

Gravity of crude	9.0° API
Bottom Hole Temperature	140°F @ 3585 ft.
Surface Temperature	100°F
GOR	210 scf/stb
Bubble Point Pressure	1486 psi
% Water	15%
Sand Production	0%
Viscosity Down Hole	1870 cp @ 140°F
Viscosity @ Surface	17,500 cp @ 90°F
Gas Gravity	0.67
Water Specific Gravity	1.05
Current Lift Method	Progressing Cavity Pump
Static Pressure	1400 psi @ 3850ft.
Avg. Depth of Perforations (TVD)	3853 ft.
Total Depth (MD)	5655 ft.
Productivity Index	2.7 bpd/psi
Casing	7"
Liner	4 ½"
Tubing	3 ½"
Diluent	20% injected in flow line

Considering the characteristics of this well, it offered an excellent opportunity to evaluate the ESPCP system. The well's completion profile is shown in **Fig 2.0.**

BCPIN SIMULATION

BCPIN is a Nodal Analysis program for Progressing Cavity Pumps developed by Intevep, S.A. which allows the user to simulate to simulate the operating conditions using equipment from different manufacturers. The program BCPIN 2.3 uses Nodal Analysis to find the optimum operating point in order to gain maximum production within the well's capacity and the operational capabilities of the pumping system. Additionally, it allows the usr the opportunity to conduct a sensitivity analysis with regard to flow, pump RPM as well as percentage of diluent necessary. The simulation of the RCPIN 2.3 program is shown in **Fig 3.0.**

After completing the simulation with BCPIN 2.3, it was estimated that a production rate of 755 BFPD at a pump speed of 243 RPM was necessary. The represented a production increase of 55% over a conventional PCP with sucker rods. In order to simulate this "rod-less" system and stay within the limitations of the program (it does not simulate systems without rods), a sucker rod diameter of ½" was used and a tubing size of **4** ½". This in effect "fooled" the program but resulted in acceptable predictions. It was also assumed that a BHT of 170°F resulted as a product of the submersible motor adding some small temperature increase to the fluid.

RESULTS

The well's production **prior** to installing the ESPCP system was one in which the average production rate for the period from January 1997 through January 1998 was 563 BFPD (11% H_2O). The pumping system installed during this time was a PCM 400TP1350 operating at a pump speed of 300 RPM. It was observed that a rapid loss of efficiency of the downhole equipment in a very short period of time thereby not taking full advantage of the well's potential. The performance of the PCP system in MPG-202 is shown in **Fig. 4.0.**

Following the pulling of this system in January 1998, the ESPCP system installed with the average production rate for the period from February 1998 through September 1998 of 1238 BFPD (16% H_2O). The operating frequency of the system was 37.5 **Hz** which equates into a pump speed of 243 RPM. The percentage of incremental production obtained with the ESPCP over the conventional PCP system was 74%. This can be seen in **Fig 5.0** & **Fig 6.0.**

When comparing the production between both lifting systems, we can say that the efficiency of the rod-driven PCP system drastically diminished over a short period of time going from 78% to 28% efficiency whereas the efficiency of the ESPCP system only dropped to 75%. The explanation of the increment in efficiency in the ESPC system is largely due to the absence of sucker rods. In a conventional sucker rod driven PCP system, the rods cause severe flow restrictions in heavy oil resulting in a large increase in flow losses and increased TDH to the system. Another factor that was thought to contribute to the increased production was the incremental temperature due to the downhole motor. Although this temperature contribution maybe slights and may not be substantiated by other industry papers, there did seem to be a reduction in the downhole viscosity. In a conventional PCP system installed at a depth of 3219 ft., it should be operating at a temperature of 125°F resulting in a downhole viscosity of 2627 cp. With the ESPCP system, a downhole temperature of 155°F was obtained resulting in a downhole viscosity of 745 cp. This is a difference of 1881 cp and is shown in **Fig 7.0.** The incremental water production was approximately 25% and is primarily due to well conditions since the current pump intake pressure (PIP) is 858 psi. This indicates that that the differential pressure (P_{test} – PIP) is not high (549 psi) and allows **us** to optimize the well's production controlling variables such as sand production, water coning and gas being produced through the pump.

With regards to the electrical portion of the system, the voltage remained constant at 262 Volts throughout the operating period whereas the amperage gradually increased from 53 Amps to 79 Amps operating the motor at 27% if it's nominal rating.

CONCLUSIONS

- An incremental production increase of **74%** was obtained with regard to the conventional rod-driven PCP system.
- The small temperature addition as supplied by the submersible motor improved the separation of the gas as well as assisting in lowering the fluid viscosity to the point that the pump handled it better.
- The efficiency of the ESPCP system was more stable in comparison to the PCP reaching an efficiency of 75%.
- The power provided by the motor during the evaluation period did not exceed 28% of the nominal power thereby demonstrating the lower consumption of the of the downhole equipment.
- Leakage of the stuffing box was eliminated thereby reducing the environmental impact.

RECOMMENDATIONS

Based upon the results of this evaluation, the following recommendations were made in the Morichal operating area:

- Recommend the use of ESPCP systems in the Traditional Operating Area of the Morichal District.
- To determine the base profile of MPG-202 so as to use it to evaluate other potential wells.
  To continue evaluating the system in order to establish operating parameters.
  To compare the behavior shown by this type of system between amongst other manufacturers so as to obtain similar indicators allowing for further acceptance of this lifting system in the Morichal District.
- To adapt the simulation software; BCPIN; to this type of system with the purpose of predicting the system's behavior while varying the variables that effect them.
- To continue training of the production personnel in this type of lifting system

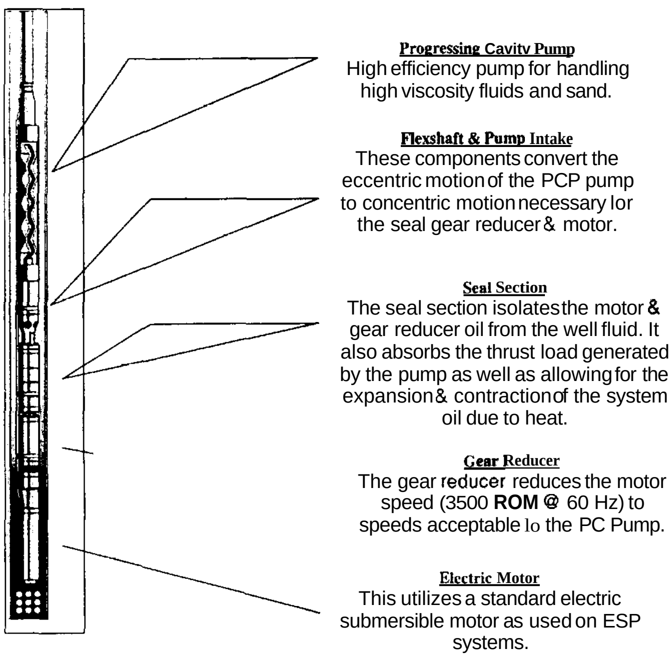

Figure 1

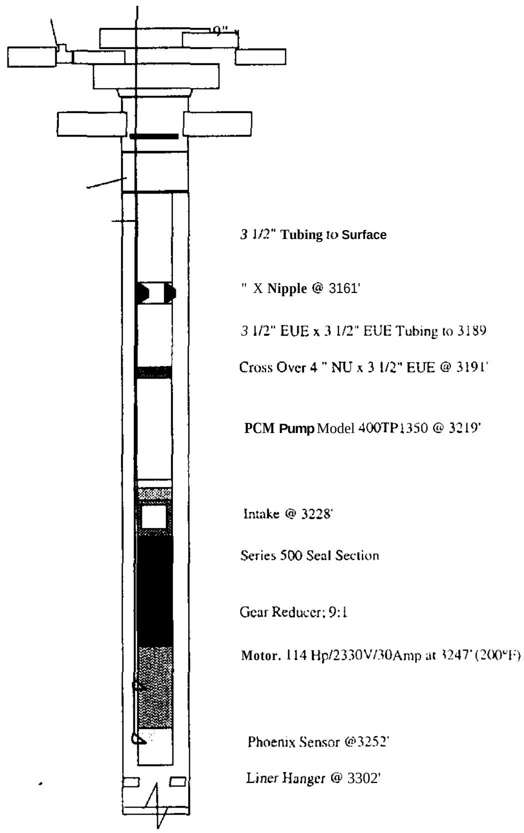

Figure 2

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SIMULACION EN BCPI A 243 RPM
DATOS:
 POLO              : MPG202                        FECHA: 10-16-1998
 IP                      2.700  (bnpd/psi)        6.156  (m3/d/bar)
 PROF PERFORA     :   3853.00  (pies)       1174.70  (mts)
 ANG INCLINACION  :      0.00  (°)
 CORTE DE AGUA    :     15 00  (%)
 R G ?                 210.00  (scf/b)          37.50   (b/b)
 EFIC ANCLA GAS   :     60.00  (%)
 VISCOS CABEZAL   :  12500.00  (cp)
 VISCOS YACIMIEN  :   1875 00  (cp)
 GRAVE CRUDO      :       9.0  (°API)           1.007  (g)
 GRAVE GAS               0.67  (aire=1)
 PROF BOMBA       :   3262.00  (pies)         994.51   (mts)
 PRESION ESTATICA:   1407.00  (psi)           97.03   (bar)
 P DE BURBUJEO    :   1486.00  (psi)          102.48   (bar)
 P DE SEPARADOR   :     40.00  (psi)            2.76   (bar)
 P DE DPSCARGA    :     90.00  (psi)            6.21   (bar)
 L LINEA FLUJO    :   6000.00  (pies)        1829.27   (mts)
 Dint  L FLUJO    :      8.07  (pul)          205.00   (mm)
 T DE CABEZAL     :    120.00  (°F)            48.89   (°C)
 T EN LAS PERF    :    170.00  (°F)            76.61   (°C)
 SUMERG MINIMA    :    200.00  (pies)          60.98   (mts)
 P ANULAR CABZ    :      0.00  (psi)            0.00   (bar)
 BOMSA: EMIP/KUDU 400TP1350   1950 (psi)     4500 (piesH2O)     1372 (MtsH2O)
 DIAMETRO ROTOR   :      1.57  (plg)           39.90   (mm)
 EXCENTRICIDAD    :     0.354  (plg)            9.00   (mm)

**,** SARTA DE TUBERIA ,,,,** ** ****** ** *******/.*******
TRAMO N° 1  LONGITUD= 3262(pies), DIAMETRO = 4 112 (plg)

EL FLUJO DE CRUDO ES POR LA TUBERIA DE PRODUCCION

****** SARTA DE CABILLAS ****************************
TRAMO N° 1  LONGITUD= 3262(pies), DIAMETRO = 1/2   (plg), ACOPLE
(RFDUCIDOI

CABILLAS GRADO: K

************** INYECCION DE DILUENTE *******************
EN LA LINEA 3E FLUJO (CABEZAL) . 20.00 %
GRAVEDAD API DEL DILUENTE      · 29.00 °
VISCOSIDADES.  (a Tcabezal)       60.0 cp.   la Tyacimien):      10.0 cp
IRESULTADOS :
 POZO                    : MPG202                        FECHA: 10-16-1998
 TEMP EN LA BOMBA        :    162.33   (°F)          12.41   (°C)
 NIVEL DINAMICO          :   -447.11   (pies)      -136.31   (mts)
 SUMERGENCIA             :   3709.11   (pies)      1130.83   (mts)
 DP fricc en eductor     :    949.62   (psi)         65.49   (bar)
 DP fricc en linea       :     39.68   (psi)          2.74   (bar)
 Q(petról)EN SUPERFI     :    755.28   (bnpd)       120.08   (m3/d)
 Q(liq) EN SUPERFICIE.       1161.97   (bnpd)       184.73   (m3/d)
 Q(liq+gas)EN BOMBA      :   1122.74   (bpd)        178.50   (m3/d)
 Q do AGUA EN SUPERF     :    174.30   (bpd)         27.71   (m3/d)
 Q de DILUENTE SUPER?:        232.39   (bpd)         36.95   (m3/d)
 ESCJRRIMIENTO           :    114.81   (bpd)         18.25   (m3/d)
 EFICIENCIA VOLUMETRI:         85.88   (% Vliq/Vtotal)
 VELOCIDAD DEL ROTOR          244.19   (rpm)
 PRESION DE CABEZAL      :    129.68   (psi)          8.94   (bar)
 DELTA P EN LA BOMBA     :   1143.11   (psi)         78.83   (bar)
 DELTP  P EN LA BOMBA    :   2638 29   (pies H2O)   804.36   (Mt H2O)
 PRESION DE SUCCION      .    843 44   (psi)         58.17   (bar)
 PRESION DE DESCARGA     :   1986.55   (psi)        137.00   (bar)
 TORQUE TOTAL            .    517.49   (lb pie)     701.71   (N m)
 POTENCIA EN EJE         .      24.1   (hp)          17 95   (KW)
 F AXIAL CABEZAL         :    h549.9   (lb)       29135.05   (N)
 ESPACIAMIENTO                 29.04   (plg)        737.68   (mm)
 CONDICION LIMITANTE  :  RPM SUGERIDO

           ESFUERZOS MAXIMOS EN CADA TRAMO DE CABILLAS

              LONGITUD      DIAMETRO        ESFUERZO VON MISES(*)
 TRAMO N°      (pies)        (plg)          (Kpsi)      (Kg/cm2)
 -------      --------      --------       --------    ---------
                3262          1/2           439.50      30900.6

(*) NOTA: Se he aplicado la teoria de MAXIMA ENERGIA DE DISTORSION.
          El esfuerzo de Von Mises debe compararse con la resistencia a
          la fluencia (yield point) de las cabillas (Sy).
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Figure 3

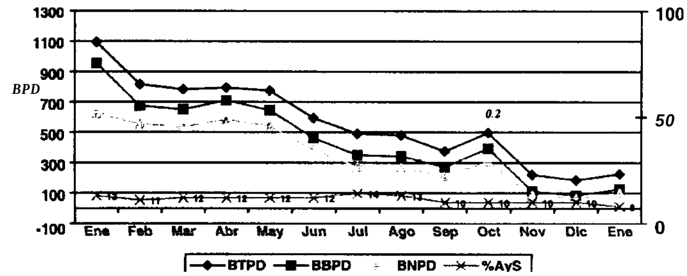

Figure 4 - MPG-202 Production From January 1997 through January 1998

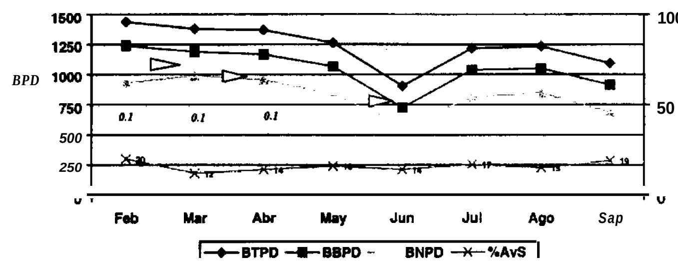

Figure 5 - MPG-202 Production From February 1998 through September 1998

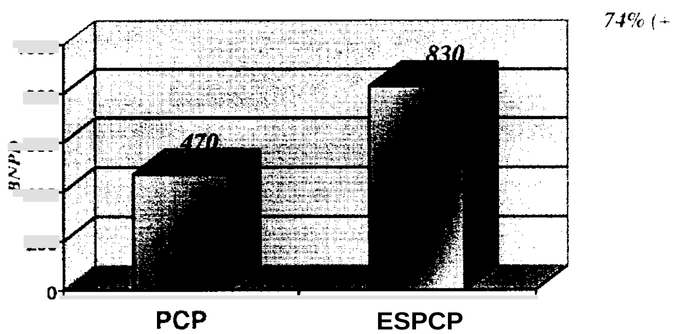

Figure 6 - Production Before & After

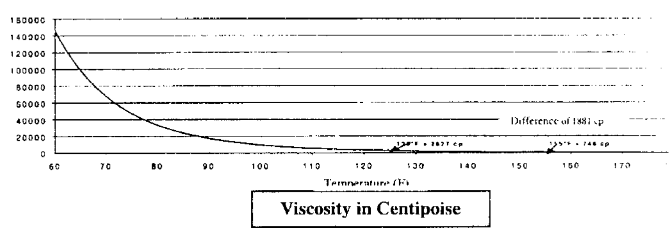

Figure 7 - Viscosity vs Temperature Well MPG-202