A PERFORMANCE STUDY OF AN ELECTRIC SUBMERSIBLE PUMP ROTARY GAS SEPARATOR IN A WEST TEXAS WATERFLOOD

Gary H. Jacobs
Amoco Production Company

ABSTRACT

The purpose of a gas separator is to separate free gas from produced fluid before the fluid enters the intake of an electric submersible pump (ESP). If free gas is allowed to enter the ESP, it tends to cause the ESP to cycle, resulting in additional pump and motor wear and eventual contamination of the motor oil with wellbore fluids.

Two types of gas separators are commonly available, the reverse flow separator and the rotary separator. This paper summarizes a recent field test in which the performance of the rotary gas separator was compared to that of a reverse flow separator under similar conditions in the same well.

This field test was done on a low volume well under waterflood. An ESP was run in this well because a beam lift would interfere with the landowner's irrigation equipment. The original ESP, which was run with a standard reverse flow separator, could not pump the fluid level down because excessive gas caused the unit to cycle on and off.

Three cases were studied. The first two cases consisted of running two identical 400 BPD ESPs, each one for a period of several months. The first ESP was equipped with a standard reverse flow separator and the second was equipped with a rotary gas separator. In the third case, a 280 BPD ESP equipped with a rotary gas separator was studied. It was necessary to run this ESP because the originally sized 400 BPD ESP became oversized once the effect of gas cycling was removed due to the rotary gas separator.

Introduction

Entry of free gas into the intake of an electric submersible pump (ESP) can cause the pump to shut down on underload. This is caused by the reduced viscosity of the gassy fluid exerting less drag on the impellers. Frequent shutdowns and restarts are known as "cycling". Cycling causes additional wear on the pump and motor, and can lead to contamination of the motor oil with wellbore fluids. Contamination lowers the dielectric strength of the motor oil and could eventually result in motor burn.

Gas separators can be used to separate the free gas from the fluid before it enters the pump and causes cycling. Two types are available, the reverse flow separator and the rotary separator. The reverse flow separator will handle up to 10% free gas, while the rotary gas separator will handle considerably more, with the actual amount depending on wellbore conditions.

The reverse flow separator separates free gas from the produced fluid by reversing the flow of the fluid. The gas tends to separate from the fluid at the point where the fluid reverses (Figure No. 1). In contrast, the rotary gas separator works like a centrifuge. Fluid is spun by impellers and thrown to the outside of the separator, while the gas, being lighter, tends to flow up the center (Figure No. 1).

Purpose

The Levelland Unit has a low average gas/oil ratio of 593 Scf/STBO (April, 1982). However, Levelland Unit No. 781 had a much higher GOR of 64,600 Scf/STBO. The well produces from the San Andres formation at an average depth of 4837 ft. through 230 ft. of open hole. When the field test was started in August of 1981, this well was producing .5 BOPD, 168 BWPD, and 32,000 SCFD of gas. The high GOR may be misleading, as the well was drilled only 6 months earlier. The GOR decreased considerably during the duration of the field test.

The well was originally equipped with a 400 BPD electric submersible pump (ESP) with a standard reverse flow separator. This ESP was unable to pump the fluid level down due to extreme gas cycling. The 400 BPD pump was used in Case Nos. 1 and 2. Later, a 280 BPD pump became available and was tested with a rotary gas separator in Case No. 3.

Procedure

The test equipment for monitoring the produced gas and fluid is shown in Figure No. 2. Casing gas and tubing gas were metered separately as shown. The produced fluid was run through the two-phase separator and the tubing gas and fluid were measured at their respective outlets. Oil production figures were taken from company well test data.

Downhole pressures and temperatures were recorded with a downhole pressure/temperature sensing device. A digital readout was provided so that this information could be recorded. Gas and amp charts were collected on a regular basis and sent to the engineering staff along with pertinent comments on the operation of the well.

Results

The results shown below were calculated using the method detailed in a paper presented at the 1980 Annual Conference of Society of Petroleum Engineers (Reference 2). Calculations were done for three data points which appear to fall close to the average.

TEST RESULTS

	Case No. 1 400 BPD ESP With Reverse Flow Separator	Case No. 2 400 BPD ESP With Rotary Gas Separator	Case No. 3 280 BPD ESP With Rotary Gas Separator
Date of Installation	06/10/81	08/27/81	01/07/82
Date of Test	08/12/81	10/16/81	02/02/82
Bottom Hole Temp.	108°F	108°F	108°F

Producing Bottom Hole Pressure	400 psia	43 psia	60 psia
Total Fluid	175.1 BFPD	272 BFPD	223 BFPD
Pump Run Time	11 hrs.	16 hrs.	24 hrs.
Gas/Oil Ratio	64,600 Scf/STBO	16,800 Scf/STBO	870 Scf/STBO
Gas/Liquid Ratio	185 Scf/STBL	117 Scf/STBL	133 Scf/STBL
% Free Gas	52%	88%	86%
TOTAL GAS SEPARATION EFFICIENCY	79%	86%	93%

The gas/oil ratio dropped considerably between Case No. 1 and Case No. 3 from 64,600 Scf/bbl. to 870 Scf/bbl. This is probably due to the recent completion of this well.

As expected, the rotary gas separator showed a higher efficiency (86% and 93%) than the reverse flow separator (79%). The combined gas separation efficiency of the annulus and the separator was calculated, as it was impossible to determine only the separator efficiency without additional information. The average run time with the 400 BPD ESP was increased from 11 hours to 16 hours with the rotary gas separator, while the average run time with the rotary gas separator equipped 280 BPD ESP was 24 hours.

In Case No. 3, the rotary gas separator showed a higher efficiency with a 280 BPD ESP than in Case No. 2 with a 400 BPD pump (93% vs 86%). This is because the 400 BPD ESP became oversized for the well once the gas volume through the pump was reduced. This was determined by using the vendor's head capacity curves. The operating points were found by adding the produced fluid volume to the calculated free gas volume and considering this as the total volume of fluid going through the pump.

When the 280 BPD ESP was installed, it went down several times on underload. This happened only when the casing gas got above 1300 Scf/hr. This indicates that the rotary separator was overloading with gas at this point. The ESP restarted by itself all but one time.

The most profitable result of the field test was the major increase in oil production obtained by pumping the fluid level down. As can be seen from Figure No. 3, oil production increased from .5 BOPD in August, 1981 to a sustained 29+ BOPD, after November, 1981, while total fluid production increased 25-40 BFPD. This increase was due to the reduced back pressure on the well caused by the lowered fluid level. The initial fluid level in Case No. 1 was 1646 feet of fluid above the pump. On February 2, 1982, the fluid level was 342 feet above the pump. This corresponds to a 490 psi reduction in back pressure on the wellbore, assuming all oil in the annulus.

Conclusions

1. A rotary gas separator should achieve a higher separation efficiency than a reverse flow separator.

2. A rotary gas separator in conjunction with a properly sized pump should produce overall gas separation efficiencies of close to 90%.

3. A rotary gas separator can lower the fluid level in a well due to increased run time.

4. Oil production can be increased with a rotary gas separator because of the reduced back pressure on the wellbore from the lowered fluid level.

Acknowledgments

I wish to thank Amoco's Levelland Unit field personnel, and Jim Lea, for their help on this project.

References

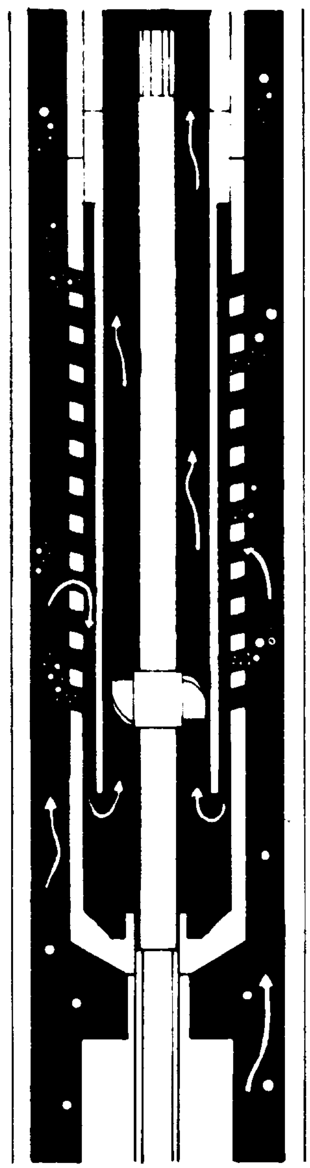
1. Beavers, John; Bearden, John; and Vandevier, Joe: Centrilift-Hughes, "Gas Calculations Aid Submersible Pump Selection," Petroleum Engineer International, July, 1981.

2. Lea, J. F., Amoco Production Co., "Gas Separator Performance for Submersible Pump Operation," Society of Petroleum Engineers of A.I.M.E. paper #9219, Presented at the 55th Annual Fall Technical Conference and Exhibition of SPE, September 21-24, 1980.

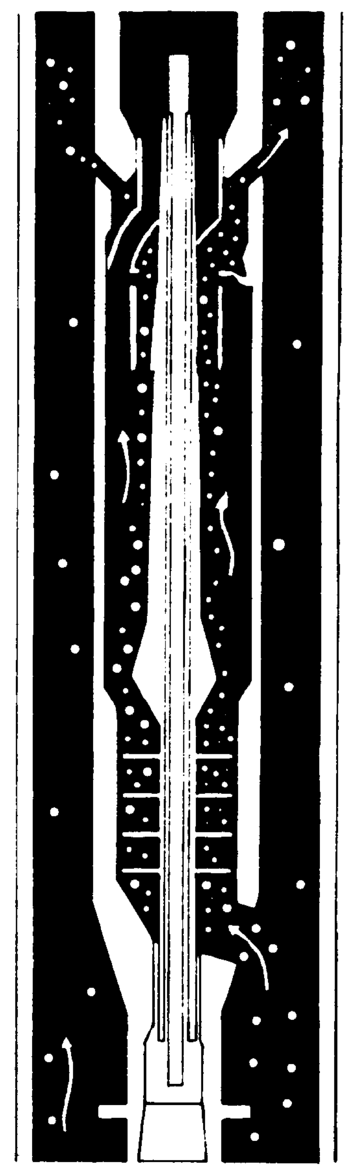
Appendix I

Abbreviations Used In This Paper

BOPD - Barrels Of Oil Per Day
BPD - Barrels Per Day
BWPD - Barrels Of Water Per Day
ESP - Electric Submersible Pump
psi - Pounds Per Square Inch
Scf - Standard Cubic Feet
SCFD - Standard Cubic Feet Per Day
STBL - Stock Tank Barrel Of Liquid
STBO - Stock Tank Barrel Of Oil



REVERSE FLOW GAS SEPARATOR



ROTARY GAS SEPARATOR

FIGURE 1

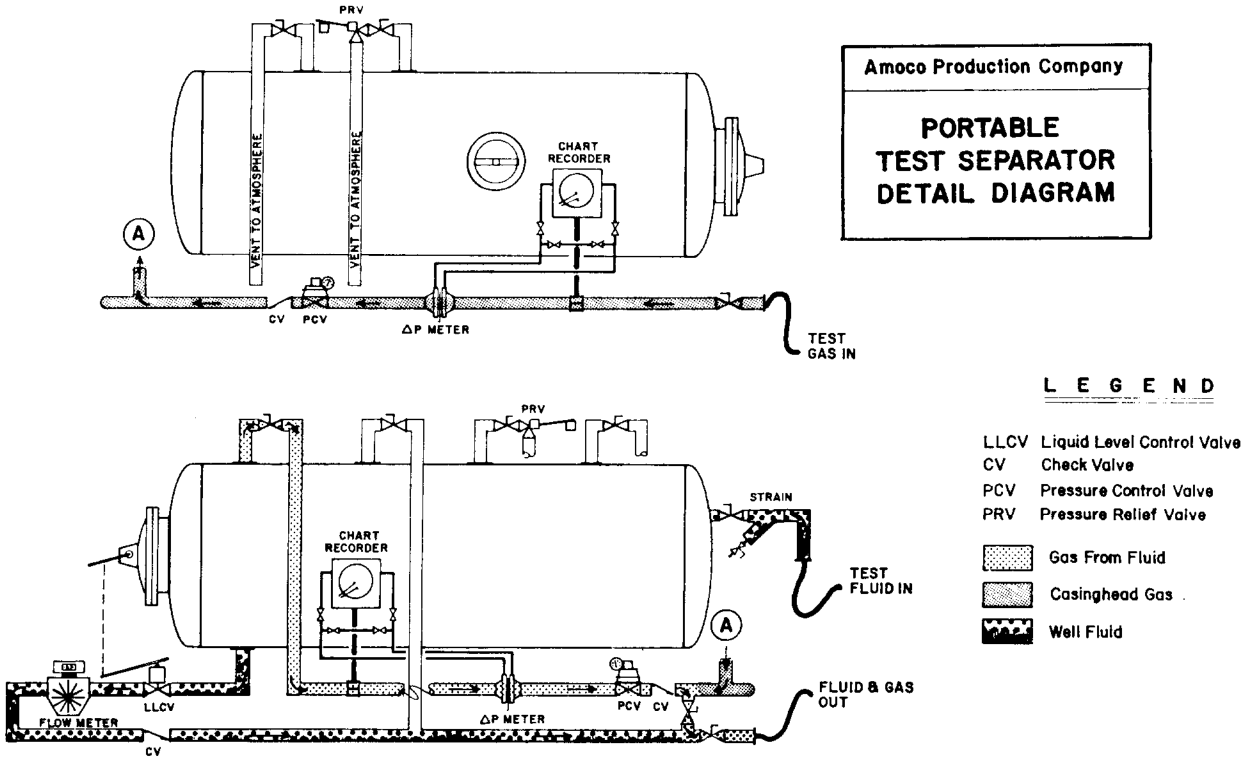


FIGURE 2

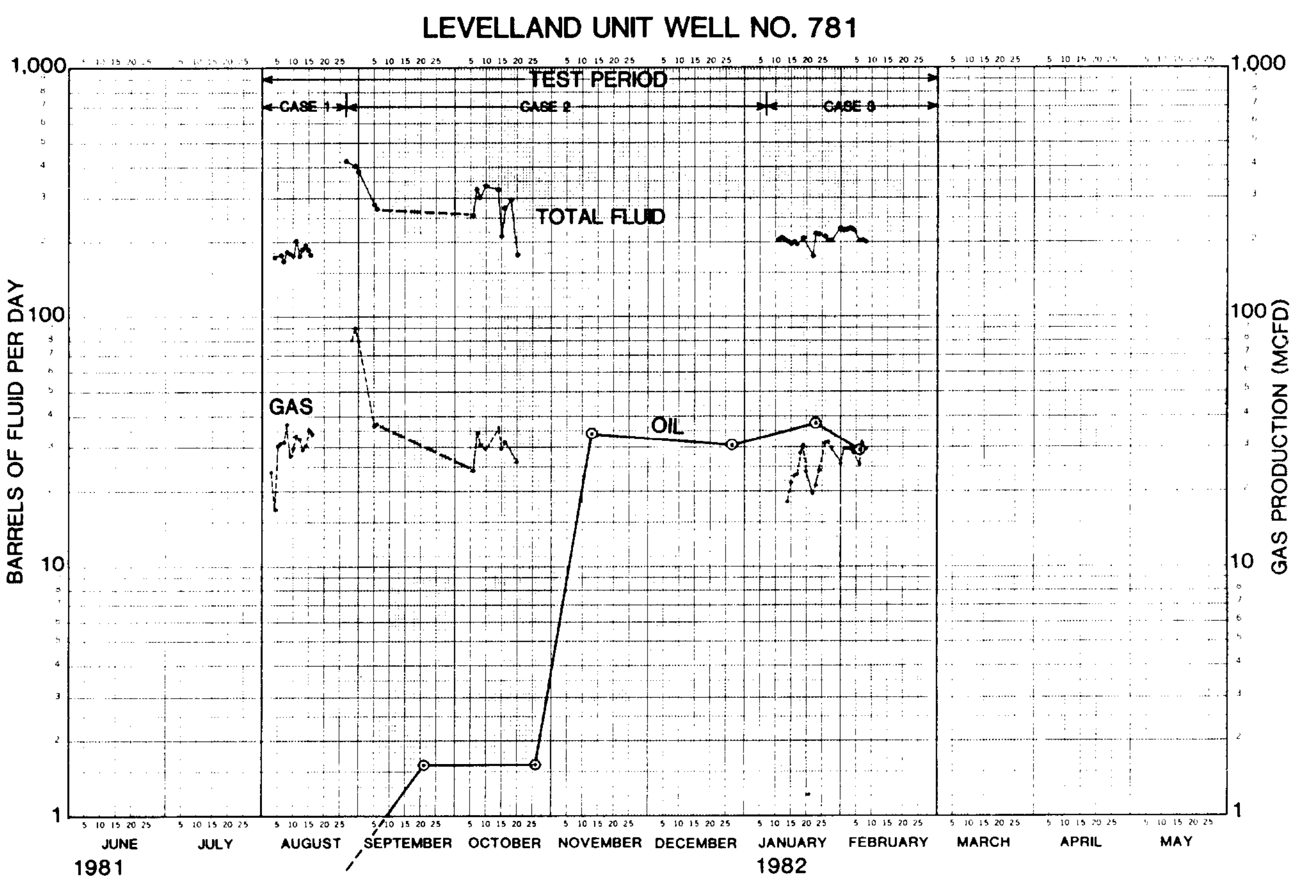


FIGURE 3