Gas Anchors Pay Dividends

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ABSTRACT

Severe production penalties often result from gas interference in the operation of pumping wells. Test results of the application of field constructed bottom hole gas separator systems have proved and re-emphasized the merit of these installations. Increased pump efficiency and increased production can be obtained through the proper use of equipment that has often been referred to as inadequate and obsolete.

INTRODUCTION

Gas interference is one of the most common pump problems. Many wells today produce less than capacity because the bottom hole pump and related equipment lack the design improvements necessary to handle gas and improve efficiency.

This paper presents a review of gas interference and several methods of locating, evaluating and correcting the problem. The scope of coverage is limited to discussion of wells and test data from the general area of West Texas and Southeast New Mexico, although the principles involved will apply to most oil well pumping installations.

DISCUSSION

Practically every bottom hole pump in oil field service is hampered to some degree by having to handle gas as well as fluid through its mechanical process of lifting oil. The efficiency is reduced by the amount of free gas or liberated gaseous vapors that have to be pumped in the same manner as an equivalent volume of fluid. Corrective measures to eliminate or minimize gas interference depend on a thorough study and understanding of the mechanical, operating and fluid conditions that contribute to gas problems.

The majority of pumping well gas troubles are caused by free gas in the well bore, gas trapped in the fluid column and gas being liberated from solution by either agitation or pressure changes. When this gas is processed through the pump, efficiency is reduced by the volume of fluid the gas displaces in the pump operation. Occasionally, when free gas enters the pump and occupies a volume equivalent to the plunger displacement, the pump valves become locked shut. Under these circumstances the pump will fail to operate until a sufficient pressure exists within the pump to overcome the fluid pressure in the tubing and open the traveling valve. Frequently, such measures as respacing the pump, tapping bottom lightly or increasing the pump speed will increase compression enough to break the gas lock.

The ideal method of eliminating gas interference would be to separate the free gas from the fluid and allow it to be vented through the casing annulus. The gas anchor serves this purpose by being a gas-fluid separator that uses gravity and agitation to separate as much gas as possible from the fluid prior to the fluid entering the pump.

Separation

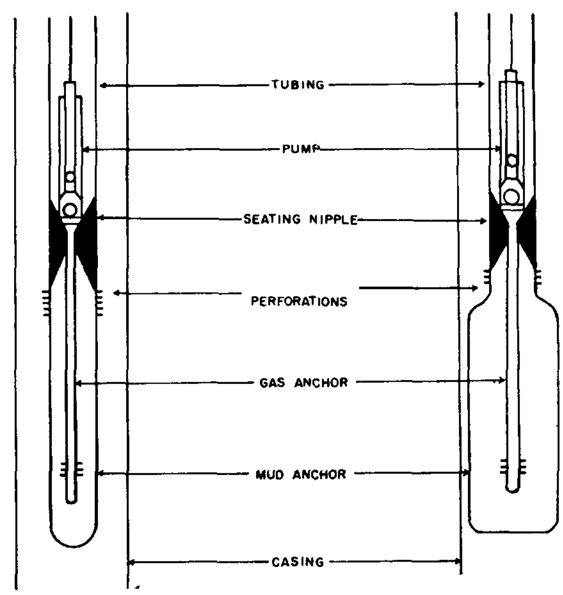
Gravity separation is attained by using sufficient down-flow area to permit the fluid to flow downward at a lesser rate than the rise of the gas bubbles. The rate of rise for bubbles has been determined to be approximately six inches per second in water.[3] Rate of rise in other fluids is dependent primarily on the bubble size and the fluid viscosity. The six inch per second rate was measured with a bubble diameter of .011 feet.

The rate of rise for bubbles of similar diameter in other test fluids having a viscosity of 1 to 15 centipoises, a viscosity range common to most West Texas crude oil, was approximately six inches per second also. This datum indicates that as gas separation becomes more critical, increased down-flow area within the anchor system is beneficial.

Separation by agitation is achieved by reduced areas and increased flow velocity between the mud anchor and the casing, and by flow direction change and turbulence as the fluid is drawn through perforations into the mud anchor, Diagrams of two types of field constructed mud anchor-gas anchor systems are shown in Fig. 1.

Both anchors, standard and oversized, function the same. When fluid and gas rise past the anchor, a portion of the free gas separates from the fluid and rises up the annulus. As the pump draws fluid through the mud anchor perforations, additional gas is separated by agitation and permitted to flow back into the casing annulus through the upper portion of the perforations. As the oil moves downward through the mud anchor-gas anchor annulus, additional gas is removed by gravity separation.

The oversized anchor system offers extra benefit by creating a greater agitation in the casing annulus and permitting a larger down-pass area inside the anchor. The oversized anchor is used where maximum separation is needed and the diameter is determined by the casing or hole diameter.



STANDARD GAS ANCHOR MUD ANCHOR SYSTEM

STANDARD GAS ANCHOR OVERSIZED MUD ANCHOR SYSTEM

FIG 1

Gas Anchor Diameter

The gas anchor diameter is limited by the size of equipment to which it is attached and by the available inside diameter through which it must be set and operated. In selecting the optimum size gas anchor, pressure drop should not be overlooked. Both the length and diameter affect pressure reductions. In low fluid level wells, increased suction lift can result in partial pump fill and additional liberated gas. Table I shows pressure drop values for two different sized anchors. The data were obtained on the basis of pumping oil with a 100 centipoise viscosity, a 1-3/4 inch pump and a speed of 20 - 54 inch strokes per minute.[1]

Gas Anchor		Pressure Drop In Pounds Per Sq. Inch
Size (inches)	Length (feet)	
3/4	10	21.2
3/4	20	42.4
1-1/4	10	2.3
1-1/4	20	4.1

TABLE I

This table indicates that the short, large diameter anchor would be preferred in wells with relatively large production volumes. Most West Texas area crude viscosities are low and pressure losses are less critical.

The length of the gas anchor should be sufficient to extend the inlet a minimum of five to ten feet below the turbulence existing near the mud anchor perforations. As the length is increased, additional gravity separation time will be available. As a general rule of thumb, the gas anchor diameter would be sized as near as practical to the pump diameter and extend approximately ten feet below the mud anchor perforations. The mud anchor should be 2-1/2 inches or larger, 20 to 30 feet in length and bull plugged. The perforated nipple should be sized to the tubing string. If cavings or sand cause a well problem, additional mud anchor length would be beneficial.

The most efficient depth for the anchor system will vary with individual wells. The foaming zone near the working fluid level and the turbulent zone where free gas enters the well bore should be avoided. The system will be more effective if a fluid seal is maintained above the tubing perforations by regulating depth and scheduling pumping time.

PROBLEM EVALUATION

Several methods of testing may be used to determine the probability of penalized production from gas interference. These methods will be discussed in three categories — (1) Production Tests, (2) Operation & Equipment Studies, and (3) Special Tools.

Production Tests

Various production tests to evaluate pumping well gas problems first involve a review of well history and producing characteristics; wells that produce less than top allowable; produce considerable gas through the tubing; produce erratically; produce with the casing shut-in or choked into a relatively high pressure flow line; and produce with a pulling history with small pump repair cost are prime examples of potential gas problems.

Wells in the above categories may be tested by measuring the gas production separately from the tubing and casing and evaluating the amount of bottom hole separation actually being accomplished. In instances of either high pressure flow lines or shut-in casing, the casing pressure can be vented to the atmosphere at full or choked flow rates and production tests taken and compared with regular tests.

Frequently the problem of back pressure can be minimized by lowering separator or heater pressures, removing unnecessary obstructions and cleaning out paraffin or scale from the flow lines. These conditions are often responsible for production tests in well head test tanks being greater than tests taken through regular lease equipment. A more accurate evaluation can be accomplished when production test results are compared with operation and equipment studies.

Operation and Equipment Studies

Equipment studies involve a review of the existing downhole equipment. Pertinent questions should be investigated and answered. Is the pump properly designed to reduce gas problems? Are the valves spaced to give maximum compression? Is the pump capacity greater than the ability of the well to produce? Does rod stretch reduce the actual pump stroke excessively?

High pump capacities can cause gas problems by effecting partial pump filling due to starved suction. Excessive pump speeds have the same effect. Theoretical pump capacity should be compared to actual production, keeping in mind that in deep wells or high fluid level wells, stock tank production may be less than the volume of fluid actually pumped because of shrinkage resulting from liberated solution gas.

A study of operating procedures will point out practices inducive to gas interference. High speed, short stroke length and excessive pumping time are good examples. Every effort should be made to eliminate agitation, choking action or pressure changes after the fluid enters the gas anchor. It is important for all of the field personnel to understand the need for good operating practices to insure that changes in procedures and equipment will not be opposed to proper design.

Special Tools

Evaluation of gas interference can best be determined by studies of dynamometer cards. The actual plunger travel, pump efficiency, underfilling of the pump, and pump condition can be accurately determined. Gas interference is reflected directly on the dynamometer card by variations in load, and the need for improvements of both an operational and mechanical nature can be determined without the need for lengthy production tests.

If equipment changes are necessary to complete proper analysis, well weighing will point out the need and furnish the necessary data for immediate evaluation after the corrections have been made. Gas interference can distort any method of determining a true picture of whether a pumping system is producing the well capacity. The dynamometer test can show the presence of gas within the pump and set the pattern for correction. Detailed methods covering dynamometer test procedures are contained in a reference publication.[5]

Sonic studies, although important, are not emphasized because it is the pump efficiency, not the annular fluid level, that points out the need for improved gas handling facilities. If dynamometer tests are not available, high fluid level, as indicated by sonic measurement, can indicate the need for increased efficiency or improved pump capacity.

Field tests of gas interference will often indicate problems common to other lease or field wells. Evaluation and corrections for the first well may require some extra expense and trial and error experimentation but, in most instances, the same adjustments will be profitable in other field wells. The need for improvement will have been established and the corrective measures and method of operation will have been determined for incorporation in other wells as they are pulled. With few exceptions, all wells should be equipped and operated to permit a minimum of gas interference.

Occasionally wells will be equipped in a manner that requires all production to be handled through the tubing. In these cases, low efficiency will be experienced or can be anticipated until economics justify improvements. When improvements of downhole equipment are impractical, emphasis should be directed toward maintaining the best operating procedures for handling gas. Production increases have been obtained by installing a back pressure valve on the flow line at the well head. Increased back pressure will usually hold a fluid seal on the pump, restrict radical pressure changes, and reduce gas breakout in the pump.

Good operating procedures, such as having a pump sized to production, a long, slow stroke, a good compression ratio and a proper time schedule, can not be overemphasized.

Frequently the success or failure of a bottom hole gas separation system is completely dependent on operating procedure. This thought is supported by Example No. 3 where a production increase of 94 BOPD was obtained by a depth change of one tubing joint.

CONCLUSION

In the area of operations discussed in this paper the author has not encountered a well with gas problems where efficiency could not be improved with proper equipment and operating procedure, provided facilities permit pumping time scheduling and casing gas venting.

Experience has indicated that a tremendous number of wells are producing below well capacity because of gas interference problems.

Whenever practical, wells should be studied and improvements applied. Flexible rules governing downhole pump and related equipment design can be compiled and applied with close observance of proper operating practices. Application of these principals will assure that gas anchors pay dividends.

EXAMPLES

1. Well A, South Eunice Field, Lea County, New Mexico

The tubing had not been pulled after completion and the original pump installation was made one joint above the open end tubing anchor joint. Production test was 30 BOPD and 12 BWPD. Dynamometer tests indicated gas interference. The rods and tubing were pulled and re-run with a bull-plugged mud anchor and a gas anchor. Production test after well work was 40 BOPD, 17 BWPD, GOR 2186, top allowable.

2. Well B, North Cowden Field, Ector County, Texas

This well was equipped with an open ended tubing anchor joint. Production test was 43 BOPD. Dynamometer test indicated gas interference. Pulled rods and tubing and re-ran with 60 feet of 2-1/2 inch mud anchor and 30 feet of gas anchor. Production test after work was 76 BOPD, capacity, and GOR 980.

3. Well C, Shannon-San Andres Field, Crockett County, Texas.

This well was equipped with a mud anchor and gas anchor. Production after workover operations had declined to 50 BOPD. Well weighing indicated severe gas interference. The tubing was lowered 30 feet. Production increased to 144 BOPD.

4. Operator B, Harper & Foster Fields, Ector County, Texas

The following examples show partial results of field surveys where the principles of improving operations and installing bottom hole gas separation systems were applied. Field constructed anchors were used in each well.

Well	Prod. Before	Improvement	Prod. After	GOR
A	10#	Installed MA & GA	64#	647
B	52#	Installed MA & GA	93	654
C	53#	Installed MA & GA	93	193
D	68#	Installed MA & GA	93	1168
E	60#	Installed MA & GA	93	739
F	20#	Installed MA & GA, & Increased Time	65#	NA
Lease G (14 Wells)	557	Installed MA & GA, & Increased Time	744	NA
Total	820		1245	

\# Capacity Increase 425 BOPD

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