Pumping Gaseous Fluids in High Gas - Oil Ratio Wells, and Means for Making Down Hole Separation

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ABSTRACT

In this paper we will explain why high gas/oil ratio wells are difficult to pump and we will discuss and explain past methods and lifting practices. Reasons why past methods were not entirely satisfactory, and types of equipment used in conjunction with those methods, are mentioned. Improved equipment and the results of its application, compared to former practices, will be discussed.

INTRODUCTION

Every competent production man knows that it is a time of utmost importance when oil fields are changing from the flowing period to a stage where artificial lifting is being considered. During this transition period, many important decisions must be made concerning the planning and future programming.

First, the various methods of lifting practices should be considered and evaluated; the choice is dependant upon the depth of the wells, type of oil to be lifted, and whether it will lend itself more readily to one method or another. If adequate gas is available, gas lifting might be considered, or bottom hole hydraulic pumping may be evaluated in light of its application. One of the oldest and most widely used principles is pumping with sucker rods, using various types of pumps designed for this method of lifting.

Most companies employ capable reservoir and equipment engineers who are charged with the proper study and selection of the lifting method to be used, as well as the type and make of equipment to be installed. These decisions are of the utmost importance, and could determine the difference between a nominal paying field or one that could yield a very profitable income.

We would advise a small independent operator, who does not have his own engineering staff, to obtain the services of some reputable consulting engineering group before making decisions in areas where methods and practices are unknown or unproved.

When wells in some fields have ceased flowing, and artificial lifting equipment is installed, production personnel are often confronted with the task of producing these same wells to some degree of expected potential. Many times the results are disappointing, and considerable expense is incurred by experimenting with different methods and types of equipment. The cost of new equipment and the labor expense involved in installing the same could jeopardize a supervisor's position, especially if he is not getting results from his experimental methods.

For those who are interested in pumping with sucker rods and obtaining the maximum efficiency from their equipment, we present the following paragraphs for what they may be worth.

Down Hole Separation

For many years, it has been highly desirable to find a method of separating gas from the oil in a pumping well at the bottom of the hole, before the fluid enters the pump. Oil permeated with large quantities of gas is frothy and very difficult to pump. Some types of oil are more difficult to pump than others, depending on the gravity, viscosity, etc.

Poor Boy Anchors

For many years "poor boy" and other type gas anchors have been used (Fig. 1) to separate the gas from the oil. This type of equipment has been designed by scores of production men. The results, needless to say, have only been partially satisfying.

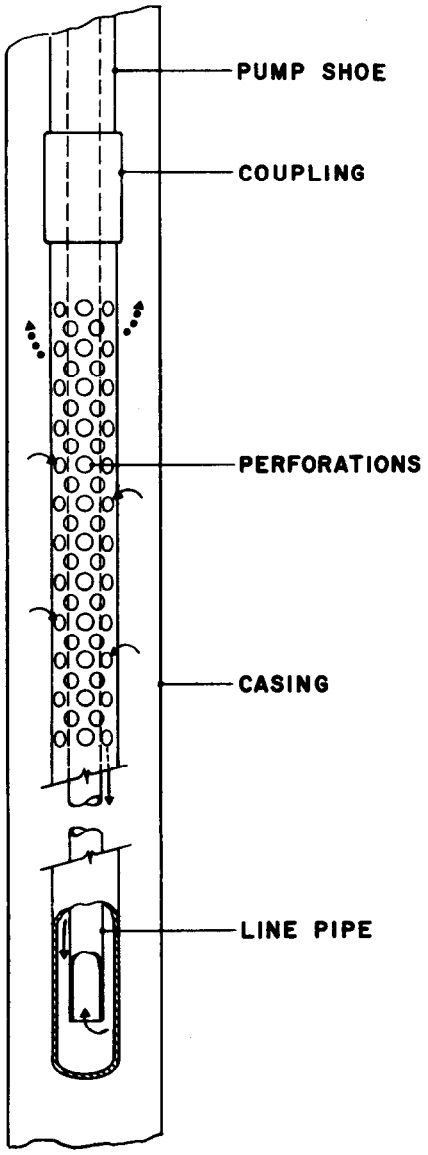
The method of using a Stinger enclosed in a perforated nipple, to anticipate gaseous fluids entering the perforations and falling down to the lower end where the fluids are picked up by the Singer, has been thoroughly exploited. This practice has been widely used, but seldom yields substantial results. A sucker rod pump has a certain daily capacity, and if it must pump oil permeated with gas, it will lose a certain amount of its efficiency.

FORCED FLOW SEPARATORS

Parallel Type

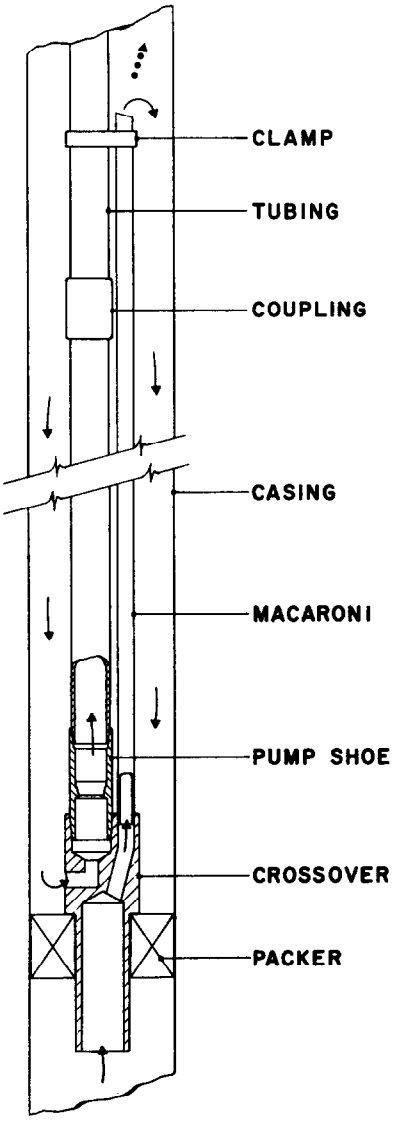
The most effective down hole oil and gas separators are the forced flow type. One design provides a small string of macaroni, strapped parallel to the tubing string. The ends of both strings are threaded into a crossover fitting (Fig. 4), which diverts all fluids from below a packer cup up through the fitting and macaroni string, where it discharges to the casing annulus.

Separation is accomplished by dropping the liquids, by gravity, to the top of the packer where intake ports feed the dead oil to the pump. This design lacks proper capacity and no provisions are made to baffle the fluids.



GAS ANCHOR

FIG. 1



FORCED FLOW

OIL & GAS SEPARATOR

PARALLEL LINES

FIG. 4

Concentric Type

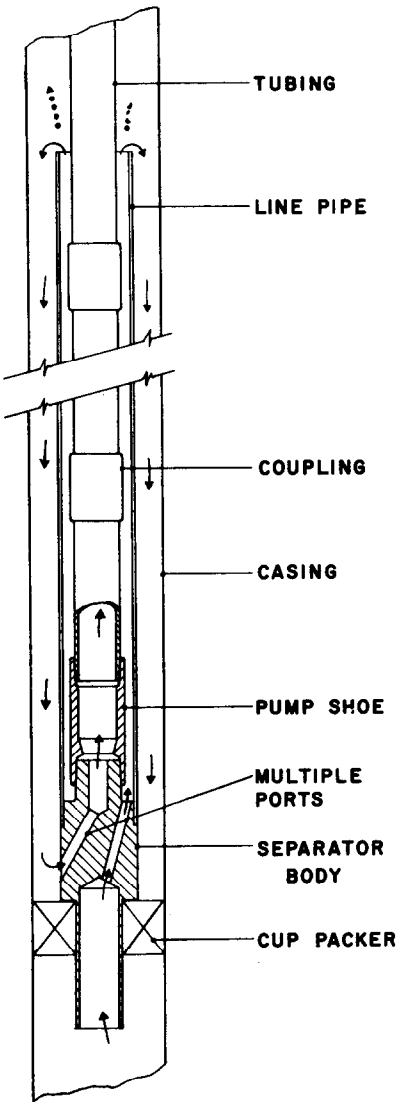
The concentric type incorporates a fitting with multiple ports carrying the fluids up above a packer cup on the outside of the tubing string. Inside is an annulus formed by utilizing one joint of standard line pipe to extend the point of discharge to the casing annulus, which is used as a reservoir to accommodate the dead oil dropping back to the intake ports above the packer. Tubing couplings and short nipples can be used about 4 feet apart above the separator to the top of the line pipe. These couplings form an annular restriction as the gas/oil flows through these spaces at high velocities.

The space between the couplings forms a larger annulus and the liquid can expand at these points. Because the fluid alternates at high velocities, then blasts into expansion chambers, a natural baffling is created without going to the expense of a very intricately designed mechanism. After discharging the fluids at the top of the line pipe in the casing annulus, the free gas goes up and the dead oil is dropped into the reservoir above the packer, where multiple intake ports carry it into the pump. The large sizing of the multiple discharge and intake ports in the fitting is important, because it permits greater capacities, to accommodate high gas/oil ratio wells.

INSTALLING TOOLS

It should be mentioned here that the forced flow separator is primarily a crossover fitting. It has three angle drilled holes to provide passage of gas/oil from below the packer to the top of the line pipe (discharge ports). It also has three more angle drilled holes which provide passage of degassed oil from the casing annulus to the pump (intake ports).

When running the packer through the fluid, a swabbing



FORCED FLOW
OIL & GAS SEPARATOR
CONCENTRIC LINES

FIG. 5

action will result. This will be amply taken care of as the fluid will pass through the discharge ports, up through the tubing line pipe annulus, and back into the casing annulus.

The separator should be threaded into a mandrel with one swab cup packer below. One joint of standard line pipe should be run above the separator to carry the gas/oil approximately 20 to 25 feet above the intake ports.

Where a forced flow separator is used, it is not recommended to use it in conjunction with a hook wall packer. Hook wall packers used in this application only encourage tubing buckling, thread leaks, and unnecessary sucker rod grooving on the inside of the tubing string.

Tension type tubing anchors, which hold the tubing in its maximum elongation, are recommended in conjunction with one packer cup full floating on a mandrel, so the tubing will not reciprocate and cause unnecessary wear on the packer cup.

The cup floating on a mandrel with approximately 2 feet of travel makes it possible to move the tubing up and down if some sand has settled on top of the packer. When a short stroke can be made up and down with a tubing string, removal of the packer should not be difficult. The packer cup, of course, will be run on a mandrel below the separator, and the tubing anchor run approximately 90 feet above the separator.

GAS BLOWS

The forced flow type separator also allows a well to make intermittent gas heads without unseating the pump or blowing the packing out of the stuffing box.

In many areas, wells that have recently gone from the flowing to the pumping stage will build up a head and make a gas blow. Without a forced flow type separator, most of the gas and oil will blow through the tubing. This velocity will sometimes unseat the pump, thereby making it necessary to send out a pulling unit to reseat and space the pump, which causes additional operating expense. This same velocity may also blow the packing out of the stuffing box on the polished rod, and cause loss of production and possible property damage.

When a gas blow occurs in a well where a forced flow separator is being used, the gas/oil blows into the casing annulus and does not disturb the pump during the duration of the blow.

TYPICAL INSTALLATIONS

The forced flow separator functions most effectively when it is not submerged too deep in the fluid. Some operators swab their tubing down to arrive at the approximate fluid level; the separator is then run about 200 feet into the fluid. This method is used by the Champlin Oil Co. in the Sydney, Nebraska area where the wells are around 5,000 feet deep. Substantial increases have been obtained from 65 barrels to 140 barrels daily, or over 100% increase.

In the Fort Morgan, Colorado area, Sinclair Oil and Refining Company has quite a number of installations, and in one area they shut the wells in for 24 hours to determine the approximate fluid level. The forced flow separator is then run into the fluid 900 to 1,000 feet. Best results in this area are obtained in wells which are producing around 300 to 1 GOR's and not more than 500 to 1 GOR's. In these particular wells, increases of 150% are not uncommon.

Wells making as high as 1500 to 1 GOR's yielded increases as low as 5%. The very foamy wells in this area showed the best results from the use of the forced flow separators.

Many other areas have had results that have been most gratifying. Only a few have not yielded results in keeping with expectations.

USE OF TUBING ANCHORS

Another important factor in effecting proper down hole separation is the selection of properly designed tubing anchors. Some tubing anchors fill the casing and have inadequate or practically no water courses (Fig. 2). Free gas, trying to make its way up the casing annulus, must have adequate and unrestricted passage to prevent gas locking the pump. A small restriction can create a column of gaseous foam that

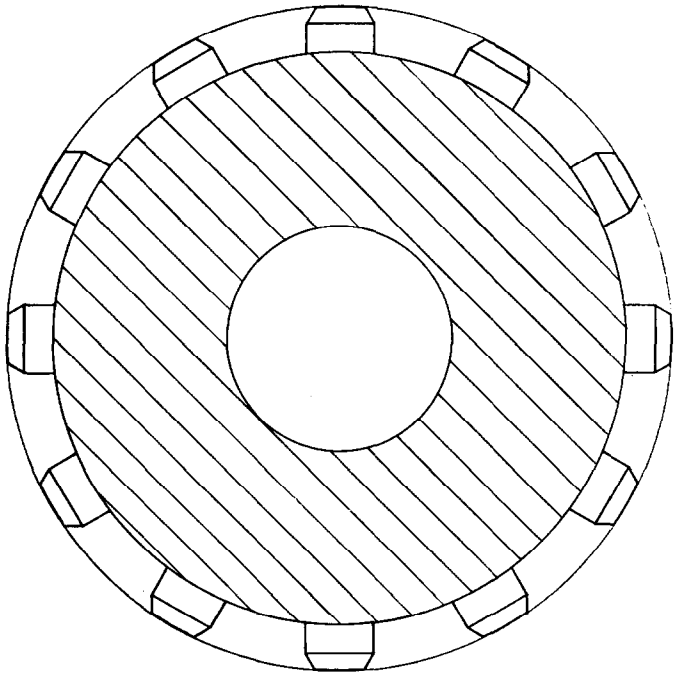


FIG. 2

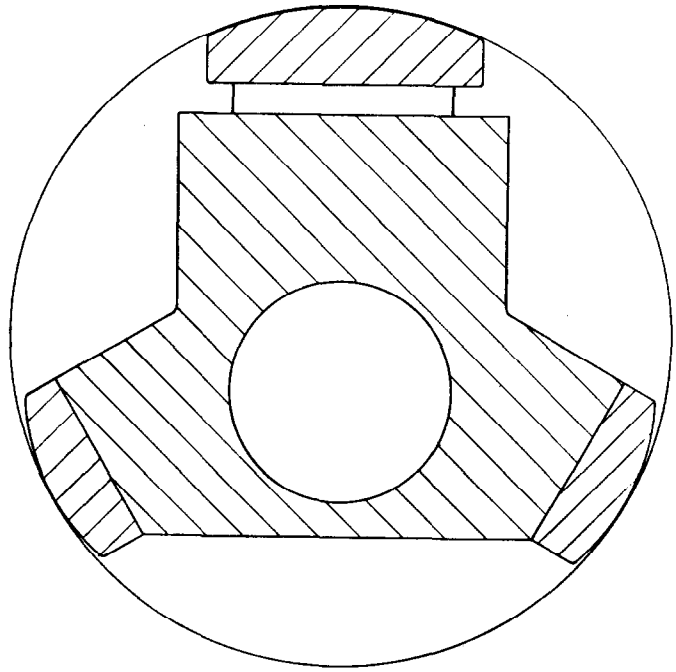


FIG. 3

builds up a back pressure, forcing more gas through the pump. The selection of tubing anchors with generous water courses is of utmost importance to permit free passage of gas (Fig. 3).

The writer will not dwell on this subject as it has been very adequately covered in a previous paper reprinted from the March, 1957 issue of Journal of Petroleum Technology, entitled "Buckling of Tubing in Pumping Wells, Its Effects and Means for Controlling It", by Arthur Lubinski and K. A. Blenkarn, Pan American Petroleum Corporation, Tulsa, Oklahoma.

CONCLUSION

As was mentioned in the introduction, many types of down hole separators have been designed and used during the past thirty five years. Of all the designs and types we have seen and used, we believe the forced flow type obtains the best results.

It is quite apparent, from a recent survey by the writer, that most fields have varying conditions. Even wells close to each other may vary substantially in that they must be produced from a different depth than some adjoining wells.

With increases in production from 100% to as much as 300%, it is quite evident that down hole separation is important and profitable.

If a comprehensive study can be made together with the selection of the proper equipment, good results should follow.