Development of Rod Pumps and Subsurface Accessories for Pumping Gaseous Wells

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INTRODUCTION

Problems of pumping gaseous wells are not always easily defined. Their effects may be quickly noted, however, as they are reflected in higher lifting costs, brought about by low pump efficiencies, increased pump and rod maintenance, and often by the unsuspected loss of production.

Early in the pumping life of an average gaseous well, the rod pump may be used merely to agitate the well to a flowing condition. This soon changes, however, to a condition of intermittant heading and pumping, usually resulting in inefficiency and higher operating costs.

Throughout the pumping life of a gaseous well, the remedial measures which may be taken to improve lifting performance involve 2 areas. First, by means of the proper design and application of conventional pumps, the use of special design pumps, and improved operating practices, the effect of gas which enters the pump may be minimized. A second method incorporates the application of various devices to separate gas from the oil previous to entry into the pump.

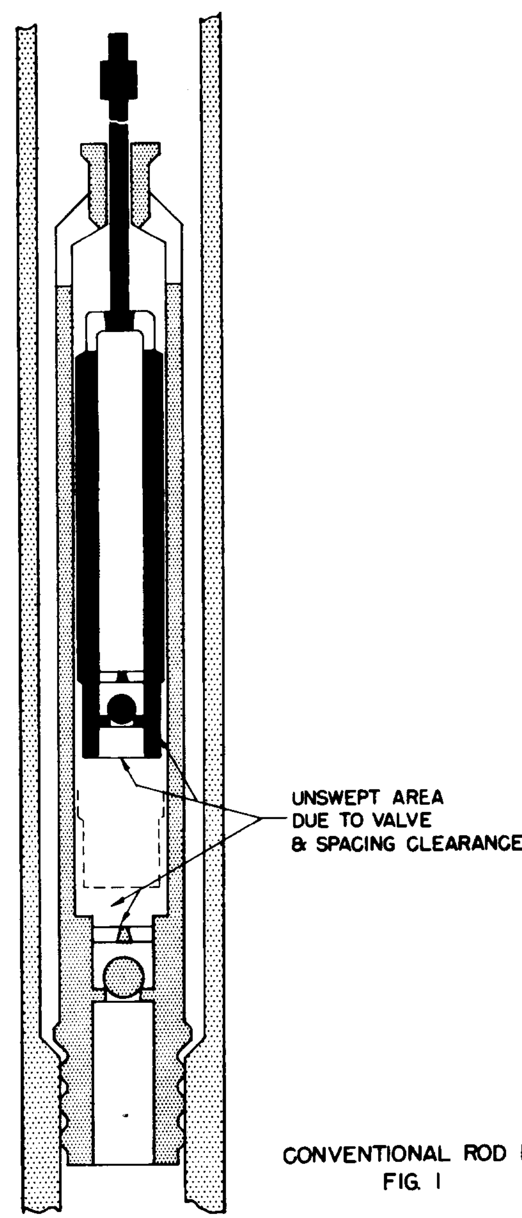
Rod Pumps

The rod pump is considered first in this paper because, regardless of the severity of the gas problem or whether accessory equipment is used, it is still the basic mechanism which must compress the fluid to lift it to the surface. Its design then becomes critical to assure maximum pumping efficiency.

Under the most favorable conditions, it must be assumed that at least some gas will pass through the oil well pump. This may be in the form of free gas which enters with the oil into the pump barrel, or in the form of dissolved gas within the liquid. In either case, the rod pump should be designed to give the maximum compression ratio.

Gas may affect the displacement of the pump in 2 ways. On the upstroke of the pump, gas entering the compression chamber occupies space the same as oil, therefore reducing the amount of liquid fill up. On the downstroke, since the compression chamber is partially filled with gas, opening of the traveling valve will be delayed until pressure in the barrel is great enough to overcome the hydrostatic head against the pump. In extreme cases, where short stroke, poor compression ratio pumps are used, this condition may reach a point where it is impossible to compress the fluid enough to raise the traveling valve. This is the condition commonly referred to as "gaslock".

Certain features inherent in the design of rod pumps will contribute to reduced compression ratios (Fig. 1). The unswept area at the bottom of each stroke includes clearance area around the traveling and standing valve, and spacing clearance between the valves. The most serious factor contributing to lower compression ratio is the inattention to close spacing of the pump after it has been hung on for pumping with a full hydrostatic load.



CONVENTIONAL ROD PUMP
FIG. 1

API recognizes a multitude of pump types. The basic consideration where gas is present, however, is to select a model in which the valves will stroke close together. It is also desirable to have streamlined fittings to avoid turbulence, and a standing valve with maximum opening to avoid pressure drop. To obtain minimum compression ratio, the pump should always be used with as long a stroke as possible.

The proper setting depth is difficult to predict and very often must be determined by trial and error. If the pump can be set at a depth where the intake pressure will be higher than the bubble point, it is probable that the fluid can be pumped without free gas breaking out within the pump. On the other hand, if the pump is set where intake pressures are low, the well will likely be a good candidate for a downhole gas anchor or gas separator.

Interference of gas may have severe effects on the pump and rod string. Delayed valve action and improper fill up of the barrel can react much the same as fluid pound due to a pumped off condition. This is usually recognizable from a dynamometer card.

Fig. 2 shows typical cards illustrating various load cycles which may be experienced in gaseous pumping. In some cases it may be difficult to accurately differentiate between gas pound and fluid pound due to a pumped off condition. In this event it may be helpful to suplement dynamometer readings with liquid level measurements.

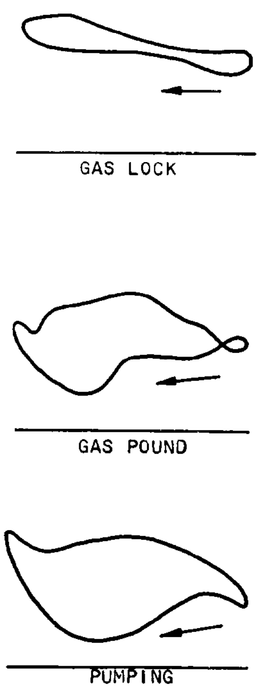


FIG. 2

Gas interference is likely to cause severe ball spin in the valves of the pump and, therefore, may result in short pump runs. A typical valve cage used under these conditions is shown in Fig. 3. The severity of this condition may be minimized by use of valve cages with either resilient guides or extremely hard guides.

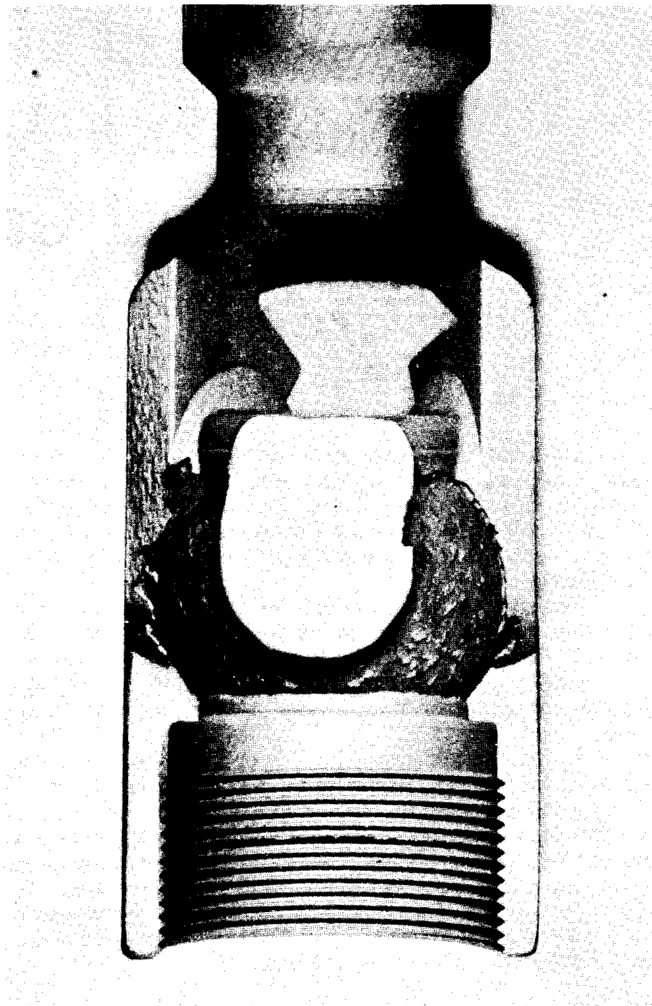


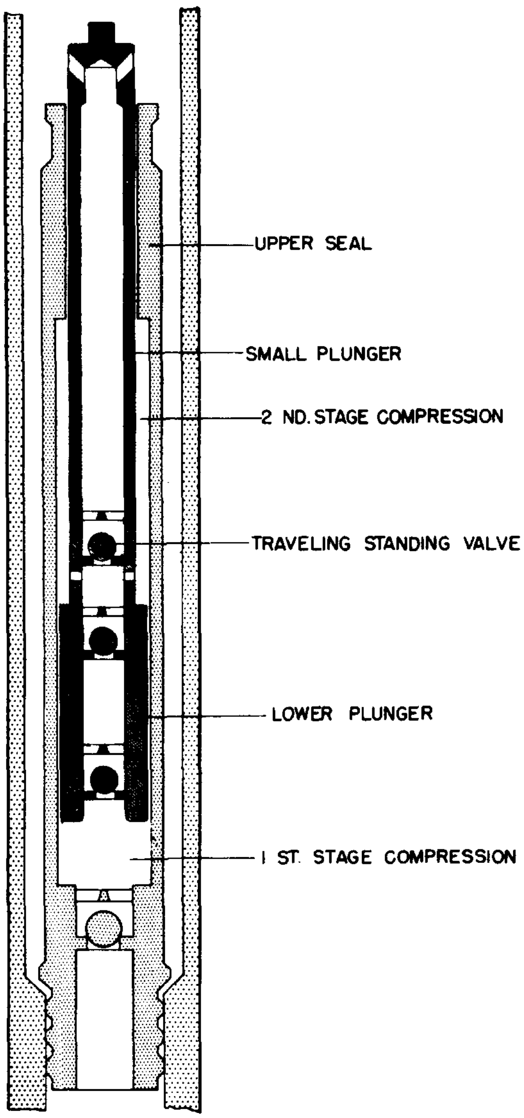
FIG. 3

Specialty Pumps

Over the years a great number of specialty pumps have been introduced for the purpose of improving pump efficiency while handling gas. It is not the intent of this paper to cover all of these types; however, one type, now in somewhat common usage, is worthy of mention. It is sometimes referred to as a "Dual Compression Pump" or "Two Stage Pump".

This pump operates on the principle of 2 stage compression of the gaseous fluid within the pump (Fig. 4). Essentially, this involves 2 pumps with a large lower plunger giving first stage compression (a.). A smaller upper plunger stroking through an upper seal provides a secondary compression chamber (b). The upper chamber displacement constitutes the annular space between the small plunger and larger barrel. This pump uses a traveling standing valve for the upper chamber. First stage compression takes place in the lower larger bore on the downstroke and second stage compression in the smaller uper bore on the upstroke.

With the dual compression pump there may be some confusion as to the necessity of spacing close at the top or at the bottom of the stroke. A preferred practice would be to space closely at the top of the stroke. In doing this there is, however, the risk of unseating the pump at the top of the stroke. A more recent modification of this idea is to add a third stage to the pump which supposedly eliminates the need for



DUAL COMPRESSION PUMP
FIG. 4

spacing at the top of the stroke. Care must be used in sizing these pumps to the desired stroke length or higher compression ratios may not result.

Various other special pumps have been designed for gaseous production; some of them permit venting of gas through hollow sucker rods and others vent gas around the hollow rod tubing annulus, pumping the liquid through the hollow rod. These pumps are primarily designed for slim hole completions where no casing annulus exists for venting gas.

Gas Anchors & Gas Separators

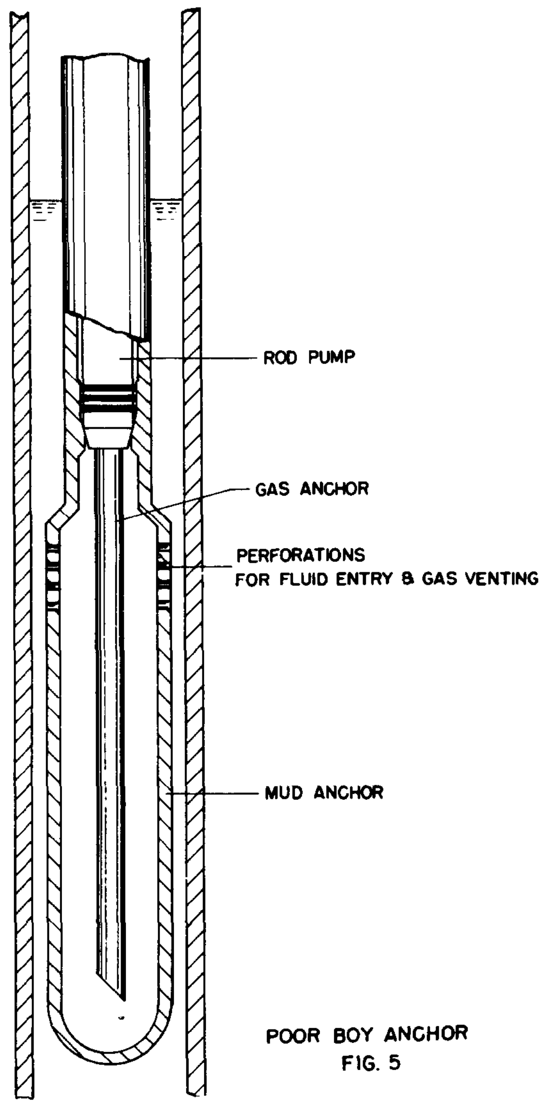
The use of gas anchors and gas separators is not new to oil well pumping. Their importance has increased, however, with more strict emphasis on lifting efficiency. A trend toward small bore completions has further complicated this problem since there can be less room for normal separation of gas in the casing annulus.

Justification for the costs of pulling tubing and installing gas separation equipment can usually be based on an expected increase in production, improved pumping efficiency, and some reduction in pump and rod maintenance costs.

Effective gas separation with downhole anchors is a function of the state of the gas, free or in solution, and the viscosity of the liquid. Generally, gas will enter the well bore at submergence pressure in the form of small bubbles entrained in the oil. Their size will vary depending on submergence pressure, and will grow as this pressure decreases. Due to a difference in quantities, these gas bubbles have a natural tendency to separate from the oil, and their rate of travel through the oil will be dependent on the viscosity of the crude. The design of most gas anchors is based on this theory of separation.

The simplest method of gas separation is merely to set the pump intake below the casing perforations. This provides a natural type gas anchor and utilizes the casing as the largest possible separation chamber. This type is limited, however, where wells have high working BHP or little or no space exists below the perforations.

The most common and probably the least expensive type anchor which can be run on the tubing, is often called the "Poor Boy" or "Mother Hubbard" gas anchor (Fig. 5). This anchor is constructed to allow the oil-gas mixture to enter through perforations at the top.



POOR BOY ANCHOR
FIG. 5

The area of these perforations should be several times the area of the pump standing valve, as separated gas must also vent back out through the same perforations. The annular area between the gas anchor and the mud anchor should be large enough to assure slow downward velocity of the oil. This permits gas bubbles to rise through the liquid and vent out the top of the anchor. When functioning properly, relatively gas-free oil will enter the pump through the gas anchor pipe. The basic principle is to keep velocity of the liquid through the anchor below the velocity of rise of gas bubbles.

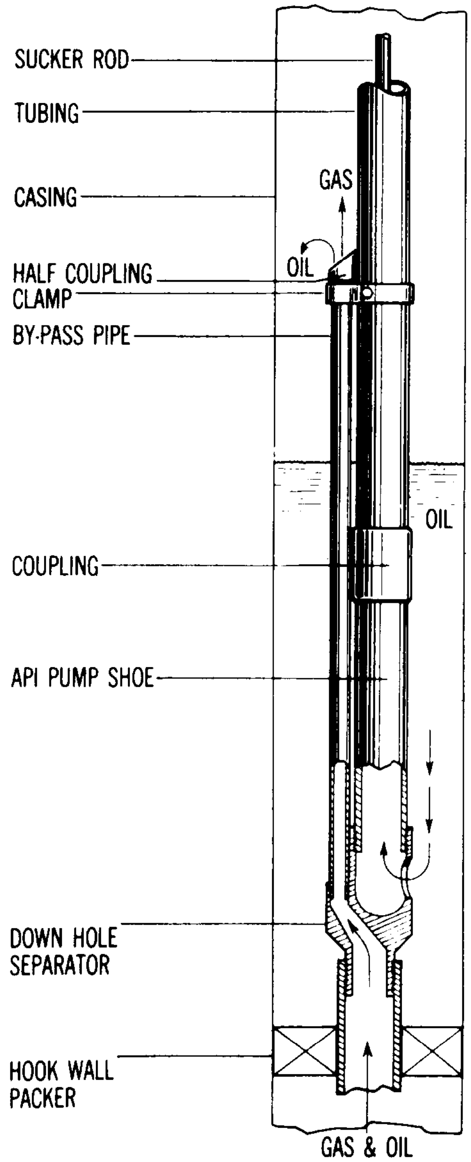
Various modifications of this type anchor have been made, usually involving different baffling within the anchor. Their principle of operation, however, is the same.

Another very effective gas separation device is the "Down Hole Separator" (Fig. 6). It is also often referred to as the "Packer Gas Anchor". It utilizes a crossover device for attaching a spill-over tube above the packer. One or more joints of by-pass pipe may be strapped to the tubing, depending on the producing characteristic of the well. Production flows up the casing annulus, through the packer and up through the spill-over tube. Production flows out the spill-over tube into the large casing annulus area above the packer. This allows gas to break out of solution and the oil to drop down, forming a reservoir above the packer where it is picked up by the pump.

One of the advantages of the Down Hole Separator is that it is gravity-filled, which tends to eliminate the problem of heading.

In some fields with high bottom hole pressure, it may be troublesome to properly design the length of the spill-over tube. For effective separation it is desirable to maintain low pressure at the point of spill-over. In fact, it would be preferable to maintain a liquid level below the end of the spill-over tube. In this event, a special back pressure valve may be used to limit the amount of liquid fill up above the packer. The gas anchor or gas separator should always be set as close to the pump as possible to avoid friction and pressure drop between the anchor and pump.

Consideration should be given to several possible disadvantages of the downhole gas separator. It is always possible to plug the small crossover ports or spill-over tube with paraffin, sand or foreign material. There is also the risk of sticking the packer, or pulling it up-hole when the pump is unseated, thereby causing tubing buckling. Even considering these possible disadvantages, it remains one of the most successful gas separation devices available.



DOWNHOLE GAS SEPARATOR
FIG. 6

SUMMARY

The rod pump has long been a practical method of pumping oil well crude. It can be said that no other pump, regardless of type, is exposed to the multitude of conditions under which the rod pump must operate. Its construction is simple, yet it is a precision piece of equipment. In recent years it has passed through a high degree of refinement in terms of both metallurgy and standardized design.

Application of rod pumps for gaseous pumping requires more than average study. However, when properly applied and with proper use of accessory equipment, efficient operation can be achieved.