IMPROVED PERFORMANCE IN BEAM-PUMPED WELLS USING ROD GUIDES

REX E. GALLOUP
Echometer Co.

ABSTRACT

There are many ways that sucker-rod systems can be improved. Performance and utilization of available equipment can be increased without the installation of larger units at greater costs.

The use of rod guides is an inexpensive method for optimizing machinery already on the lease. This method keeps capital expenditures to a minimum and also reduces pulling costs up to 50 percent.

Rod guides were originally designed to combat crooked-hole wear, but operators have been quick to find other money-saving uses for them.

INTRODUCTION

The predominant method of artificial lift in the oilfield has been the use of beam pumping units. As of January 1972, of the total 527,000 wells 403,000 were being rod pumped. Stimulation via waterflood and the encroaching water in water drive reservoirs have increased fluid loads appreciably, thus requiring increased efficiency in beam pumping equipment so that it remains the primary method of artificial lift in oil wells.

A few of these improvements are as follows.

- Unique pumping geometry
- High slip motors
- Rolled sucker rod threads
- Spray metal couplings
- Low friction rod guides

This paper describes rod guides, which are fast becoming as important as any tool on the list. The original concept of rod guides was to combat crooked holes, but it did not take operators long to perceive other money saving uses for them.

There are many areas in which we can make improvements in order to use each sucker-rod system to its full capacity before considering a costly change to larger equipment. Rod guides contribute an additional means of optimizing the available pumping capacity while keeping capital expenditure as low as possible.

ROD-GUIDE CONSIDERATIONS

There are several areas that have not been given much attention by sucker-rod designers. In fact, the SPI RP 11L sucker-rod design calculation does not consider any of the following factors.

(1) Pump friction
(2) Friction between rods and tubing (vertical or slanted holes)
(3) Rod coupling piston effect (can be a factor with some types of rod guides)
(4) Very viscous fluids
(5) Paraffin and scale
(6) Excessive sand production
(7) Corrosion
(8) Impact loading (fluid pound or gas interference)
(9) Use of sinker bars
(10) Use of high slip motors
(11) Excessive tightening of (shallow-well) stuffing boxes
(12) Fluid friction
(13) Wells attempting to flow

Good well-analysis tools such as fluid-level instruments and dynamometers have contributed to better utilization of pumping units and available downhole equipment. Let's take an example of a 4200 foot lease that has been waterflooded. The producing wells have begun to respond, so that total fluid production has increased to the point that producing fluid levels have risen to 2800 feet. This has been confirmed through monitoring fluid levels with an echometer-type fluid level instrument. The maximum producing capacities are exceeding the capabilities of our equipment. We can do one of two things—install a bigger pumping unit at considerable cost, or raise the pump up to 3200 feet. and increase the pump size, thus producing more fluid with the equipment on location without overloading the capacity of the pumping unit. We follow up the program with a regular fluid level check and dynamometer readings to make sure that we still have adequate pump submergence and that all mechanical equipment is working properly at maximum efficiency. We will produce a lot more fluid since we have increased the equipment capability at the shallower depth, and the equipment capability is more nearly matched with the enhanced producing capability of the well.

Rod guides can save you money and increase the operating efficiency of your pumping equipment by improving the mechanical advantage and lowering the energy requirements. They also serve to reduce the detrimental effect of impact loading (fluid pound or gas interference).

There are four types of rod guides and materials offered.

(1) Nylon—Snap-on, snap around and two-piece compressions type.

(2) Bonded Nylon—Shop installed by J. M. Huber. Same configuration as well guard rod guide but listed by Huber as a scraper.

(3) Oil Resistant Rubber—Snap-on.

(4) Urethane—Well guard wedge lock. 400 pound compression grip.

All of the above except headed Nylon guides are field installed.

Care should be used in selecting the rod guide material, especially if the produced fluid contains rust, scale, and iron accumulations. A soft resilient rod guide will readily accept these abrasive substances and will cut through tubing walls quickly. Very dense materials are the most desirable because they resist the encroachment of foreign abrasives, and in the case of urethane, are highly lubricious (slick).

When coupling wear is detected and the decision is made to run rod guides in the old tubing, some means of keeping the rod guides away from the worn spots should be used. The addition of a sinker bar or pony rod at the bottom of the string is recommended. Failure to do this will result in fast wear of the guides, because they will peel much the same as when you hand-sharpen a pencil.

One of the important factors not given consideration in sucker-rod design is downhole fluid-rod and rod-tubing friction. Admittedly some of these values are dependent on well conditions and are not readily attainable. However, it is in this problem-well area where we feel we can show the operator a money-saving improvement.

Getting down to basics, downhole friction can be separated into two basic types: fluid friction and drag friction. Excessive fluid friction results when large volumes of produced fluids are forced up relatively small tubing strings. If rod strings are improperly designed, rod equipment, couplings, and certain types of rod guides can be a detrimental factor.

Fluid friction is velocity dependent and normally reaches its maximum near midstroke. Our main contribution in helping to alleviate this problem is in providing a centralized rod string devoid of cavitation and with a fluid by-pass area as good or better than any other portion of the string.

Excessive drag friction usually results from tubing deflection caused by crooked-hole or set-down weight-slack when packers or tubing anchor-catchers are used or caused by paraffin deposits. Another equally important cause of drag friction is the fact that rods weigh less on the downstroke than on the upstroke because of buoyancy of the produced fluid. This buoyancy causes the rods to cork-screw because they travel slower on the downstroke and drag against the tubing walls. Some operators attempt to combat this by running six or eight large rods or sinker bars right above the pump. This explains the fact that one company in evaluating problems in one field noted that the highest percentage of their rod failures were in the lower section of the rod strings.

We can all agree on the definition of wear. Wear is simply the removal of metal by frictional rubbing against other metal or two slightly abrasive surfaces. In our case it can be serious, particularly in crooked or deviated wells and in wells in which tubing or rods are operating with inadequate tension (that is, too much slack). This wear cannot always be prevented by using a hardened rod box, because we may only change the location of wear from one surface to another. A better solution is the use of a long wearing (slick) rod guide centralizer which will keep the rod body and the box from contacting the tubing wall. One company in the Sprayberry area found that by using a very high grade, properly finished spray metal coupling, and rod guides on the bottom 25 percent of the strings, it was able to cut pulling costs slightly over 55 percent. This was an appreciable saving monitored over an 18-month period. Another company in a shallower New Mexico field started using rod guides on just the bottom 10 percent of their rod strings, and monitored over a 20-month period they showed a saving close to 60 percent in pulling costs. This New Mexico field was plagued by excessive rod corrosion, and it was felt that the stabilizing effect of the rod guides and the prevention of cork-screwing were big factors in prolonging the life of their corroded rods. Additional improvement was made in this area by using a friction-reducing corrosion inhibitor. By causing the tubing and rods to become oil-wet, it was easy to maintain an oil film between the rods and boxes and the tubing wall. Further savings were noted.

Metal fatigue is another area in which we lower the chance of rod failure. By preventing corkscrewing and centralizing the corrosion-weakened rods, the fatigue factor was lowered. Metal rods under cyclic stress during pumping cycles have an endurance limit which is lower than the strength they have under a static load. As load decreases, the number of cycles-to-failure increases until at some load the number of cycles-to-failure becomes so large that we need not fear failure. This stress point is called the endurance limit. This endurance limit is lowered when the metal is immersed in fresh water; it is lowered still further in salt water. In addition, the range of stress plays a big part in fatigue. At high loads a very narrow stress range can cause failure, while at low loading the range can be fairly wide. In the pumping cycle, the rod string should not be put into compression because of column bulkling (corkscrewing). This is also related to impact loading (fluid pound). Also, yield strength should not be exceeded—60 percent of ultimate strength is a fair rule of thumb.

Conclusion No. 1: Where corrosive fluids are a problem the stabilizing effect of rod guides, especially when used in the lower portion of the rod string, has been found to extend the life of corroded and embrittled rods an additional 40 percent beyond what has been considered the normal replacement period.

Conclusion No. 2: Rod guides used in conjunction with spray metal couplings can further reduce friction and lower operating loads as attested to by dynamometer weighings. We have had many instances showing a 30 percent improvement and a 25 percent average in some areas is not uncommon. Properly finished couplings will hold wear to a minimum, but improperly finished couplings cause wear in a direct relation to their finish and the percentage of water produced. This situation can be further aggravated by sand and excessive amounts of iron and scale.

Rough, badly finished couplings plus a high water cut fluid equals a highly abrasive action on the tubing. This type of well should have a rod guide within 18 inches of the coupling. Smooth, properly finished couplings used in wells producing a high percentage of oil will rarely show more than minimal tubing wear.

This is a good place for a brief discussion on paraffin scrapers which not only guide the rods, but cut away and prevent paraffin accumulations.

(1) For many years, a metal paddle type scraper was used. Few metal scrapers are presently being used because their disadvantage of excessive wear more than offset their paraffin cleaning capabilities.

(2) Typical applications: Many deeper wells need scrapers only on the upper section where fluids cool and paraffin accumulations start. In the Crane area (North McElroy), for example, paraffin starts about 2800 feet from the top of the hole.

The operator first used two scrapers per rod and used a pulling unit to raise and pass the rods approximately every ten days. This proved to be economically poor, and we started installing scrapers in direct relation to the stroke length.

In a well with a 92-inch stroke we installed a scraper every 88 inches, spaced to overlap 1-1/2 times the length of the scraper (in this case 6 inches).

Wells in the Northwest Snyder area and San Angelo area with literally no bottom-hole temperature require scrapers from top to bottom. Wells with low or no bottom-hole temperature are aggravated by gas production. In some cases the use of a bottom-hole separator reduces accumulations by diverting the gas up the annulus.

Many shallow Panhandle wells with short-stroke beam units have over 1000 scrapers per well and frequently run from 20 to 30 months with no problems.

Long trouble-free runs with both rod guides and scrapers often lull the operators into careless habits, and they fail to make periodic checks while thinking the guides and scrapers will last forever. About that time "up jumps the devil." Guides and scrapers are not designed to last indefinitely, but are there to absorb and keep wear off the tubing and reduce friction.

Like any other good tool, rod guides serve a useful purpose and in the long run will save money, but there are occasions on which they should not be used.

(1) Where well bottom hole temperatures are excessively high and can affect guide materials.

(2) Where produced fluids consistently carry high sand or other abrasive materials.

(3) There are some rare instances where the produced fluids are not compatible with materials from which rod guides are made.

(4) There are many areas in the Permian Basin where the gas produced with the fluid has a very adverse effect on rod guides made of rubber compounds. In fact, there is no single rubber compound that will resist produced gases in the West Texas and New Mexico area. There are even some rare instances where the produced fluids are not compatible with some of the plastic rod guide material. This situation is usually compounded by chemical treatment being used in the wells.

CONCLUSION

We have not attempted to get technical in this paper, but we hope we have given the individual operators and supervisors some inexpensive means for improving rod life under varying conditions by utilizing proven equipment that has had increased usage in the last few years throughout the Permian Basin.

REFERENCES

1. James N. McCoy: *Analyzing Well Performance*, Echometer Co.

ACKNOWLEDGMENTS

The author would like to express his appreciation to Mr. W.B. Bud Steward of Red Arrow Mfg. Co. and Mr. Mel Pourchott of Central Plastic Company for their assistance in preparing this paper.