The Long Stroking Sub-Surface Hydrauliic Pump

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The assignment which I will discuss with you today, the advantages of the long stroking, sub-surface hydraulic pump lends itself to so many possible angles of discussion, that in the limited time we have today, I will endeavor to discuss my ssubject as simply, yet as thoroughly as time will allow.

First may I say that I do not consider myself an expert, in fact hydraulic pumping, both surface and sub-surface, are advancing and changing so rapidly that it is difficult to keep up with its progress. However, there are many things which we do know about hydraulic sub-surface pumping, and I would like to discuss some of these known factors with you today.

The problem of finding, refining, transporting and producing oil are each one in themselves a separate phase of the oil industry. Today in this discussion, we are interested in but one of these phases, that of producing oil.

Our subject has been further narrowed to the discussion of the advantages of the long stroking, sub-surface hydraulic pumping, which eliminates for this discussion, flowing well, gas-lift, wells and some phases of conventional pumping methods.

Let me say here and now that I am also a firm believer in the good old fashioned sucker rod pumping systems. All types of pumping have their application, their advantages and disadvantages. No two wells are necessarily the same, even though they be in the same field and the same zone. Therefore, it does not necessarily follow that the equipment which is successfully pumping one well will successfully pump an adjacent well.

Regardless of how we approach our subject, there is always one answer that we should be right about, and that answer is the most economical method of producing a well.

The two major factors in the cost of producing oil today are equipment and manpower. Therefore, we must constantly search for equipment which will do the job better, faster, or reduce the man-power to operate it. The long stroking sub-surface hydraulic pump is such a tool.

Here in the Mid-Continent area, or more specific, in Texas, the problem is not only the production of extra volumes of oil, it is also the economy of production, because each well or lease in this area has a pre-determined allocation. Therefore, the problem is to get all the oil allowable with the most economical methods.

Any set of figures which I may show you will vary from field to field and they will even vary from well to well within the field. Therefore, while I will show you specific charts, I use them as a trend, rather than a hard and fast rule. I have before me several charts which we will use in our discussion.

The first figure will show an actual survey made for a period of twenty-four months on the number of rod and tubing breaks and the cost of fishing, repairing, or replacing the rods and tubing. Also, the pulling of the rods to remove or to insert the pump.

Now I would be the last one to say that rod pumping is the cause of all tubing failures, however, several studies have been made which tend to show that due to the transfer of shock load, friction of the rods on the tubing, especially in slanted or crooked holes (and what holes are not crooked) rod vibrations and a variance of harmonics set up between rods and tubing cause a great many tubing failures.

Figure 1 is information which was taken from an API paper presented in 1936 by Walton E. Gilbert entitled "An Oilwell Pump Dynagraph." In this paper Mr. Gilbert discusses and shows cards or charts which show thirteen different well pumping conditions. These thirteen examples are as follows:

Of the cards shown in Figure 3, five eliminate themselves from this discussion as three of these cards, A, H, & J are not problem cards. Cards B & C also eliminate themselves because sticking valves are not a function of long, short, surface or sub-surface prime movers.

Of the remaining nine cards which are shown in Mr. Gilbert's paper, seven can be eliminated with the use of the long stroking bottom hole hydraulic pump. When the unit is installed with a good tubing anchor and a good down hole gas-oil separator (gas anchor) gas locking, and shortening of stroke due to excessive gas will be minimized because the unit is so designed that the valves are spaced on the surface (which is usually 1/4 inch between valves) before the unit is installed in the well. The unit cannot reverse its stroke until the plunger has reached the predetermined length of its stroke, thus obtaining maximum positive spacing of the valves which gives minimum unswept area and maximum compression between the valves. This close, positive spacing of the valves when used with a good gas anchor eliminates the major part of the gas compression problems often found in pumping wells.

Hitting up and hitting down are also automatically eliminated for as previously stated, the plunger stroke is accurately and positively spaced on the surface before the unit is run into the wells. Therefore, there can be no over-travel or under-travel of the plunger, which automatically takes out all of the guess work as to the problems of the plunger hitting up or hitting down due to the over-travel or under-travel of the rods, as there are no rods with this method of pumping. Thus we eliminate all of the problems associated with rods.

There are two remaining cards in Mr. Gilbert's diagram.

Card E—In which there is gas compression, no fluid being pumped. This is the result of a well that does not have enough oil, but does have large quantities of gas, or a well in which the pump is not properly placed in the well (placed in a gas zone or the pump needs more submergence).

Card K—Pumping and Pounding Fluid, is usually the result of the pump being too big for the amount of fluid to be handled, operating the pump in excessive speeds, or in some cases, not enough pump submergence.

Corrosion is often a major problem in an oil well. Experience has shown that excessive corrosion takes place where metal parts rub together, because the surface is wiped clean with each stroke, thus exposing the clean surface for the corrosive agents to work on. Experience has also shown that moving parts are more effected by corrosion than stationary parts.

Again coming back to our original premise that one of the principal causes of high cost of operation is the cost of manpower. The long stroke bottom hole hydraulic free pumping unit automatically eliminates a considerable amount of manpower because the free pump is surfaced by one man merely reversing pressures. It is likewise put into the well again by one man reversing pressures which eliminates considerable manpower in rod pulling jobs and pulling machines to install or remove rod type pumps. Loss of production due to down time for pump changes is minimized because of the short time it takes to remove or install a free pump. In most wells, it is an hour each way. The actual time, however, depends upon the depth of the well. The regulation or setting of the speed, or cycles per minute, also give the botton hole hydraulic pump a tremendous advantage because its speed is regulated by a valve on the surface which controls the power oil to the pump, thus controlling the strokes per minute. Also, most long stroking sub-surface hy-

COST OF ROD PUMP OPERATION
EXAMPLE—ONE FIELD WITH 240 INSTALLATIONS

Type or Repairs	*No. of Repairs Per Month*	*Cost Each*	*Total Cost of Rod Pump Operation*
Rod breakage	25	$200.00	$5,0000.00
Tubing leaks due to rod pumping	15	$350.0	$5,250.00
Pulling of rods to change pumps	40	$200.00	$8,000.00

draulic pumping units can be actuated by one main power plant which again reduces the volume of work and the amount of incidental travel of personnel.

In marginal areas or where curtailment is in effect, a number of wells can be pumped intermittently by the same surface unit at a considerable savings in surface equipment. Thus eliminating the costly purchase of individual well pumping units and sucker rods which would be used only part time in these intermittently pumped wells, or the pump can be slowed down to the productivity index of the well which has tremendous advantages in sandy wells. We have wells which are now pumping on a long hydraulic sub-surface stroke as slow as one stroke per minute.

In many bottom hole hydraulic pumping units the time proven production pump is used to produce the well with the hydraulic unit being used as the power for this pump. This has a tremendous advantage in that the pump can be designed to meet specific well conditions such as gas, sand and heavy viscous oil, etc. Also, special metal can be built into the pump to meet well conditions such as corrosion, acid or abrasion.

One of the first questions in the minds of many operators is the factors which control operating pressures. Operating pressures depend upon height fluid is to be lifted, volume of power oil and production to be handled, diameters of tubing strings, and operating speed of the downhole pump. Pumping fluid level and not well depth is the chief factor in selecting a downhole hydraulic unit. For instance, we might have a well tubed to 8,000 feet and desire to take 200 B.P.D. from the well at which rate the fluid level would stand at 4,000 feet. Having this information beforehand we would select the pump to do the best job in a 4,000 foot well because it is, in fact, a 4,000 foot well insofar as the pump is concerned. If, however, we wanted to pump the 200 B.P.D. with the fluid level holding at 7,500 feet, the pump selection problem would be considerably changed.

Where exceptionally high operating speeds are not anticipated (20 S.P.M. or more) operating pressures may be estimated for standard ratio units by taking one-half the depth from the surface of the well to the estimated pumping fluid level.

Example:
6,000' Fluid Level
Operating Pressure = 1/2 (6,000) = 3,000 PSI for a standard ratio unit.

If a larger production pump is desired, then the approximate operating pressure would be:

$$\frac{(\text{Bore of larger production pump})^2}{(\text{Bore of standard ratio production pump})^2} \times 3{,}000.$$

This method will hold and give a margin of safety up to operating speeds of approximately 18 to 20 S.P.M. and in most cases where large volumes of salt water are not to be pumped, will hold up to greater speeds.

Among the mechanical advantages of the long stroke sub-surface hydraulic pump are:

1. Less percentage of unswept area, therefore, a greater efficiency in gassy wells.
2. The long stroke units are single acting, thus allowing larger standing valve immediately adjacent to the bottom hole fluid. As a result this unit has much lower pressure drop across the standing valve, which in turn, eliminates a considerable amount of the gas problem often found in an oil well pump.
3. The long stroke decreases the number of cycles or strokes per minute, therefore, giving longer wear to the production pump, and particularly to the valves of the production pump.

Referring to an article written by John Eastman on "Pumping Slant Holes," he quotes a survey made over a large group of wells in which accurate cost accounting methods and records were kept. This survey shows that over a long period of time, an operator using the sub-surface hydraulic pumping units operated at 16 percent less total cost then rod pumping.

Another survey also shows that the sub-surface hydraulic pumping cost 20c per barrel per day as compared to 98c per barrel per day with rod pumping on the same lease.

There are several sub-surface hy-

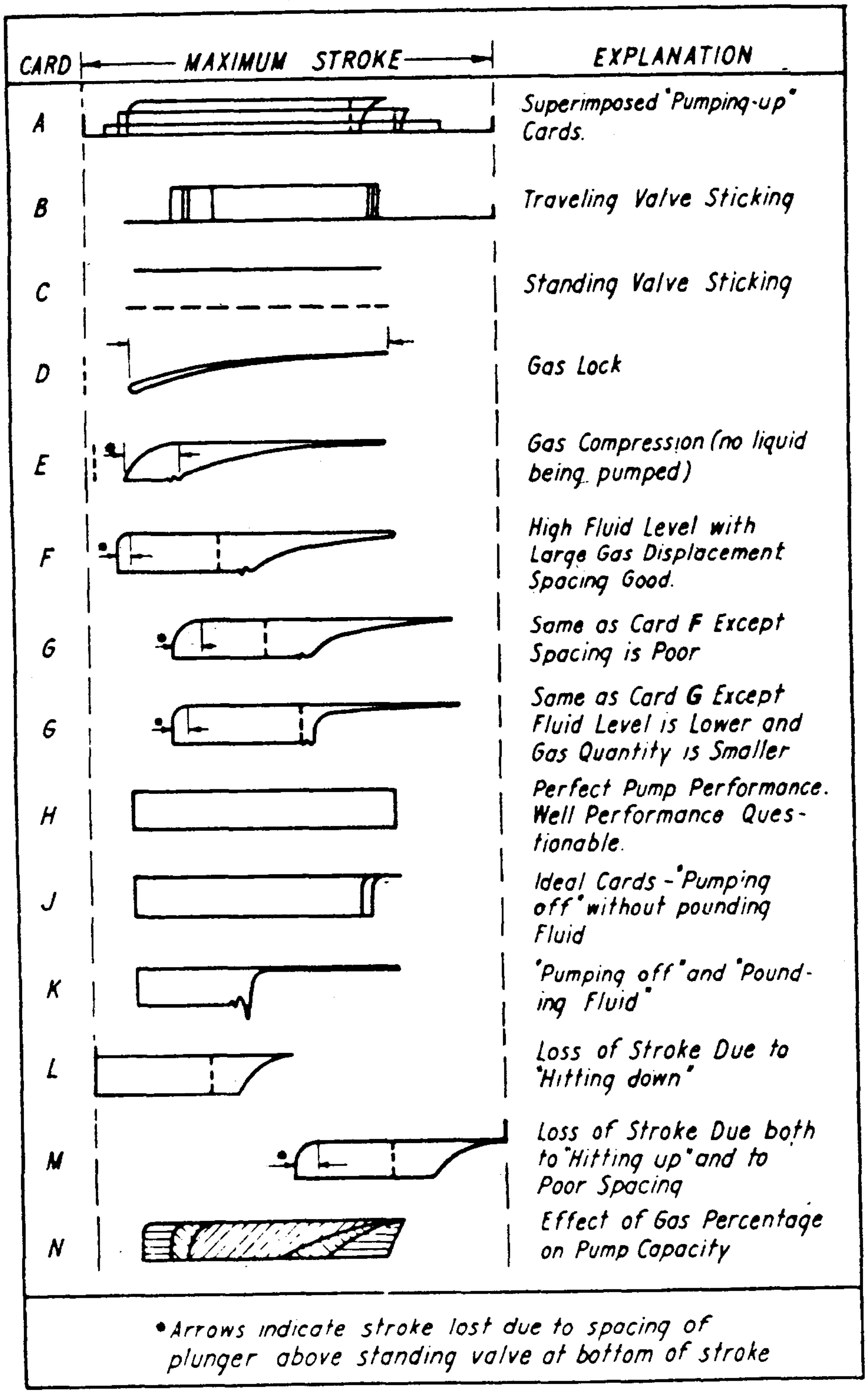

Figure 1—Interpretation of Pump Cards.

draulic pumps on the market. It is advisable when planning your tubing installation to install a cavity which will take any or all of the hydraulic pumps without pulling your tubing to change pumps.

We strongly recommend the single acting sub-surface hydraulic pump for many reasons, one of which is the fact that the equipment is kept in tension at all times. Another is that the long stroking sub-surface hydraulic design allows large valving.

In summary, we find that some of the advantages of the long stroking sub-surface hydraulic pump is:

1. Cost of installation in a single well is comparable with cost of rod pumping systems, however, when installed to pump multiple wells, marginal wells, or intermittently pumped wells, hydraulic installations become much more economical, as more wells are hooked up with a surface hydraulic system.
2. The long stroke sub-surface hydraulic free pump can be surfaced or installed by one man in approximately one hour for each direction (depending upon depths) thus saving considerable cost of operation in man hours and equipment.
3. Considerable loss of production due to down time for pump changing is eliminated because of the rapidity which the sub-surface long stroking free unit can be changed.
4. Spacing of the valves or unswept area is no longer guess work, as the valves are spaced before the pump is run in the well. This minimizes the unswept area and gives maximum compresssion ratio to the pump.
5. Hitting up and hitting down of the plunger is also eliminated for the same reason. The plunger stroke is predetermined and accurately and positively set before the pump is run into the hole.
6. All of the problems associated with use of rods such as: parting, breaking, becoming unscrewed, rod fatigue, rod friction, and tubing wear due to rod friction are eliminated.
7. The long stroke has fewer reversals per barrel of oil handled, thus resulting in longer life of operating equipment.
8. The long stroke sub-surface unit has the maximum size valving possible in a production pump.
9. The speed or strokes per minute can be easily regulated by one man adjusting a valve which is on the surface.
10. The long stroking sub-surface hydraulic system uses the time-proven production pump, which allows for a large selection of designs and metals to meet specific area or well conditions.
11. Surveys have been made which show that the cost of production was much more economical in some wells when the hydraulic system was used in place of the rod pumping system.
12. The long stroking sub-surface hydraulic unit is so simple in design and the component parts are standard A.P.I. parts that in most cases, the unit can be repaired right in the field.

Disadvantages of the long stroking sub-surface hydraulic pump:

There are admittedly disadvantages as well as advantages to the long stroking sub-surface hydraulic pumping system. The biggest disadvantage which I know of at present, is the fact that most of our competitors have now, or soon will have, a competitive pump on the market.

In conclusion, I would like to say that I do not know of a single cure-all method of pumping oil. All pumping systems have their applications. The long stroking sub-surface hydraulic pump is a tool that, in most cases, can help you intelligent operators do a better job of producing oil at a lower ultimate cost.

QUESTIONS & ANSWERS

Q. What kind of anchor does this pumping system use?

A. The pump seating mechanism can be readily adapted to fit either a Kobe conventional shoe, A.P.I. bottom lock shoe, top lock shoe, cup hold-down, Kelly shoe, or may even be run with a pump packer so that the pump setting depth may be varied at will of the operator without raising or lowering the production tubing string.

Q. What is the stroke of this pump?

A. The length of stroke will vary with the manufacturer. However, our 2 1/2" hydraulic engine is standard with a 65" stroke length. The 2" unit is standard with a 52" stroke length. However, with sufficient notice prior to installation, units can be built with stroke lengths to specifications.

Q. Will this hydraulic pump handle sand?

A. This downhole hydraulic pumping unit can be expected to handle sand laden production fluids just as well or better than the standard rod string pump. The production pump is, in fact, a standard rod pump throughout.

The amount of sand which can be handled will vary with the sub-surface hydraulic pump installed. In the system which uses a standard production pump with the hydraulic unit as the prime mover, normal amounts of sand can be handled. In fact, the problem is the same as that found with rod pumping. In a great many cases the sand will pass through the pump which has smaller tubing or areas, thus giving it greater fluid velocity. In the Free Pump, both the production oil and spent power fluid are pumped to the surface through the smaller parallel tubing. However, as is the case with the standard Rod Pump, when the fluid passes through the pump into the tubing string, the area is much greater in the tubing than the area in the pump. Therefore, the fluid velocity is less in the tubing which allows the sand to fall out of solution and settle back on the pump, thus causing what is commonly known as a sanded up well.

However, even in sanded up wells the rodless pumping system has an advantage over the rod type pumping because in the rod type pumping the rods must be stripped out and in many instances cut while in the hydraulic system there are no rods to strip out.

Q. What are the recommended operating speeds (SPM) of the hydraulic pump?

A. I am not familiar with all of the work which has been done on all of our competitors' pumps. However, the recommended top operating speed for our unit is 20 to 25 SPM. Maximum satisfactory operating speed to date has been found at 4,000 PSI operating pressure with a standard ratio unit lifting fluid 95 percent water from a depth of 5,000 feet. Recently changes have been made in our power unit which lead us to believe that a greater operating speed can be attained at the 4,000 PSI operating pressure—possibly near 30 SPM. Needless to say, this is faster than we like to operate the unit.

Q. What is the displacement of the hydraulic engine?

A. 2 1/2" Unit—25.8 BPD per SPM.
2" Unit — 13.1 BPD per SPM.

Q. What has been maximum setting depth for your hydraulic pump to date?

A. 15,000 feet for the 2 1/2" and 12,000 feet for the 2".

Q. Why don't you build a double-acting hydraulic pump?

A. This would eliminate the possibility of using a standard rod pump on the production end. It would necessitate use of extremely small diameter valving on the production pump resulting in undesirable increased pressure drop through valving. Also, small diameter ball check valving gives more trouble especially in deep wells. Double-acting design in a long stroke hydraulic engine would present a serious column design problem in the connecting rod between hydraulic engine and production pump plungers.

Q. What volumes can be handled with the long stroke sub-surface pumping unit?

A. Recommended at present is approximately 500 BPD from about 4,500 feet depth with the 2 1/2" engine and 2" bore production pump.

Q. What are main limitations of application of hydraulic pumping?

A. Main limitation is that of operating pressure. Generally 4,000 PSI is at present considered absolute maximum. If maximum operating pressure could be boosted, then units could be made to operate at greater speeds, at greater depths, and displace more production fluid. Also, stroke lengths are fixed and can only be varied by design changes by request from the operator. This limitation being of little importance in most all cases.

Q. What factors or pressures are involved in unseating and surfacing the long stroke sub-surface hydraulic pump?

A. Factors involved in calculating unseating pressures are:

1. Weight of pump in fluid (weight in air has been used in calculations).
2. Area to which unseating pressure is applied.
3. Difference in density of fluids in big tubing and macaroni. (No difference assumed in calculations.)
4. Friction drag of "O" ring leaving packer collar (neglected in calculations).
5. Depth of well.

6. Bottom hole pressure.

Unseating pressure for 2 1/2" free pump:

Unseating pressure for 2-1/2" free pump:

$$\frac{\frac{\pi}{4} \times 1.375^2 \times .4 \times \text{Depth of Well}}{\frac{\pi}{4} \times (2.331^2 - 1.375^2)} + 90 \text{ PSI (for weight of pump)} = .214 \times \text{depth} + 90$$

Unseating pressure for 2" free pump.

$$\frac{\frac{\pi}{4} \times .875^2 \times .4 \times \text{depth}}{\frac{\pi}{4} \times (1.893^2 - .875^2)} + 79 \text{ PSI} = .11 \times \text{depth} + 79 \text{ PSI}$$

Conclusion: The pressures actually experienced, vary greatly from calculated pressures due to friction which causes higher pressures and leakage in certain areas which can cause lower pressures than calculated.

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