Economics and Flexibility of Hydraulic Pumping Systems

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INTRODUCTION

Economics dictate the decisions most of us make in our personal lives and economics also dictate the courses of action for the companies we represent. More specifically as an oil operator, economics dictate the life of a producing well since it is usually plugged and abandoned when it reaches it "economic limit." One primary factor on which the economic limit of a well depends is its artificial lift equipment. For a longer profitable life, the artificial lift equipment selected should be capable of producing the maximum amount of fluid at minimum operating and repair costs until depletion is reached.

There are many factors which should be considered when selecting artificial lift equipment. All of them should be considered in order to make as complete a lift study as possible so that the final decision will result in the greatest profits for the company. Here are some of the important factors:

(1) Number of wells in need of artificial lift equipment.
(2) Desired producing rate (primary and secondary) and depth of lift.
(3) Location of wells and proximity of wells to each other.
(4) Will lift being considered produce the wells to depletion?
(5) Initial cost of various types of artificial lift equipment.
(6) What is the cost to supplement inadequate equipment?
(7) Availability of service and repair parts.
(8) Cost of operation and servicing equipment.

EQUIPMENT DEVELOPMENT

Hydraulic pumping is relatively new to the oil industry. The first successful installation was made in 1932. Progress was rather gradual until the late 1950's. Since that time, however, greater progress has been made in the development of new hydraulic pumping equipment than with any of the other types of artificial lift equipment. If one's experience or knowledge of hydraulic pumping was obtained prior to 1960, one would be pleasantly surprised at just how much progress has been made in the last five or six years. This progress has been with regard to each category of components which make up a hydraulic system. A brief discussion of several of the more significant developments will illustrate this point.

Subsurface pumps are now available with a double engine end or a double production end to reduce operating pressure or increase the producing rate. Displacement rates for 1:1 ratio pumps have been increased from 174 BPD to 650 BPD in the 2-in. size, from 349 BPD to 1127 BPD in the 2½-in. size, from 604 BPD to 1925 BPD in the 3-in. size and from 1200 BPD to 3913 BPD in the 4-in. size. Pumps have also been developed for use in 1¼-in. and 1½-in. tubing.

Wellhead assemblies used in "free" pump installations are now available which will indicate the arrival of the pump, permit reverse circulation, provide an external release mechanism and contain an automatic reset relief valve. These same features are included in a new high flow wellhead assembly which has been developed with larger flow passages to permit minimum pressure losses when operating large pumps with high power oil requirements.

The one area in which new developments have provided the greatest increase in safety is with the Power Control Manifold. Standard and high flow manifolds are available which have a design pressure of 20,000 psi and a rated operating pressure of 5000 psi. All flanged construction is used with face type O-ring seals. Modular design affords complete flexibility of application and greatly simplifies installation. Figure 1 is a picture of a four-well, high-flow dual-pressure, multiplemeter manifold which illustrates the sturdy, low profile, low pressure loss manifold equipment which is now available.

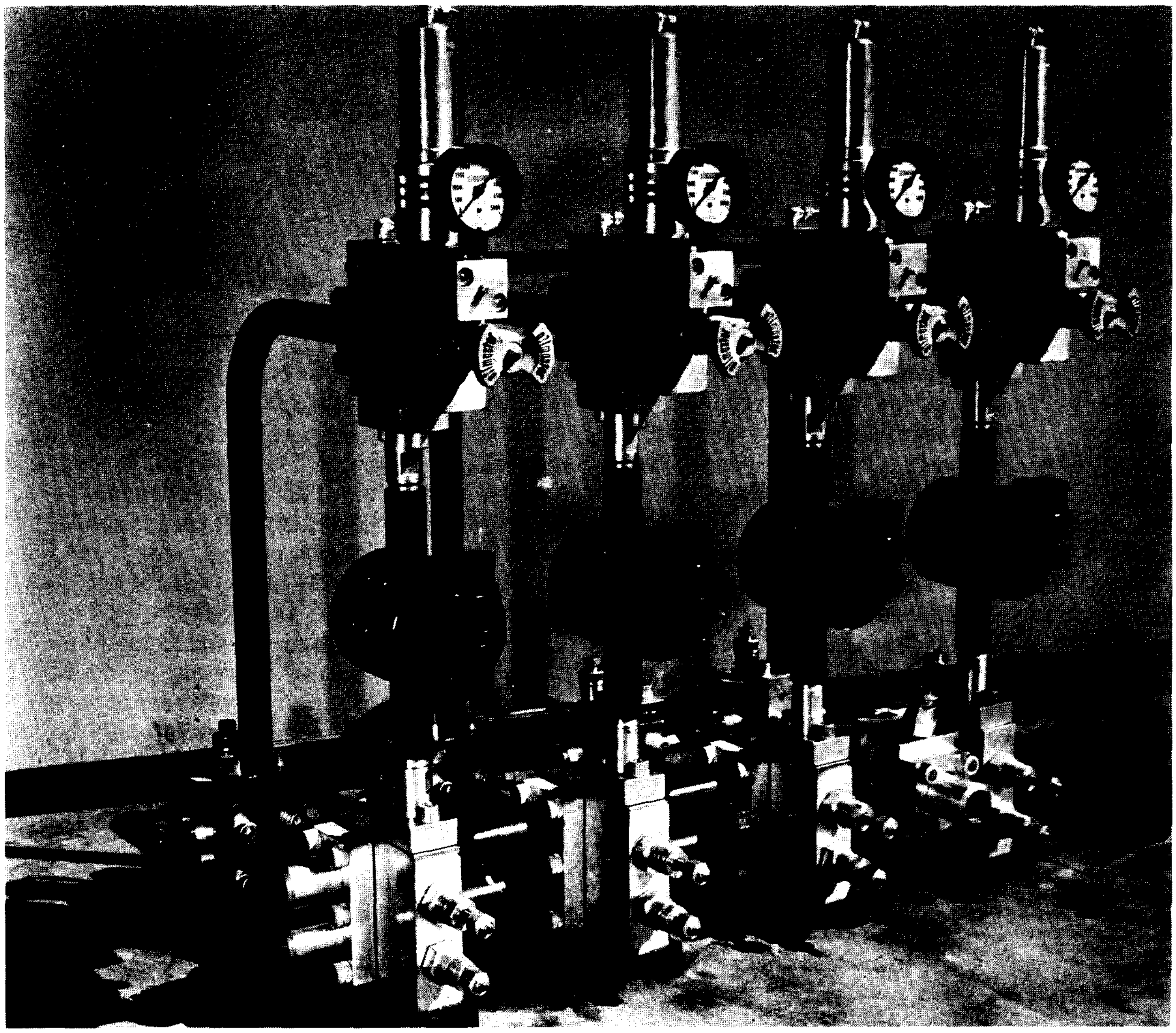

FIG. I

The horizontal line of pumps equipped with close fitting plungers and liners have proven themselves for power oil service. They are now being used along with the original vertical triplexes. Pump horsepowers have increased considerably with the most recent development being a quintuplex rated at 250 HP.

INSTALLATION ECONOMICS

Table I shows tabulated installation costs for beam pumping equipment and hydraulic pumping equipment—both being displacement types of artificial lift. These costs were based on a four-well installation and using a casing free system for our hydraulic installation. In general, this tabulation indicates that at depths below about 3000 ft and for producing rates in excess of 200 BFPD hydraulics can show a lower initial installation cost. The greater the depth of lift, the greater the economic advantage. There are other factors which enter into the selection of lift equipment, all of which must receive their appropriate consideration in making the final selection. Such factors will be discussed throughout the paper and will indicate some of the other advantages hydraulics have to offer the operator.

TABLE I

COMPARATIVE INSTALLATION COSTS*

Rate BPD	Depth Feet	Beam Units	Hydraulic System
200	2,750	$ 6,500	$ 6,680
	4,250	9,700	7,060
	6,250	13,500	7,480
	10,000	24,300	8,220
400	2,750	9,200	8,390
	4,250	12,800	8,930
	6,250	19,040	10,570
	7,500	24,300	11,410
600	2,750	10,300	10,450
	4,250	15,600	12,220
	6,250	23,500	14,700

*Based on a four well casing free system.

FLEXIBILITY OF HYDRAULIC PUMPING EQUIPMENT

When speaking of flexibility, basically we mean the ability to more efficiently use the artificial lift equipment which has been installed. The economic value of flexibility becomes quite tangible when the unexpected occurs.

If rod pumping equipment is selected to produce a maximum amount from a given depth and later a greater rate is required, it is usually necessary to replace the bulk of the installation with larger equipment. For example, if an operator wanted to provide 200 BFPD of displacement in each of four wells, Table I indicates this would cost him $9700/well to install rod pumping equipment and only $7600/well to install hydraulic pumping equipment. The rod pumping installation would probably consist of a 1½-in. pump on ¾-⅝-in. sucker rods in 2⅜-in. o.d. tubing with an API 114 unit having a 54-in. stroke. If we would assume this operator recompleted these wells and increased their productivity such that a 400 BPD/well displacement rate were desired, this would require practically a complete changeout to larger rod pumping equipment. Rod pumping equipment capable of this larger displacement rate could consist of a 2-in. pump run on ⅞-¾-in. sucker rods in 2⅞-in. o.d. tubing with an API 228 unit operating with a 74-in. stroke. If this were the case, the only item which could be reused would be some of the ¾-in. rods; therefore, this operator would be out the bulk of the $12,800/well cost of the larger equipment. For four wells this would be an expenditure of over $50,000 less salvage of used equipment.

Since it is possible to provide a displacement rate of 200 BPD as well as 400 BPD in 2⅜-in. tubing with a 2-in. pump, hydraulics would not have required changing out any of the equipment. The only thing required would be the addition of triplex and power oil tank capacity. A 60 HP triplex and an additional 750 bbl power oil tank would be more than adequate for the additional displacement required and could be provided for a total cost of about $11,500.

Many operators in the older producing areas obtain a significant part of their daily production from waterflood properties. Hydraulics have a real place in such operations because of unpredictable flood performance. For example, suppose an operator equipped eight producing wells in a waterflood with rod pumping equipment capable of providing a maximum displacement rate of 400 BPD/well. If the flood pattern developed such that four of the wells needed to be produced at a rate of 600 BPD and four of the wells had a producing ability of only 200 BPD, it would necessitate the expense of going to larger rod pumping equipment on four of the wells.

Such is not the case with hydraulics. A central battery installation has the combined ability to produce a group of wells at an anticipated maximum rate. If some wells will produce more than others, a greater amount of available horsepower in the form of a high pressure power oil is used by these wells. By the same token, if a well requires a lesser displacement rate to produce available well fluids, then a reduced amount of power oil is directed to this well.

No doubt one can think of other examples of flexibility that the hydraulic method of artificial lift can provide but this will give some understanding of the point discussed.

CENTRALIZATION AND SATELLITE STATIONS

The practice of centralizing producing facilities has dictated the need to centralize power fluid equipment like triplex pumps and power oil tankage but not necessarily power control manifolds. For example one operator had five wells being produced hydraulically—each with its own individual triplex and power oil tank. When the decision was made to drill additional development wells increasing the number of producing wells to 18, the decision was made to centralize all battery equipment. A single large 5000 bbl tank served as a single power oil tank. The five triplex pumps were located at the central power oil tank and discharged into a common header. High pressuer power oil lines went from this header to satellite power control manifold stations each of which served four or five wells. By centralizing the triplexes, it was possible to produce all 18 wells with the five triplexes which originally pumped only five wells. Such an installation permits the ultimate use of triplex horsepower. This installation is schematically shown on Fig. 2.

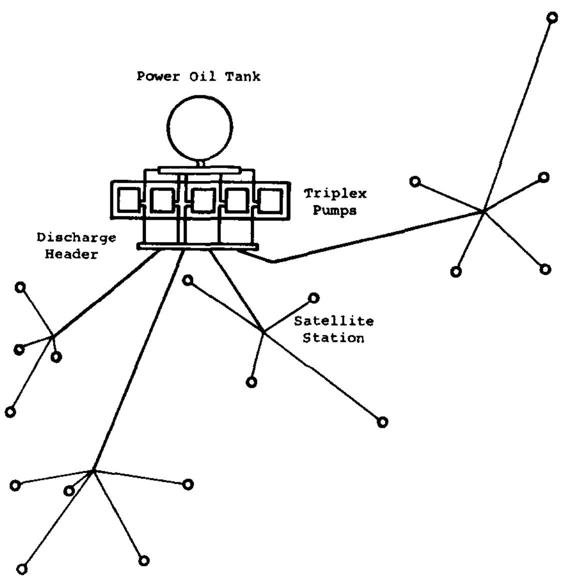

FIG. 2

CLOSED POWER OIL SYSTEM

There are several trends in artificial lift requirements which are generating new thinking in hydraulic pumping. These trends are:

(1) Increased producing rates from high water cut wells.
(2) Spacing of wells so far apart that each well can be more economically equipped with a one-well installation.
(3) Wells which produce a crude oil unsuitable for power oil.
(4) Well locations which have insufficient space for extensive treating facilities.

The answer to these problems is the use of a closed power oil system.

Closed power oil systems are gaining wider acceptance. For some one-well installations it is a must. However, this concept can also be advantageously used in multiple well installations. In this system, exhausted power oil is not commingled with production after actuating the bottomhole pump; it is returned to the surface through a separate flow passage. Consequently, the need for treating sizable quantities of power oil is eliminated. Power oil quality can be maintained at a higher level which can be quite important if the lease crude contains difficult to remove abrasive particles. If power oil containing only 1/10 of 1 per cent of such abrasives is used to operate a pump requiring only 100 BPD over a period of only 10 days there would have been a total of one bbl of abrasives pass through the engine end of the pump. This can cause severe pump wear even when the finest pump materials are used. There are other advantages associated with the closed power oil system. Paraffin problems are reduced since after a period of operation only the produced well fluid contains possible paraffin deposits. Improved accuracy in testing is another advantage of the closed power oil system since measured production is fluid actually produced from the well plus the small amount of slippage which may have occurred.

The amount of power oil lost due to slippage would depend largely on the fit of the pump and length of seal surfaces. In one field installation there was a loss of only ½ of 1 per cent.

The quality of the power oil can be maintained by filtering and/or properly treating the make-up oil. Make-up oil can be added automatically by float switches in the reservoir tank, can be added manually using available lease equipment or could be added from a tank truck.

The size of the reservoir tank is largely dependent on the type of refilling procedure used and the type of installation being operated. Refilling should be done at convenient times and sufficient power oil should be available to adequately supply all operations of the system. For free pump operation, the reservoir tank should have a capacity of two or three times the volume of the subsurface system to permit removing and reinstalling the subsurface pump.

A closed oil system is capable of providing lower treating costs, lower triplex operating costs, longer pump runs and lower pump repair costs—all of which should more than pay out the cost of the additional flow passage in a very short time.

SUMMARY

It is hoped that this discussion has shown you the "new look" in hydraulics and has created renewed interest in this artificial lift system with the many new developments. In complete fairness, however, there are a few basic considerations regarding hydraulics which have not changed. It is still important to have clean power oil. It is still important to educate personnel unfamiliar with hydraulics in proper operating procedures. It is still important to have a good working arrangement between field operation and equipment service operation. A recognition and application of these important considerations, however, need not be disadvantageous but rather should be considered as a positive approach to achieve peak performance.