IMPROVED PERFORMANCE OF HYDRAULIC PUMPING SYSTEMS THROUGH PROPER APPLICATION PRACTICES

Jack J. King
NATIONAL-OILWELL Production Systems

ABSTRACT

This presentation is directed toward providing application guidelines for hydraulic pumping systems, in an effort to improve the performance of the system which in turn should make the system more acceptable to the operator. In the last 20 years the manufactures of down well hydraulic pumps have invested a great deal of time and money in research and development programs to improve both reciprocating and jet type products that they offer to the industry. However, the success or failure of the system depends largely on the equipment being properly applied as is the case with the application of any method of artificial lift.

The presentation will deal with (1) When hydraulic systems can or should be considered. (2) What types of production units and surface equipment are available. (3) Where can the different production units be best applied. (4) How can the system be installed to maximize its performance.

A summary of the information provided puts forth the contention that given equal consideration with other systems and being properly applied, hydraulic pumping systems is a viable selection for artificial lift equipment.

INTRODUCTION

Hydraulic pumping systems have been used as a means of artificial lift since 1932. During its 56 year history this lift system has received mixed reviews. In many instances the system has performed very well and has proven profitable to the operator. On the other side of the ledger, there are many instances where the performance of the system was un-acceptable and the expense to the operator was prohibitive. For whatever reason, when hydraulic lift is discussed, you hear more of the bad experiences such as short pump runs and high repair cost and seldom do you hear of the units that run for long periods of time and have minimal cost involved.

There are many possible explanations for the different performance experiences with this lift system and this presentation is to emphasize one of the possible solutions to some of the problems, this being guidelines for the application of the equipment.

DISCUSSION

WHEN HYDRAULIC SYSTEMS CAN OR SHOULD BE CONSIDERED

Artificial lift of one form or another is found in over 90% of the producing wells in the U.S. Beam pumping systems are used in approximately 85% of these applications and is considered the industry standard. There are however, some combinations of well depths and/or fluid volumes that make consideration of alternate lift types practical. One of these alternates is the hydraulic pumping system. In generalized terms, the following is considered the common application range for these systems.

	Lift Depth	BPD-Total Fluid
Reciprocating Pumps	1,500' to 15,000'	50 to 1,200
Jet Pumps	1,500' to 12,000'	100 to 12,000
Surface HP range	30 to 275	

As with any generalized figures there are exceptions. Different manufactures may have units with greater displacement rates or differing depth limitations, but the number of installations using this equipment are few and would not be classified as common applications.

The above application considerations of depth and volumes are the ones generally associated with hydraulic systems. Other applications where this system can or should be applicable are:

Directional drilled wells or crooked holes
Wells just coming off flowing status
High GOR wells
Low profile requirements
"Town site" locations
Remote locations (can be powered with gas engine)
Wells with widely variable producing rates
Wells that need continous treatment for corrosion or paraffin
Casing size restrictions
Multiple zone completions
Limited space on offshore platforms
Highly corrosive wells (Jet Pumps)

This list of possible applications runs the risk of labeling the hydraulic system for use only in problem wells or in troubled situations and this is not the case at all. The facts are that in comparison with a beam pumping system, the hydraulic system can be price competitive and performance compatible in any application requiring a 228 pumping unit or larger.

WHAT TYPES OF PRODUCTION UNITS AND SURFACE EQUIPMENT ARE AVAILABLE

The surface equipment required by the hydraulic system has not changed greatly since its inception. There has however been changes in the way the system is configured. The system still requires a means to pressure up on the downhole production unit and a multiplex pump is still the primary equipment to perform this task. The method of handling the power fluid has changed somewhat. Up until 1970 the surface system used the power fluid tank and surface hookup shown in figure #1. Since that time the trend has been to the well site type of unit, shown in Figure #2. This trend was brought about for several reasons. One was the prohibitive cost of installing a treating system to handle not only the produced fluid from the well or wells, but also the large volumes of power fluid that was being used to operate the downwell production unit or units. Secondly, the increased use of water as a power fluid allowed the operator to sell any oil that the wells produced and not carry an excess in stock to be used as power fluid. Probably the most attractive aspect of the well site unit is the flexibility that it offers the operator. The unit can be moved from well to well and lease to lease without having to make any changes in the existing tank battery arrangement.

The subsurface production units that are available for use in the hydraulic system continue to have the basic objective of the application of hydraulic pressure to activate the downhole pump. The design of the units differ somewhat due to the various manufactures approach to their unit design. An example of these differences are shown in Figure #3. All have essentially the same elements with the main difference being in the fluid flow pattern through the unit. The jet type units that are available are even more similar as far as design features are concerned. Again the major difference in the units is the flow pattern and fluid passages provided by the individual suppliers.

The units are available for two types of common applications. One is the "conventional type" and the other is for "free type" installations. The following figures are considered to be the maximum fluid displacement totals using the two most common tubing sizes.

Unit Type	2 3/8" Tubing	2 7/8" Tubing
Conventional Insert	380 BPD	700 BPD
Conventional Casing Pump	2500 BPD	2500 BPD
Free Type Units		
Reciprocating Pumps	1000 BPD	2000 BPD
Jet Type Pumps	3000 BPD	6000 BPD

The conventional type unit is one that is ran in the well attached to the bottom of the tubing string and requires pulling the tubing string to retrieve the unit. The free type is a complete unit that can be circulated in and out of the well inside the tubing string.

WHERE CAN THE DIFFERENT PRODUCTION UNITS BE BEST APPLIED

When we come to the area of what particular type of production unit is best suited for a given application, we reach an extremely gray area. This area contains so many variables that it would be difficult to put forth a positive set of guidelines for the application of the different type units. In reality, the conditions that exist in the individual well will dictate the type production unit best suited for the producing requirements. In general terms, the following could be used to provide some guidance in the selection process.

Reciprocating type pumps can be considered for applications requiring 50 BPD up to 1000 BPD from wells 5000' deep or deeper and that have low to medium producing bottom hole pressures. Also the well should have a GLR that would allow a pump end displacement efficiency of 40% or higher. The higher the pump end efficiency of the unit, the lower the maintenance cost.

Jet type pumps can be considered for applications requiring 100 BPD up to 6000 BPD from wells 5000' deep and deeper, that have a medium to high producing bottom hole pressure, or that have GLRs above 100. A produced fluid with the GLR as high as 500, is an excellent jet application and wells may be produced with a GLR as high as 1000.

The reciprocating pump has the capability of producing more fluid at a lower pump intake pressure (producing bottom hole pressure) and require less horsepower than the jet. However, if the pump intake pressure remains fairly high the jet can move the greater volumes. It can be added that it has been shown that the jet can produce wells with low PIPs, as long as the volumes are fairly low.

An example of the flexibility of the hydraulic system would be on a well coming off of flowing status. The system can be installed and using the jet pump, the well can be produced while the BHP remains high. As the BHP declines, the jet can be circulated out and a reciprocating pump circulated in and continue to produce the well to its depletion. Should the well be involved in a second or third stage recovery program, as the volume requirements increased the jet could be reinstalled to produce the well at the higher rate.

With the increased number of CO_2 projects, the jet unit is a good application. The system can not only produce the variable production rates but the unit and the accessory items can be furnished in corrosive resistant materials that are giving and will give excellent per-

formance in that environment where other systems have failed.

HOW CAN THE SYSTEM BE INSTALLED TO MAXIMIZE ITS PERFORMANCE

The one most limiting factor on various production unit configurations is the casing size in the well to be produced. Almost any conceivable downhole arrangement is possible if the tubing strings needed will fit inside the casing. The hydraulic pump is powered by fluid and you must return the power fluid plus the production consisting of oil, water, and gas, back to the surface in the tubulars that are used. These factors will usually dictate the type of downwell installation that you can use to produce the well.

Figure #4 provides schematics of typical downhole arrangements that are used for hydraulic pumping installations. A brief description of these arrangements and their application is as follows.

Conventional Insert: The production unit is run on the bottom of a power string of tubing and inside of the production tubing. The unit is landed on a seating shoe and the exhaust power fluid and production is returned up the annulus between the power string and production string. The casing is left open for gas venting or treating purposes. This type unit can be installed in the same manner as the rod drawn pump. The production capabilities would be limited due to the tubulars used.

Conventional Casing Pump: The production unit is also run on the bottom of a tubing string but it is set on a packer above the producing zone. Exhaust power fluid and production are returned up the casing annulus. Everything coming from the well bore, oil, water, and gas, must come through the pump. This type unit is being phased out, due to the increased displacement of the free type units. Both of the conventional units require a service unit to change out the pump.

Parallel Free: The pump cavity is run on the bottom of the tubing string and the power fluid is conducted down the power string and exhaust power fluid and production are returned inside a second tubing string installed parallel to the power string. The production unit is circulated in and out of the well inside the power string. This is accomplished by changing the flow of power fluid at the surface. The casing is left open for venting purposes. Again, the volumes that can be produced are limited by the tubulars that can be used.

Casing Free Gas Vent: This type installation uses two strings of tubing and also a packer. The power string is run in the well and set on a packer above the producing zone. The production unit is circulated in and out of the well inside the power string. The exhaust power fluid and production are returned up the annulus between the two tubing strings and the casing. The gas is vented from below

the packer through the second string of tubing. In this instance the limiting factor is the volume of gas to be vented and the size of the vent string in the well.

Casing Free: This type installation is the simplest and least expensive method of installing the production unit. A single string of tubing is run in the well and set on a packer above the producing zone. Power fluid is conducted down the tubing string to power the unit and exhaust power fluid and production are returned up the annulus between the tubing and casing. The production unit is circulated in and out of the well inside the tubing string. As with the fixed casing pump, everything coming from the well bore must come through the pump.

The casing free type of installation is by far the most widely used method of hydraulically producing a well. From 80% to 85% of the hydraulic installations operating are of this type, the reason being the use of the single tubing string and the free type pump is economically very attractive. However, realistically looking at the performance data, this type of installation is the worst conditions under which any artificial lift system can operate. Without a doubt this contributes to the higher downhole pump maintenance experienced in these types of hydraulic installations.

SUMMARY

As was stated at the beginning of the presentation, hydraulic systems have been used as a method of artificial lift for many years. There has been and continue to be improvements made in design and performance of both surface equipment and subsurface units. The manufactures of the systems should continue to provide what ever assistance that is required to improve the operators understanding of the system and how it operates. These things along with efforts to properly apply the equipment should enhance the use of hydraulic systems and improve their acceptability by the producing companys.

References:

1- W. B. Bleakley: "Design Consideration in Choosing a Hydraulic Pumping System" - Petroleum Engineer International, July 1978

2- Spencer E. Duke: "The Laid-back Adaptable Hydraulic Downhole Pump" - Drilling Magazine, January 1982

3- Kermit E. Brown: "Overview of Artificial Lift Systems" Journal of Petroleum Technology, October 1982

SURFACE FACILITIES OPF SYSTEM

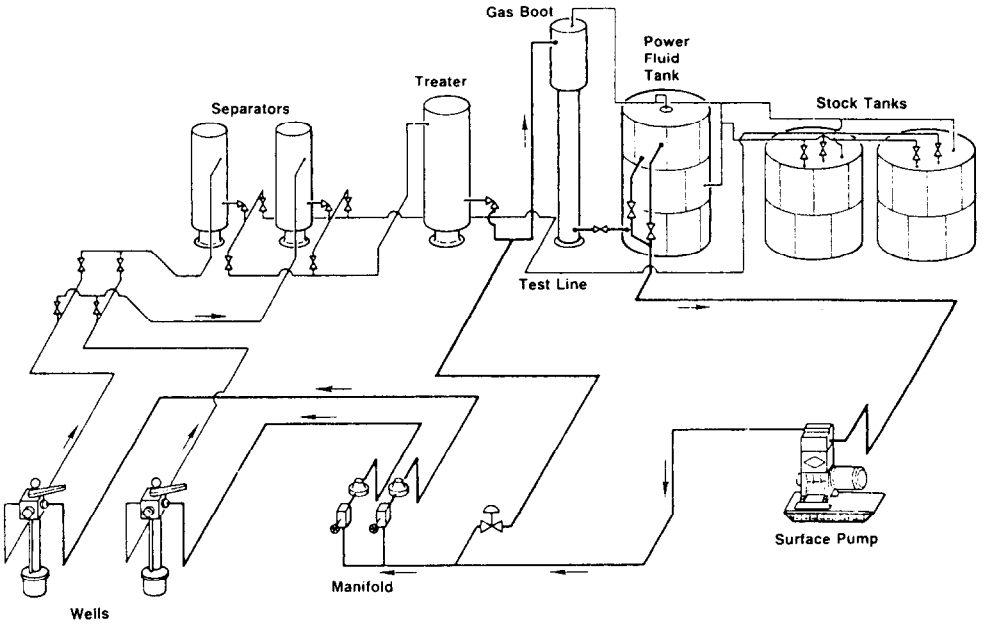


Figure 1 - Power fluid tank and surface hookup

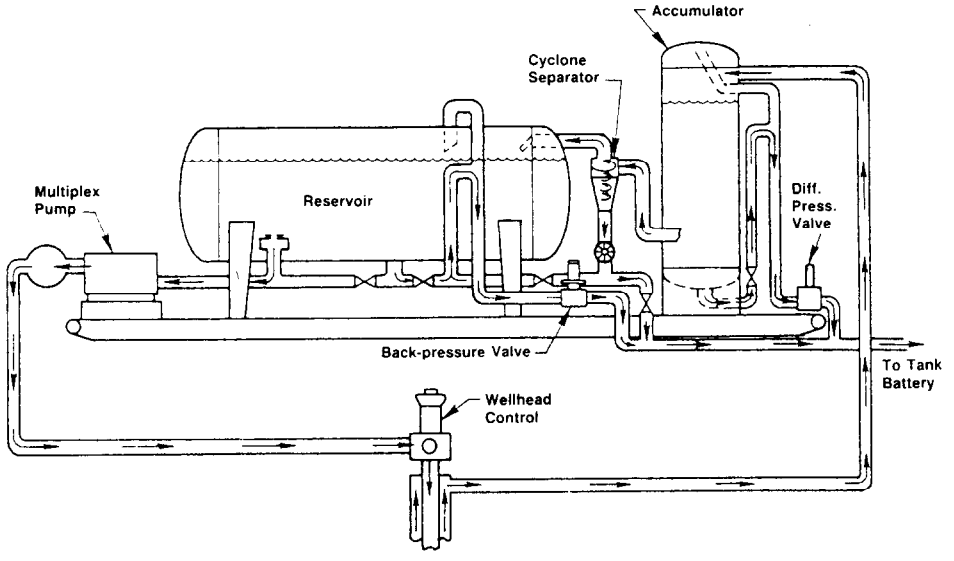
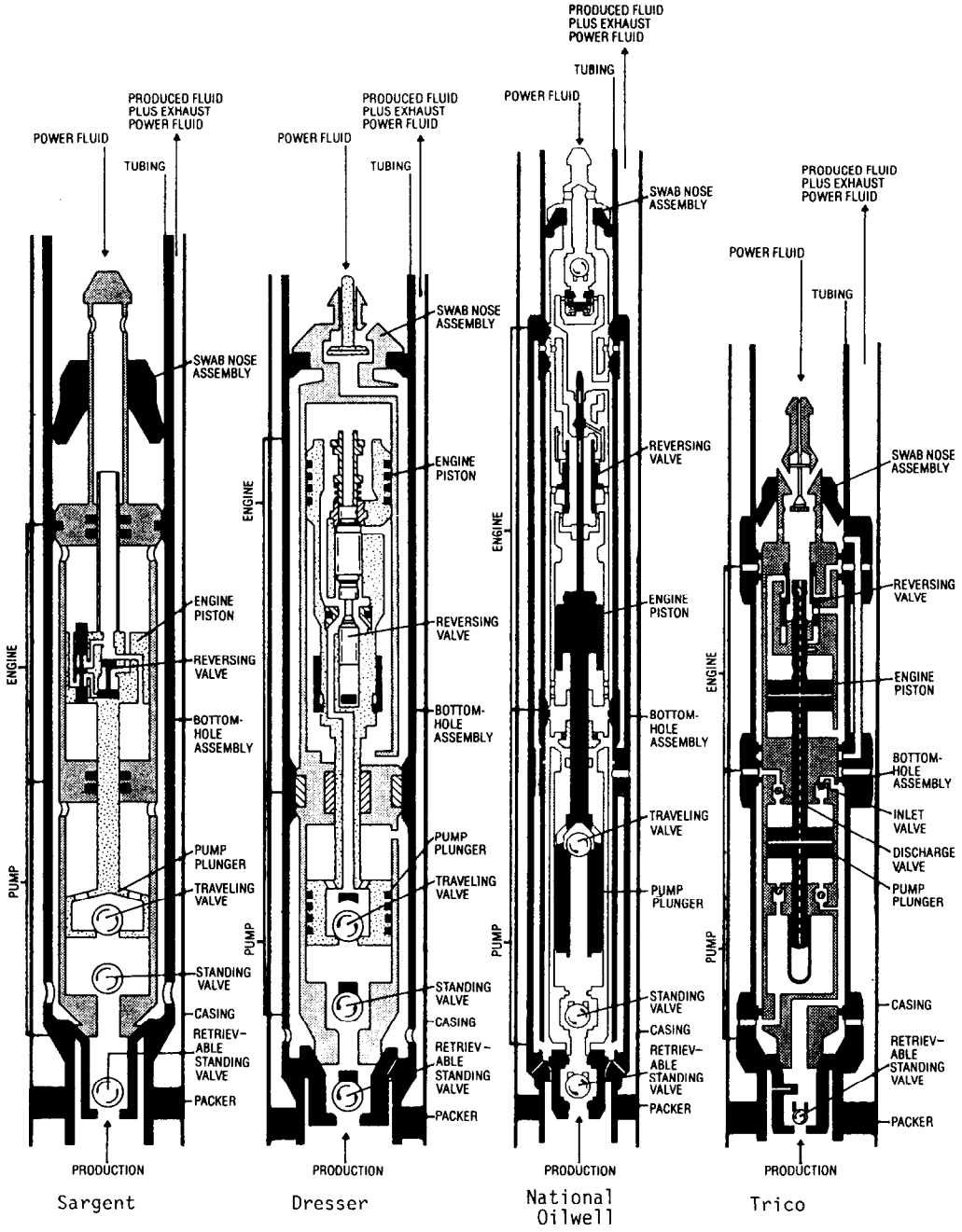
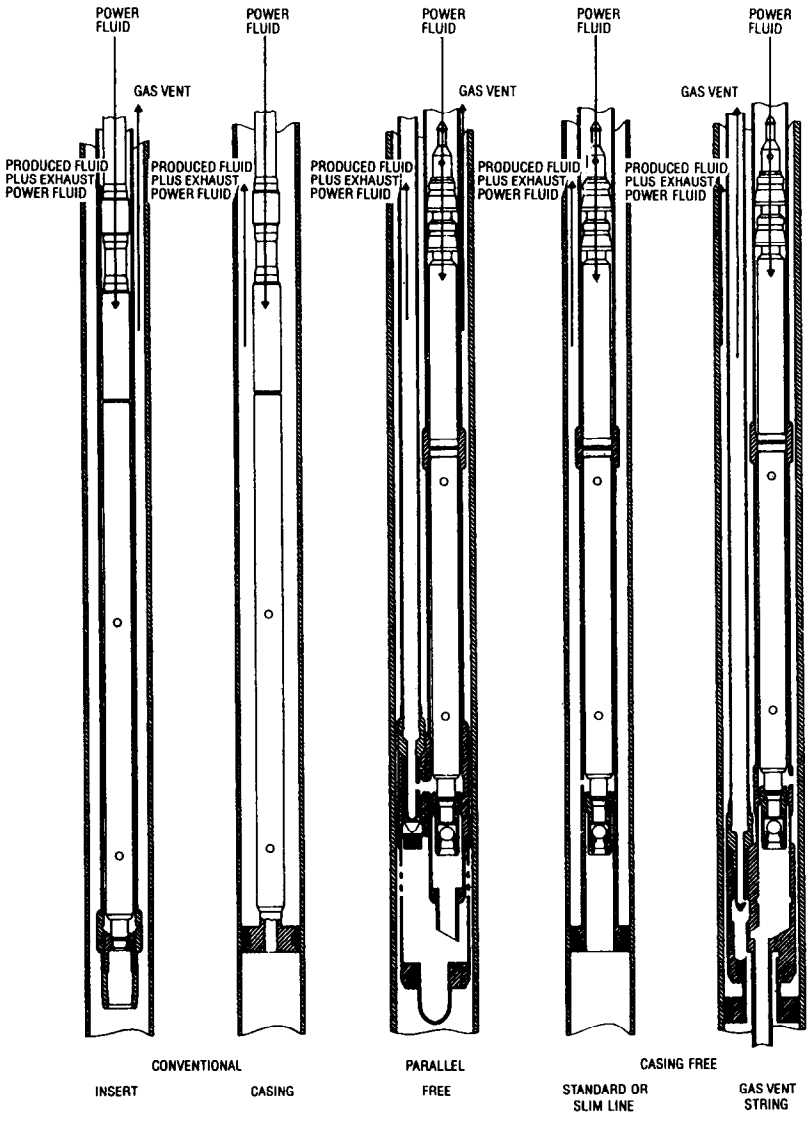


Figure 2 - Well site unit



These schematics represent products from the four current suppliers of downhole hydraulic pumps. All have essentially the same elements but incorporate design differences appealing to customer preferences. All shown here are single engine, single pump models. Other types are available from all suppliers. The Kobe pump shown has a double-acting pump, discharging fluid on both up and down strokes. All others have single-acting pumps.

Figure 3



Here are schematics of typical downhole arrangements for single zone hydraulic pumping installations. While these do not cover all possibilities, they are representative. The conventional insert and casing installations require tubing to be pulled for pump servicing. The parallel free and casing free installations all permit pump retrieval by reversing power fluid flow, eliminating the need for a pulling unit. Three of these configurations account for high GOR and provide a path for vented gas.

Figure 4