Closed Power Hydraulic Pumping Systems

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INTRODUCTION

Hydraulic pumping systems are typically operated using produced crude oil as power fluid. Since this power fluid is circulated by power pumps on the surface to the bottomhole unit, it is sufficient to say the fluid should be of good quality. Clean fluid with good lubricating characteristics coupled with low viscosity is ideal. Many crude oils exhibit these properties and normal production cleaning or treating facilities typically produce acceptable power fluid.

Quality of power fluid, while important to the hydraulic operation, is not the whole story. Quantity of power fluid used, or available, is a factor in many cases. Most of us are acquainted with the basic hydraulic system where the power fluid, under pressure, is directed to the bottomhole pump, exhausted into the production stream and returned to the surface mixed with the produced fluid. Most hydraulic systems are produced in this manner and are referred to as "open systems". The bottom-hole hydraulic pump, which is actually a reciprocating engine connected to a pump, requires power fluid circulation rates ranging from slightly less than the production rates to volumes in excess of the produced volume. We cannot significantly change this requirement but we can separate the power fluid returns from the produced fluid and provide systems that have certain advantages. This is the "closed power fluid system".

OPEN POWER FLUID SYSTEM — OPF

Figure 1 shows a typical surface layout for an open power fluid (OPF) system. Power fluid is supplied from a receiving tank which may be a bulk gravity separator, wash tank, heater-treater or other conventional production treating facility. The power fluid is pressured by the power unit, directed to a central control manifold and circulated down the well tubing to operate the bottomhole unit. Figure 2 shows a common OPF bottomhole arrangement. In this case, the well tubing and bottomhole assembly are landed on a packer and the pump is "free" in the tubing. Power fluid down the tubing operates the unit and is returned in the casing annulus with the produced fluid. The gross returns are circulated by the production line (see Fig. 1) to the receiving tank. Power fluid continues to be supplied to the power unit and the net production is taken off to a stock tank or pipe line. This bottomhole arrangement is referred to as a casing type free OPF system and provides for landing the pump by circulating down the tubing and retrieving the pump by circulating down the casing annulus.

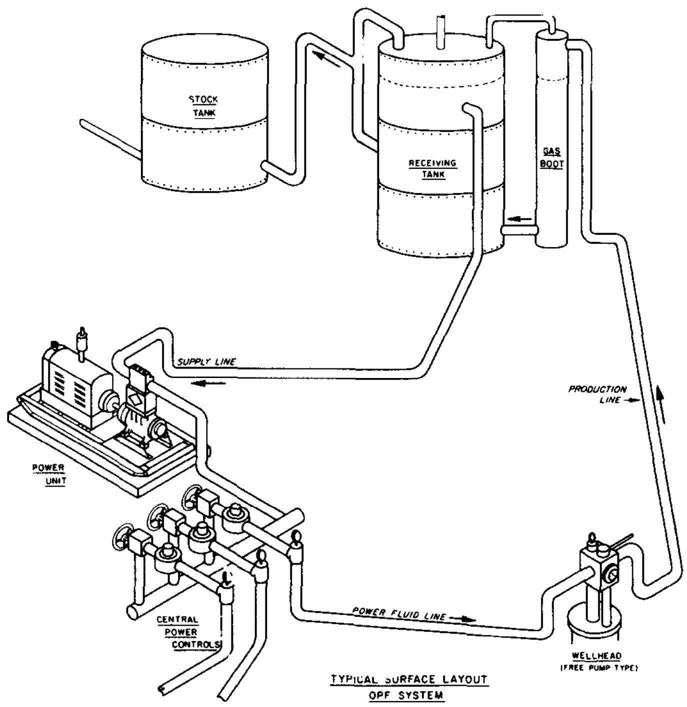
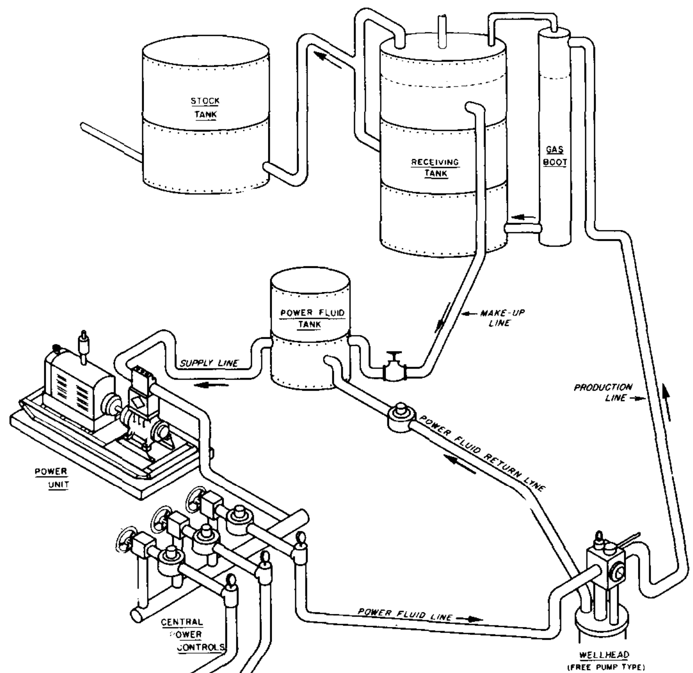


Fig. I

CLOSED POWER FLUID SYSTEM (CPF)

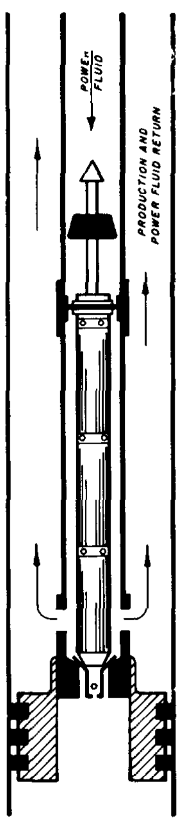
Figure 3 shows a typical surface layout for a CPF system. We see that the system is identical to the OPF layout except for the addition of a small tank which supplies the power unit. Figure 4 shows a casing type free CPF bottom-hole arrangement which is identical to the OPF system in Fig. 2 except for the parallel power fluid return string. We now see that the power fluid delivered down the well tubing from the control manifold is exhausted into the parallel string and returned to the small power fluid tank in Fig. 3 and recirculated. Produced fluid from the casing annulus goes to the receiving tank and then to stock.

Since the power fluid has been returned to the power fluid tank, requirements from the re-



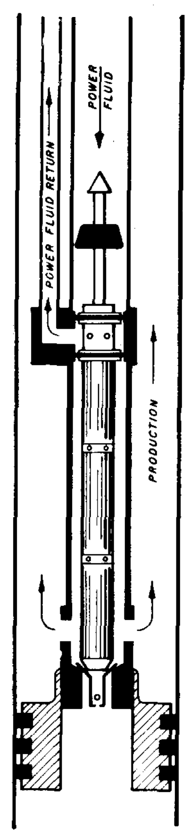
TYPICAL SURFACE LAYOUT CPF SYSTEM

Fig.3



CASING TYPE
OPF FREE PUMP

Fig. 2



CASING TYPE
CPF FREE PUMP

Fig.4

ceiving tank are now limited to the initial filling of the power fluid reservoir; intermittent requirements for landing and retrieving free pumps and; small make up volumes to replace losses in the system. The size of the power fluid tank will vary with the number of wells operating on the system. However, even larger batteries can be serviced from small tanks. The system should be designed to permit the infrequent landing and surfacing of free pumps without interfering with the operation of the other installations on the system.

APPLICATION AND ADVANTAGES OF CPF SYSTEMS

Since introduction in 1950, the CPF system has been almost exclusively applied to town-lot and offshore island-platform operations. Hydraulic pumping is particularly adapted to these applications and the ability of the "closed system" to minimize the size of power fluid treating facilities is advantageous where space limitations exist.

Normally, space limitations have little to do with the problems involved in producing most wells. When considering the use of CPF systems, we should be concerned with problems that can be answered or minimized by the separation of power fluid and produced fluid. With this facility at our disposal, let us look at the CPF system as applied to hydraulically pumping wells involving:

(1) High water cuts
(2) Produced fluid treating or cleaning problems
(3) Dual or multiple zones
(4) The use of fluids other than produced crude as power fluid

HIGH WATER CUT WELLS

In recent years, we have seen an increase in the water volumes produced, primarily due to the widespread use of water injection. To meet the need for pumping greater volumes, hydraulic equipment capable of large displacement has been made available. We have stated previously that the power fluid volume requirements in most cases are equal to or greater than the volume of fluid produced. We can see then that, regardless of the production rate, when the water cuts are high, the crude available for power fluid is limited. In many cases, separation of the water and oil is difficult. Through the use of CPF systems, we can limit the power fluid supply needs to the small make-up requirements of the operation. In fact, some installations have been economically provided with power fluid brought from nearby oil supplies by pipe line or truck.

High water cuts in marginal producers can create production measuring problems in the "open" hydraulic system. The need for determining small net production rates from the relatively large gross returns puts a premium on metering accuracy. The use of CPF reduces the meter accuracy requirement to a minimum and demands that we only account for the small system loss.

PRODUCED FLUID TREATING OR CLEANING PROBLEMS

The hydraulic pump is recognized as particularly capable of producing wells that make large amounts of sand or other foreign materials. This is especially true with pump designs that use small amounts of clean power fluid to lubricate and scavenge the pump. The problem here is providing the clean power fluid. Simple gravity separation does the job in many cases. However, production involving fine sand, heavy crudes, emulsions and corrosion do present treating problems that can be expensive. While these problems will exist regardless of the pumping system, the need for providing only small quantities of clean power fluid in the CPF system keeps expense at a minimum. As brought out in the comments on high water cut productions, we may find that supplying power fluid from some other source may be preferred here also.

DUAL OR MULTIPLE ZONE PUMPING

We have discussed the CPF system in general and have shown a basic tubing arrangement in Fig. 4. Of course, this is only one type of system and many tubing arrangements can and have been employed. We have been concerned to this point with the ability of the CPF system to provide for and maintain an acceptable power fluid system for hydraulic pumping applications faced with certain problems. Multiple zone pumping presents some new problems.

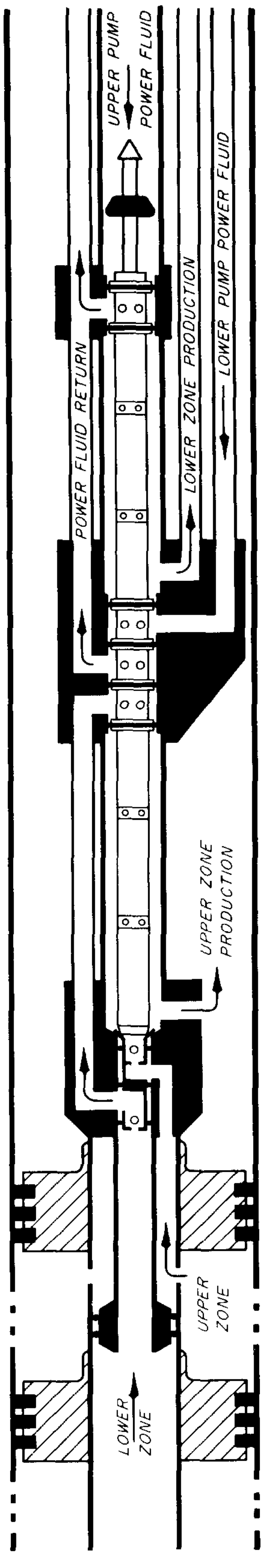
Hydraulic pumping systems are particularly adapted to two-zone (or more) production due to the fact that two or more pumps can be run in the same tubing system. With proper bottomhole design, multiple zones can be produced separately or together. Figure 5 shows a two-zone system that produces the zones separately. Power fluid, from a common source on the surface, is directed to each pump which exhausts into a common power return line. The produced fluid from each pump is returned separately. In this case, one zone is produced in the casing and one zone is produced in a parallel tubing string. The system is completely closed.

In many areas, state, local or unit legal requirements demand that complete zone separation be maintained. This applies to power fluid as well as produced fluid. The CPF two-zone system shown meets these requirements while allowing the choice of using fluid produced from either zone as power fluid.

OTHER FLUIDS

When CPF systems were made available, it became immediately apparent that fluids other than produced crude should be considered for use as power fluid. While many fluids may have been considered, water seemed to be the most logical choice. Water is available in most areas, inexpensive, clean or easily cleaned, and safe to handle. Offsetting these features, water exhibits poor lubricating properties, can be corrosive and is a very low viscosity fluid. The latter may be a circulating advantage but leakage at elevated pressures and temperatures may be a problem. Examination of the problem showed that to make water an acceptable power fluid for the hydraulic pumping system, chemical additives were needed to provide for the necessary lubricity and corrosion protection required by the equipment. The problems involving the low viscosity of water could be answered mechanically by relatively minor modifications to the equipment.

At present there are approximately 75 hydraulic systems operating using water for power fluid. The chemical additives employed are relatively expensive but used in such small quantities that the cost of treating is nominal. With the exception of experimental opertaions, these water power fluid installations are operated using fresh water. Experiments using produced brines and sea water have shown that the available additives are not compatible with salt water, requiring excessive and, for the present, uneconomical amounts of chemical. The problems of salt water compatibility are being studied and



CASING TYPE
FREE PUMP
CPF TWO ZONE

Fig.5

we believe the problem will be answered in the near future.

For obvious reasons, all of the water power operated systems are CPF. Experience to date has shown that the surface and bottomhole equipment operates quite satisfactorily on water. Operations have shown that make-up requirements to the CPF system are greater than for oil primarily due to losses in downhole tubing systems and in surface valving and plumbing. As in the case of the equipment, these problems are mechanical and can be answered by the proper use of positive sealing tubing joints and valving designs.