Closed Power Water/Oil Hydraulic Pumping

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INTRODUCTION

A study of Denver Unit, Wasson (San Andres) Field, waterflood lift requirements for both current and future lift requirements, was completed in December 1966. This study indicated that for lift capacities exceeding 400 BPD a capital cost saving of $1000 to $2000 per well over beam pumping could be realized by utilizing a closed hydraulic free-pump system. Available data also indicated that $100 per month per well savings in operating costs could be expected with hydraulic pumping. A closed system is more economical due to the expense required to expand treating facilities to handle the power fluid in an open system. In view of the possible economic advantages of hydraulic pumping, a 2-well Closed Power Water (CPW) and a 4-well Closed Power Oil (CPO) pilot project were installed and put into operation in June 1967. The CPW system was justified from the fire safety standpoint since many unit wells are located in inhabited areas.

Major points covered in this paper are installation and operation of equipment, operating problems, and costs for both systems.

DOWN-HOLE INSTALLATION

All six installations are free parallel-type with a string of 2-3/8-in. "Seal-Lock" and two strings of 1-1/4-in. API "IJ" tubing inside 5-1/2-in. casing. Completions are approximately 300-400 ft of open hole to total depth of about 5200 ft. The bottom-hole assemblies were located just above the casing shoe with a 2-3/8-in. dip tube extending to the bottom of the open-hole section (Fig. 1). The power fluid "unseat" feature is employed in the BHA to preclude contamination of power fluid with "dirty" well fluids. Production return is not connected through the 4-way wellhead valve.

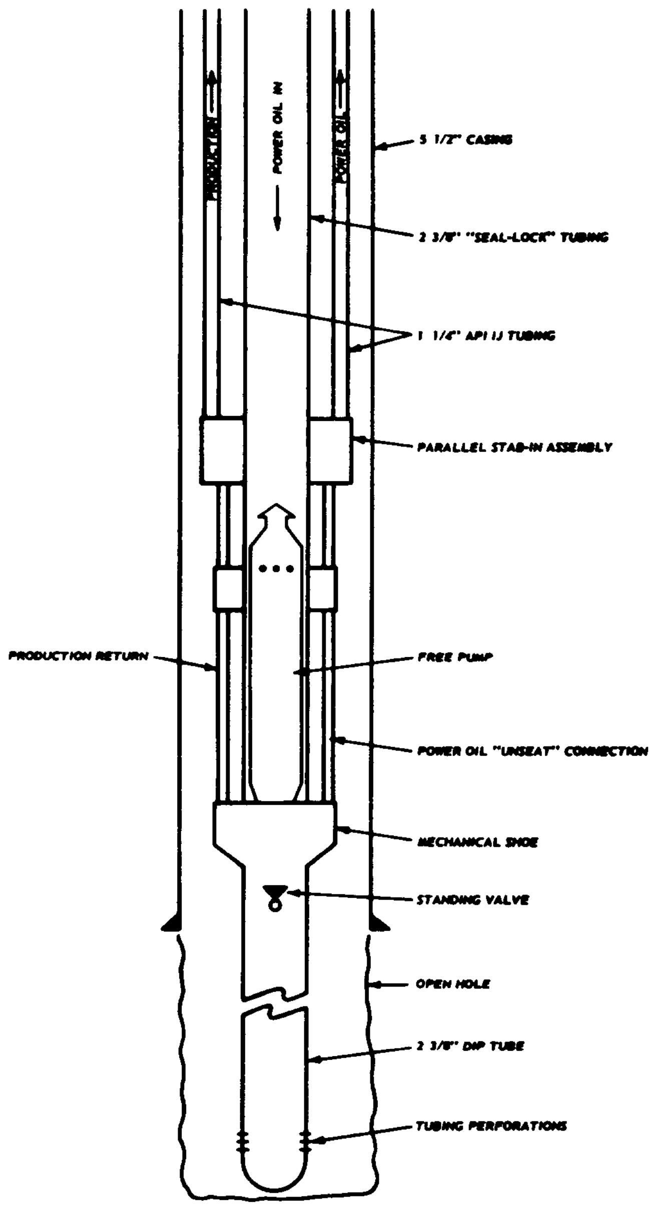

FIGURE 1

Schematic of Downhole Installation
Denver Unit Hydraulic

CLOSED POWER WATER SYSTEM

Installation

Kobe equipment is utilized throughout the 2-well CPW system. A skid-mounted size 3FA power water triplex package with a 75-Hp electric motor supplies the power water through a 5000 psi WP flanged manifold. A 90-barrel mixing tank is used, and 75-micron filters were initially installed in the power water return and makeup lines to remove solids (Fig. 2). No special metallurgy or coatings were used since additives to inhibit for corrosion and increase the lubricity of the power water were to be employed. The downhole pumps were 2 x 1-3/8 x 1-3/16 x 1-3/16 Type B power water trim pumps. These pumps are basically the same as power oil pumps except for having the lubrication port plugged, and a Teflon seal and smaller clearances around the middle rod.

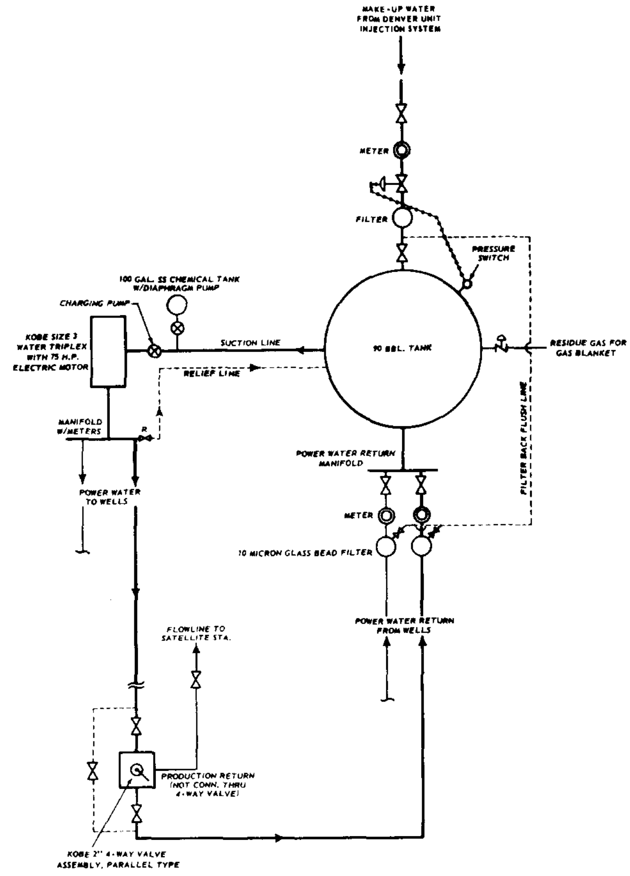

FIGURE 2

Denver Unit Power Water System

Power Water Quality

The source water used for the CPO system is an oxygen-saturated fresh water. High-pressure power water required from the triplex is about 800 BPD.

During the first three months of operation, rapid wear of the middle rod resulted in water losses as high as 20 per cent (160 BPD) in one to two weeks of pump operation and an average pump run of 21 days (Fig. 3). The pumps were operated at 80 to 100 spm at about 2000 psi. The power water additive was maintained at 600 to 800 ppm concentration. It was determined that much of the wear was caused by abrasives becoming imbedded in the Teflon seal, as well as those entrained in the power water slipping past the middle rod. To tolerate this condition, standard power oil pumps with the metal-to-metal seals and greater clearances but with the lubrication port plugged were run. Chemical analyses and corrosion rate tests showed that the abrasives were sand particles as large as 75 microns (filter size), either in the system from start-up or introduced into the system with makeup water, and solids from the corrosion of the bare steel system by the oxygen-saturated fresh power water and ineffective inhibition.

To improve the quality of the power water, the 75-micron filters were replaced with 10-micron, washable element glass bead filters, and an oxygen scavenger and inhibitor were added to combat corrosion. The power water additive was retained for its lubricating properties. These measures were successful in reducing the suspended solids from 97 to 19 ppm (3 to 10 microns) and Corrosometer corrosion rates from 11 to 2 mils per year. After repairing one oil trim pump shortly after cleaning up the power water, water losses stabilized at 5 per cent (40 BPD). Subsequent to oxygen scavenging, sulfate-reducing bacteria developed in the oxygen-free power water. These bacteria are being controlled with a quaternary amine biocide without any significant problems.

CLOSED POWER OIL SYSTEM

Installation

The CPO system has two Kobe Size 3E triplexes driven by 75-Hp electric motors supplying power oil through an Oilmaster 5000 psi WP flanged manifold. Oilmaster has modified its threaded connection on the inline Floco meters to a welded connection in order to supply a completely flanged and welded manifold. Two wells were equipped with 2 x 1-3/8 x 1-3/16 x 1-3/16 Kobe Type "B" and two with Oilmaster Type FR 201616 pumps. Wellhead equipment is of corresponding manufacture. Power oil lines, production and power oil return tubing is plastic-coated for paraffin control. The primary tubing is not plastic-coated to preclude the possibility of plugging pump engine valves with plastic. Pipeline quality San Andres crude for power oil is supplied to the 750-barrel power oil tank through an automated makeup system from the battery which is located about one mile from the installation (Fig. 4).

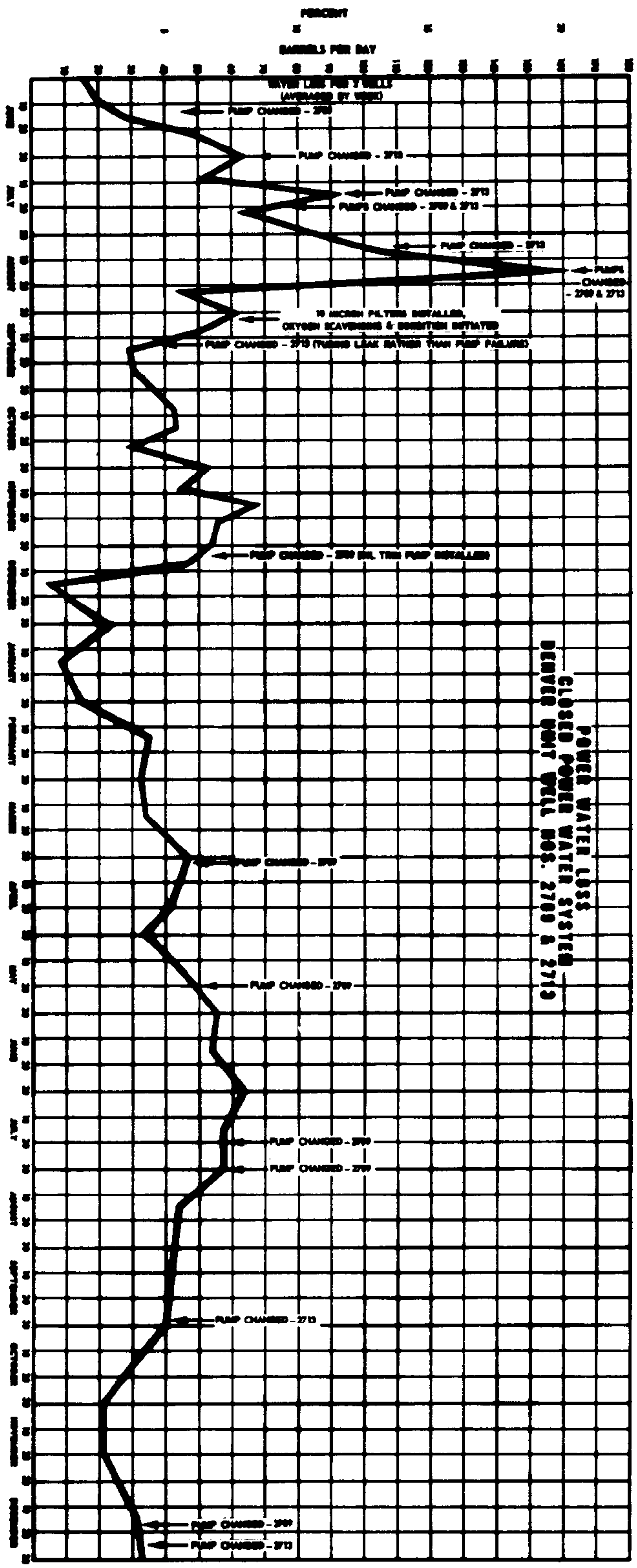

FIGURE 3

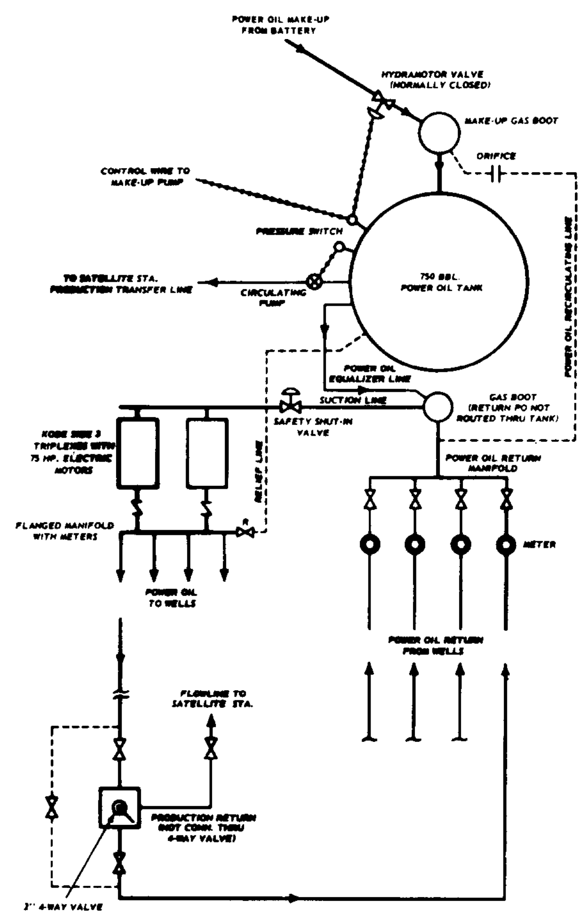

FIGURE 4

Denver Unit Power Oil System

Several features to minimize fire hazards have been incorporated in the system. The power oil tanks, triplexes, and manifold are each located 150 feet from fired vessels. Additionally, these components are spaced 150 feet apart, and 20-foot separation is provided between triplexes. All surface connections are flanged or welded, and check valves are installed in each triplex discharge line. Safety shutdown switches are used in the triplex discharge line and a safety shut-in valve, actuated by heat-sensitive elements at the triplexes, is employed in the suction line to shut off the source of power oil in case of fire at the triplexes.

Power Oil Quality

Current high pressure power oil requirement is 1600 BPD with loss through the down-hole pumps of one per cent (15 to 20 BPD).

Power oil quality in the CPO system has not been as good as desired. During the first few months of operation, solids content reached a concentration of 61 ppm and salt content of 15 lbs per 1000 BO. Revising the return lines to recirculate one-fourth of the power oil through the setting tank and maintaining a fresh water blanket in the bottom of the tank reduced solids to 23 ppm (3-20 microns) and salt content to 6.3 lbs per 1000 BO. These solids have contributed to both the stuck pump problem as mentioned elsewhere in this paper and to engine end wear of the down-hole pumps.

OPERATING PROBLEMS COMMON TO BOTH SYSTEMS

Low pump efficiency (20-50 per cent) due to gas interference from the high gas-liquid ratio (1000-2200 SCF/Bbl) of the produced fluid has been a significant problem in both systems. Production rates have been 100 to 250 STB per day with water-cut less than 10 per cent. The BHA was lowered into the open hole to provide a "natural" gas anchor on two wells but failed to improve pump efficiency. Apparently, the 5-1/2-in. casing annulus is sufficiently restricted by the BHA and three tubing strings such that gas cannot be separated effectively from this relatively high-ratio fluid.

Another problem encountered in both systems has been pumps sticking in the BHA. A small quantity of solids collecting around the seal between the power fluid discharge ports and the production end of the pump has caused some pumps to stick in the BHA. These pumps are generally retrievable with wireline fishing tools, but a round trip with the tubing was necessary on one occasion to recover a CPO pump. Both Kobe and Oilmaster are investigating modifications to alleviate this problem.

COSTS AND PUMP LIFE

Initial Cost

Cost per well, installed and operating, for the two systems was $39,500 for a lift capacity of 600 BPD per well, or $13,500 higher per well than estimated in the aforementioned study. Since this cost is for a pilot project, it is estimated that the per well cost would still approach $26,000 for a system of either type serving the more usual 10 to 15 wells per surface pumping installation.

CPW Operating Cost and Pump Life

Disregarding the short pump life and warranty repairs during the first three months of operation, CPW pump runs have averaged 4.0 months with operating (repair and maintenance) costs of $283 per month per well. These costs do not include power costs of about $90 per month per well, lease operator, and supervision costs. The longest pump run has been 13 months.

CPO Operating Cost and Pump Life

The average pump run in the CPO system has been 4.9 months with operating (repair and maintenance) costs of $378 per month per well. This figure reflects the same exclusions as noted above for the CPW system. The longest pump run has been ten months.

The discrepancy in longer pump runs but higher operating cost for the CPO system is due primarily to two pulling jobs to repair BHA's and one pulling job (as noted previously) to recover a stuck pump in the CPO system.

SUMMARY AND CONCLUSIONS

Conclusions that can be made from operation of the two Denver Unit Closed Power Fluid hydraulic systems to date are:

1. Hydraulic pumping with a Closed Power Water system utilizing fresh water will give performance comparable to that of a Closed Power Oil system operating under similar conditions.
2. The power water must be chemically treated to provide an inert, low-solids-content power fluid.
3. A means of re-treating circulating power fluid to remove solids, introduced into or generated in the system, must be provided in a closed system.

Due to slow waterflood response, low watercut and gas-oil ratio well above solution ratio, the high-volume lift capability of the hydraulic systems has not been utilized in this application. Since most Denver Unit wells have similar reservoir conditions on initial artificial lift installation, no expansion of the hydraulic systems is anticipated in the near future.