Operation Of Hydraulic Pumping Units

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Hydraulic pumping units are classified as surface or sub-surface. Our discussion refers only to surface units which reciprocate a sucker rod string connected to a sub-surface plunger pump. Hydraulic units may be classified as counterbalanced and non-counterbalanced. The counterbalance is provided by weights or compressed gas. Our discussion will be based on compressed gas — counterbalanced units and non-counterbalanced units.

Operation

A non-counterbalanced unit is considered to be a light duty pumper. Consequently, it is able to perform its required work with a minimum number of operating parts. A comparison may be drawn between hydraulic and beam unit components as follows: A working piston and cylinder assembly replaces the horse-head, bridle carrier bar and walking beam; the reversing mechanism replaces the crank; the power pump replaces the gear reducer and the piping replaces the pitman. Each of the aforementioned components and their relation to the unit must be clearly understood for proper maintenance and trouble shooting. The functional flow diagrams show four positions of the working piston through the cycle, two for the upstroke and two for the downstroke. From the diagrams it is apparent that during the upstroke a closed circuit is maintained from the power pump to the lower side of the working piston. During the downstroke an open circuit exists; that is, power fluid enters the cylinder at one port and exits from another. This type of circuit indicates that speed of the complete cycle is controlled by two methods. First, changing the speed of the power pump, which either reduces or increases the upward piston velocity. Second, changing the downstroke speed by manipulation of the cylinder discharge valve.

Control of the discharge valve is the governing factor in successfully operating a hydraulic pumping unit. It must remain closed during the upstroke and be open during the downstroke. This has been accomplished by use of a spool type valve which when closed will seal the discharge port. Operating pressure on the underside of the spool during the upstroke prevents the spool from opening the discharge port.

Prior to the piston reaching the maximum point on the upstroke a control port on the cylinder is pressurized by the passage of the piston. Pressure in the line shifts a differential area pilot valve such that the source of pressure holding the discharge valve closed is blocked and the fluid previously pressurized is vented to a gravity drain, back to the fluid reservoir. The discharge valve then opens and an open type circuit is created.

The piston will continue as fluid leaves the cylinder and only by shifting the pilot valve back to its previous position will the hydraulic circuit be once again closed as required for the upstroke. Analysis of the diagrams show that the pilot valve will be shifted when the lower cylinder control line is vented.

Operation of the compressed gas or air counterbalanced unit is in general similar to a non-counterbalanced unit. The unit differs in that the power pump utilizes pressurized fluid and merely boosts this pressure to provide power to the working piston during the upstroke; and to take the cylinder discharge fluid, on the downstroke, and return it to the pressurized oil receiver. Both portions of the cycle have been diagramed in Figure 2. It is seen that the pilot valve merely ports pressurized fluid to an auxiliary piston which operates a rotary type reverse valve. The pilot valve operation is essentially the same as previously explained. Control ports located on the cylinder actuate it as required.

Two types of power pumps have been successfully used on units of this type, the positive and the variable displacement. The variable displacement or centrifugal pump requires the least amount of attention once it has been properly applied. After the proper pump speed has been determined the correct counterbalance setting may be made. This setting will provide identical time for the up and down portion of the cycle. If sufficient air counterbalance is used, the upstroke will be slower than the downstroke. Excessive pressure will unbalance the unit oppositely.

Maintenance—Installation
Alignment

Maintenance and unit downtime may be reduced considerably if proper steps are taken prior to the installation of a hydraulic unit. It is imperative that the unit be properly aligned in order to reduce stuffing box packing wear, polished rod wear and hydraulic oil leakage.

A cement mat of proper dimensions and level with respect to the surrounding terrain does not alone insure proper alignment of the unit. It is important to surface the mat so that it is perpendicular to the well bore. If this perpendicularity cannot be achieved with the mat it is then advisable to shim the unit until properly aligned.

An alignment problem recently occurred wherein no leakage resulted, but extreme polished rod friction resulted, represented by an appreciable increase of load range on the unit. Analysis indicated shimming to be necessary. Shims were placed at various points underneath the unit base until operating pressure reading showed the unit load to be campatible to fluid and rod weight only. A 6 inch maximum differential height was measured at one point on the base as compared to the original mat.

Air Leakage

It is inconvenient for a manufacturer to transport a unit in a complete-leaks will reduce excessive operation of a compressor, this of course reduces unnecessary compressor wear as well as horsepower requirements.

Piping

It is inconvenient for a manufacturer to transport a unit in a completely assembled package. It is the general practice to ship the unit as several sub-assemblies requiring auxiliary piping and bolting at the well site.

It must be emphasized that whether the piping is supplied by the manufacturer or the operator, it must be kept clean. Should foreign matter become lodged within one of the valves a malfunctioning unit may result.

Maintenance—Operation

Filters

Most manufacturers provide filters installed and engineered to keep the hydraulic oil clean. A non-counterbalanced unit may be equipped with a suction strainer leading into the pump. An air breather on the fluid tank prevents sand and dirt from settling in the oil reservoir. These two filter types are considered to be reusable and only require periodic cleaning The intervals between cleaning depend on the ambient conditions. Until experience dictates a schedule, it would be advisable to clean every 30 days. The filters may be cleaned in a solvent and dried with an air blast.

The larger counterbalanced units are equipped with a by-pass type filter. They operate from the auxiliary scavenger pump, filtering 3 to 5 gallons per minute. These filters are of the replaceable pack type. Replacement of these packs may be determined by the pressure gauge, located on the filter unit. For example: at the time of initial unit operation the gauge may read 10 psi. As the filter performs its work, foreign matter will become incased within the pack, restricting fluid flow appreciably. This restricted flow will be indicated by a gradual increase of pressure gauge reading. The pressure will eventually increase sufficiently to operate a safety valve, thereby bypassing all filterable fluid. Filter pack replacement should be accomplished prior to this final high pressure reading.

Some installations warrant use of a secondary filter of the waste rag type. Here again, experience will dictate the cleaning schedule. The waste is merely replaced by a fresh rag.

Sutffing Box

A manually loaded, as well as a spring loaded stuffing box is successfully used on hydraulic units. Provisions have been made to use the maximum spring compression initially, as the packing wears the spring will continue to supply sufficient force to prevent fluid leakage. Of course, the packing eventually requires replacing at which time the spring is again fully compressed.

The manually operated stuffing box should be tightened until a full fluid seal exists, then, backing off slightly to allow lubrication of the polished rod. Continual packing adjustment and additional maintenance is required for this type stuffing box, however

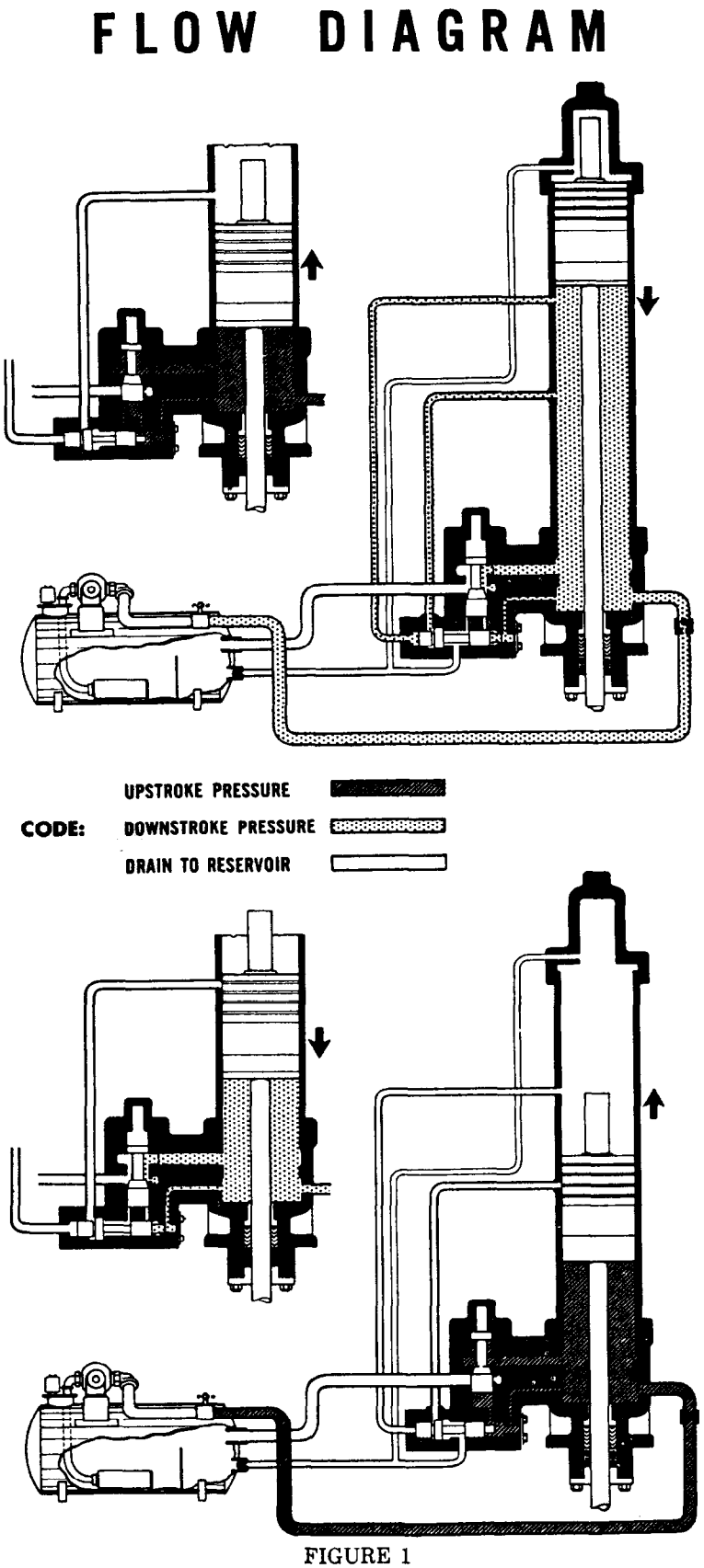

FIGURE 1

longer packing life is gained over the spring loaded type.

Oil Temperature

Operating oil temperatures are indicative of the power put into the unit. As the temperature mounts, so must the time schedule for maintenance. Filters clog more rapidly, due primarily, to an accumulation of sludge; stuffing box leakage increases due to the oil being less tenacious or of lower viscosity. If the operating temperature is 170 deg. or over one should expect considerable valve maintenance. Close tolerance valves are considered "hot spots" in hydraulic equipment and are likely locations for the formation of sludge.

Coolers are available to cool the oil and, hence, prolong oil life and reduce the rate of sludge formation.

Jackshaft

The majority of units are equipped with "V" belt drives for operating the power pump. This is economically feasible through the use of a jackshaft or auxiliary shaft, which is supported by radial load bearings and is connected to the pump by a coupling. The bearings and coupling, if flexible, should be lubricated periodically. The manufacturer can supply the proper lubricant specifications.

A high and low oil level check should be scheduled for units having the jackshaft completely enclosed. A premium type lubricating oil similar to that used in engines is recommended.

The open type jackshaft requires more frequent inspection and lubrication to avoid excessive heat and wear.

Vee Belts

A periodic check should be made on the main auxiliary belt drives. Proper tension will lengthen belt life appreciably. Loose belts slip and generate heat with resulting accelerated belt wear. In addition, slippage must be accounted for in an increase of applied horsepower.

Tension of belts depend upon the type used; standard duty, super duty or steel cable. Standard and super duty belts will stretch under use, but steel cable will not. Consequently, shortly after the former belts are in operation a secondary adjustment must be made. After the initial stretch has been accounted for, subsequent belt adjustment will be minor. The steel cable belt should never be required to operate with an initial tension as great as a standard or super belt. It is recommended that steel cable belts be used only when absolutely necessary.

Gages

Gages are provided for visual inspection of operating loads and/or pressures at various points on the unit. The service life and accuracy of these gages may be appreciably extended if valves leading to the gages are kept shut and opened only for a periodic reading. Disassembly of a pressure gage should be done by experienced personnel only.

Cleaning

Regardless of the care taken in maintaining clean hydraulic oil, eventually replacement will be required. A new charge of oil should never be put into the system without first purging the complete circuit with a fluid cleaning compound. Then, after completion of the flushing program all auxiliary tubing lines should be disconnected and steam cleaned. Although time consuming the procedure will prove advantageous by providing a maximum service life of the new oil. The cleaning program also should provide new filter elements.

Compressor Piping

Air, taken into the compressor at atmospheric pressure, is boosted to the counterbalance pressure. The ambient air contains moisture which breaks out from the compressed air in the form of droplets. This, has of course been anticipated by the manufacturer, consequently water traps are strategically located on the unit. These traps should be vented daily to reduce the possibility of water entrapment within the hydraulic circuit.

We have purposely omitted any discussion regarding features or advantages in utilizing hydraulic pumping equipment. Digressing on one point only mention is made of the personal safety feature of these units. There are no large masses in motion. Barriers need not be constructed to protect against counterbalance weights. This of course is of considerable importance in residential areas.

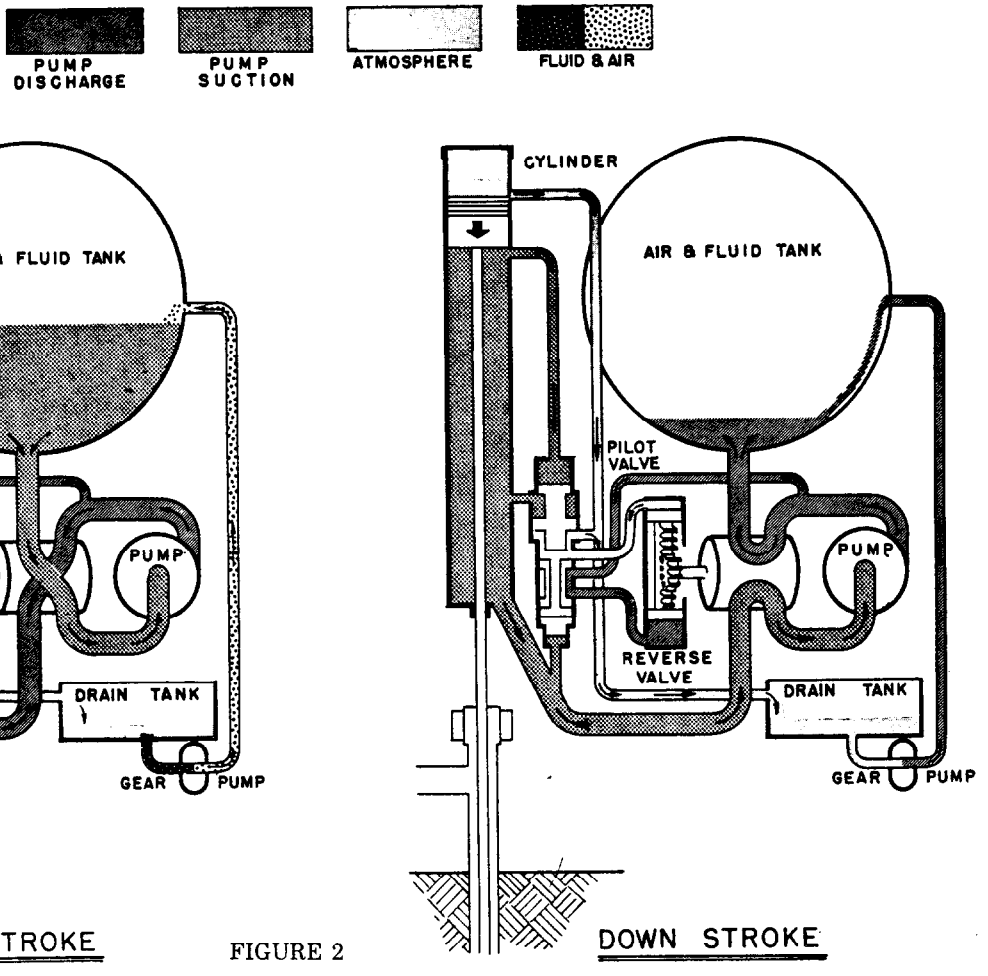

FIGURE 2