DEWATERING GAS WELLS WITH PNEUMATIC PUMPING EQUIPMENT

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INTRODUCTION

The removal of accumulated liquids from the wellbores of gas wells is a problem which has faced operators for as long as natural gas has been produced. The reduction of deliverability resulting from these liquid accumulations and the expenditure of cash and energy to remove the liquids are at best expensive nuisances, and at worst, economic catastrophes.

Many approaches have been taken toward the solution of this liquid removal problem with varying degrees of success. The type of approach taken depends upon a number of factors including the type of liquid to be removed, available reservoir energy, and economic considerations.

With adequate available reservoir energy and optimized production practices, expenditures for artificial lift aids may be minimized or eliminated. With slightly less energy to draw upon, these aids may take the form of gas lift or cycled pulsing or purging of the wellbore liquids.

The worst conditions, from an economic standpoint, involve those wells which due to pressure decline, excessive liquid influx, or low permeability, require mechanically lifting an unsalable product. This is recognizable as pumping water from gas wells, and is not a new idea to many operators including El Paso Natural Gas Co. which has been operating pumping units on gas wells since 1964.

One of the most recent entries in the field of pumping equipment is the pneumatic pumping unit. The units which El Paso now has in operation are proving to be a valuable addition in dewatering low-pressure gas wells.

At present El Paso operates some 69 pumping units in the East Panhandle Field in Texas and the South Erick Field in Oklahoma. Of these, six are pneumatic units and the remainder are conventional beam-type units powered by gas-fueled engines or electric motors.

DESCRIPTION

The pneumatic pumping unit used by El Paso Natural Gas Co. is the Klaeger pneumatic pumping unit manufactured by Bravo Manufacturing Corp. The unit is available in two cylinder diameters, 8 in. and 11½ in., and is stocked in 5, 10, and 15-ft lengths, with other lengths available on order.

Figure 1 illustrates the external appearance of the 8-in. diameter, 5-ft unit which is typical of the East Panhandle Field application. A typical well on which this unit is implemented has conditions and producing characteristics as follows:

Production casing: 5.500 in., 14.0 lb, J-55 set at 2003 ft
Tubing: 1.900 in., 2.90 lb, EUE continuous weld set at 1980 ft with a 15-ft, 2.375-in. perforated mud anchor on bottom
Casing perforations: from 1927 to 1963 ft
Wellhead shut-in pressure: 145 psig
Liquid production: 4 bbl brine per day
Liquid gradient: 0.463 psi/ft
Gas production prior to pumping: 33 MCFD
Gas production after pump installation: 255 MCFD

This well had been previously tested with a portable test pumping unit to determine the feasibility of installing a permanent unit. The installation illustrated in Fig. 1 is described below:

Pumping Unit: Klaeger 8-in. dia. x 5-ft length

Pump: 1½ in. x 1 in. x 10 ft RWB with 12-ft gas anchor
Sucker rod size: ½ in.
Stroke: 60 in.
Ballast pressure: 50 psig (41 psig calculated)
Depressant pressure: 20 psig (11 psig calculated)
Calculated pump displacement at 100% efficiency at 1 SPM: 7.02 BPD
Calculated gas volume vented at 20 psig depressant pressure: 7.3 MCFD
Ballast tank: 32 cu ft ASME-coded 200 psi working pressure

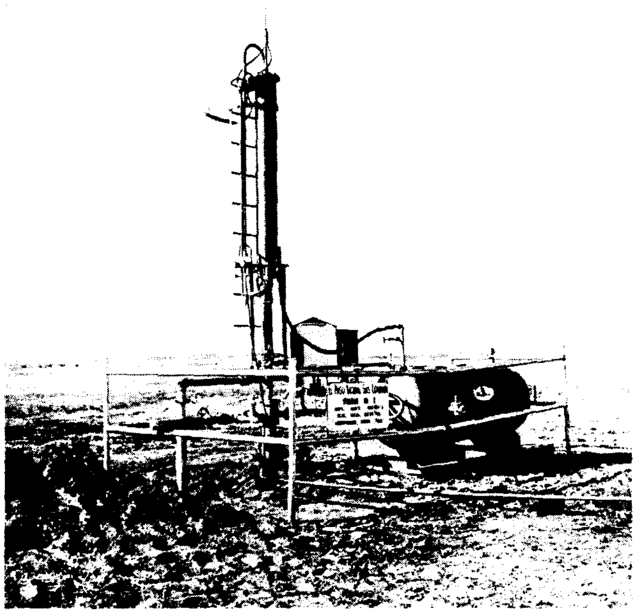
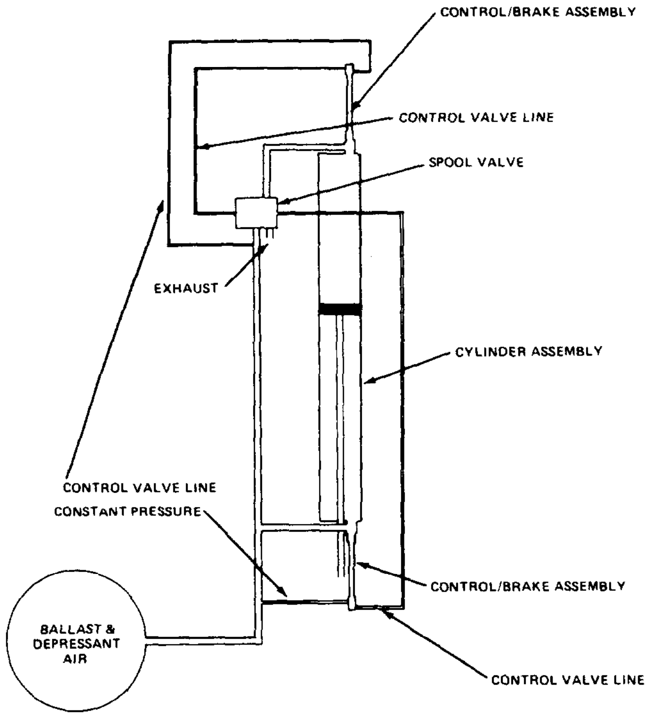


FIG. 1—KLAEGER PNEUMATIC PUMPING UNIT

OPERATION OF UNIT

Lift capability in the pneumatic pumping unit is achieved by applying gas pressure below the piston as shown in Fig. 2. When the applied ballast pressure exceeds the combined rod and fluid weight, the piston moves upward to the top of the stroke at which time it engages the upper control assembly. Moving the upper probe upward allows shifting of the spool valve permitting a portion of the ballast gas to enter the cylinder above the piston. This serves to compensate for the displaced fluid weight, equalizing the pressures across the piston, allowing the rod mass to pull the piston downward, initiating the downstroke.



CONTINUOUS BALLAST SYSTEM

A single pneumatic source with receiver is required. Counter balance is achieved when sufficient pressure is exerted against the bottom of the piston to lift both rod and fluid weights. This pressure is required to overcome the fluid weight loss which occurs on the down stroke allowing the rod string to fall.

The operating cycle begins when air from the receiver is admitted underneath the piston forcing the piston upward. When the piston reaches the top of the stroke, it activates the upper shifting control mechanism which shifts the spool valve, allowing depressant air to enter above the piston. During the down stroke, a portion of the air from beneath the piston shifts to the top of the piston serving as depressant pressure. The remainder of the ballast air is forced back into the ballast tank. When the piston reaches the bottom of the stroke, it activates the lower shifting control mechanism which returns the spool valve, closes off the air entering above the piston and exhausts this compressed air. With no pressure above the piston, ballast pressure forces the piston to the top of the stroke, beginning a new cycle.

Up and down stroke speeds may be regulated independently.

FIG. 2—CONTINUOUS BALLAST SYSTEM

On the downstroke the remaining gas below the piston is forced back into the ballast tank which should be fairly large in relation to the cylinder capacity in order to minimize energy requirements to overcome the pressure rise in the ballast tank.

At the bottom of the downstroke, the lower control assembly is activated which allows the spool valve to shift, shutting off the depressant gas and exhausting the cylinder above the piston to atmosphere. This allows the ballast gas to again force the piston upward, beginning a new cycle.

The piston has a replaceable neofab or urethane cup, a piston backing plate, and a wear ring. This construction prevents the piston from making contact and possibly scoring the piston in the event of cup failure.

A positive displacement lubrication system is employed which injects an antifreeze-type lubricant into the depressant gas entering the cylinder and at the polish rod packing box.

The 8-in. diameter gives a mechanical advantage of 50:1, while the 11½ in. diameter piston has an advantage of 102.6:1. Operating pressures are determined by rod and fluid loads and by piston diameter. Stroke length is governed by the length of the unit and by means of adjustable set collars on the control probes.

Should the upstroke cycle be stopped for any reason, or should it be desired to stop or shorten the upstroke cycle, a "bleeder button" on the unit may be depressed. This action permits the spool valve to shift, equalizing pressures across the piston, which allows the rods to drop from their own weight. "Short stroking" in this manner may aid in freeing a sticking bottomhole pump or in dislodging foreign materials from pump valves.

The speed of the upstroke or downstroke is regulated by separate control valves, and the ballast pressure is controlled by a pressure regulator.

At the slow stroke speeds at which the pneumatic unit may be operated in gas well dewatering, bottomhole pumps should have close plunger fit to prevent slippage. The close tolerances also serve to prolong pump life by prohibiting abrasive material from getting between the plunger and barrel.

BOOSTER SYSTEM

A more recent innovative application to the pneumatic unit is the booster system diagrammatically illustrated in Fig. 3. This system operates in a manner somewhat similar to refrigerated home air conditioning. It employs a small prime mover and an ammonia-type booster compressor in a closed system. Once pressurized, additional gas is required only to replace small amounts which may be lost due to leakage in fittings or around the polished rod, or to temperature contraction. This closed system has the additional advantage of being relatively moisture free which minimizes freezing and corrosion problems. The low compression ratios required reduce heat which also should aid in making for optimum operation.

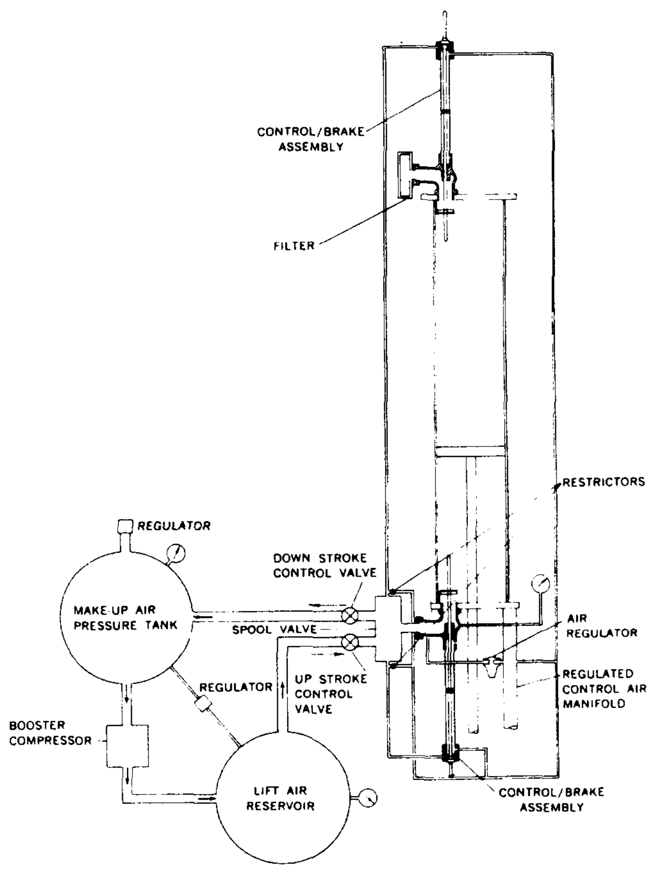


FIG. 3—KLAEGER PUMPING UNIT BOOSTER SYSTEM

APPLICATION

The pneumatic units employed by El Paso use wellhead gas both in the continuous ballast system and the booster system. Compressed air and an isolated ballast system may be used where sufficient gas volume and pressure are lacking to meet lift needs. This would necessarily entail additional outlay for compression equipment.

Of the 69 pumping unit installations previously mentioned, 6 are pneumatic, 10 are electrically driven beam units while the remainder are beam units powered by gas-fueled engines. The beam units are for the most part 16-D wide base, high sampson post units with small multicylinder internal combustion engines. In addition to the above installations, there are eight gas lift/bottomhole separator installations and over 100 intermitters. It is upon the data obtained from these facilities that the following comparisons are drawn.

COMPARISON WITH OTHER EQUIPMENT

In comparing the pneumatic unit to conventional beam units the major advantages realized are:

1. Lower initial cost of the continuous ballast unit (22-32%)
2. Greater adaptability to pumping small volumes, particularly where electricity is not available for intermittent pumping
3. Lower maintenance and repair costs
4. Easier installation (the 8-in. x 5-ft unit weighs only 450 lb)
5. Increased overall pump efficiency.

The main disadvantage of the pneumatic unit is the 10-12% higher lift cost per barrel experienced with the continuous system. The booster system has a lower lift cost, but is only some 10% lower in initial cost than the beam unit.

A comparison of pneumatic pumping to gas lift shows that although the pneumatic unit is some 5% higher in initial cost, the lift cost per barrel is 35% higher for gas lift. Maintenance and repair costs are almost identical. The major advantage of pneumatic pumping over gas lift is its adaptability to low pressure wells on which gas lift is not economically feasible.

Intermitter installations, including a gas/liquid separator which El Paso finds desirable for optimum operation, cost approximately half as much on the initial installation as the pneumatic unit. Field consumption tests indicate the intermitter lift costs per barrel average 80% more than the pneumatic unit.

Figure 4 graphically represents the data obtained from the El Paso wells on which the various lift facilities are installed.

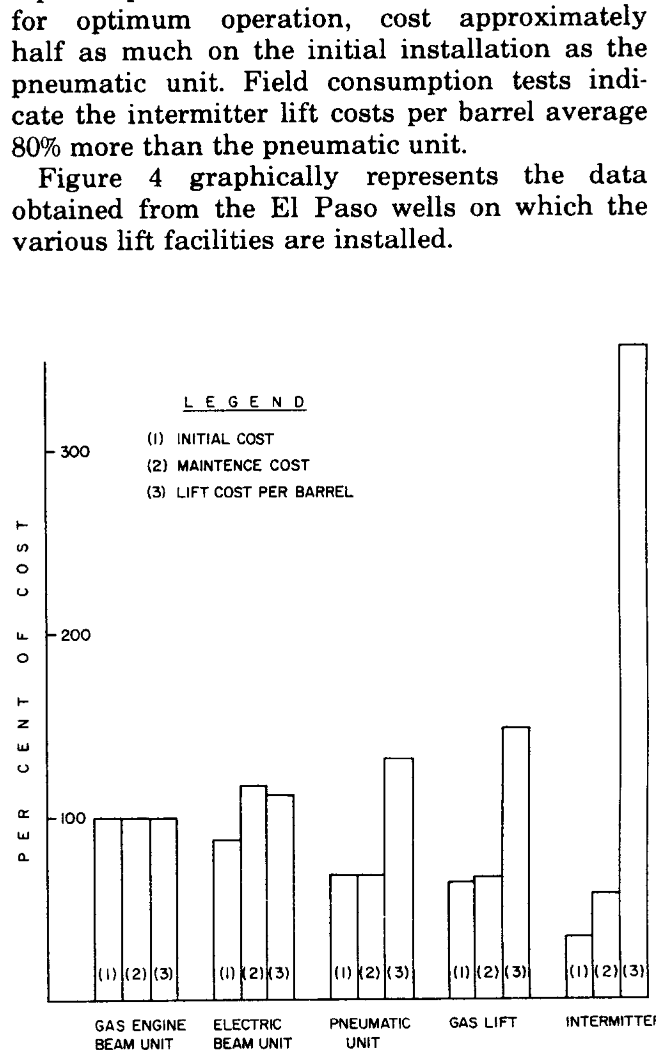


FIG. 4—INITIAL, MAINTENANCE, AND LIFT COST COMPARISONS
(Beam Unit with Gas Engine = 100%)

CONCLUSION

We believe that, while pneumatic pumping is certainly not a panacea for all dewatering ills, it represents a useful and economical tool which may be applied to a wide range of conditions. Although oil well application is beyond the scope of this paper, it may be recognized, and is already proven, an efficient oil lifting device when properly implemented.