Specialty Pumps - Double Displacement and Two Stage

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DOUBLE DISPLACEMENT PUMP

Introduction

The double displacement type pump is of relatively recent vintage. It was primarily designed to provide an economical method of producing oil under certain conditions. As "slim hole" completions became more and more common, it became obvious that production requirements could not always be met with an insert or tubing pump. This was especially true in areas where water encroachment had become a problem, or a water flood program had been initiated. These pumps are considered a specialty item and as such are somewhat more complicated than the single plunger type pump. Understanding the operation of this pump should encourage its use.

Operation

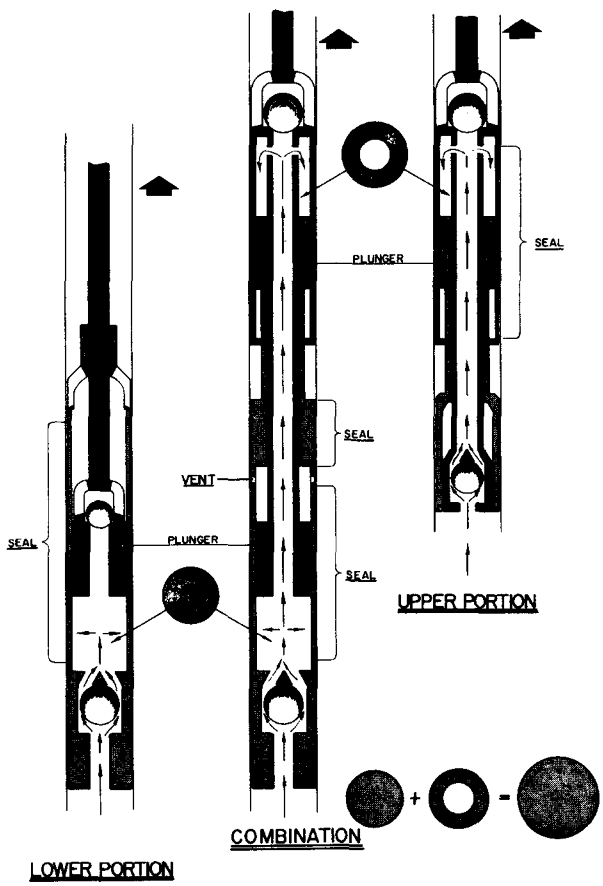


Fig. 1 DOUBLE DISPLACEMENT PUMP

The double displacement pump is constructed as two pumps in tandem, but operates as two pumps in series. It has two pumping chambers, one above the other; hence, the term "double displacement." For purposes of clarity, Fig. 1 has been prepared. A typical double displacement pump is shown, indicating its construction as an assembly as well as an independent lower and upper pump.

The lower portion is nothing more than a standard stationary insert pump. The location of the standing valve is in a normal position, at the inlet of the pump chamber. The sucker rods reciprocate the plungers, which, during the "up" portion of the cycle, creates a pressure drop across the standing valve, raising the ball off its seat and causing the pump chamber to fill. During the "down" portion of the cycle, the standing valve acts as a common check valve, the ball dropping on its seat, effecting a seal. The traveling valve opens and fluid is transferred from the pump chamber to the tubing string.

The upper portion of the double displacement pump operates in much the same manner as already described. However, instead of a single plunger traveling upward, a double plunger, one within the other, is utilized. An annulus, created by the I. D. of a working barrel against a stationary plunger, and the O.D. of a traveling plunger operating against a stationary seal, is telescoped upward during the upstroke. Again, a pressure differential across the standing valve (traveling type standing valve) is created, raising the ball off its seat, and allowing fluid to enter this annular chamber.

All double displacement pumps operate on this principle. A double plunger provides an annulus which telescopes upward and downward, and a lower plunger which operates as a standard pump. The two larger plungers are identical in diameter. As a matter of interest, these large plungers have nominal diameters of 1 1/2 inch for 2 inch tubing, 2 inch for 2 1/2 inch tubing and 2 1/2 inch for 3 inch tubing. The internal plunger of the upper portion of the pump varies in size, depending on the manufacturer. The smaller the internal plunger, the greater capacity of the pump.

Theoretically, production capacity is based on the strokes per minute times the plunger travel times the total area of the lower plunger plus the annular area created by the two upper plungers. Fig. 2 shows the relative capacity of a typical double displacement pump versus an insert and tubing pump.

Application

Uses for this pump vary. It is certainly not the panacea for all applications involving high volume. For example, this type pump should not be used where large amounts of sand must be produced. Sand will

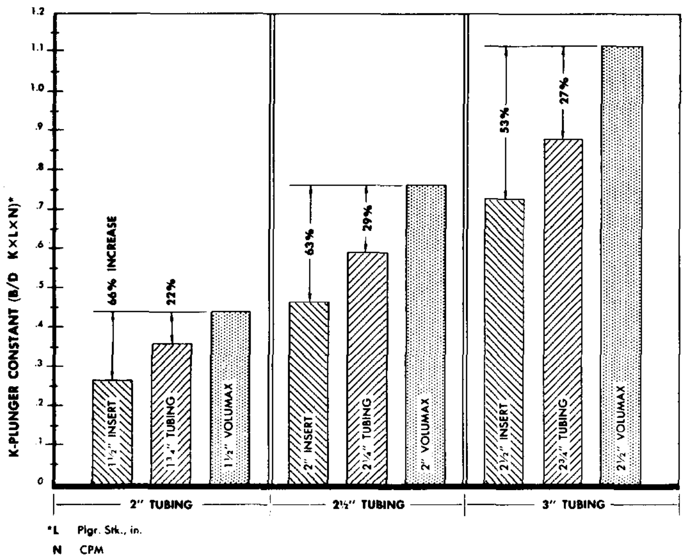


Fig. 2

cause accelerated wear on the three plungers, thus reducing the volumetric efficiency with resultant high operating costs. Nor should this pump be used in a low gradient well. Compression ratios at best are lower than encountered on a standard insert or tubing pump and aerated fluid will result in gas locking. However, in high water-cut wells this pump will provide more production than any type of insert or tubing pump. Furthermore, since this is an insert pump tubing need not be pulled when adapting to the well. The load range is increased, as would be the case if a single equivalent diameter plunger were used. Strokes per minute may be decreased if the features of an insert double displacement pump are desired, but production requirements of a tubing pump need only be met. Consequently, fewer stress reversals are imposed on the sucker rod string, thereby extending its life.

TWO STAGE PUMP

Introduction

Two stage pumps are used primarily in low gradient wells where ordinary single plunger type pumps would gas lock. Two stage pumping may be compared to a two stage air compressor, detail for detail. A two stage air compressor consists of a large, primary piston and a small, secondary piston. These pistons are independently valved and each are reciprocated from a common shaft. As one piston compresses, the other expands. The large, primary piston boosts inlet air to a higher pressure, forcing it into the intake side of the secondary piston. The secondary piston compresses this air still further, forcing it into an air receiver. Compression ratios are thus compounded. For example, if the primary piston has a compression ratio of 10 to 1, and the secondary piston volume is 1/3 that of the primary piston, a compounded ratio of 30 to 1 would result. These same principles are used in a two stage pump.

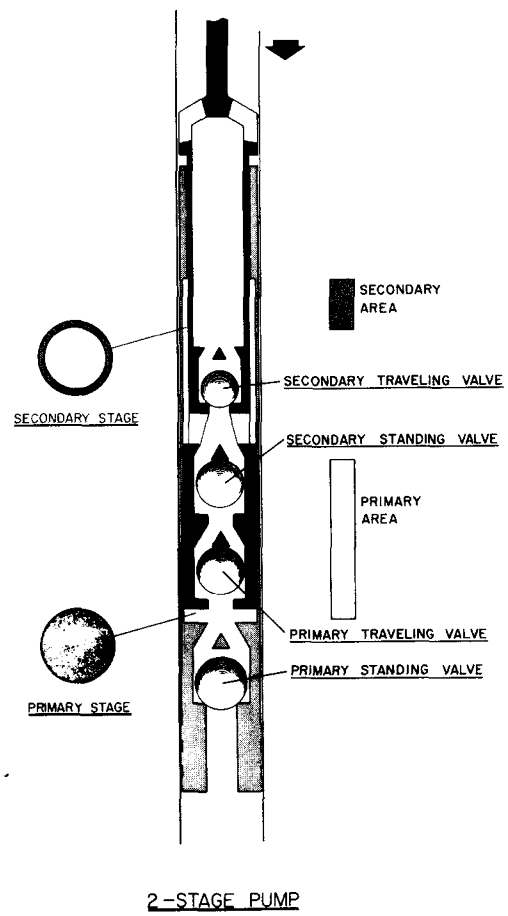
Operation

The lower section of a two stage pump is identical to a single plunger type pump. This section is called the primary stage. Fig. 3 shows a schematic drawing of the various elements which make up a two stage pump. As the lower plunger travels upward, a pressure drop is formed across the standing valve which opens, allowing formation fluid to enter the chamber. At the upper reversal, the standing valve closes and the primary stage compression stroke begins. Pressure builds up as the plunger travels downward. This pressure will continue to increase until sufficient to overcome the pressure within the secondary stage. As pressure builds up in the primary stage, pressure in the secondary stage is continually being reduced. This reduction takes place due to the telescoping action of the annulus in the secondary stage.

When the intermediate traveling valve opens, the fluids in each of the stages are at identical pressures. If the downstroke has not been completed, an additional pressure build up within these combined stages will result. This pressure may be sufficient to overcome the fluid head within the tubing column and, therefore, the upper traveling valve opens.

However, this pump was constructed to operate under even more severe conditions. Assume that the fluid/gas mixture enters the secondary stage, but pressure does not build up sufficiently to open the upper traveling valve. The lower reversal is reached and the plungers once again begin the upstroke. The secondary stage begins its compression stroke. The intermediate standing valve closes and pressure is increased within the secondary stage until, finally, the upper traveling valve does open and fluid is ported into the production tubing string.

We have done exactly what is done in a two stage compressor - ratios have been compounded. Assume



2-STAGE PUMP

Fig. 3

that by properly spacing the pump, a 20 to 1 compression ratio is realized in the primary stage. The relationship of primary stage volume and secondary volume is 3 to 1. The compounded ratio is thus 60 to 1, which can only be expected from an extremely long sub-surface, single plunger pump.

Application:

The two stage pump is not a cure-all for all pumping problems involving crude oil/gas mixtures. This pump may perform very poorly in a low gradient well when producing from under a packer. It will not necessarily gas lock, but its volume capacity may be totally absorbed in handling the gas, leaving no additional volume capacity for the fluid. However, if the packer can be accommodated with a vent to reduce the actual gas/oil ratio handled by the pump, good volumetric efficiencies will result.