API PUMP WITH GAS AND SAND PROBLEMS, CONSIDER THE TWO-STAGE HVR PUMP

Jimmy Kemp
Harbison-Fischer
A Dover Corporation

ABSTRACT
If gas and particulates (sand & iron-sulfide) are becoming a problem for your API Pump, consider the rugged Two-Stage Hollow Valve Rod Pump. Which is the most popular and successful pump ever produced. This pump has several benefits and can be designed for numerous pump configurations. This paper will give a basic understanding of the sequence of operation of the Two-Stage Hollow Valve Rod Pump and its application.

INTRODUCTION
The API Pump is a long ran proven pump in wells with little gas interference and particulate problems. Once you have one or a combination of either gas or particulates, the pumps volumetric efficiency is reduced and the chance of a premature pump failure is increased. Therefore, what can be done to improve the pump efficiency and extend or lengthen the pumps run life?

OBJECTIVE
To give those that are not familiar with the Two-Stage Hollow Valve Rod Pump, a basic understanding of how the pump operates during the lifting process and what type of well conditions would warrant running this pump. For the veterans, a refresher on the Two-Stage HVR and give reasons why it is a great option in those wells were gas and sand continue to reek havoc and discuss the different types of pumps that can be converted to a Two-Stage that you might not be aware is possible.

BACKGROUND
The development of the Two-Stage Hollow Valve Rod Pump came about due to problems with valve rod breaks on large bore pumps in long stroking wells. Companies were seeing tubing failures in the first couple joints above the pump from bucking valve rods and sucker rods. Since the valve rods were buckling, the tubing I.D., the valve rod guides, and even the pump barrels were seeing wear or rod cutting that caused premature failures. By replacing the valve rod with a pull tube will give any solid valve rod pump added ruggedness. The larger pull tube resists bending on the down-stroke better than a solid valve rod. In addition, by borrowing “Compound Compression Chamber pumping theory” from the proven Gas Chaser Pump, the Two-Stage Hollow Valve Rod Pump eliminates moderate gas locking by compressing the gas/oil mixture twice. In order to handle some sand (particulates) and gas locking conditions, a compromise had to be made by making the clearance between the hollow pull tube and the guide slightly larger. With this slightly larger clearance, some fluid could pass between the auxiliary compression chamber and the tubing, thus keeping sand from building up in the upper chamber. In addition, the turbulence in the upper compression chamber keeps moderate amounts of sand in suspension and moving out of the pump with the fluid. One of the initial tests of the Two-Stage HVR Pump was in a field under water flood and CO2 injection. The wells also had gas interference and iron sulfide particulates during shut down periods. After running the Two-Stage HVR Pump, it was discovered that not only does the Two-Stage valve help during periods of shut down, but it also helps open the bottom traveling valve during pumping operation.

SEQUENCE OF OPERATION (REFERENCE: FIGURE-1)
At the Top of The Upstroke, the plunger valve has the hydrostatic pressure load. The two-stage valve is in equilibrium and the weight of the ball closes on the seat. On the Start of The Downstroke, the plunger starts down, vacating the chamber above the plunger and below the close fitting guide. This creates a lower pressure in this chamber, which as the effect of pulling down the top valve, aided by the hydrostatic pressure above the top valve ball. At the same time, this small differential (low) pressure assists in lifting the plunger valve ball off the seat. The two- stage valve is, in effect, a traveling standing valve and performs the same function as a sliding top valve on a solid valve rod pump. The top valve will not open until the plunger valve opens, which transfers the hydrostatic

pressure to the bottom standing valve. As the plunger starts down, fluid in the lower chamber is displaced and travels through the plunger I.D. to the upper chamber. On the Downstroke Completion in the case of a 1-1/2" bore pump with a 1-1/8" O.D. pull tube, the displacement is 1.767 cubic inch per inch. With the pressure being equal in the chambers above the plunger, the displacement fluid will fill the vacated annulus of the pull tube and barrel with an area of .773 cubic inch per inch and discharge the balance to the tubing column. When the fluid is void of gas-that is, incompressible liquid-the discharge will be primarily up the pull tube and through the top valve.

At the Start of The Upstroke, the plunger valve seats and all pressure load is on the plunger area. The standing valve opens due to a pressure differential created by the plunger vacating the chamber, allowing well fluids to enter. Pump intake pressure is equal to bottom hole pressure at the intake point, and is the force that fills the pump chamber. On the Upstroke Completion, the plunger displaces fluid in the annulus between the pull tube and barrel through the pull tube and the top valve. The perforated pull tube coupling accepts the turbulent fluid as the plunger displaces it. Particulates will be pumped with the fluid through the pull tube and the top valve. A small amount of the displaced fluid will exit around the pull tube to guide area.

BUCKLING OF VALVE RODS AND PULL TUBES (REFERENCE FIGURE-2)

Valve Rods "buckle" or bend on the downstroke when pushing a plunger with a ball and seat valve. The resistance of the plunger imposed on the valve rod is due to the differential area above and below the ball and seat. When valve rods buckle, they can only bend to the point where the tubing wall stops and supports the rod. Failures of valve rods are predictably found at the last engaged thread of either end of the valve rod, and are a result of bending or buckling. Since bending terminates at the threaded ends of the valve rod, a fatigue crack develops in the root of the last thread progressing through the cross sectional area. Then the parting of t he valve rod is from tensile overload. Extended service life of valve rods are noticeable when using the collet type fittings along with a Spiral Rod Guide on top of the pump. In the attached chart (figure 2), there is a table with the critical column bucking load and converted to four pumping depths or more accurately, "fluid lift." The lengths shown are total length of valve rods or pull tubes withdrawn from the pump at the top of the upstroke. In addition, loads and lengths given are for the differential pressure across the plunger ball and seat only; did not consider friction of the system like inertia, fluid velocity, or abrasion.

TYPES OF TWO-STAGE HVR PUMPS

You can have your bottom hold-down 1-1/16", 1-1/4", 1-1/2", 1-3/4", and 2" bore insert pumps designed with the top two-stage valve. The 1-1/16" bore uses a 13/16" hollow valve rod, 1-1/4" bore uses a 15/16" hollow valve rod, 1-1/2" bore uses a 1-1/8" hollow valve rod, and the 1-3/4" and 2" bore both use 1-1/2" hollow valve rod (Figure3).

How about your top hold-down pump? Yes, you can design them using the top two-stage valve. Now you have a pump that discharge at the seat nipple to help reduce the chance of an expensive stripping job with the rugged two-stage attributes.

If you are running a 1-3/4" or 2-1/4" tubing pump, you too can add the top two-stage valve (Figure 4). The pull tube used in a tubing pump could help reduce that sucker rod cutting in to the sidewall of the tubing pump barrel due to rod buckling.

Another pump that you might not be aware you can make in to a Two-Stage Hollow Valve Rod, is on the Oversize Tubing Pump (Figure 5). Again, the benefit is to help with gas interference and reduces buckling that may cause your rod to cut the I.D. of the barrel.

When running a Two-Stage Hollow Valve Rod pump, it is recommended to have a Spiral Rod Guide and Lift Sub already on top of the pump before leaving the pump shop. By using the Spiral Rod Guide, you get the added support for the pull tube. By using the Lift Sub, the pulling unit crew has something to pickup the pump with, and it keeps the pulling unit company from applying a wrench to the two-stage cage not allowing it to get damage and not operating properly.

CALCULATE BARREL LENGTHS

It is important to know how to figure the length for either an API Pump or Two-Stage Hollow Valve. By running to long a barrel on an API or Two-Stage HVR Pump, that does not utilize most of the barrel. When it comes time to pull the pump and the plunger is pulled up into the unswept area or the area the plunger is not traveling into, if there is build up in that unswept area, the plunger could get stuck. Then during the lay down process on location, the plunger and or barrel could be damaged. Then during tear down of the pump with the plunger stuck in the unswept area, it might not be able to be removed and both barrel and plunger could have to be replaced. In addition, with the Two-Stage Hollow Valve Rod, if the barrel length is to long the compression in the upper chamber could be effected. You can use this simple calculation to help aid in running the proper barrel length. Take your stroke length, plunger length, fittings, and spacing allowance (24" to 4000', then 6" per 1000' below 4000') and add them together for barrel length. Make sure you know this calculation is for steel rods only.

SUMMARY

If you are having gas locking, consider the Two-Stage Hollow Valve Rod that eliminates moderate gas locking issues. If you also have sand along with gas locking, this pump has a relatively large clearance between the hollow valve rod and the rod guide so some fluid could pass between the auxiliary compression chamber and the tubing keeping sand from building up in the upper compression chamber. Also with the valve on top of the pump on the wells down time, the sand is not allow to settle down on top of the plunger causing sticking problems and shortened run life. The rugged design will help were you experience valve rod breaks on long stroke, high volume pumping wells. The large hollow valve rod has a larger area thus resisting bending during the downstroke compare to that of a smaller solid valve rod will perform.

REFERENCES

1. SPE 18828 – Methods to improve the Efficiency of Rod-Drawn Subsurface Pumps by B.R. Cox and B.J. Williams, Harbison-Fischer Mfg. Co.
2. Harbison-Fischer Engineering Department: Training Manual by Benny Williams & Bob Cox.

The Two-Stage
Hollow Pull Tube Pump

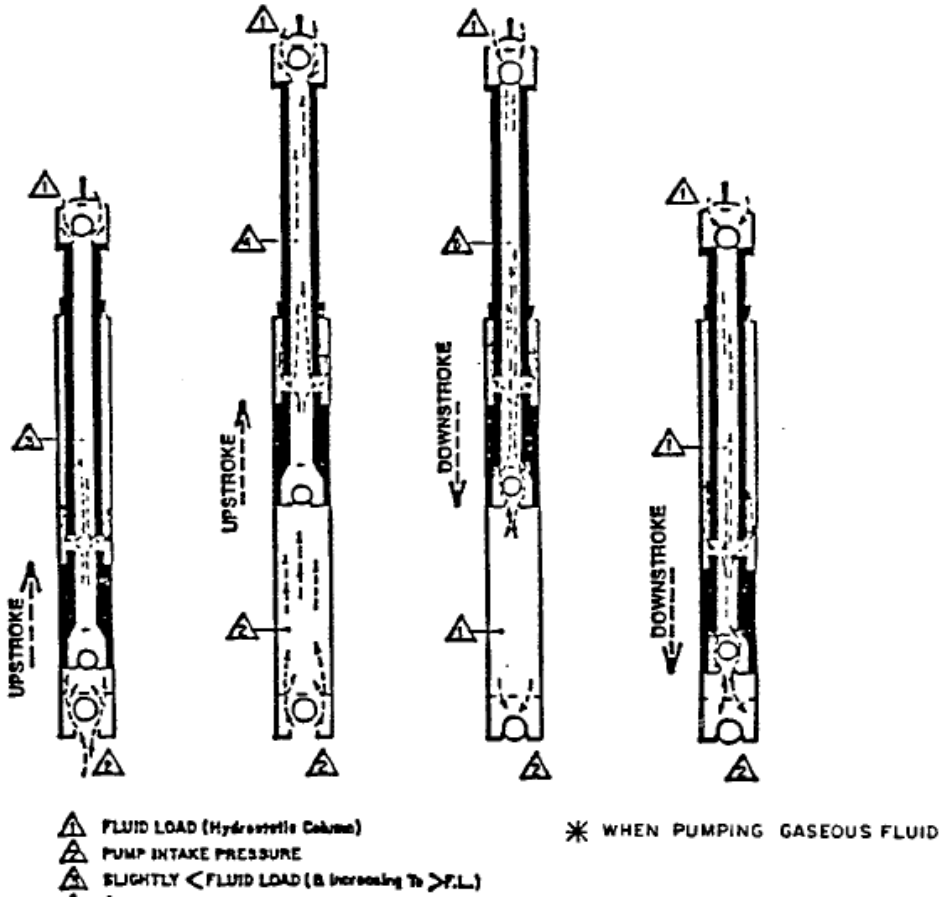


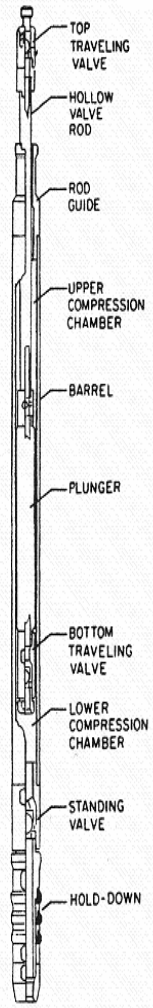
Figure - 1

COLUMN CRITICAL BUCKLE LENGTH IN INCHES

Plunger - Valve Rod / Pull Tube	Fluid Lift 2300' (1000 PSI)	Fluid Lift 4600' (2000 PSI)	Fluid Lift 7000' (3000 PSI)	Fluid Lift 9200' (4000 PSI)
1-1/4" 11/16"	120"	86"	70"	60"
7/8"	192"	138"	108"	98"
Sta. Bbl. Pull Tube	200"	140"	115"	100"
Trav. Bbl. Pull Tube	(95")	(60")	(50")	(45")
1-1/2" 11/16"	100"	74"	60"	52"
7/8"	168"	115"	95"	81"
Sta. Bbl. Pull Tube	215"	170"	140"	120"
Trav. Bbl. Pull Tube	(115")	(80")	(64")	(56")
1-3/4" 7/8"	164"	116"	94"	82"
1-1/16"	220"	170"	140"	121"
Sta. Bbl. Pull Tube	245"	230"	216"	200"
Trav. Bbl. Pull Tube	(160")	(115")	(95")	(78")
2" 7/8"	155"	105"	86"	75"
1-1/16"	215"	160"	130"	115"
Sta. Bbl. Pull Tube	240" +	220"	210"	186"
Trav. Bbl. Pull Tube	(140")	(98")	(80")	(69")
2-1/4" 7/8"	144"	104"	84"	72"
1-1/16"	208"	151"	124"	108"
Sta. Bbl. Pull Tube	240" +	240" +	230"	220"
Trav. Bbl. Pull Tube	(179")	(126")	(103")	(89")

Figure 2

TWO-STAGE HOLLOW VALVE ROD PUMP



The Two-stage Hollow Valve Rod Pump is available as a bottom hold-down pump, top hold-down pump, tubing pump or over-size tubing pump.

Figure 3

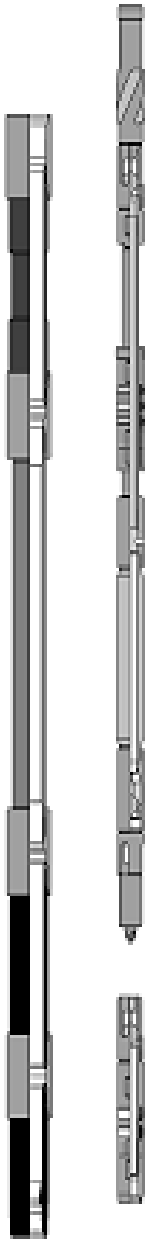


Figure 4
2S-HVR Tubing Pump
Tubing Pump

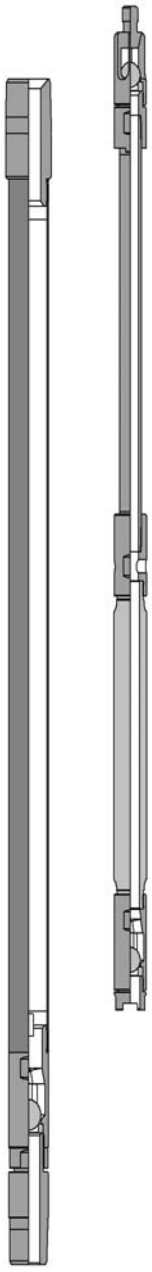


Figure 5
2S-HVR Oversize