PRODUCTION OPTIMIZATION
BY
VORTEXING IN SUCKER ROD PUMPS

A.A. Pennington
POSSI

A valve consisting of a standing or traveling valve cage with a fixed vortex producing blades can, in conjunction with oversized valve seat and increased internal flow through capacity, augment pump efficiency while relieving some common sucker rod pump problems.

The vortex valve is fitted to the barrel of the pump to form the standing valve or to the plunger to form a traveling valve.

In the standing valve position there exists in every pump a restriction to entry of the oil, water, or other well fluids into the pump. The restriction is the standing valve assembly that consists of the cage, ball, and seat. All sucker rod pumps try to overcome this restriction with the vacuum that is created on the up-stroke. Another force that is at work is the formation pressure which when high can help overcome the standing valve restriction and when low offers very little assistance as is found in older pumped off formations.

At present sucker rod pumps cannot be made more efficient by increasing the vacuum in the barrel of the pump. The current design of a close fit plunger moving inside a barrel creates approximately 22 inches of vacuum. If the pump manufacturers could increase this vacuum it would revolutionize pumps. Sucker rod pumps manufactured today are the best the oil patch has ever seen and probably will not change much in coming years.

In the mouth of the pump is a ball and seat valve that is very efficient in its operation. This ball and seat has proved over years of field use to be the best and longest lived type of valve for the reciprocating sucker rod pump. It has also shown its faults in the fact that it is a restriction to the flow of oil because it sits directly in the center of the flow column.

This creates a second problem of high cage wear because as the fluid flows in, the ball rotates or slams back and forth under the force of the fluid. Guided cages have been designed to try to force the ball to travel in a straight path up from the seat and return it to the seat. Some success has been seen in the use of the guided cage. There is a great debate on how to make the guides, what material is longer lived, whether the cage causes premature ball failure, and many other variables. The fact that we can recognize is the ball and seat by its inherent design causes turbulent flow that is not consistent with pump fillage nor keeping gas in solution.

At present, formation pressure will not be addressed. It is enough to say that in many cases this pressure can be changed by certain secondary recovery methods that are very costly in their implications. In a later part of this paper it will be shown how formation pressure can be regulated to some degree by well fluid levels.

The rehtoricial question is, "If we could solve these problems would pump efficiency increase?" Of course the pump would be more efficient, but nearly every type of device know to man has been tried with varying rates of success: bigger pumps to add suction area, gas breaker to get rid of gas caused by the pump process, and many more.

To understand vortexing as a solution, it is first necessary to define the unused potential that is available in the pump.

Our example will be based on a pump with a 24' barrel pumping at 10 strokes per minute.

Our first unused potential is pump horsepower. To keep this explanation simple suffice it to say the same surface pump system can pump pumps 1-1/4" to 2-3/4" or larger at the same 10 strokes per minute without a problem. Some have substantial unused horse- power available for our use.

24 Feet 10 Strokes	240 Feet 60 Minutes
240 Feet per minute	14,400.00

$$\frac{14{,}400}{5280} = 2.73 \text{ MPH}$$

Our second unused, in fact misused, potential is this fluid velocity. This velocity is what causes the cage and ball wear described above.

It is necessary to state at this point the vortex valve assembly is designed to be installed onto any API pump design. Installation of the valve is simple and can be accomplished by any pump shop without special tools or procedure. The valve simply replaces the normal standing or traveling valve assembly. Pump installation at the well is not affected and should be carried out normally.

The vortex valve is shown in figure one. This figure also shows the flow characteristic created by this valve.

Vortexing is caused by stationary blades fixed at the center of the fluid flow. The blades take the oil as it enters the pump mouth and force it to rotate. This rotation increases fluid velocity by the distance traveled in the helical motion around the cage.

There are three basic actions caused by the vortexing action or the oil.

A.) A whirlpool effect stabilizes the ball at its center and smoothes flair etc.

B.) The ball is lifted higher and for a longer period due to increased velocity and the centering, lifting effect of the vortex whirlpool action in the fluid.

C.) An ability to lift the ball higher allows the ball to come up into the larger area in the cage which allows increased flow area.

The combination of the above effects causes increased pump fillage and decreased breakout of gas in solution.

The normal pump design as described in the beginning has a restricted entry caused by the required size of the ball and by the turbulent action of the ball in the flow path. Vortexing eliminates to some degree both restrictions.

First, the fluid enters the pump in a forced circular flow pattern called a vortex. By definition the vortex has more lift than the normal turbulent entry method. This action causes the ball to rise higher for a period of time.

The cage wall design is unique in the fact that the inside wall decreases as the ball is lifted higher. As the cage ID decreases, the restriction to flow decreases. The result is increased pump fillage.

A second effect is that the AP (Delta) across the cage decreases with increased flow area. The result of this decreased pressure change is less pressure drop; therefore, there is less gas breakout in the pump.

A question that should be addressed because of this unique thin wall design is "How can this thin wall support the extreme conditions of down hole service?"

First, the cage is a one piece casting made only from monel. This material lends four times the strength of normal steels while being resistant to nearly all forms of corrosive fluids.

Second, the fin or blades in the cage serve two purposes other than creating the vortex action. They stiffen and support the outside wall and prevent the ball from causing wear.

These valves are designed for use in all types of wells, but special mention should be made that in field tests they have proven very effective in pumped off wells.

In the Pembia field of Western Canada pumped off operations are the norm. Vortex valves in this field have shown overall fluid recovery increases.

The explanation for this relates to the fact that when a pump can no longer lift fluid from a well, it's pumped off but not dry. In most pumped off wells, when the pump cannot overcome the restriction at the standing valve and the low formation pressure, there is still 10 feet to even 100 feet of fluid above the pump. Using the vortex valve allows the removal of the restriction at the standing valve and the pump then can lift out the remaining oil. This creates a new lower pumped off level in the well. A new lower level means less hydrostatic load against the formation and thereby more oil can flow in easier.

Vortex valves in the traveling valve position follow all of the above explanations. The purpose of the valve when used as a traveling valve is to increase down hole stroke length and to decrease pump and rod wear.

The Vortex valve's increased flow area when used as a traveling valve will move the pump restriction from the travel valve to the I.D. of the plunger. This results in better plunger fall at higher velocity. Higher velocity on the down stroke, at the pump, will equate to more inches of down hole stroke. More inches of down hole stroke means more oil lifted per stroke.

The increased plunger fall velocity also equates to less rod compression. When rods do not compress they are less likely to rub the tubing, rod guides, and rod boxes.

Vortexing of fluid to improve flow and flow characteristics is new to down hole production but has been used for many years in fluid transfer and fluid pumps. The key to using this technology down hole was first a recognition that a power source existed in the sucker rod pump. Second, the development of metal that would support the thin wall design was required to increase the effective internal flow area.

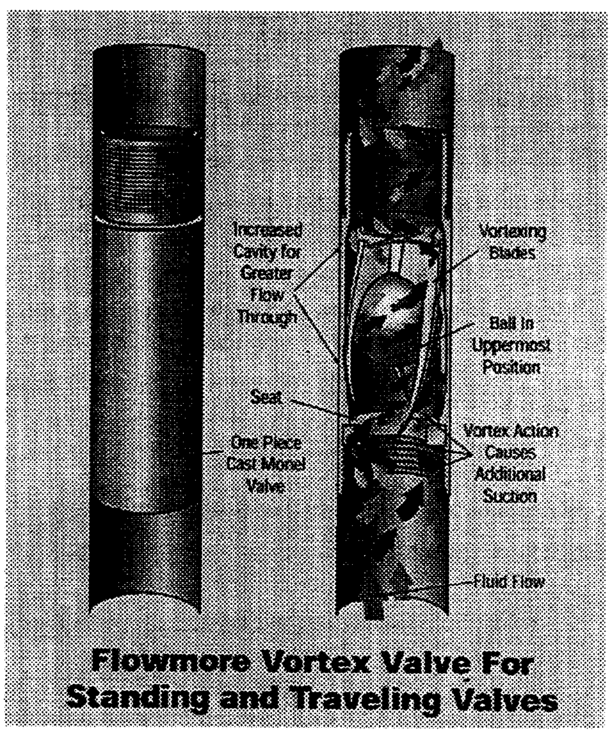

Figure 1