SUCCESSFUL SUCKER ROD PUMPING OF PARTICULATE-LADEN FLUIDS

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ABSTRACT AND SCOPE

Sand, Iron Sulfide, Frac Sand, and other particulates produced with the fluid often cause sucker rod pumping problems that shorten sucker rod pump runs to unacceptable times, or actually prevent successful use of sucker rod pumping. Common sense methods of successfully dealing with these particulate problems are covered as are developments in sucker rod pumps for successful particulate production.

INTRODUCTION

Sucker rod pumps are fluid pumps and thus work best with clean, lubricating fluids. The presence of particulates in the fluid causes problems with the working parts of the sucker rod pump, and will normally shorten the life of the pump and possibly cause it to cease functioning soon after installation.

BACKGROUND

Plunger Stuck In Barrel: Particulates can become lodged between the plunger and barrel to the extent that the plunger is stuck in the barrel, with the result that the pump does not function and the sucker rods may be damaged.

Cages Packed Off: The passages through the traveling valve and standing valve cages present the smallest fluid flow area of the sucker rod pump. These can become packed with sand or other particulates during pumping. The result is severely reduced flow through the pump or total fluid blockage.

Valves Stuck Open: A common problem with production of particulates is valves “hanging open” during pumping. This is caused by sand or other particulates becoming trapped between the ball and ball guides in the valves. There must be some clearance between the ball and its guides, but not enough to allow excess movement of the ball so that it can beat out the ball guides, and not too little such that sand or other particulates can easily become trapped between the ball and the guides thus stopping ball action.

Pump Stuck In Tubing: Sand and other particulates can build up in the stagnant fluid area between the sucker rod pump and the inside of the tubing, above the hold-down seal assembly at the bottom of the pump. Only a small amount of particulates is needed to pack into this small space and stick the pump in the tubing, preventing it from being unseated and pulled to the surface with the sucker rods. In this case the tubing must be pulled to retrieve the sucker rod pump.

Plunger And Barrel Wear: During the operation of pumping fluids with entrained solids, the plunger and barrel will wear at a faster rate than when pumping clean fluids. This wear eventually causes excess slippage of fluid past the plunger on the upstroke. This reduces efficiency to a point that the sucker rod pump cannot produce enough fluid for the operator’s needs and the pump must be pulled and repaired. Harder materials are available to help extend run time, and operational choices will be covered that extend run time while reducing pumping problems.

Valve Wear: The valve consists of the cage, ball and seat. These hard-working components see most of the mechanical damage in a pump, mostly consisting of: cage guide wear, ball pitting or wear, and seat wear, pitting or cracking.

DISCUSSION

Particulate Size: Sand and other free moving particulates can range in size from silt or clay at about .003” or less to particulates that resemble gravel at sizes above .040”. See figure A. Most produced sand or particulates are toward the smaller end of the scale, but exceptions abound with some wells producing the entire range of sizes.

Analysis: Operators can help their operations significantly by evaluating the size of the particulates that are found during pump repair. The valves and dip tube/mud anchor often have particles trapped within. These can be measured with common pump shop micrometers, calipers or a mesh screen to determine their size. See Figure B. This data can be used to select an optimum plunger/barrel clearance and/or a sucker rod pump designed for the size of particles being produced. However, finding no evidence of sand in the sucker rod pump valves or dip tube does not fully indicate that there is no sand being produced. During pulling of the pump the rods and pump are accelerated upward, then stopped quickly, possibly washing out any evidence of sand that may have accumulated in the pump.

Initial Steps: After determining the size of particulates an operator can use the conventional approach of either choosing the plunger/barrel clearance to exclude particulates or to allow them to pass between the plunger and barrel. Either approach works toward the goal of not allowing the particulates to lodge between the plunger and barrel or otherwise be continually crushed and cause premature wear to the plunger and barrel. Choosing a plunger/barrel clearance larger than the particulates allows them to pass between without being crushed or sticking the plunger in the barrel. By making the choice of a much smaller plunger/barrel clearance than the size of the particulates an operator excludes the particulates. Care must be taken to allow enough clearance for lubrication of the metal plunger through slippage of fluid between the plunger and barrel.(1)

SOLUTIONS

Plunger Stuck In Barrel: The choice of the plunger/barrel clearance for a metal plunger is the most important consideration for stuck plungers, with most operators benefiting from a larger clearance than normal. This approach "passes" the particulates between the plunger and barrel and does not allow them to be crushed, causing wear, or lodged, causing a stuck plunger. The downside to this choice is increased slippage, or put differently, less sucker rod pump efficiency. However, many years of operational choices of larger clearances have convinced many operators that the trade off is financially beneficial due to increased run times and decreased pulling expenses. A side benefit is that there is plenty of fluid slippage for lubrication, but it should be calculated prior to implementation.(2) A general rule-of-thumb is to allow about 2% of the produced fluid per day to slip past the plunger. For large particulates a close fitting plunger can be chosen to reduce their effect on the wearing surfaces of the metal plunger and barrel. This has been shown to be most successful in the Pampa Pump configuration, i.e. long plunger and short barrel.

If a metal plunger cannot be made to work, due to sticking in the barrel, a soft-packed plunger will. A valve cup plunger or composition ring plunger will pump the fluid in heavy particulate concentrations but will not last as long as a metal plunger. These are sometimes used in combination with metal plungers as wipers, to extend the life of the metal plunger and prevent it from sticking in the barrel.

There are two accessory devices that are dependable and are designed to keep sand from falling back into the sucker rod pump during shut down periods. The first is the Sliding Top Valve. It has a bronze sleeve that opens on the upstroke of the pump and closes on the downstroke. When the pump is shut down it automatically closes and prevents sand from settling into the inside of the pump. Another, less expensive solution is to use a Sand Check. These install inside a standard valve rod guide at the top of the pump and form a seal around the valve rod and against the fitting below the valve rod guide. It is not as long as the sleeve on the Sliding Top Valve and therefore does not have as much wearing surface, but it is effective in holding back sand.

Cages Packed Off: Most sucker rod pump valve cages have fluid passages around the ball and then through three holes above the ball stop. These three holes, or the area around the ball can become packed off with particulates, particularly coal fines in coal bed methane wells. The easy solution to this problem is to use the full-flow valve, which has the ball stop area enlarged in order to prevent particulates from packing into this area.

Valves Stuck Open: A standard sucker rod pump valve cage has about .030" clearance between the ball and the ball guides. This is not an API standard but rather an industry standard that was apparently developed through years of operational experience. This clearance is optimal for most pumping conditions with clean fluid. However, when particulates are produced with the fluid, it has been found to be slightly too tight, causing the ball to hang up in the ball guides, perhaps only occasionally, thus mimicking gas locking. Many operators have spent a lot of time, effort and money trying to cure gas locking problems which were actually particulate problems holding the ball off of the seat. One of the historical solutions to this problem was to run an alternate (or California) size ball. This size of ball ranges from 1/16" to 3/16" smaller than the standard API standard size ball. See Figure C. This solution, while solving the stuck valve problem introduces too much clearance and allows the ball to wear out the cage faster than normal. Better solutions are to use a 4-Guide Cage or insert cage with selectable ball clearances of .030" (standard), .045" or .060". See Figure D. These have shown to provide enough clearance to overcome most stuck valve problems without introducing so much clearance that the cages wear out quickly. Another choice is the Rubber Lined Cage, which, due to its relatively soft ball guides, can accommodate .090" ball clearance without affecting cage life. Advancements in adhesives for rubber ball guides have made this a dependable choice.

Double Valves are often used when particulate problems cause valves to stick open. The idea is that when one valve is stuck open then the other will be free and hold the fluid load. This has been shown to be a dependable solution. Some operators run an alternate size ball in one of the double valve cages when a pump is run behind a fracture job or other remedial well action. The alternate ball takes care of the ball hanging problem, and by the time it has worn out the cage the standard ball is functioning because the well has been cleaned up by then.

Pump Stuck In Tubing: The simplest solution to the problem of a bottom hold-down sucker rod pump being stuck in the tubing is to switch to a top hold-down sucker rod pump. It discharges fluid just above the no-go ring on the hold-down, making it almost impossible to stick in the tubing due to particulates. Or, switch to a traveling barrel sucker rod pump. The motion of the outer barrel keeps the fluid and particulates in motion above the bottom hold-down and prevents sticking in the tubing.

However, bottom hold-down sucker rod pumps are more rugged and are used in wells that are too deep for top hold-down or traveling barrel pumps. In that case an expandable Sand Shield can be run on top of the pump. It sets automatically when the pump is seated and releases when the pump is pulled. The expandable rubber seal is mechanically pushed out against the inside of the tubing, forming a seal between the sucker rod pump and the inside of the tubing, and preventing sand from settling around the barrel and bottom hold-down.

Another solution is to use a Bottom Discharge Valve. This auxiliary valve is installed just above the standing valve and discharges some fluid into the pump/tubing annulus on the downstroke of the pump, keeping the fluid and particulates in motion above the hold-down.

Plunger and Barrel Wear: This is not a catastrophic problem but rather occurs over a long run time. If it is not an acceptable run time then the plunger and/or barrel can be upgraded to a harder material to achieve a longer run time. New plunger and barrel choices have been recently announced to give operators even harder options for combating this type of wear. The clearance between the plunger and barrel can affect the rate of wear, as discussed above, with a larger clearance being favored in the past decade.

Valve Wear: There are three components to a sucker rod pump valve; the cage, ball and seat. The wear of the cage has been discussed above in the "Valves Stuck Open" section. In addition, fluid and gas pound, low production compared to the pump capacity, or high velocity gas flowing through a valve will wear out the cage prematurely due to excessive ball movement. Ball and seat wear can be caused by these also, or by the use of an alternate size ball in a standard size cage. Furthermore, particulates are frequently trapped between the ball and seat causing a point stress which can chip out small areas of the ball and seat. These can appear to be sand blasted or they can have large areas spalled away where many of the small, chipped out areas come together to form a large mechanically chipped away area. An upgrade to a harder ball and seat, such as Tungsten Carbide, can help with this situation.

SUMMARY

Sand and other particulates frequently reduce the normal run time of sucker rod pumps, but with proper pump selection, accessory application and operational parameter optimization, run times can be lengthened to justifiable periods of time.

REFERENCES

(1) "Particulate Problem Solutions for Rod Pumped Producing Wells," by Benny J. Williams, Harbison-Fischer, SPE Paper #30640.
(2) "Progress Report #4 on Fluid Slippage in Down-Hole Rod-Drawn Oil Well Pumps," by John Patterson, ConocoPhillips, Jim Curfew, OXY Permian, Kyle Chambliss, OXY Permian, Lynn Rowlan, Echometer, Southwestern Petroleum Short Course, 2007, pp 45-59.

Below .003”	Silt and Clay
.003” - .005”	Very fine sand
.006” - .010”	Fine sand
.011” - .020”	Medium sand
.021” - .040”	Coarse sand
.041” and above	Very coarse sand and gravel

Note: 1 micron = .00003937”

Figure A – Particulate Sizes

Mesh Size	Particulate Size
140	.004”
100	.006”
65	.008”
48	.012”
35	.016”
28	.023”
20	.033”
14	.046”

Figure B – Mesh Screen Size

Valve Size	API Ball Size	Alternate (California) Ball Size
1-1/4”	.750”	.688”
1-1/2”	.938”	.875”
1-3/4”	1.125”	1.000”
2”	1.250”	1.125”
2-1/4”	1.375”	1.250”
2-3/4”	1.688”	1.500”

Note: A Valve Seat is lapped for either an API size or Alternate size ball.

Figure C – Ball Sizes

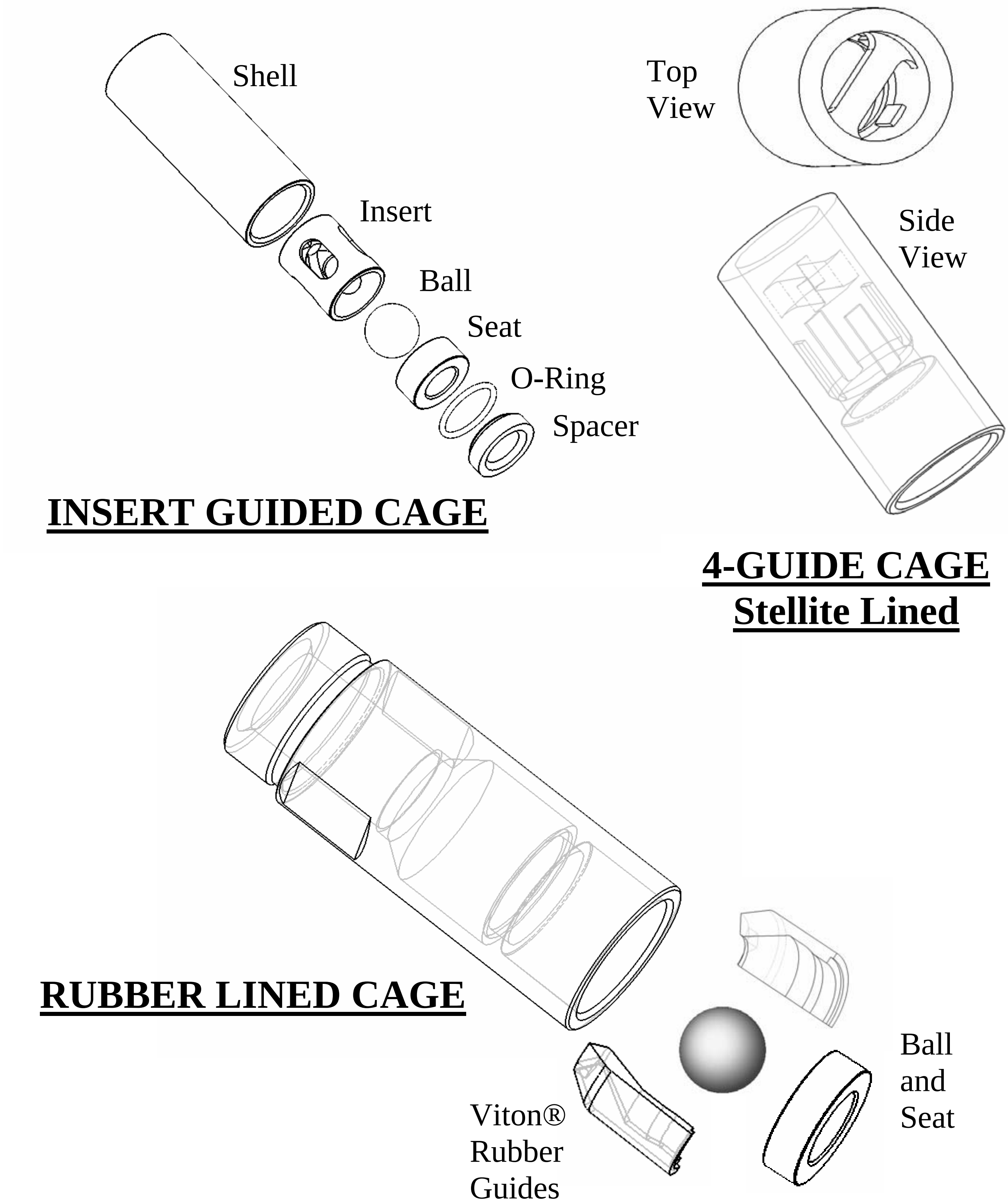

Figure D – Cages