TROUBLESHOOTING THE BOTTOMHOLE PUMP – A PRACTICAL APPROACH

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ABSTRACT

The bottomhole sucker rod pump is the workhorse of artificial lift around the world. When the pump stops working, your company is losing revenue. Prior to calling in a service rig to find out what is wrong with the pump, this paper will provide a series of procedures to try BEFORE you call the service rig. The goal is to get the pump function back, return production to normal and keep your lifting costs down. These procedures are in a random order and are meant as a practical guide in the field.

INTRODUCTION

The basic assumption with a fouled pump is that the pump will not pressure up on its own – meaning that the wing valve/flowline valve on surface has been closed and the pumping unit was left pumping. By monitoring the tubing pressure on surface, you can determine that the pump is not increasing this surface pressure and pump function is not evident.

SPACING

One of the first things to establish is if the pump was correctly spaced after the service rig left location. It should be verified that the well had been producing at a stable rate prior to losing its function. Traditionally service rigs leave the plunger/traveling valve assembly anywhere from 6 inches to two feet off of tap. This spacing is arbitrary - it could be a company policy or at the discretion of the service rig. Attention should be paid to depth of well, type of rods, pumping speed, and size of pump to determine what is a correct spacing with the well full of dead fluid. There are excellent design software programs available to determine how much spacing is needed. Different spacing is required for different sizes of pumps – a "one-size spacing" does not fit every well.

An example of this is the following well under the same operating conditions. It is producing at 5 SPM x 100-inch surface stroke length, has the same rod string of an API #76 taper, producing from a depth of 5500 feet and producing 150 Bbls/d total fluids. The following downhole stroke at the pump is calculated:

	Stroke @ the Pump		
	1.5"	**1.75"**	**2.0"**
High PIP	97"	95"	93"
Low PIP	81"	76"	69"
Spacing Required	**16"**	**19"**	**24"**

As you can see from the above example, the required spacing varies significantly from each size of bottomhole pump. Improper spacing can affect the compression ratio of the pump and result in poor pump efficiency.

Once the well has recovered all the load fluid and "live wellbore fluids" are present, the dynamics along the rod string change, affecting the bottomhole stroke at the pump. This will dictate the spacing from the traveling valve to standing valve, and in most situations with steel rods in a well, usually the bottomhole stroke is less than the surface stroke. It is important to get the traveling valve as close to the standing valve as possible during normal pumping conditions to maximize the compression ratio in the pump. Failing to do this could lead to an inefficient pump or promote gas locking. Also, remember that a hard tag on bottom can eventually damage the pump and rods and lead to an early pump failure.

FLUID LEVEL TESTING

After it is established that the pump's compression ratio is maximized by being as close to tap without tagging the clutch assembly on an insert pump, if production does not improve, a fluid level should be taken to determine if in fact there is any fluid in the well to pump.

An acoustic pressure wave (fluid level) introduced down the casing can determine if there is fluid above the pump, and with some extra work, can also determine what the gradient of the fluid in the annulus is. This usually takes the form of a fluid depression test. This test will calculate what the annular gradient is and if it is pumpable or not. The Industry rule for determining annular gradients is if the annular gradient is less than 0.2 psi/ft, it is considered to be gasified fluids, and if the annular gradient is greater than 0.2 psi/ft, it is considered to be pumpable fluids.

Fluid levels can even be used to help calculate the producing bottomhole pressure of a pumping well, something which can then be used to calculate the IPR of the well. Often producing companies have their operations/technical staff equipped with their own fluid level equipment, or third party contractors are available to perform this work at a nomimal fee, but in the author's opinion, is money well spent.

If a fluid level cannot be taken easily, or the expense of getting one done is in question and the pump will not pressure up, no worries. Often the well may be pumped off, has gas/gasified fluids in the wellbore and the pump is being starved. Rather than call the service rig, consider just shutting down the well from two to four hours. With the pump shut down, any inflow into the well will start to fill the pump. After a few hours of being shut down, or even over night, monitor the well on start-up. If the pump pressures up, operates with a cool polished rod, or fluid is discharged from the bleeder valve on surface, pump function has been restored. The new inflow from the well filled the pump and there is nothing wrong with the pump, it just did not have any fluids to pump. If this is a common occurrence in a well you operate, you may want to consider slowing down the well or shortening the stroke length.

FLUSHING/CIRCULATING/PRESSURE TESTING

When the pump will not pressure up, one common technique to re-establish pump function is to flush the well with CLEAN, produced fluids or hot oil the well, attempting to flush any debris from the valves in the pump. The key concept here is to use clean fluids. Filtering workover fluids is often done, but is expensive. An alternative to this is keep one tank at your battery filled with only clean, recycled oil for workovers. Try and eliminate taking workover fluids off the bottom of a storage tank, as this is where the sediments, wax, debris, etc. tends to settle out. Taking dirty oil saturated with wax from the bottom of a tank and heating it up to circulate the well can be a recipe for disaster. Often an off-load line fabricated higher up on the tank wall is an easy way to eliminate this. If you can use clean, hot water instead of oil as a heating medium, that is much better, as water holds more heat and does a better job of cleaning up the well and then chasing the last bit with clean oil.

Keep in mind that it is important to monitor the volume of fluids pumped into the casing or tubing. For example, if you have a well with a casing volume of 36.5 barrels, and you called in third party contractor to pump oil down the casing and they tell you it took 35.2 barrels of fluid to fill the casing, this is an indication that the casing was pretty much empty and the well was pumped off. The same can be said for the tubing. If the tubing volume was 19.5 barrels to fill with rods in the well, and it took 18.9 barrels to fill, you pretty much know the tubing was empty. This is also an excellent way to determine if a hole in the tubing exists by knowing how much it took to fill tubing.

While we are talking about filling the tubing, an outside pressure unit is often used to verify if the tubing will hold pressure and confirm if the pump is seated properly. Remember, if you take this approach, be sure you know how much fluid it took to fill tubing as this can be used to calculate holes in tubing, etc. Be sure that while you are pressuring up on the tubing that you pay attention to the casing pressure at the same time. If the tubing pressure is increasing, but you notice that the casing pressure is also increasing, that is a sure indication of a hole in the tubing.

After you have tried some of the above techniques and you still do not have pump function, you need to dig a little deeper to solve the problem. Lets say that the fluid level you took indicated a very high fluid level, and a mini depression test verified that this annular fluid is a high pumpable gradient (based on our Industry rule), yet the pump still will not displace fluid. This may be an indication that the strainer nipple on the pump or standing valve is plugged/scaled off and no fluids can enter into the barrel and the pump is starved.

PRESSURING –UP TECHNIQUES

While pressuring up the well with the bottomhole pump, there are also a few other things to be aware of. Make sure that the surface check valve (which isolates the casing from flowline) is in fact in place and is not leaking, as this could cause the fluids to circulate from the tubing back around and down the casing. Check valves are often removed to perform workovers such as hot oiling the well, or adding chemical to the well. Also, if the wing valve/flowline valve on surface is closed and the pump is building pressure on the upstroke, but loses all that it gained on the downstroke is usually an indication that the standing valve is damaged (washed, plugged, worn, etc.). It is always a good idea when pressuring up the tubing with the pump that you pay attention to details. If you do not know that this well has a large tubing pump in it, and the tubing is equipped with a tubing drain, and you start to pressure up the pump successfully, but then get distracted and come back and find zero pressure on the tubing usually indicates that the drain has blown. Now you really do need to call the service rig!!

Sometimes the bottomhole pump will pressure up but very slowly. This could be an indication of a worn traveling valve/plunger assembly, or it could indicate that either there is very little fluid left in the well to pump. More common though is this is an indication that the tubing fluids are very gasified and it will take a long time to compress this mixture to a point where the tubing pressure really starts to build. Remember gas is compressible, and a bottomhole pump is not a compressor.

Another phenomenon that frequently occurs is when a pump only pressures up marginally on the upstroke. This could indicate that there is a very deep rod part and the only displacement in this well is from the rod displacement from the collars and scrapers as they move upwards. A deep rod part is very difficult to diagnose without any specialized tools such as a dynamometer, as the pumping unit will appear to be balanced and the working prime mover sounds balanced.

PUMP DESIGN

When a bottomhole pump is correctly designed, it is usually sized for the maximum stroke length of the surface pumping unit. It is often a good idea to check the pump description and calculate what the maximum stroke of the pump was built for. Sometimes a surplus pump is run in a well “because the pump was in inventory and saved building a new one”. It may be that this pump is too short for the surface stroke on the unit, - nobody checked this - and the pump plunger hits the top of the barrel and the pump unseats. Often you see a sudden drop in tubing pressure near the end of the upstroke as the pump unseats, and then pressure is maintained on the downstroke as the pump tries to re-seat itself.

SURFACE AND DOWNHOLE CONSIDERATIONS

It is always a good idea to check the downhole information of the well. Many times we assume that the pump is landed below the perforations (sumped/rat-holed/snorkeled) and it is pumping from the bottom of the well, which is typically where the best pump efficiencies occur. Sometimes, due to economics, or a strong flowing well, the tubing and pump are landed up-hole and no downhole separation is occurring at the pump. This will cause a very gasified mixture to be entering the pump intake, and as we discussed earlier in this paper, a pump is not a compressor – it is a positive displacement machine and it cannot handle this light mixture efficiently.

When an oilwell first comes on line, it may in fact be flowing under its own pressure. Eventually this pressure dies off to the point that the well can no longer flow. When this happens, artificial lift is required to lift the fluids to surface. At the time the well is flowing up the tubing, the casing is usually shut in, forcing all the fluids up the tubing. Another way to regulate this excess pressure is to install a Baird back pressure regulator on the casing. This regulator can be adjusted to any pressure, and it prevents fluids flowing up the casing and potentially waxing in the tubing. In the transition from flowing to pumping, the Baird regulator is not re-adjusted and the casing pressure is kept artificially high. This high pressure will act as a choke against the formation and prevent the inflow of fluids into the wellbore. Ensure that if there is a Baird back pressure regulator installed, it is adjusted during the life of the well to minimize the back pressure on the formation and allows the pump to do its job of lifting fluids to surface. The pump cannot pump what is not there.

MISCELLANEOUS OBSERVATIONS

At times, the pump plunger will seize in the barrel due to scale, sand or debris. Depending on where the plunger seizes in the barrel will indicate different symptoms. A hot polished rod may be evident, but usually the prime mover will be excessively loaded and one point in the stroke. The biggest tell-tale will be the polished rod clamp will separate from the carrier bar of the pumping unit on the downstroke.

A hot polished rod is the first symptom the pumper will notice before doing just about any other test on the well. The hot polished rod indicates there are no fluids in the well to pump, the pump is gas locked, the strainer nipple is scaled off and the pump is starved of fluids or the well is pumping too fast. The next thing that the pumper will notice is that the tank is not filling with produced fluids. This could be due to a plugged flowline caused by a hydrate, a stuck pig or paraffin, but more seriously is a broken flowline. When this happens, you are putting more fluids on the ground than in the tank. Operators should be looking for fluids on the ground, and start monitoring pressures along the flowline.

DYNAMOMETER TESTING

Lastly, the best tool that can be utilized to evaluate the bottomhole pump performance is a dynamometer. The dynamometer is a machine designed to measure load at a specific position along the stroke length at surface. Extrapolating these loads through a wave equation software program will result in loads at the pump. It is the loading at the pump and the corresponding graphical representation that needs to be studied to know exactly what is happening at the pump. A dynamometer can calculate the pump fillage, pump efficiency, give the equipment loadings of the pumping unit, prime mover and rod string, required horsepower, fluid level, balance condition, friction and much more valuable information. A dynamometer used in conjunction with a fluid level is the ultimate diagnostic tool available to determine what is happening at the pump. Often with a dynamometer/fluid level and proper analysis, the costly service rig can be avoided.

CONCLUSION

The bottomhole pump is a simple, positive displacement machine that requires basic troubleshooting techniques to keep it operating at a high efficiency. From this paper, you can see that many of these suggestions require very little capital expense to do a satisfactory job of maximizing production and reducing lifting costs. That is the bottom line.