# THE SKILLMAN DOWNSTROKE PUMP
# LIFTING FLUID IS HISTORY - DOWNSTROKING IS THE FUTURE

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Since the inception of the rod pump it has been assumed that all rod pumps must lift fluid. For centuries that has been true. In modern times leathers and flapper valves have been replaced with spray-metal plungers and balls and seats, metal barrels have replaced bamboo and wooden sucker-rods are now made of metal, but the concept and primary design has stayed the same. Many advances in metallurgy and precision manufacturing have extended pump runs, but for the most part oil producers today are using the same technology their grandfathers used on the ranch to water their cattle with windmills. There is a new technology so disruptive and unique the US government has granted a patent. Open your mind, remove your prejudices, and get ready to start thinking upside down. You are about to enter the world of the Skillman Downstroke Pump.

The Skillman Downstroke Pump is more than just a new pump, it is a new pumping system. The well must be tubed up right. The rod design must be modified, and the polish rod must be the same diameter or larger than the pumps plunger. These changes, along with the Skillman Downstroke pump design, create the most efficient method of producing sub surface fluids with a rod pump.

Let's begin with the pump itself. For simplification purposes we will use the tubing pump version of the Downstroke pump. The standing valve is attached to the bottom of the barrel The barrel is of sufficient length to accommodate the stroke length of the pumping unit. Inside the pump barrel is the plunger, but this plunger is slightly longer than the pump barrel itself. The traveling valve is attached to the bottom of the plunger. A top open cage connects to the top of the plunger, which in turn connects to the rod string. A key thing to remember here is this, <u>even when the pump is scoped all the way in or when the pump is at the bottom of it's down stroke, the top of the plunger ***always*** protrudes out the top of the barrel into the tubing string.</u> This is true with either a tubing pump or an insert pump. Another important factor to understand and remember is when the fluid is static and when the fluid is under pressure and moving. **As** we go through the pumping cycles I will make comparisons between the conventional lift pump and the Downstroke pump, their relationship with the rods and tubing and physical laws and properties that come into play.

We will start our pump comparison assuming the tubing is anchored and full of fluid without the presents of gas and the pressure in the annulus is less than that of the tubing. <u>*Fact:* The tubing is a sealed contained area. With the traveling valve open the seal points are the standing valve at the bottom of the tubing, the stuffing box, and the check-valve in the flow-line. This is a known area and does not dimensionally change with conventional pump or a Downstroke pump design. With the traveling valve closed the seal points are still the stuffing box, and the check-valve in the flow-line on the surface but with the traveling valve attached to the plunger the lower seal is now the barrel and plunger seal. In a conventional pump the top of the plunger is the closest part of the seal to the tubing. This seal point changes up and down in relation to the stroke of the pump as the plunger is shorter than the barrel and reciprocates within the barrel. With the Downstroke pump the seal point is always the top of the barrel. The plunger only seals where it is in contact with the barrel. This effectively keeps the tubing a constant volume, which does not change dimensionally throughout the stroke.</u>

## <u>THE CONVENTIONAL LIFT PUMP</u>

As the conventional pump starts the up stroke, the traveling valve closes effecting the plunger seal within the barrel. The fluid above the plunger must now be lifted. The plunger rising has the same effect as shortening the tubing, in that our sealed contained area is getting smaller. As we add the fluid from the barrel to the tubing, the fluid pressure increases as the area gets smaller. The check-valve in the flow-line opens at the surface. The rods stretch as the plunger they're connected to lifts a column of fluid equal to its diameter. <u>*Fact:* load, is measured in pounds, pressure is measured in pounds per square inch. Loads can change (by increasing or decreasing surface inches) even when PSI stays the same.</u> As the pressure increases the rods stretch more. This stretching shortens the net travel of the plunger reducing the efficiency of the pump. Pressure increases as long as there is upward movement of the plunger within the barrel until the polish rod and plunger are moving at the same rate, creating a constant load. When watching a pressure gauge on the tubing or flow-line what you see reflected is fluid being added to the tubing or plunger movement. This does not necessarily reflect or equal the movement of the polish rod. Besides rod stretch, causing the polish-rod to travel more distance than the pump plunger, there is also what we call slippage *Fuct.* Pressure or in our case pressurized fluid seeks the path of least resistance. it will escape through that path until it equalizes with where it is escaping to, or you cut off the path. Slippage is a term used to describe pressurized fluid slipping between the pump barrel and plunger from above a closed traveling valve to below a closed traveling valve. The greatest pressure in the barrel of a conventional lift pump takes place on the up stroke. The barrel above the traveling valve and plunger swells or slightly expands under this pressure increasing the gap or fit between the barrel and plunger. Couple that with a low pressure area below the traveling valve and plunger and it's easy to see why fluid slips by. If a plunger can stroke freely within the pump barrel, it is impossible to make a perfect seal. When on a timer, with a conventional pump. sand and other solids settle out of the produced fluid in the tubing string, and fall inside the pump barrel on top of the plunger. On startup, sand-laden fluid is forced between the barrel and plunger causing excessive wear. More wear means more slippage. Any fluid below the traveling valve is not produced. Gravity and pressure tries to move the fluid downward when you try to lift it. And pressure can greatly exceed the gravitational force. I would like to define *hydrostatic load* as the static gravitational weight of fluid at a given depth. *Hydrostatic pressure,* is any load greater than that. This is important because the two different conditions of fluid act differently. Static hydrostatic load reacts equally against cross-sectional area. Hydrostatic pressure will seek a path of least resistance and will direct its energy to that path. This can be seen in a fluid cut valve, which continues to get worst once the path has started.

With a high fluid level in the annulus or a very shallow well, the conventional rod pump can be somewhat efficient. The conventional pump lifts the fluid in the barrel above the plunger and adds it to he tubing to be produced. While below the plunger, the barrel is being filled with more fluid. The standing valve is open and the traveling valve is closed. With high pressure from the annulus at the pump intake, the pump will easily fill. When the volume and pressure of fluid in the annulus are greater than needed to fill the barrel at the rate the plunger is moving upward, it actually helps lift the plunger or fluid load. This reduces the horsepower required to lift the fluid to the surface. This also greatly reduces slippage and rod stretch, making the conventional pump more efficient. If the pressure in the annulus exceeds the pressure in the tubing, the well will flow causing the standing valve and traveling valve to stay open through the up and down strokes. In our well the annulus pressure is lower than the tubing pressure so when the conventional pump starts the down stroke the standing valve shuts and the traveling valve opens. The traveling valve does not necessarily open when on the surface the polish-rod is moving downward, the rod stretch must be removed. The time this takes depends on the SPM of the pumping unit. At this time the lower (and smaller) rods will go into compression, as the bore of the pump is larger than the I.D. of the plunger. *Fuct:* Going from 8 strokes per minute to 7 strokes per minute eliminates five hundred twenty five thousand and six hundred strokes per year. It also eliminates one million fifty one thousand and two hundred rod reversals per year! As rods go from tension to compression it fatigues or weakens the metal. This is why rod reversals are so hard on the rod string. As pump speed or SPM increases and as well depths increase the problem is compounded. The result is rod parts and a net loss of plunger travel in the pump. With the conventional pump the fluid in the tubing is static on the down stroke. Nothing happens, the plunger just passes through the fluid loaded on the previous up stroke. To sum up the conventional rod pump, it lifts and loads on the upstroke and does nothing on the downstroke. The deeper the well and the lower the fluid in the annulus gets, the less efficient a conventional pump is. You use more horsepower to get less fluid. The cost of a barrel of produced fluid increases.

## THE SKILLMAN DOWNSTROKE PUMP

For comparative purposes we will start with the Downstroke pump on the upstroke. The traveling valve closes and the standing valve opens. Remember the top of the plunger always protrudes into the non-sealing tubing area, even when the pump is scoped all the way in. With the barrel to plunger seal below the top of the plunger there is no ability to contain or keep or lift the column of fluid on top of the plunger. How much fluid could you lift placing a 1 1/16 plunger in a 1 1/2 pump barrel? If you were to run a dyno, your card would be flat and no fluid would be lifted to the surface. You can't carry much water in a bucket without sides. Just because you don't lift a fluid column at all doesn't mean there is no load at all. There is a given pressure at a given depth but this load is a constant. *Fuct:* Perfect constants can be perfectly counterbalanced. The horsepower necessary to do the required work is the difference between the up-stroke and downstroke loads, which are not counterbalanced.

A dynamometer reading is based on loads through the pumping cycle. The load cell is just a scale reflecting weight and changes in weight. There are several things that produce loads in a pumping well. Iron weight, pressures, fluid weight, restriction and friction, all can produce loads. A load cell can measure the load, but it cannot determine what is causing the load.

Back to the upstroke of the Downstroke pump. As the upper portion of the plunger inters the sealed contained tubing area, on the surface the polish rod or liner of equal diameter and mass is exiting the sealed contained tubing area. Therefor there is no pressure increase or increased load. There is no fluid from the barrel being added to the tubing string; therefor the fluid is static with no added pressure or load. The rods do not stretch any more as there is no increase in weight. Without rod stretch the down-hole stroke or plunger travel is equal to the travel of the polish rod. Through the open standing valve, fluid from the annulus is filling the area in the barrel as it is being vacated by the rising plunger. The only process taking place on the up stroke is filling the pump barrel with fluid.

As we start the downstroke the standing valve closes. The pump barrel is now full of fluid. The traveling valve opens as the falling pump plunger displaces the fluid in the barrel. This pressurized fluid in the barrel flows through the traveling valve, through the plunger and is added to the tubing string. On the surface the check-valve in the flow line opens and the produced fluid goes to the tank. All of the work to produce this subsurface fluid to the surface is being done with the weight of the rods and gravity.

This may be a good time to discuss the rod string design. What has to be achieved to pump on the down stroke is the weight required to displace fluid from a given depth and bore size to the surface. Anything short of this will throw the bridle off the horse head. The formula for displacement is- *bore X bore X . 7854 = sq. in. X fluid X depth = load + friction + restriction + buoyancy = required weight.* The lower rod string or displacement rods (the required weight) must be made from 7/8" rods, with slim hole couplings in 2 3/8 tubing, or 1" rods with slim hole couplings in 2 7/8 tubing. If large rods alone do not equal the required weight formula, sinker bars must be used. With the Downstroke pump, the rod string from the neutral point up to the surface is always in tension. From the neutral point down, these rods are neutral or compressed. Large rods can compress without significantly changing their length. This is important to achieve the same plunger travel in inches down hole, as polish rod travel in inches on the surface. One of the incredible things about the Downstroke pump is getting the net stroke down hole that you have on the surface! It doesn't matter if the well is 150 feet or 15,000 feet! If well conditions allow the pump to freely load or fill, and the valves hold, there are only two problems that keep a pump from being 100% efficient, slippage and loss of plunger travel or rod stretch. The Downstroke pump has conquered the lift pump problems.

When looking at a dyno of the Downstroke pump, it is very similar to a conventional lift pump. The loads are heavier on the up stroke and they are lighter on the down stroke. It is very important to understand how the Downstroke pump works because what you are seeing is not what you think you are seeing. It's always been assumed that the work is being done is when the loads are the highest, but I say the work is being done when oil is going in the tank. Before us is a mountain. Halfway up the mountain are two 1000 pound boulders. 500 yards up the mountain is the top of the hill and 500 yards down the mountain is the bottom of the hill. One boulder must be moved 500 yards to the top of the hill and the other boulder must be moved 500 yards to the bottom of the hill. Our jobs are equal, to move two equal loads an equal distance. I think I'll move the boulder to the bottom of the hill, but don't assume we will both equally feel like dancing when we get through with our work. **A** conventional lift pump picks up and moves a column of fluid on the up stroke with a traveling valve and plunger attached to the rods. On the down stroke it loses the fluid load from the rods as it transfers the load to the standing valve. A good card on a conventional pump has a wide spread showing it's picked up a heavy load, real efficient, moving lots of fluid. With the Downstroke pump we can't pick up a load of fluid on the up stroke, the fluid in the tubing is static. Now on the down stroke whatever weight is required to push the fluid to the surface comes off the weight of the rods. The dyno card may look a little flat and you may assume that the Down stroke pump is not very efficient, but go look in the tank. It's funny; oftentimes the rod programs interpret the Downstroke pump and tell you the rods are parted, but go look in the tank. No matter what kind of rod pump you use its job is to fill tanks with oil. Now if you want fewer rod parts, longer pump runs, the ability to pump sand and trash, to slow your pump down, use less horsepower and fill the tank faster, then you should be using the Skillman Downstroke Pump. In comparison to the conventional lift pump the Downstroke pump performs better as wells get deeper.

## BENEFITS OF THE DOWNSTROKE PUMP

### Trashy Wells

Iron sulfide, fracsand, formation sand, course to baby powder fine, pipe scale all of these abrasives are known culprits for wearing out and sticking pumps. With the plunger of the Downstroke pump always sticking out into the tubing, sand can't settle out and get inside the pump barrel. We are now pumping wells that were shut down because no other pump could pump them. I'm reminded of a well in Oklahoma that the longest run was with a PA plunger pump. The PA pump ran almost 40 minutes. The well is about 8000 ft. deep. It started off flowing but when it stopped flowing everything was sanded in. The tubing couldn't be pulled and they tried to put it on pump. They tried every brand of sand pump made. No pump would run long enough for the crew to rig down before it stuck. They sent the rig home after running several different pumps and shut in the well. About 2 years later with oil prices back up, they decided to look at the well again. The Oil Company thought the well would make 50 to 60 barrels of oil a day. We ran a 1 1/4 bore Downstroke pump in that well and made 144 barrels a day for about 6 months until the pull tube wore into. The rest of the pump was stuck so they decided run another Downstroke on a pump anchor just above the other pump. About **9** months later the pull tube wore into again. They run another downstroke pump on top of the last one, which is still pumping. The well has averaged 140 barrels of oil a day pumping through several hundred feet of sand and two other pumps. When the company man was asked, with all the money this well has made why don't you fix the well right? His response was why, there is room to put 4 or *5* more Downstroke pumps in there before we have to.

Another well in New Mexico makes a lot of super fine sand. They daily have to clean out the separator but we doubled production and ran many times longer than previous pumps. It's not that Downstroke pumps don't wear, they do, although by design not as fast as conventional lift pumps. The big difference is in the way they operate, the barrel and plunger fit is not so critical in a Downstroke pump. I will address this in the next benefit.

### Efficiency

A key to understanding slippage is understanding where the pressure in a pump is, as fluid is being produced. In a conventional lift pump the fluid is being produced on the up stroke. The greatest pressure in the pump barrel when the fluid is being produced is ***above*** the traveling valve. Below the traveling valve is a low-pressure area. The low-pressure area is where fluid wants to slip to, so the smaller the path (or the tighter the barrel and plunger fit) less fluid can slip by. Any fluid below the traveling cannot be lifted or produced.

On the other hand, the Downstroke pump produces fluid on the down stroke. The greatest pressure in the pump barrel when the fluid is being produced is *below* the traveling valve. With the greatest pressure in the pump barrel being between the standing valve and the traveling valve. The low-pressure arca is the tubing. As fluid slips by the plunger of a Downstroke pump it is being produced. What does it matter if fluid goes through the plunger or around the plunger if the fluid is going to the tank? Isn't that incredible, with a Downstroke pump fluid slips to where you want it to go!

### Rod Life

With an API rod string design and a conventional lift pump, rods go from tension to compression through the pumping cycle. The greatest fatigue in the rods takes place when going from compression *to* tension. The Smaller the rod diameter the greater the stress. Smaller diameter rods also have more side to side movement within the tubing, which take the rods out of axial alignment under compression, this in turn creates more stress.

The Downstroke pump uses the rods in a totally different manner. The upper part of the rod string, the part above the neutral point is always in tension. The lower part of the rod string (this is the part with the required weight for displacing the fluid to the surface) is neutral or compressed. This compression of rods takes place in the sinker bars or the large rods, which can easily take the compressive loads without undo stress. Because of the design of the Downstroke pump and the way the rods relate to it, the rod string stays virtually the same length throughout the up and down strokes of the pump. This is astonishing, not just because we have reduced the rod stress to the point where rod parts are almost nonexistent, but we can achieve net stroke length in the pump equal to the stroke length on the surface! This allows for pump efficiencies, long thought impossible, to be achieved using the Downstroke technology.

### Horsepower and Energy Requirements

The horsepower required to produce fluid to the surface is the unbalanced difference between the peak and minimum loads. A high peak load has bearing on the structure load of the pumping unit, but it actually has little to do with the horsepower required to do the work. Place one million pounds on each end of a teeter-totter, and with your finger, you can raise or lower one million pounds depending on which side of the fulcrum you place your finger. Any load that is counterbalanced doesn't cost you to move. The closer the peak and minimum loads are to each other, the less horsepower required. The peak and minimum loads are closer together on shallow wells. The deeper the well, the greater the difference between the peak and minimum loads. Therefor more horsepower is required. No mater what depth the well is, the Downstroke pumps peak and minimum loads are closer together than a conventional lift pump of the same size. With the Downstroke pump you can perfectly balance the pumping unit. Don't worry about the flat looking card, go look in the tank and enjoy the savings.

## cost

True cost can only be measured one way, cost per barrel of produced fluid. That must reflect all related expenses. The greatest costs to producers are *lost production* from inefficient or worn out pumps and down time. The other is ***rig*** *time*, for rod parts or pump changes and pump repairs. Now, unless the pump company you are now using gives you 15 barrels of crude oil for every 85 barrels you produce, gives you free pumps and pays your rig bill to replace them, pays your rig bill to fish rods and pays 5% to 40% of your electric bill, then you should think about using the Downstroke Technology.