Sucker rod pumping system engineering essay

Artificial lift allows wells to be produced that are non-flowing. Generally this is achieved by a mechanical device inside the well, such as pump; decreasing the weight of the liquid/gas mixture via high pressure gas; or improving the lift efficiency of the well. In the production string (tubing) that is usually set without a production packer, a pump placed below the dynamic fluid levelling the well lifts the crude up to the surface. This energy input allows the fluid to continue on its way and relieves the pay zone of all or part of the back pressure downstream from the pump.

Sucker Rod Pumping is the most common method of artificial lift (85%), with gas lift second (10%), and then electrical submersible and hydraulic pumping about equal (2%) in usage. Sucker rod pump uses a vertical positive-displacement pump consisting of a cylinder and a hollow plunger with a valve i. e. it works by creating a reciprocating motion in a sucker rod string that connects to the downhole pump assembly. It is run into the tubing screwed onto the end of a rod string. The system is actuated from the surface by a motor that drive a walking beam or a hydraulic elevator.

Introduction

Sucker Rod Pumps, also called Donkey pumps or beam pumps, are the most common artificial-lift system used in land-based operations. Motor drives a reciprocating beam, connected to a polished rod passing into the tubing via a stuffing box. The sucker rod continues down to the oil level and is connected to a plunger with a valve.

On each upward stroke, the plunger lifts a volume of oil up and through the wellhead discharge. On the downward stroke it sinks (it should sink, not be pushed) with oil flowing though the valve. The motor speed and torque is controlled for efficiency and minimal wear with a Pump off Controller (PoC). Use is limited to shallow reservoirs down to a few hundred meters, and flows up to about 40 litres (10 gal) per stroke

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Technical Details:

Artificial lift allows wells to be produced that are non-flowing. Generally this is achieved by a mechanical device inside the well, such as pump; decreasing the weight of the liquid/gas mixture via high pressure gas; or improving the lift efficiency of the well. Artificial lift consists of two main processes:

Mechanical lifting by pumps.

Lessening the fluid density by mixing with gas injected in the part of the production string , or gas lift

In the production string (tubing) that is usually set without a production packer, a pump placed below the dynamic fluid levelling the well lifts the crude up to the surface. This energy input allows the fluid to continue on its way and relieves the pay zone of all or part of the back pressure downstream from the pump. The two most common pumping methods in the world are:

Sucker rod pumping

Centrifugal pumping

Sucker Rod Pumping:

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Components

Every part of the pump is important for its correct operation. The most commonly used parts are described below:

Barrel: The barrel is a large cylinder which can be from 10 to 36 feet long and a diameter from 1. 25 to 3. 75 inches (95 mm). After using several materials for its construction, the API (American Petroleum Institute) standardized the use of 2 materials or compositions for this part which are carbon steel and brass, both with an inside coating of chrome. The advantage of brass against carbon steel, weather is a more soft material, is its 100% resistance to corrosion.

Piston: This is a nickel-metal sprayed steel cylinder that goes inside the barrel. Its main purpose is to create a sucking effect that lift the fluids beneath it and then, with the help of the valves, take those fluids above it and, progressively, out of the well. It achieves this with a reciprocal up and own movement.

Valves: The valve has two components – the seat and the ball – which create a complete seal when closed. After trying several materials, the most commonly used seats are made of carbon nitride and the ball is often made of silicon nitride. In the past, balls of iron, ceramic and titanium were used. This last type of balls, made of titanium, is still being used but only where crude oil is extremely dense and/or the quantity of fluids is too much. The most common configuration of a rod pump requires two valves, called the travelling valve and fixed or static valve.

Piston Rod: It’s a rod that connects the piston with the outside of the pump. Its main purpose is to transfer the engine produced by the “ Nodding Donkey” above in an up/down reciprocal movement.

Fitting: The rest of the parts of the pump is called fitting and is, basically, small pieces designed to keep everything hold together in the right place. Most of these parts are designed to let the fluids pass uninterrupted.

Filter: The job of the filter, as guessed, is to stop big parts of rock, rubber or any other garbage that might be loose in the well from going into the pump. There are several types of filters, being a common iron cylinder with enough holes in it to permit the entrance of the amount of fluid the pump needs the most commonly used.

Explanation Of How It Works/ Is Used:

Figure A: Components of Sucker Rod Pump

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A motor and gearbox supply power to turn the power shaft. There is a counterweight at the end of the crank. A pitman arm is attached to the crank and it moves upward when the crank moves counterclockwise. The Samson arms support the walking beam. The walking beam pivots and lowers or raises the plunger. The rod attaches the plunger to the horsehead. The horsehead (not rigidly attached) allows the joint (where rod is attached) to move in a vertical path instead of following an arc. Every time the plunger rises, oil is pumped out through a spout. The pump consits of a four bar linkage is comprised of the crank, the pitman arm, the walking beam, and the ground.

Figure B: Operational Detail of Sucker Rod Pump

Here the plunger is shown at its lowest position. The pitman arm and the crank are in-line. The maximum pumping angle, denoted as theta in the calculations, is shown. L is the stroke length. After one stroke, the plunger moves upward by one stroke length and the walking beam pivots. The crank also rotates counter clockwise. At the end of the upstroke the pitman arm, the crank, and the walking beam are in-line.

For name and location of parts, see Figure A:

A motor supplies power to a gear box. A gearbox reduces the angular velocity and increases the torque relative to this input.

As shown in Figure B, (the crank turns counter clockwise) and lifts the counterweight. Since the crank is connected to the walking beam via the pitman arm, the beam pivots and submerges the plunger. Figure B also shows the horsehead at its lowest position. This marks the end of the down stroke. Note that the crank and the pitman arm are in-line at this position.

The upstroke raises the horsehead and the plunger, along with the fluid being pumped. The upstroke begins at the point shown in Figure B. At the end of the upstroke, all joints are in-line. This geometric constraint determines the length of the pitman arm.

Figures C (a) and C (b) show the plunger and ball valves in more detail. These valves are opened by fluid flow alone.

During the plunger’s upstroke the plunger valve or riding valve is closed. The column of liquid corresponding to the stroke will be lifted up to the surface while, relieved of the weight of the fluid, the pressure of the pay zone can then open the bottom valve or standing valve, thereby allowing the pump barrel to fill up with effluent.

During the down stroke the valve of the hollow plunger opens and the standing valve closes, thereby preventing the fluid from returning into the pay zone and allowing the plunger to return freely to its initial point at the base of pump barrel.

The pump is single acting and its theoretical output is equal to the volume generated by the plunger’s stroke and cross-section multiplied by the pumping rate, i. e. in a homogenous system:

Q= S*N*A

Where,

Q= Flow rate. S= Stroke.

N= Number of strokes per time unit. A= Area of the plunger.

In practice following parameters are also involved:

An efficiency factor

A coefficient depending on the units that are use

Figure C(a)

TABLE OF VARIABLES THAT AFFECT SUCKER ROD

STRING AND PUMPING UNIT LOADING

Polished rod load

Pumping speed

Pump setting or depth

Physical characteristics of the rod string

Dynamic characteristics of the rod string

Plunger diameter of the pump

Specific gravity

Pump intake pressure

Polished rod acceleration pattern

Mechanical friction

Fluid friction

Pump submergence

Compressibility or gas interference

Pumping unit inertia

Pumping unit geometry

Counterbalance

Torque characteristics of prime mover

Flow line pressure

Innovativeness and Usefulness:

Any liquid-producing reservoir will have a ‘ reservoir pressure’: some level of energy or potential that will force fluid (liquid and/or gas) to areas of lower energy or potential. You can think of this much like the water pressure in your municipal water system. As soon as the pressure inside a production well is decreased below the reservoir pressure, the reservoir will act to fill the well back up, just like opening a valve on your water system. Depending on the depth of the reservoir (deeper results in higher pressure requirement) and density of the fluid (heavier mixture results in higher requirement), the reservoir may or may not have enough potential to push the fluid to the surface.

Most oil production reservoirs have sufficient potential to produce oil and gas – which are light – naturally in the early phases of production. Eventually, as water – which is heavier than oil and much heavier than gas – encroaches into production and reservoir pressure decreases as the reservoir depletes, all wells will stop flowing naturally. At some point, most well operators will implement an artificial lift plan to continue and/or to increase production.

In relative to US data sucker rod pumping is the most common method (85%); with gas lift second (10%), and then the electrical submersible and the hydraulic pumping about equal (2%) in usage. Plunger lift and several variations of all these processes are in limited use. The prominence of sucker rod pumping is due, in part, to the large number of shallow, low productivity wells in the Midwestern and western United States. Mainly sucker rod pumps are used for onshore areas.

Sucker rod pumps are used primarily to draw oil from underground reservoirs. The mechanisms it employs however are found in a wide variety of machines. The four bar linkage can be found on door dampers, on automobile engines, and on devices such as the lazy tong. The Sterling engines also use a linkage similar to the one used by the pump.

Current Status of Development:

Every project requires an in depth study of the topic. Being in the starting phase of our project, currently we are going through as many books, journals and online material as we can. Collecting as much data as we can, we plan to go through an extensive study of sucker-rod pumps and artificial gas drive techniques, principles etc.

Having a comprehensive knowledge of sucker-rod pumps is our first objective, after which we will think of ways in which we can apply practically.

Current sources being referred: