

Artificial Lift to Boost Oil Production

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Abstract— Increase in world energy demand has encouraged the producers to search for methods to improve production and economics for oil wells.

Artificial lifts improves the production and economics by increasing flow rates and optimizing the production cycle of oil and gas reservoirs. It is one of the most important methods to boost oil production from oil well. Artificial lift solutions are designed to overcome bottom-hole pressure to enable a well to produce at the desired rate. This typically involves either using a pump or injecting gas to reduce its hydrostatic pressure to provide additional lift pressure downhole.

Keywords— Artificial Lifts, Oil & Gas Production, Offshore, Sub-sea.

I. INTRODUCTION

Production of oil requires energy to lift the fluids from the reservoir to the surface. In the early phase of their production lifetime, the majorities of oil wells flow naturally and are referred to as flowing wells. In a naturally flowing well there is enough energy stored in the reservoir to flow the produced fluid to the surface. Reservoir pressure and formation gas provide this energy in the flowing well. When reservoir energy is too low for natural flow, or when the desired production rate is greater than actual production rate then it becomes necessary to use artificial lift to get desired production.

Even though subsea completed wells enable development of deep water resources as well as marginal fields in normal water depths, without some form of subsea processing, these wells are expected to experience poor ultimate recoveries due to the high backpressures. Study of researchers' shows that operating on continual high backpressure has direct impact on production decline behaviour that wastes reservoir energy. Energy that could be used to move reservoir fluids to the wellbore and out of the well is instead lost to flow through a choke or a long flow line. It is expected that some form of subsea boosting and/or processing of produced fluids will be necessary to improve efficiencies, allowing longer production from these wells and better recovery factors. Subsea processing covers a wide spectrum of subsea separation and boosting scenarios.

And also, an increasingly large number of producing wells are maturing so operators must resolve a number of new problems which will impact the total economics of their production. The most common development for maturing gas wells is

reduced bottom hole pressure and increased production of liquids, predominantly water.

Abandoning a mature well was once an option but now regulatory bodies are appearing more and more unreceptive toward abandoning producing wells too early so operators are looking at new technologies such as multiphase boosting as options to enhance oil recovery and maintain economical late-life production.

II. ARTIFICIAL LIFT

Artificial lift process is used to increase reservoir pressure and encourage crude oil to the surface. Artificial lift is employed when the natural drive energy of the reservoir is not strong enough to push the oil to the surface. Artificial lift is used to recover more crude oil from the reservoir. While some wells contain enough pressure for oil to rise to the surface without stimulation in beginning but it will reduce over the time. Artificial lift is generally required on most of the wells at some time during their production life or to increase oil well life.

Artificial lift is used to overcoming bottom-hole pressure so that a well can produce at some desired rate, either by using a pump to provide additional lift pressure or injecting gas to reduce its hydrostatic pressure.

Artificial lift uses to increase the flow of liquids to the surface of a production oil well and this is usually achieved by

- A mechanical device inside the well, such as a pump;
- Decreasing the weight of the liquid/gas mixture via high pressure gas;
- Improving the lift efficiency of the well via velocity strings.

Generally, people tend to associate artificial lift with mature, depleted fields, where reservoir pressure has declined such that the reservoir can no longer produce under its natural energy. But these artificial lift methods are also used in younger fields to increase production rates and improve project economics.

III. TYPES OF ARTIFICIAL LIFT

Selection of the proper artificial lift method is critical to the long-term profitability of the oil well; a poor choice will lead to low production and high operating costs. There are several methods of artificial

lift but following two main categories of artificial lifts are:

- A) Pumping Lifts
- B) Gas Lifts

A. Pumping Lifts

Pumps are used to increase reservoir pressure to lift fluid from reservoir to the surface. These pumps can be divided into two basic categories:

- Positive displacement pumps ,
- Dynamic displacement pumps.

Pumping lift is the most efficient and cost effective lift methods of crude oil from the reservoir and pumps can be modified to lift corrosive fluids. Pumps can be employed on high-temperature wells. .

1) Positive Displacement Pumps:

A positive displacement pump works by moving fluid from a suction chamber to a discharge chamber. Positive displacement pump operates on the principle that a definite amount of fluid is transferred through the pump based on the volume created by the pumping chamber and the speed at which this volume is moved. The amount of differential pressure that develops in the pump is a function of the resistance to flow downstream of the pump that incurs the pressure losses which must be overcome to deliver the fluid to a set pressure downstream of the pump. For any positive or near positive displacement pump, the interaction between the pump and the adjacent pipeline segments determines pump performance.

This basic operating principle applies to sucker-rod pumps, progressive cavity pumps and hydraulic piston pumps.

a) Sucker-rod Pump: Sucker-rod lift method is the oldest and most commonly used artificial lift method for a wide range of production rates and operating conditions. A sucker-rod pumping system is made up of several components, some of which operate aboveground and other parts of which operate underground, down in the well. The surface-pumping unit, which drives the underground pump, consists of a prime mover and, normally, a beam fixed to a pivotal post. The post is called a Sampson post, and the beam is normally called a walking beam. This system allows the beam to rock back and forth, moving

the downhole components up and down in the process. The entire surface system is run by a prime mover, V-belt drives, and a gearbox with a crank mechanism on it.

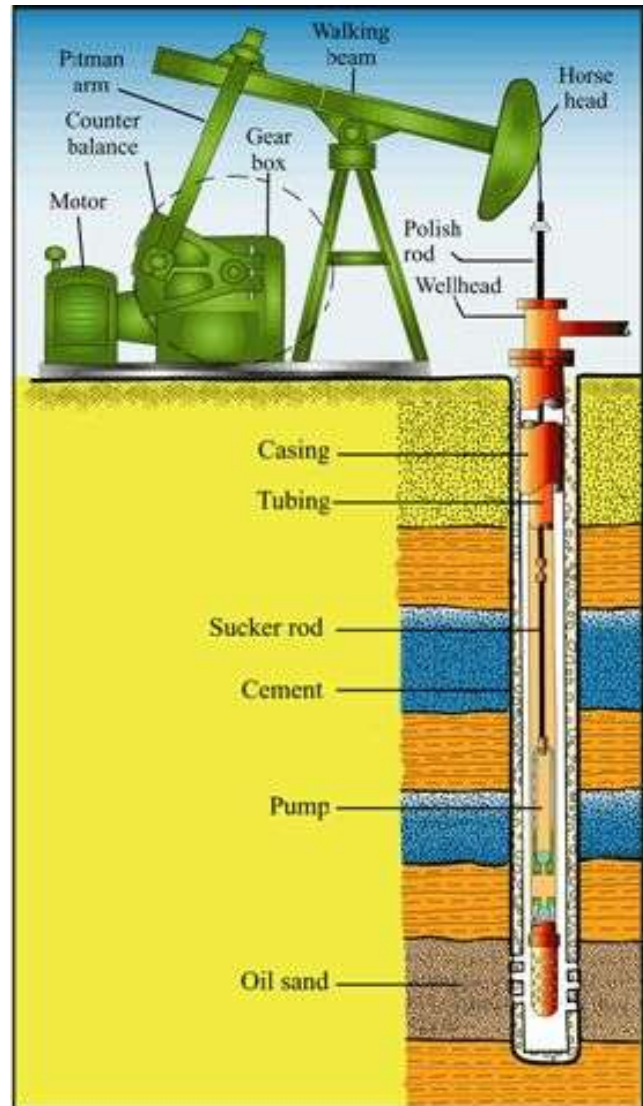


Fig. 1 Sucker-rod Pump, Source [14]

Rod pumping systems can be used to reduce bottomhole pressures to very low levels, and offer great flexibility for low-to-medium production rates. They are relatively simple with respect to design, operation and maintenance, and can be adapted to a wide range of operating conditions. They account for the large majority of artificial lift wells, and are one of the most well-known and generally understood systems in the field. Surface and downhole equipment can easily be refurbished, and tends to have high salvage values.

b) Progress Cavity Pumps: Positive displacement pump that consist a single helix rotor turning inside a double helix

stator. As the rotor turns, driven by a topsides motor, an advancing series of cavities are formed between the rotor and stator, in which the fluid is displaced through the pump and up the tubing. The stator is attached to the tubing string while the rotor is attached to a rod string, attached to and rotated by the topsides pump.



Fig. 2 Progress Cavity Pump, Source [13]

Progress Cavity Pumps are widely used in shallow wells as an artificial lift method; the Progressing Cavity Pump has been adapted for surface pumping. These pumps are comprised of a rubber stator and a rotating metal rotor. This pump is effective for low flow rates (less than 30,000 bbl/day total volume of gas, oil and water) and for lower discharge pressures (maximum of 400 psig).

Progress Cavity Pumps very efficient and excellent for handling fluids with high solids content. However, because of the torsional stresses placed on rod strings and temperature limitations on the stator elastomers, they are not used in deeper wells.

- c) Hydraulic Piston Pumps: One of the simplest forms of pump. Hydraulic piston pumps operate similarly to sucker rod pumps, but are actuated hydraulically from the surface rather than mechanically with a sucker rod. The system uses the well fluid as the power fluid, and not hydraulic oil. The fluid is pressurized at the surface by the pump through the tubing string to actuate the piston pump.

Hydraulic pumping systems produce economically and reliably from deep wells. Our pumps are also easily installed in deviated wells, offshore platforms, remote jungle areas, urban areas, and

environmentally conscious areas. Special pump designs are available for such completions as sliding sleeves, gas lift mandrels, coil tubing, DST, well cleaning and testing. The hydraulic jet pump is used with higher pressure reservoirs while the hydraulic piston pump is geared towards low pressure reservoir applications.

The Hydraulic piston pump gives you easily controlled changes in pumping rate over a wide range of capacities. This allows rapid “trimming” of the system to accommodate changing well conditions, such as the effect of water flooding or declines in well production capability.

This approach is effective in the low and moderate flow rate ranges with a maximum capacity of approximately 110,000 bbl/day (total volume of gas, oil and water) and maximum discharge pressure of approximately 1,400 psig.

2) Dynamic Displacement Pumps:

A dynamic displacement pump works by causing fluid to move from inlet to outlet under its own momentum, as is the case with a centrifugal pump. It operates on the principle that kinetic energy is transferred to fluid which is then converted into pressure. In dynamic displacement pumps, this occurs when angular momentum is created as the fluid is subjected to centrifugal forces arising from radial flow through an impeller. This momentum is then converted into pressure when the fluid is slowed down and redirected through a stationary diffuser.

Dynamic displacement pumps commonly used in artificial lift include Helico-axial Pumps (ESPs) and Multistage Centrifugal Pumps.

- a) Helico-axial Pumps: The Helico-axial pump is a type of dynamic displacement pump and fluid flows horizontally through a series of pump stages, each consisting of a rotating helical shaped impeller and a stationary diffuser.

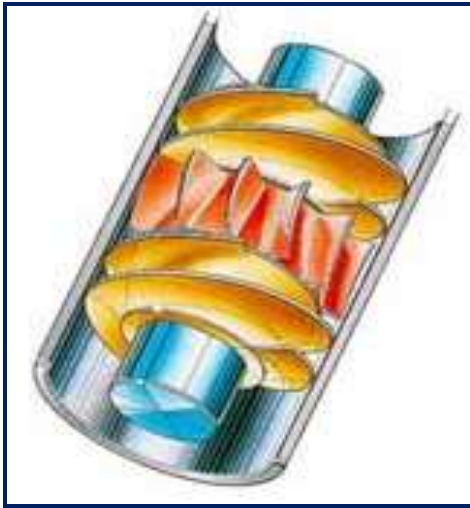


Fig. 3, Helico-axial Pump, Source [5]

- b) **Multistage Centrifugal Pumps:** Multistage Centrifugal Pumps are dynamic pumps and they contain several impellers within a single casing. Electric Submersible Pumps (ESP's) are basically multistage centrifugal pumps and are used as an artificial method in oil wells.

There are different drive mechanisms for the pump and different ways of delivering the motor force to the oil, but at the end of the day, each of them add energy to the system.

B. Gas Lifts

Gas lift is the process of injecting high pressure gas in the annulus between tubing and casing through one or more subsurface valves at predetermined depth. The gas will then reduce the weight of the produced fluid column, which will lower the bottom-hole pressure. Reservoir fluid will then experience lower resistance to flow, resulting in increased flow rates and increased production.

The main idea in gas lift technology is that by compressing gas at the surface and injecting it as deep as possible into the well, the density of the fluid decreases, thereby reducing the hydrostatic pressure loss along the flow path. Due to the reduced pressure drop in the well, the pressure in the bottom of the well becomes sufficiently low to continue production, in other words, the injection of gas at the riser base mixes with and lightens the oil and hence enhances the production rate. This method is favourable for offshore fields due to flexibility in its production rates, ability to handle corrosive fluids, suitable for high temperature.

Gas lifts use gases such as natural gas, nitrogen, or carbon dioxide (CO₂) that expand in a reservoir to push additional oil to a production wellbore, or

other gases that dissolve in the oil to lower its viscosity and improve its flow rate.

Gas lift systems can be classified in following categories:

1) *Continuous gas lift:*

A gas is injected in a constant, uninterrupted stream in this lift. This lowers the overall density of the fluid column and reduces the hydrostatic component of the flowing bottomhole pressure. This method is generally applied to wells with high productivity indexes.

Continuous gas lift is cost effective, easy to implement, and very effective in a wide range of operating conditions, in addition to requiring less maintenance in comparison to the other alternatives, and is considered as one of the most typical forms of artificial lift in oil production.

2) *Intermittent gas lift:*

Intermittent gas lift is designed for lower-productivity wells to increase the production. In this type of gas lift installation, a volume of formation fluid accumulates inside the production tubing. A high-pressure "slug" of gas is then injected below the liquid, physically displacing it to the surface. As soon as the fluid is produced, gas injection is interrupted, and the cycle of liquid accumulation-gas injection-liquid production is repeated.

Gas lift systems can be classified in another way based on the reuse of injection gas.

1) *Rotational Gas Lift:*

In this gas lift system, the gas recovered from oil is compressed and sent back for production. This system is known as 'Rotational Gas Lift' systems. This is a closed system and uses a fixed amount of gas over and over again for gas lift. External supply of injection gas is not required for rotational gas lift system.

2) *Recoverable Gas Lift:*

The injection gas is supplied from an external source in this gas lift system. Gas recovered from gas lift is sent for commercial uses through a pipeline and this gas is not re-injected for production.

IV. APPLICATIONS

Artificial lifts can be used for offshore, onshore or sub-sea applications to boost oil production from low and medium pressure wells.

V. CONCLUSIONS

In this study, I have analysed that artificial lifts are viable option to boost oil production and it prove to be most useful. Artificial lifts acquire major share of their revenues and help oil recovery markets generate better returns from difficult international reservoirs.

Artificial lifts can reduce back pressure on the well by boosting the untreated well flow, and by allowing the reservoir to accelerate production and the operator to delay abandoning a producing well.

Energy of a reservoir reduces later in the field life so artificial lift systems are useful for mature oil reservoirs but it can also be used in younger fields to increase production rates and improve project economics.

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