

UDC 622.276

Ponomarenko O.S. student group 185m-23-2

Scientific supervisor: Khomenko V.L., Candidate of Sciences, Senior Lecturer of the Oil and Gas Engineering and Drilling Department

(Dnipro University of Technology, Dnipro, Ukraine)

A COMPARATIVE REVIEW OF ARTIFICIAL LIFT METHODS

Introduction

In the petroleum industry, artificial lift methods are crucial for enhancing oil recovery, especially as natural reservoir pressure declines. The main objective of artificial lift is to reduce the pressure in the wellbore, facilitating the flow of hydrocarbons to the surface. This review highlights the main artificial lift methods, emphasizing their operational principles, advantages, and limitations.

Results

The selection of an artificial lift method depends on various factors, including reservoir depth, fluid characteristics, sand content, gas-oil ratio, and economic considerations [1]. Table 1 summarizes the most commonly used artificial lift techniques, outlining their operational mechanisms, specific advantages, limitations, and optimal application environments. This overview allows for a more precise understanding of each method's suitability for different well conditions.

Table 1.

Comparison of Common Artificial Lift Methods

Method	Mechanism	Advantages	Limitations	Optimal Application Conditions
Gas Lift	Injection of gas into the well to reduce fluid density	Effective in deep wells; adjustable production rates	Requires continuous gas supply; high maintenance costs	High gas-oil ratio wells, especially in deep fields
Electrical Submersible Pump (ESP)	Electric motor drives a multi-stage centrifugal pump to lift oil	High production rates; suitable for high-flow wells	Sensitive to gas entrainment; susceptible to sand damage	Deep wells with stable oil flow and low gas/sand content
Progressing Cavity Pump (PCP)	Positive displacement pump suitable for high-viscosity fluids	Tolerant of heavy oil and sand; low shear, minimizing emulsion formation	Limited depth; lower efficiency in high gas wells	Shallow-to-medium depth wells with viscous or heavy oil, and moderate sand
Rod Lift (Beam Pump)	Surface motor drives a sucker rod to lift oil to the surface	High energy efficiency; reliable in shallow wells	Limited to shallow depths; challenging with high gas content	Shallow, low-flow wells, especially in mature or low-pressure fields
Hydraulic Pump	Uses pressurized fluid to move oil to the surface	Adaptable to a wide range of depths; less sensitive to well deviation	High maintenance cost; complex surface equipment	Wells with varying depths and challenging geometries

Gas Lift: Gas lift systems introduce gas into the production tubing, reducing the fluid density and facilitating oil flow to the surface. They are particularly effective in high gas-oil ratio wells and in deeper fields where mechanical pumps may encounter limitations. However, gas lift requires a steady supply of injection gas and extensive infrastructure, making it less suitable in remote or cost-sensitive fields [2].

Electrical Submersible Pumps (ESP): ESPs are highly effective in high-flow environments and can operate efficiently in deeper wells. Their design involves an electric motor connected to a multi-stage centrifugal pump, allowing them to handle high production rates [3]. However, ESPs can be sensitive to gas and sand, which can clog or damage the pump, thereby requiring careful monitoring in wells with such characteristics [4].

Progressing Cavity Pumps (PCP): PCPs, known for their suitability with high-viscosity fluids, are positive displacement pumps that can tolerate abrasive materials. Their low shear rates reduce the risk of emulsion formation, which is beneficial for heavy oil recovery. However, PCPs have a limited depth range due to mechanical constraints, and their performance may decline in wells with high gas content.

Rod Lift (Beam Pump): Widely used in shallower wells, rod lifts are driven by a surface motor that powers a series of rods to lift oil. This method is reliable and energy-efficient in shallow, low-flow wells, especially those in mature fields where other methods may be economically impractical. However, rod lifts have limitations in depth and can experience issues with gas interference, which reduces efficiency.

Hydraulic Pumps: Hydraulic pumps employ high-pressure fluid to lift oil, making them adaptable to various depths and effective in wells with deviated paths. Their flexibility is valuable in complex well geometries, though they require high-maintenance surface equipment and may have higher operational costs than other lift methods.

Each artificial lift method has specific advantages and limitations, with effectiveness determined by well characteristics, reservoir conditions, and economic constraints.

Conclusions

Artificial lift methods have become essential in maximizing the extraction of oil from mature reservoirs. While each method has advantages and drawbacks, their effectiveness largely depends on specific reservoir characteristics, fluid properties, and economic factors. Future improvements in artificial lift technology should focus on enhancing adaptability and efficiency under extreme reservoir conditions.

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