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Role of Artificial Lift Techniques in Oil and Gas Production with Respect to Gas Lift System in Tertiary Recovery

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Abstract: When a self-flowing oil well ceases to flow or it is not able to deliver the required quantity to the surface, the additional energy is supplemented by means of mechanical or by injecting compressed gas to lift required quantity of oil to the surface is called as artificial lifting. The main purpose of artificial lift is to create or maintain a required low bottom hole pressure against the formation sand so that the well fluid can flow continuously from reservoir to the well bore and there to surface. This is the fundamental basis for the design of artificial lift.

I. PATH – SECTORS

The path sector influencing design and analysis of ALT can be classified into 4 sectors. The first component includes reservoir drainage area to around the well bore and second from around the well bore to the well. I.e. the first and second one represents the wells ability to bring fluids from reservoir to the well. The third component of flow path is the entire tubing in the vertical /inclined / horizontal path which includes all systems like, down hole artificial lift equipment, sub – surface safety valves, non return valves etc. The fourth component includes the surface flow path which consists of length and diameter of flow line, valves, bends, wellhead, chokes, manifold, separator etc. Any change in the parameters in any of the four sectors, will affect the parameters of other sectors.

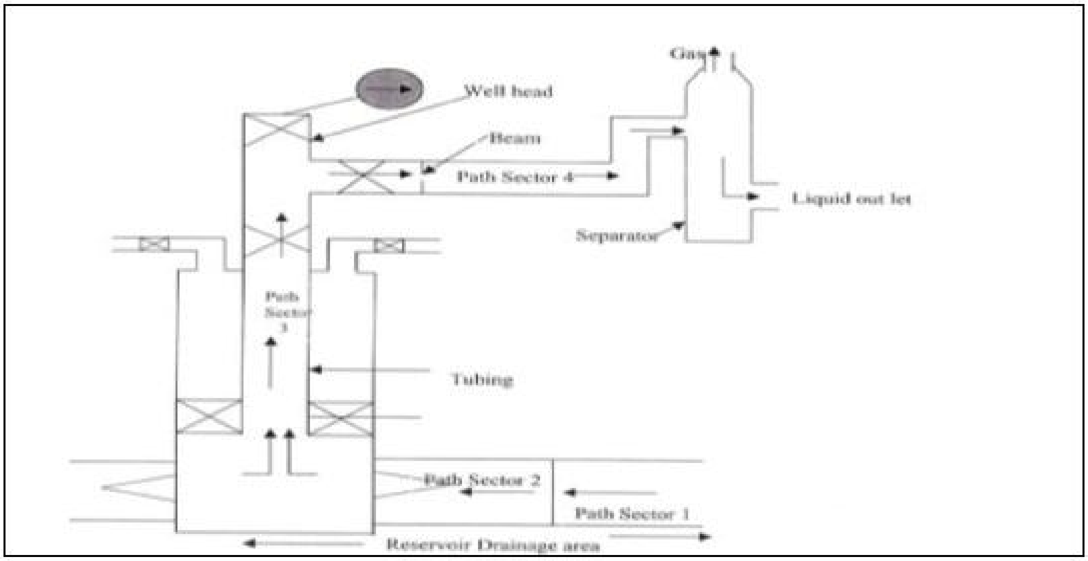


Fig.1.1. Schematic diagram of different path sectors of fluid from reservoir to surface

The four main sectors can be simplified into two categories naming Inflow and outflow performance. The fluid flow from the reservoir up to the wellbore can be termed as inflow performance and similarly flow from wellbore up the tubing to surface equipment can be termed as outflow performance. So the outflow system must be designed in such a way to exploit the well"s inflow capability. For any given well, outflow performance and inflow performance must be equal. In other words, we can produce no more fluid from the reservoir than we can lift to the surface and vice versa.

II. INFLOW PERFORMANCE PREDICTION

Productivity index is the measure of the ability of well to produce fluid into the wellbore at a given reservoir pressure. The productivity index is generally measured during a production test on the well, by first shutting-in the well. So that the well bottom hole pressure starts rising up to reservoir pressure. The well is then allowed to produce at a constant flow rate, q and a stabilized bottom-hole flow pressure, Pwf. When flowing bottom hole pressure equal the reservoir pressure, no flow is observed while, maximum liquid rate occurs when flowing bottom hole pressure is zero. IPR is a graph plotted between production rate and flowing bottom hole pressure. It can be straight line nd curve. PI can be denoted as a point in IPR when it is curved .

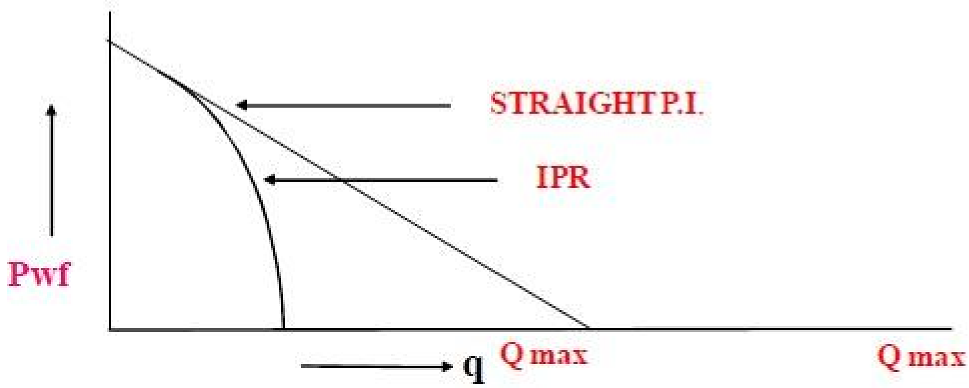


Fig.1.2 Inflow performance relationship

III. OUTFLOW PERFORMANCE PREDICTION

One of the major factors affecting the production performance of a well is the pressure loss in the production tubing. Around 80% of the well"s total pressure loss is in lifting the fluid to the surface, while the remaining percentage is lost in the reservoir. Tubing intake pressure / outflow pressure is the pressure required at the bottom of the tubing to pump a required amount of liquid to the surface at a given well head pressure.

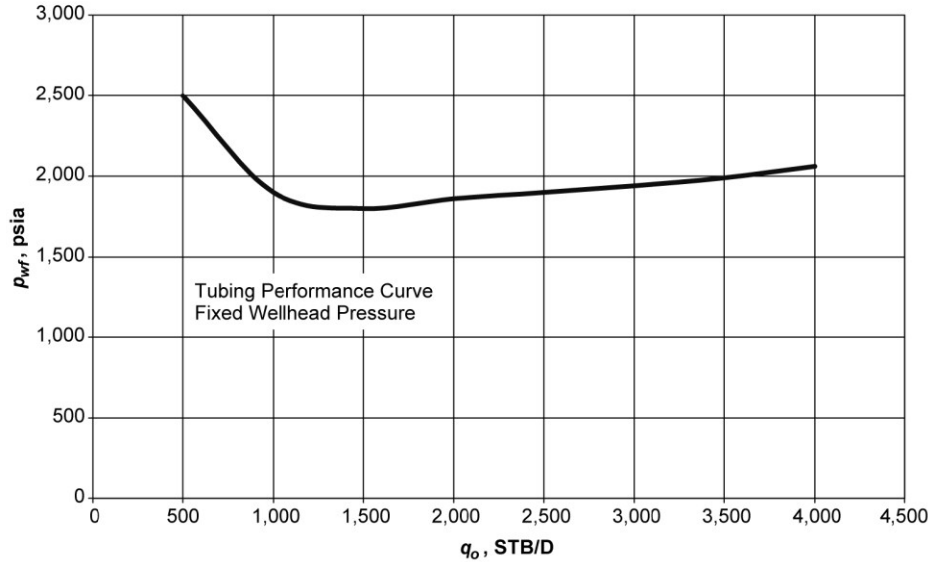
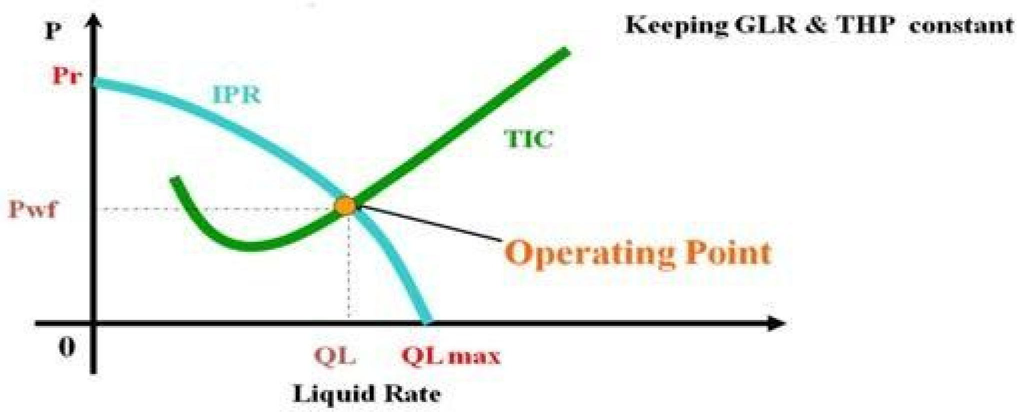


Fig. 1.3. Outflow performance relationship

IV. OPERATING POINT DETERMINATION

Operating point shows us the required bottom hole pressure that need to be maintained to achieved desired production rate. This operating point can be found out by combining both IPR curve with TIC curve. The point of intersection of IPR with TIC is called Operating Point, since both the IPR and the TPR relate the bottom hole flowing pressure to the surface production rate.

Once the tubing has been installed, tubing head pressure is the only paramater to control the flow rate of the well. For a given gas liquid ratio, tubing diameter and tubing depth, the vertical lift performance curve (VLC) is a function of tubing head pressure and liquid flow rate. If the tubing head pressure is reduced to zero, then the tubing intake pressure decreases, which cause an increase in drawdown pressure between the well bore and the reservoir. Thereby increasing the flow rate. In this case IPR cuve intersect with TIC curve representing self flow condition of well.



Zig.1.4. Operating Point Determination

An increase in tubing head pressure will cause an increase in the tubing intake pressure or bottom hole pressure and a corresponding decrease in flow rate. Similarly decresing the tubing head pressure, say to zero, will result in achieving the maximum production rate from the well. Once the tubing head pressure is reduced to zero and maximum self flow is achieved, it is not possible to produce fluid from the well at a higher rate without modifying the installation or introducing some form of artificial lift.

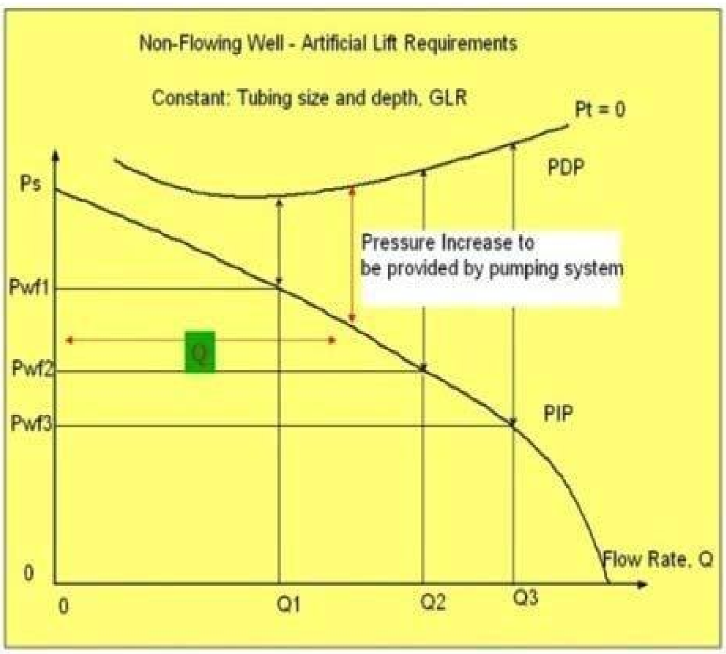


Fig.1.5. IPR and VLP matching

Artificial lift methods increase the production rate by reducing pressure drop along the well or by lightening of the hydrostatic column with the help of mechanical means and by injecting gas respectively.In other words, maintaining a required flowing bottom hole pressure, is the fundamental basis for design of an artificial lift installation.

The second category of artificial lift mentioned above is called “gas lift” method. By decreasing the weight of hydrostatic fluid column in the well will help in lifting of the fluid easily and the reduction in fluid column will cause low bottom hole pressure,

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which increases the draw down. One of the main advantages of gas lift that makes it popular among the oil industry is its flexibility under various operating conditions.

V. GAS LIFT SYSTEM

Liquid removal by using gas lift started during 18th century for the removal of water from flooded mine shafts and the lifting medium then used was air. The same system of lifting, i.e. with the air was adopted by oil industry to lift oil in Pennsylvania oil fields around 1865 in the beginning for lifting oil. It continued up till around mid-1920's. The people started realizing the problems involved in the use of air as a lifting medium for oil, as mixing of air with hydrocarbon may not only causes explosive mixture but also corrosion because of the presence of oxygen. So, from then onwards compressed natural gas or high pressure natural gas is being used in lifting oil.

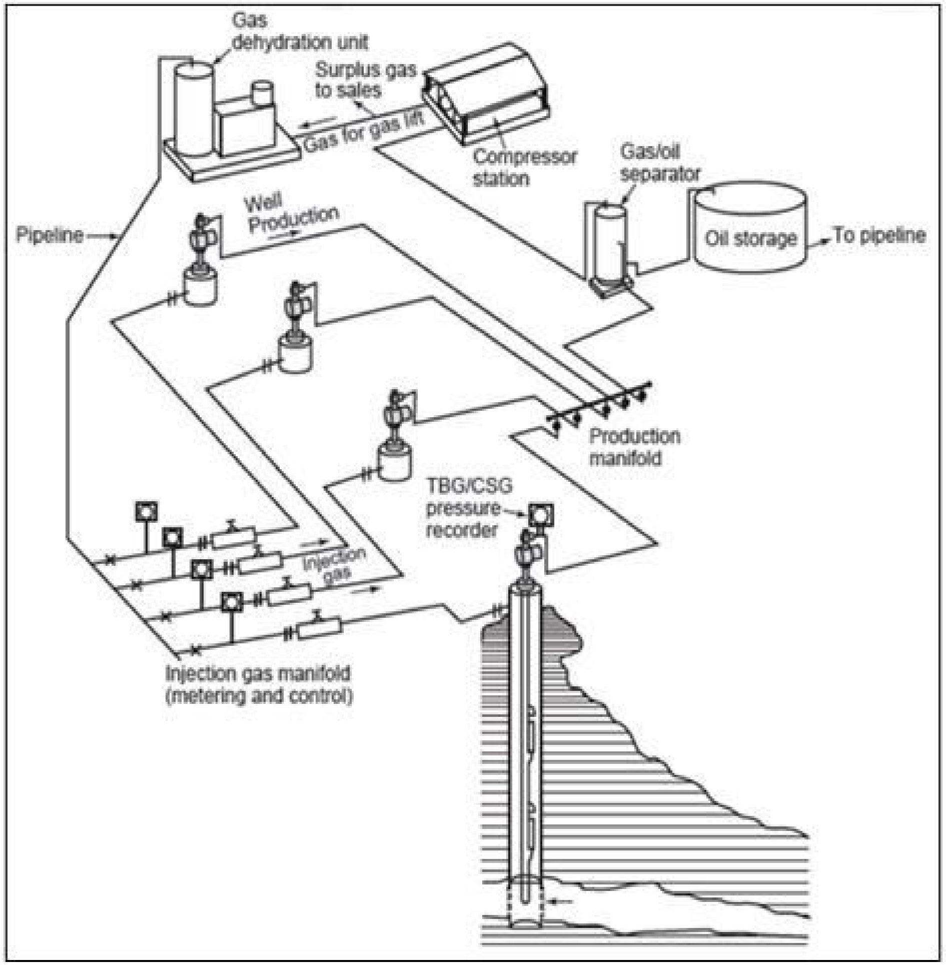

Fig.1.6. A typical gas lift system

Early simple "U"-tube or pin-hole principle was used in lifting oil from shallow wells. With the advent of gas lift valves, the gas lift application could be extended to deeper wells. Because of the abundance of gas and low operating cost, the gas-lift is one of the major artificial lift systems used extensively around the world.

VI. OVERVIEW OF A GAS LIFT SYSTEM

Gas lift system is a type of artificial lift system used to start the flow from a well which cease to flow or increase the production rate of a well to desired rate by injecting high pressure gas through casing tubing annulus. Gas upon entering the tubing, improves liquid flow in two ways, one isthe expansion energy of high pressure gas which pushes the oil to the surface and next isby aerating the oil column by gas, so that the density of the fluid column get reduced, which in turn reduce the flowing bottom hole pressure. This leads to increased pressure draw down across the well bore and sand face, increasing well inflow.

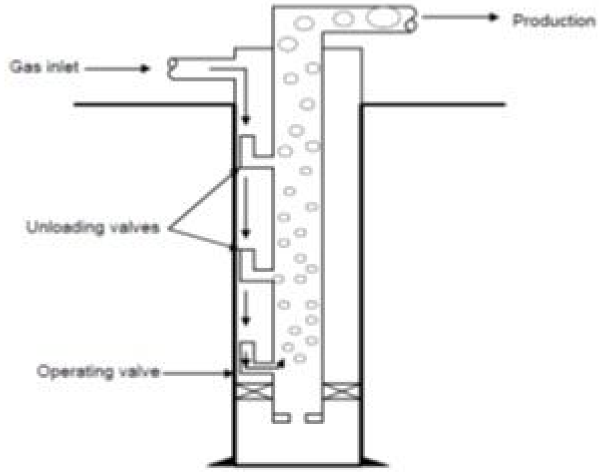

Fig.1.7. configuration of typical gas lift well

When a self-flowing well cease to flow and the reservoir pressure as well as productivity are sufficiently large so that the liquid get loaded in the well and there is an adequate flowing bottom hole pressure, then by injecting gas, the fluid gradient mixture will get reduced and well starts to flow. The effect of increase of GLR in formation fluid on production can be shown with the example of increase in GLR Ratio from 150scf/bbl (formation GLR) to 600scf/bbl for a fixed liquid production rate of 500bbl / day. The tubing head pressure is kept constant at150 psi, since this pressure is required for other surface equipment processes. The tubing intake pressure at 5250 feet is reduced from a value of 1850 psi for 150 GLR to a low value of 1320 psi when the GLR is increased to 300scf/Bbl. The tubing intake pressure get further reduced when more gas is introduced into the tubing, i.e. to a value of 980 psi for 600scf/bbl. This reduction in tubing intake pressure will result in high flow rate.

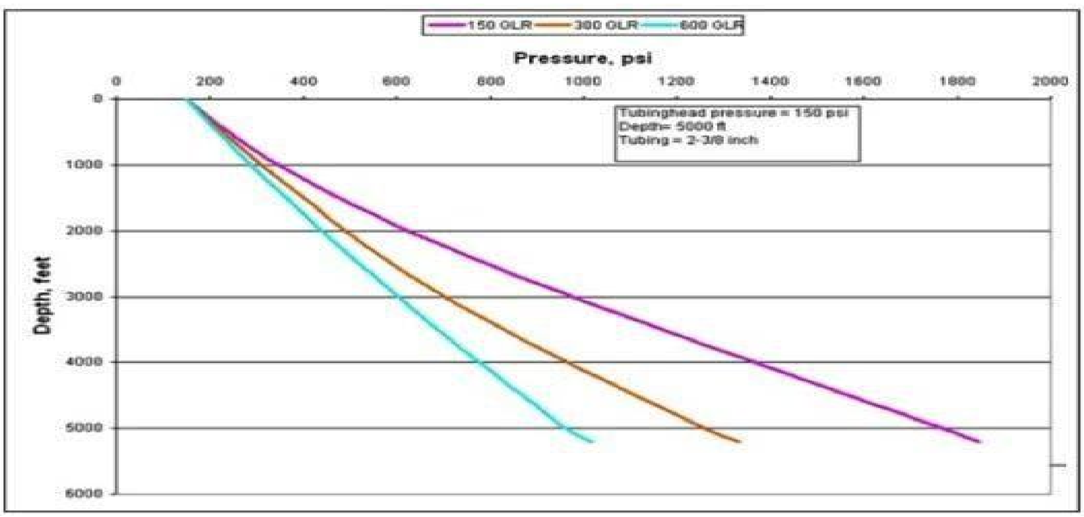

Fig.1.8. Wellbore Pressure vs. Depth Traverses for Various Gas-to-Liquid Ratios

The second example shown below is tubing intake pressure relation with liquid flow rate for different GLR. 700bbl/day is the maximum achievable flow rate when bottom hole flowing pressure reduced to zero obtained with the help of IPR curve. Self-flow of oil to the surface is not achieved with a THP of 150 psi since TIC curve for the pressure does not coincide with IPR curve. In order to start the flow additional gas is injecting in the tubing at considerable depth to achieve a GLR of 300scf/bbl, lowers the TIC curve so that it intersects with the IPR curve to give flow rate of 350bbl/day. By increasing the injecting gas rate further lowers the TIC curve, so that it is possible to achieve flow rate of about 500bbl/day for a gas injection rate of 600 GLR. If the desired rate of production is 500bbl/day, gas lift installed to provide a GLR of 600scf/bbl.

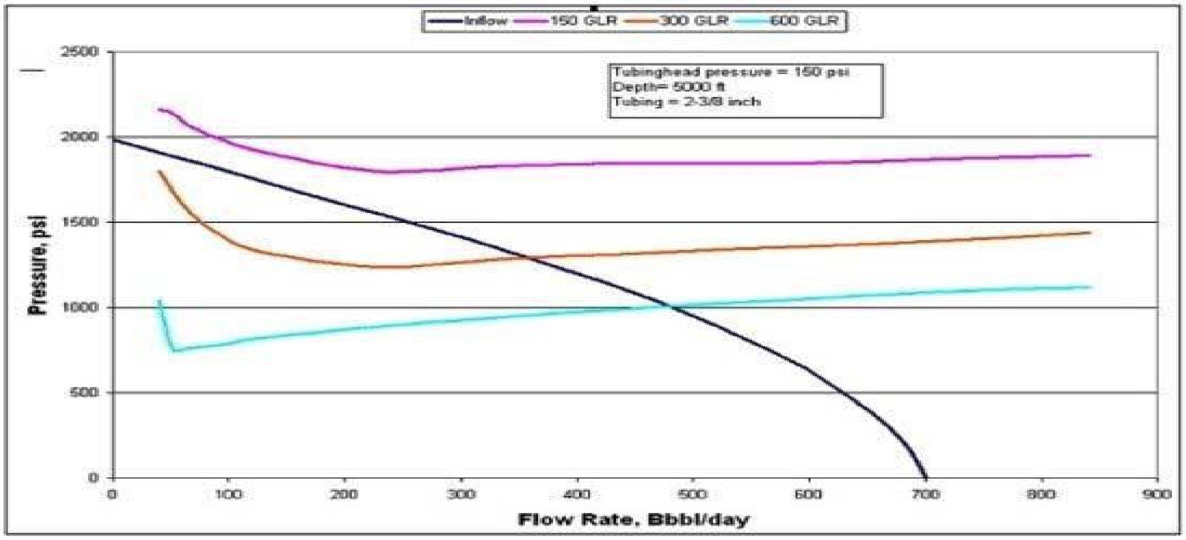

Fig1.9. ressure vs. Flow rate IPR and VLP Relations for different Gas-to-Liquid

VII. APPLICATION OF GAS LIFT

- *A.* Oil wells: The main target of gas lift in oil wells is to increase the production of depleted fields. It"s often used in self-flowing wells to achieve desired production rate.
- *B.* Water wells: Gas lift is used in water wells to produce water from aquifers.
- *C.* Starting wells: Kick off wells that will flow naturally once the heavier completion fluids are evacuated from the production string.
- *D.* Applicable for lifting fluids in wells that have a significant amount of gas produced with crude.

VIII. ADVANTAGES OF GAS LIFT

- *A.* Takes full advantage of the gas energy available in the reservoir.
- *B.* A poorly designed gas lift well with few well data is able to perform well. This is an advantage because usually the spacing design must be made before completion and testing of well.
- *C.* Deviated or crooked holes can be lifted easily with gas lift. So it have an application for directional drilled well in offshore.
- *D.* Gas lift is the best artificial lift method for handling sand or solid materials. Many wells produce some sand even if sand control is installed.
- *E.* High-formation GORs are very helpful for gas-lift systems but hinder other artificial lift systems. Produced gas more means less injection gas is required; whereas, in all other pumping methods, pumped gas reduces volumetric pumping efficiency drastically.
- *F.* Gas lift is flexible. A wide range of volumes and lift depths can be achieved with essentially the same well equipment.
- *G.* Well subsurface equipment is relatively inexpensive. Repair and maintenance expenses of subsurface equipment normally are low.
- *H.* Wire line-retrievable gas lift valves have an advantage of replacing the valve without killing a well or pulling out the tubing.

IX. LIMITATIONS OF GAS LIFT

- *A.* Adequate gas supply is needed throughout life of project. If the field runs out of gas, or if gas becomes too expensive, we need to switch to another artificial lift method.
- *B.* It is difficult to lift low gravity (less than 15°API) crude in gas because of greater friction, gas fingering, and liquid fall back.
- *C.* Gas lift is very sensible to wellhead pressure variation.
- *D.* Wide well spacing and lack of space for compressors on offshore platforms may limit application of gas lift.
- *E.* Poor compressor maintenance can increase compressor downtime and add to the cost of gas lift.
- *F.* Compressors are expensive and must be properly maintained.

G. Good data are required to make a good design. If not available, operations may have to continue with an inefficient design that does not produce the well to capacity.

X. TYPES OF GAS LIFT

Gas lift system is classified into two categories
A. Continuous gas lift.
B. Intermittent gas lift.

1) *Continuous Gas Lift :*The basic principle underlying the natural flow and continuous gas lift is same. The only difference between them is the source of gas. In the case of natural flow, gas comes into the well bore either along with oil or in the dissolved condition in the oil whereas, in the latter case, the gas is conveyed down the hole and is injected into the oil body. That is why continuous gas lift can be seen
2) as an extension of the self-flow period of oil well. It is usually applied on wells with high productivity index (PI).

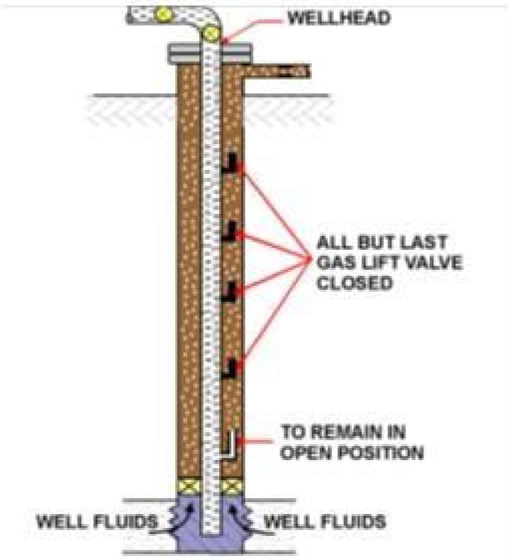

Fig.1.10. A typical continous gas lift operation

The basic principle of continuous flow gas liftis to inject the gas in the oil body at some predetermined depth at a controlled rate to aerate the oil column above it and as a result the density of oil column gets reduced to a point where a flowing bottom hole pressure for a desired rate of production is sufficient to lift the oil to the surface. Thus, oil is produced continuously from the well. Gas injection is done at a slow rate and continuously. Because of this reason, the port size of the gas lift valve is smaller in comparison with port sizes of the gas lift valves for intermittent gas lift. Generally, the port sizes for continuous gas lift are 3/16", 1/4" and 5/16". It is also generally intended and the accepted practice that in the continuous gas lift, only one valve will be accomplishing the gas injection work and that this valve should be as deep as possible as per the available normal gas injection pressure. This valve is termed as 'operating valve'. The valves above it are used to unload the well to initiate the flow from the reservoir. Once the gas injection begins through the operating valve, the upper valves, termed as "unloading valves" are closed. In case there is disruption in gas injection, the well will be loaded. So, when gas lift is resumed, the well is required to be unloaded with unloading valves.

XI. INTERMITTENT GAS LIFT

Intermittent gas lift is applicable for the wells which have the following characteristics:
1) High PI, low bottom hole pressure
2) Low PI, low bottom hole pressure
3) Low PI, high bottom hole pressure

In intermittent gas lift sufficient volume of gas at the available injection pressure is injected as quickly as possible into the tubing under the liquid column and then the gas injection is stopped. This volume of gas expands and it displaces the above liquid slug on to the surface. So, the assistance of flowing bottom hole pressure is not required in this case for lifting oil. In this system, a pause or idle period is provided, when no gas injection takes place. In this period the well is allowed to build up. Then gas injection starts and gas is injected for a period of time and stops. Then again, next injection cycle is started to produce oil. In this way, intermittent gas lift works. It is to be noted that in the cycle, injection time should be as short as possible, so that a large volume of gas can be injected quickly underneath the oil slug. As a result oil slug above the point of gas injection will acquire the terminal velocity (maximum velocity) within shortest possible time, which would minimise the liquid fall back in the tubing string. Less fluid fall back will not only increase production but also help reduce the paraffin accumulation problem in the tubing.. For injecting large amount of gas, large ported gas lift valves are required having port sizes 1/2", 7/16", 3/8" or 5/16". In intermittent gas lift, gas injection can be achieved in either multipoint injection system or single point injection way. In multipoint injection way, the gas is injected from bottom valve and while the gas expands and liquid slug is lifted up, above valve open and more gas is injected below the slug. This prevents liquid fall back and reduction in gas volume which leaks through the liquid slug. This process continues till the liquid slug reaches the surface, which arresting further liquid fall back and thereby increasing production. In single point injection system, gas is injected only through the bottom valve.

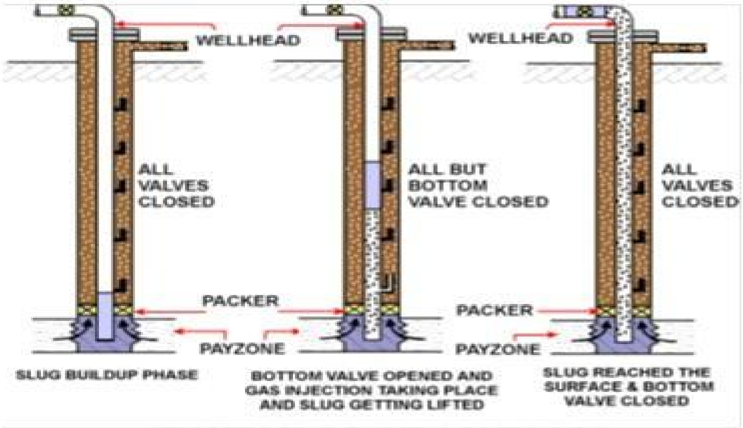

Fig.1.11. A typical conventional intermittent single point gas lift operation

A. Condition For Continuous Flow And Intermittent Flow

CONDITION	CONTINUOUS FLOW	INTERMITTENT FLOW
Production Rate (bbl/day)	100 – 75,000	Up to 500
Static BHP (psi)	> 0.3 psi/ft	< 0.3 psi/ft
Flowing BHP (psi)	> 0.08 psi/ft	150 psi and higher
Injection gas (scf/bbl)	50 – 250 per 1000 ft of lift	250 – 500 per 1000 ft of lift
Injection Pressure (psi)	> 100 psi per 1000 ft of lift	< 100 psi per 1000 ft of lift
Gas injection rate	Larger volumes	Smaller volumes

Table.1.1. Condition for continuous and intermittent flow

XII. CONCLUSION

Artificial lift systems are among the most widely used production technologies in global oil and gas operations. Wells that cannot produce liquids to the surface under their own pressure require lift technologies to enable production. Some liquid wells need lift assistance from the beginning and almost all require it sooner or later. The majority of the producing wells worldwide currently use artificial lift. One of the most popular artificial lift methods applied in the oil industry, in order to enhance oil recovery, is the gas lift method. Its main principal is the injection of gas in the well to reduce the average density of the fluids produced from the reservoir, hence the weight of the fluid column. As a result, the declined reservoir pressure is sufficient to lift the fluids up to the surface.

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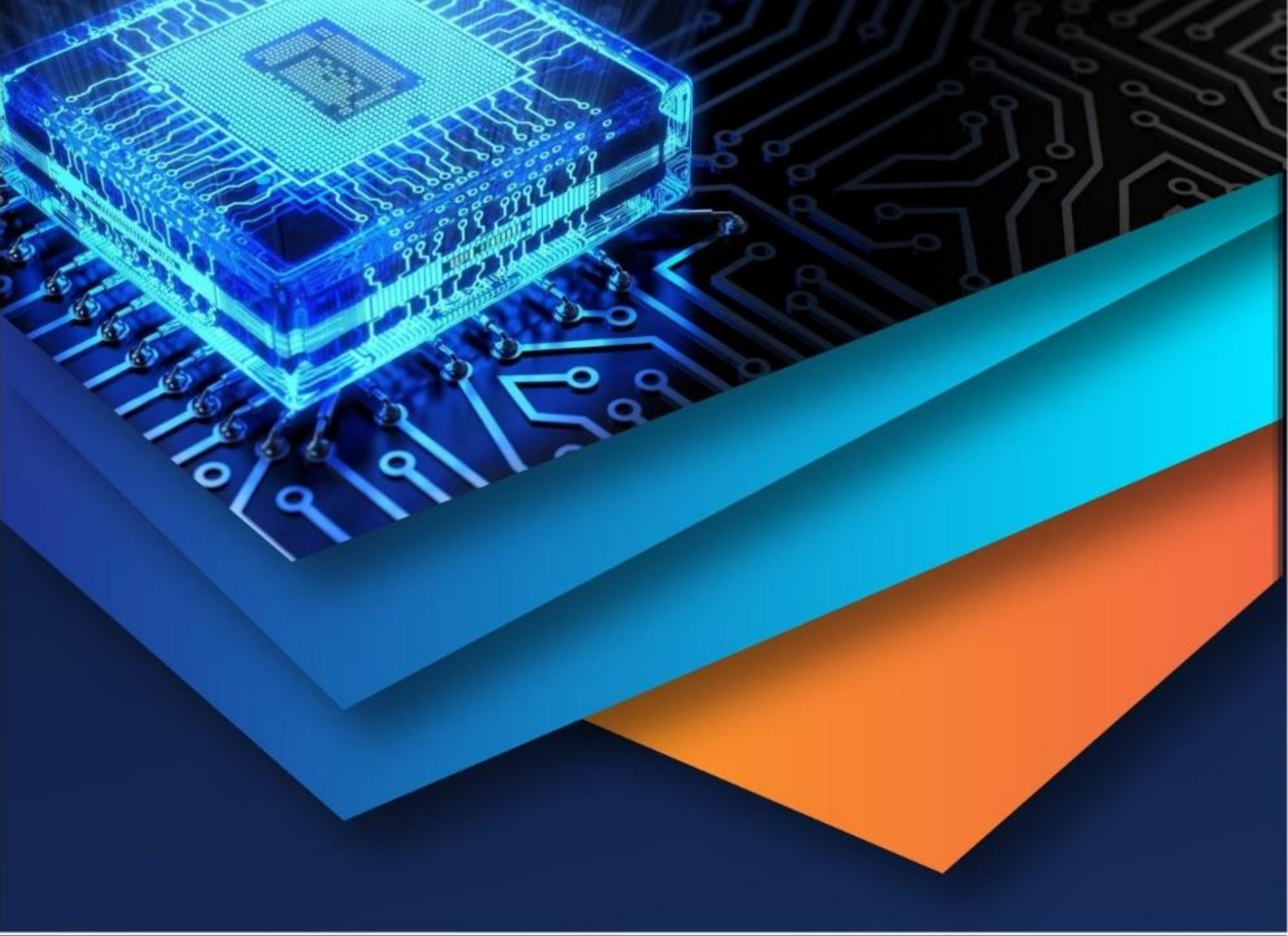

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