Artificial Lift Systems

By

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Lecture Outline

• Artificial Lift Systems
  – Sucker Rod/Beam Pumping
  – Plunger Lift
  – Progressive Cavity Pump (PCP)
  – Hydraulic Pump
  – Electric Submersible Pump (ESP)
  – Gas Lift
  – Foam Lift

• Design and Selection Considerations
  – The Reservoir and Well Deliverability
  – The Piping and Artificial Lift System
  – Environmental Constraints
  – Operational Constraints
  – Economics
Introduction

• AL systems are the technologies used to augment fluid production from the reservoir. These fall into several categories depending on the operating principle, design and energy source. Production rate from wells may need to be augmented principally for two reasons;
  – Inadequate reservoir drive and energy to produce fluid from the reservoir
  – Non-economic production rate from reservoir’s natural energy drive

• Aim of Artificial Lift Systems
  – Reduce the weight of the hydrostatic column on the reservoir, by reducing the density of the fluid column, thereby reducing the drawdown on the reservoir ($\bar{\rho} - \rho_{wf}$), so the formation can give up the desired reservoir fluid
  – Add energy to the reservoir fluid for lifting, this also achieves the aim above.
When Do we Need Artificial Lift?

Low Reservoir Pressure/ Production Rate

- When reservoir pressure drops and cannot support the weight of column and losses in the line
  \[ P_{\text{reservoir}} < P_{\text{line}} + P_{\text{hydrostatic}} \]

- When economic production rates cannot be achieved by natural drive and energy of the reservoir.

Liquid Loading

When the hydrostatic gradient of the liquid column prevents gas from coming into the well in low rate gas and condensate reservoirs.

\[ P_{\text{reservoir}} < P_{\text{hydrostatic}} \]
Most wells will Need Artificial Lift Sometimes in their Productive Life
Operational Classification of Pumps

**Dynamic Pumps**
These pumps operate by developing a high liquid velocity and converting the velocity to pressure in a diffusing flow passage. They continuously impart kinetic energy to the pumped fluid by means of a rotating impeller, propeller or rotor.

A centrifugal pump consists of an impeller with an intake at its center. Centrifugal pump include radial, axial and mixed flow units.

Examples include;
- Submersible pump
- Vertical multistage pump
- Horizontal multistage pump

**Positive Displacement Pumps**
The positive displacement pump operates by trapping a fixed amount of fluid and forcing the trapped volume into the pumps discharge, it alternately fills a cavity and then displacing the trapped volume of liquid. The positive displacement pump delivers a constant volume of liquid for each cycle against a varying discharge pressure or head.

Examples;
- Reciprocating pumps- piston, plunger
- Rotary pumps – Progressive cavity pumps (PCP)
Operational Classification of Pumps

- Dynamic
  - Rotodynamic
    - Centrifugal
    - Axial
    - Progressive Cavity Pump (PCP)
  - Reciprocating
    - Sucker Rod/Beam Pump
- Positive Displacement
  - Rotary
  - Other
    - Jet or Venturi Pump
    - Electric Submersible Pump
Sucker Rod or Beam Pump
(Reciprocating Positive Displacement Pump)

In this pump, a down-hole plunger is moved up and down by a string of rods (sucker rods) connected to an engine at the surface. The plunger’s movement displaces produced fluid into the tubing via a pump consisting of a combination of travelling and standing valves located in the pump barrel.
Plunger Lift is a method of artificial lift that uses the well’s own energy, either pressure or gas rate, to effectively lift fluids to the surface. The plunger creates a seal with the tubing wall to reduce the amount of gas/liquid slippage and lift the fluid to surface as completely as possible.
Progressive Cavity Pump (PCP)
(Rotary Positive Displacement Pump)

**PCP** - This pump employs a helical metal rotor rotating inside an elastomeric, double helical stator. The rotating motion is supplied by either a downhole electric motor or by rotating rods from an engine at the surface.

- **Helical metal Rotor**
- **Stationary elastomer**
- **Shape of cavity between stator and rotor for moving fluid**
Hydraulic Pump
(Dynamic Pump)

Hydraulic pumping are in two categories;

- **Hydraulic Piston Pump**: This uses high pressure power fluid to drive a downhole turbine pump.
- **Jet Pump**: This uses high pressure flow through a venturi or jet, creating a low pressure which produces an increased drawdown and inflow from the reservoir.
Electric Submersible Pump (ESP)  
(A Dynamic Centrifugal Pump)

ESP employs a downhole centrifugal pump driven by a three phase electric motor. The electric motor is powered via an electric cable that runs from the surface, on the outside of the tubing.
Gas Lift Systems

Gas lifts fall in two categories, **Continuous** and **Intermittent**.

Gas Lift Systems

In gas lift, high pressured gas is supplied to the casing/tubing annulus and the gas is injected into the tubing string through specially designed gas valves, positioned in the mandrels on the tubing. The injected gas lessens the density of the hydrostatic fluid column.
Lift Technology By Energy Source
Lift Technology By Lift Capacity

- **Plunger Lift**
- **Foam Lift**
- **PCP**
- **Rod Lift**
- **Hydraulic Lift**
- **ESP**
- **Gas-Lift**

Lift Capacity:
- **Low**: 200
- **Medium**: 5000
- **High**: 6000
- **Very High**: 35000, 60000, 75000

Diagram showing different lift technologies with corresponding lift capacities.
Artificial Lift Market Share by Type Based on Dollars Spent

- ESP - Electrical Submersible Pump
- RRP - Sucker Rod Pump
- PCP - Progressive Cavity Pump
- GL - Gas Lift
- PL - Plunger Lift
- HL - Hydraulic Lift

From Spears Oilfield Market Report, Oct, 2011
Design and Selection Considerations

- Reservoir and Well Deliverability
- Surface Piping and Treatment Facility
- Environmental Constraints
- Operational Constraints
- Economics
Reservoir and Well Deliverability

• Reservoir Characteristics Like;
  – Deliverability of the reservoir-This is the well’s inflow performance (IPR) which represents the ability of the well to produce fluid.
  – Properties and nature of produced fluids
  – Liquid Productive Capacity of the Well
  – Gas Production Expected from the Well
  – Long term recovery plan

• Well Characteristics Like;
  – Well Inflow characteristics
  – Formation depth and dogleg limitations and Effective Lift
  – Production Casing size
  – Annular and tubing safety system
  – Hole Characteristics
  – Completion Type
Location and Environmental Constraints

- Offshore or Onshore locations: This will determine the space constraints and what is possible on location, for example, Sucker rod pumps would not be feasible offshore.

- Urban Center or remote locations

- Climatic and Weather Extremes

- Distance from wellhead to processing facilities: This is determine the design well head pressure.

- Power source: What power source is available? Diesel, Natural gas, solar etc. to power the ALS.
Surface Piping and Treatment Facility

- The surface treatment facility in place would affect the type of ALS to be selected. This consideration on the following:
  - flow-line,
  - flow-line restrictions such as chokes, safety valves
  - separator,
  - artificial lift mechanism
Operational Constraints

- Operating Problems such as solids, formation fines. Some ALS are more tolerant of solids than others.

- Choice of ALS material will depend on the operating conditions of:
  - Bottom hole temperature,
  - Corrosive fluids
  - Extent of solid production
  - Production rate

- Automation: Will the system be automated once installed e.g. Intelligent Wells and Smart fields

- Operating Personnel: Is there capable manpower to run and operate the ALS

- Service Availability- Availability of ALS maintenance service provider in area.

- Available Power Source: This will limit the type of engine that the ALS system can have.
Economics

• CAPEX (Capital Expense) - This is the initial acquisition and installation cost of the ALS. Centralized or standalone system.

• OPEX (Operating Expense) – This is the cost that would be incurred in the daily running of the ALS. Costs here include, fuel, servicing, replacements parts etc. Its best to choose a system with low OPEX.

• Personnel Training Costs

• Repair and Replacement Costs

• Economy of scale: Number of wells in the field with same system may give better project economics..

• Reliability
• Production engineers are sometimes faced with the question; how big a ALS should I design for? Should I design for immediate production or design for future production rates. An ALS can be under-designed or overdesigned for fluid and well conditions.

• Hence a good projection of future production profile must be taken into considerations when carrying out a ALS design.
A Comparison Table Showing the Relative Strength of Artificial Lift Systems

<table>
<thead>
<tr>
<th></th>
<th>Gas Lift</th>
<th>Foam Lift</th>
<th>Plunger</th>
<th>Rod Lift</th>
<th>PCP</th>
<th>ESP</th>
<th>Hyd Jet</th>
<th>Hyd Piston</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max Depth</strong></td>
<td>18,000 ft 5,486 m</td>
<td>22,000 ft 6,705 m</td>
<td>19,000 ft 5,791 m</td>
<td>16,000 ft 4,878 m</td>
<td>8,600 ft 2,621 m</td>
<td>15,000 ft 4,572 m</td>
<td>20,000 ft 6,100 m</td>
<td>17,000 ft 5,182 m</td>
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<tr>
<td><strong>Max Volume</strong></td>
<td>75,000 bpd 12,000 M³/D</td>
<td>500 bpd 80 M³/D</td>
<td>200 bpd 32 M³/D</td>
<td>6,000 bpd 950 M³/D</td>
<td>5,000 bpd 790 M³/D</td>
<td>60,000 bpd 9,500 M³/D</td>
<td>35,000 bpd 5,560 M³/D</td>
<td>8,000 bpd 1,270 M³/D</td>
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<tr>
<td><strong>Max Temp</strong></td>
<td>450°F 232°C</td>
<td>400°F 204°C</td>
<td>550°F 288°C</td>
<td>550°F 288°C</td>
<td>250°F 121°C</td>
<td>482°F 250°C</td>
<td>550°F 288°C</td>
<td>550°F 288°C</td>
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<tr>
<td><strong>Corrosion Handling</strong></td>
<td>Good to excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good to Excellent</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Gas Handling</strong></td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Fair to good</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Fair</td>
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<tr>
<td><strong>Solids Handling</strong></td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Fair to good</td>
<td>Excellent</td>
<td>sand&lt;40ppm</td>
<td>Good</td>
<td>Fair</td>
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<tr>
<td><strong>Fluid Gravity (°API)</strong></td>
<td>&gt;15°</td>
<td>&gt;8°</td>
<td>&gt;15°</td>
<td>&gt;8°</td>
<td>8°&lt;API&lt;40°</td>
<td>Viscosity &lt;400 cp</td>
<td>≥6°</td>
<td>&gt;8°</td>
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<tr>
<td><strong>Servicing</strong></td>
<td>Wireline or workover rig</td>
<td>Capillary unit</td>
<td>Wellhead catcher or wireline</td>
<td>Workover or pulling rig</td>
<td>Wireline or workover rig</td>
<td>Hydraulic or wireline</td>
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<td><strong>Prime Mover</strong></td>
<td>Compressor</td>
<td>Well natural energy</td>
<td>Gas or electric</td>
<td>Electric</td>
<td>Gas or electric</td>
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<tr>
<td><strong>Offshore</strong></td>
<td>Excellent</td>
<td>Good</td>
<td>N/A</td>
<td>Limited</td>
<td>Limited</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
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<tr>
<td><strong>System Efficiency</strong></td>
<td>10% to 30%</td>
<td>N/A</td>
<td>N/A</td>
<td>45% to 60%</td>
<td>50% to 75%</td>
<td>35% to 60%</td>
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<td>45% to 55%</td>
</tr>
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<th>Form of lift</th>
<th>Rod Lift</th>
<th>PCP</th>
<th>Gas Lift</th>
<th>Plunger Lift</th>
<th>Hydraulic Lift</th>
<th>Hydraulic Jet</th>
<th>ESP</th>
<th>Capillary Technologies</th>
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<tr>
<td>Maximum operating depth, TVD (ft/m)</td>
<td>16,000</td>
<td>12,000</td>
<td>18,000</td>
<td>19,000</td>
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<td>20,000</td>
<td>60,000</td>
<td>500</td>
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<td>Maximum operating temperature (°F/°C)</td>
<td>550°</td>
<td>250°</td>
<td>450°</td>
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<td>Compressor</td>
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<td>Multicylinder or electric</td>
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<td>Electric motor</td>
<td>Well’s natural energy</td>
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<tr>
<td>Offshore application</td>
<td>Limited</td>
<td>Limited</td>
<td>Excellent</td>
<td>N/A</td>
<td>Good</td>
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<td>Progressive Cavity Pumps</td>
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<tr>
<td>Rods</td>
<td>Relatively simple system design</td>
<td>Not so depth limited-can lift large volumes from great depths</td>
<td>Can lift extremely high volumes, 20,000 B/D (19078 m³/d) in shallow wells with large casing.</td>
<td>Can handle large volume of solids with minor problems.</td>
<td>Retrievable without pulling tubing.</td>
<td>Retrievable without pulling tubing.</td>
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<td></td>
<td>Units easily changed to other</td>
<td>500 B/D (70 48 m³/d) from 15,000 ft (4672 m) have been installed to 18,000 ft (5486 m)</td>
<td>Currently lifting 120,000 B/D (10908 m³/d) from water supply wells in Middle East with 600-hp (440-kW) units; 720-hp (537-kW) available, 1,000-hp (746-kW) under development.</td>
<td>Has no moving parts.</td>
<td>Very inexpensive installation.</td>
<td>Some types are retrievable with rods</td>
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<td></td>
<td>wells with minimum cost</td>
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<td></td>
<td>Handles large volume in high-PI wells (continuous lift) 500 B/D (7943.37 m³/d).</td>
<td>No problems in deviated or crooked holes.</td>
<td>Moderate Cost</td>
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<td></td>
<td>Efficient, simple and easy for field people to operate</td>
<td>Crooked holes present minimal problems.</td>
<td>Fairly flexible-convertible from continuous to intermittent to chamber or plunger lift as well declines.</td>
<td>Unobtrusive in urban locations.</td>
<td>Unobtrusive in urban locations.</td>
<td>Low Profile</td>
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<td></td>
<td>Applicable to slim holes and multiple</td>
<td>Power source can be remotely located.</td>
<td></td>
<td>Applicable offshore.</td>
<td>Applicable offshore.</td>
<td>Can use high gas oil ratio wells.</td>
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<td></td>
<td>scenarios.</td>
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<td>Can use water as a power source.</td>
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<td>Can pump a well down to vary low pressure (depth and rate dependent).</td>
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<td>Power fluid does not have to be so clean as for hydraulic piston pumping.</td>
<td>Can be used in conjunction with intermittent gas lift.</td>
<td>Can be used to unload liquid from gas wells.</td>
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<td></td>
<td>System usually is naturally vented for gas separation and fluid level soundings.</td>
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<td>High electrical efficiency</td>
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<td>Flexible-can match displacement rate to well capability as well declines.</td>
<td>Analyzable.</td>
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<td>Analyzable.</td>
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<td></td>
<td>Can lift high-temperature and viscous oils.</td>
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<td>Can use gas or electricity as power source.</td>
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<td>Corrosion and scale treatments easy to perform.</td>
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<td>Applicable to multiple completion's.</td>
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<td>Available of different sizes.</td>
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<td></td>
<td>Hollow sucker rods are available for slim hole completion's and ease of inhibitor treatment.</td>
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<td></td>
<td>Have pumps with double valving that pump on both upstroke and downstroke.</td>
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<td></td>
<td>Adjustable gear box for Tripex offers more flexibility. Mixing power fluid with waxy or viscous crudes can reduce viscosity.</td>
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<tr>
<td>Rod Pumping</td>
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<tr>
<td>Crooked holes present a friction problem.</td>
<td>Power oil systems are a fire hazard.</td>
<td>Not applicable to multiple complications.</td>
<td>Lift gas is not always available.</td>
<td>Relatively inefficient lift method.</td>
<td>May not take well to depletion, hence, eventually requiring another lift method.</td>
<td>Elastomers in stator swell in some well fluids.</td>
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<tr>
<td>High solids production is troublesome.</td>
<td>Large oil inventory required in power oil system which detracts from profitability.</td>
<td>Only applicable with electric power.</td>
<td>Not efficient in lifting small fields or one well leases.</td>
<td>Requires at least 20% submergence to approach best lift efficiency.</td>
<td>Good for low-rate wells only normally less than 200 b/d (31.8 m³/d).</td>
<td>POC is difficult.</td>
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</tr>
<tr>
<td>Gassy wells usually lower volumetric efficiency.</td>
<td>High solids production is troublesome.</td>
<td>High voltages (1,000 V) are necessary.</td>
<td>Difficult to lift emulsions and viscous crude.</td>
<td>Design of system is more complex.</td>
<td>Lose efficiency with depth.</td>
<td>Loss efficiency with depth.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is depth limited, primarily due to rod capability.</td>
<td>Operating costs are sometimes higher.</td>
<td>Impractical in shallow, low-volume wells.</td>
<td>Not efficient for small fields or one-well leases if compression equipment is required.</td>
<td>Pump may cavitate under certain conditions.</td>
<td>Good for low-rate wells only normally less than 200 b/d (31.8 m³/d).</td>
<td>Rotating rods wear tubing, windup and after-spin of rods increase with depth.</td>
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<td>Obtrusive in urban locations.</td>
<td>Usually susceptible to gas interferences—usually not vented.</td>
<td>Expensive to change equipment to match declining well capability.</td>
<td>Gas freezing and hydrate problems.</td>
<td>Problems with dirty surface lines.</td>
<td>Requires more engineering supervision to adjust properly.</td>
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<td>Heavy and bulky in offshore operations.</td>
<td>Vented installations are more expensive because of extra tubing required.</td>
<td>Cable causes problems in handling tubulars.</td>
<td>Gas freezing and hydrate problems.</td>
<td>Problems with dirty surface lines.</td>
<td>Engineering supervision to adjust properly.</td>
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<td>Sodium cannot be internally coated for corrosion.</td>
<td>Limitation of downhole pump design in small diameter casing.</td>
<td>System is depth limited, 10,000 ft (3048.9 m), due to cable cost and inability to install enough power downhole (depends on casing size).</td>
<td>Some difficulty in analyzing properly without engineering supervision.</td>
<td>The producing of free gas through the pump causes reduction in ability to handle liquids.</td>
<td>Engineering supervision to adjust properly.</td>
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<td>H₂S limits depth at which a large volume pump can be set.</td>
<td>Difficult to obtain valid well tests in low volume wells.</td>
<td>Gas and solids production are troublesome.</td>
<td>Cannot effectively produce deep wells to abandonment.</td>
<td>Requires makeup gas in rotating systems.</td>
<td>Engineering supervision to adjust properly.</td>
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<td>Limitation of downhole pump design in small diameter casing.</td>
<td>Requires two strings of tubing for some installations.</td>
<td>Not easily analyzable unless good engineering know-how.</td>
<td>Lack of production rate flexibility.</td>
<td>High surface power fluid pressures are required.</td>
<td>Engineering supervision to adjust properly.</td>
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</table>
References

• James F. Lea and Henry V. Nicken, “Selection of Artificial Lift”, SPE 52157
• Heriot Watt University, Production Technology Course Notes
• Wikepedia, www.wikipedia.org
Artificial Lift Systems

By

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