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Unconventional Lift for Unconventional Wells

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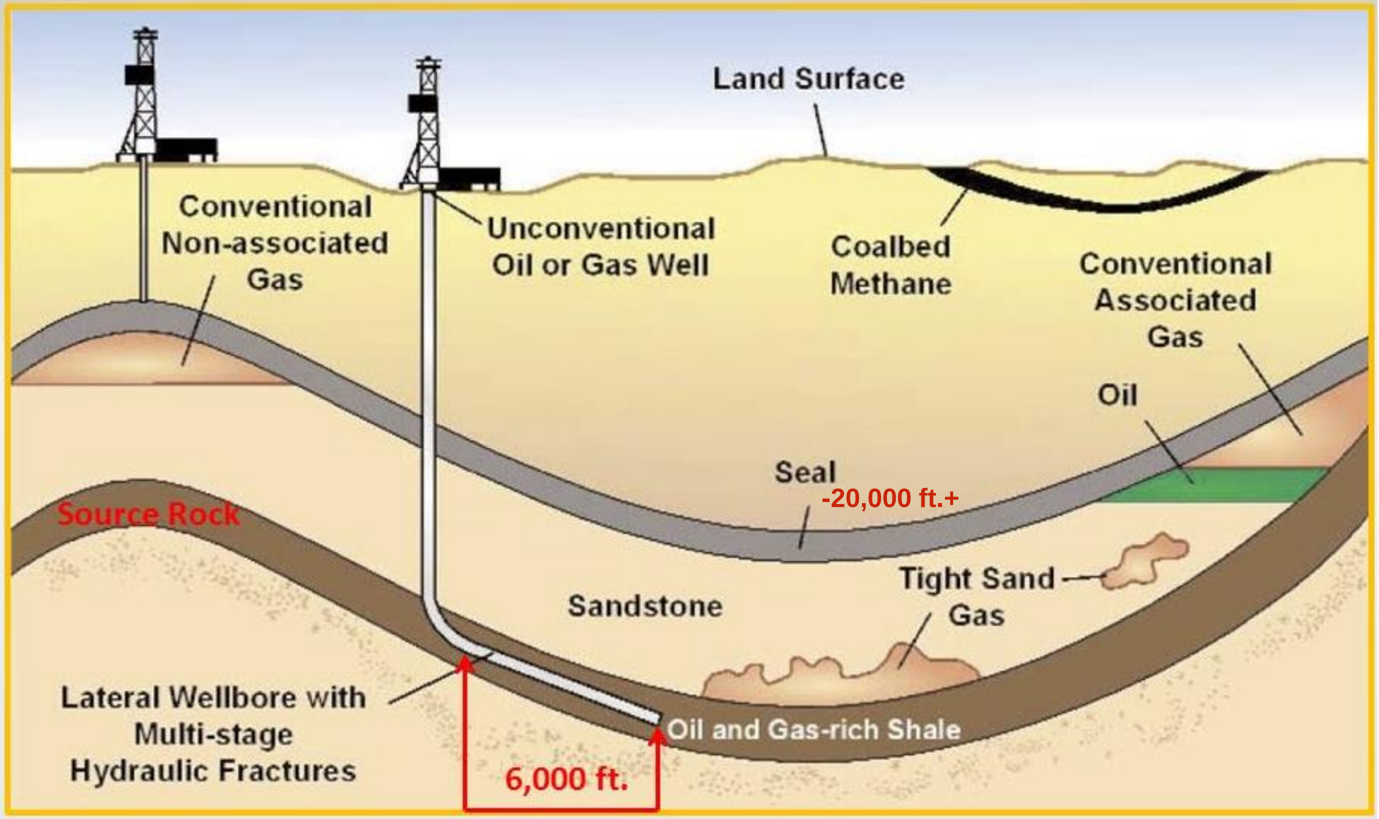
The Pressure Will Drop

At some point during production, all wells experience a drop in reservoir pressure that hinders production. This drop requires an artificial lift system to reduce the hydrostatic pressure on the formation, in order to encourage more production to the surface. While our industry has shifted from conventional to unconventional wells, resulting in a change to the makeup of our production, we have done little to advance our approach to artificial lift

PRESSURE DROP

The Differences in Conventional and Unconventional Drilling



Source: U.S. Energy Information Administration

Vs. conventional wells, unconventional wells are:

- Deeper, leading to deviated wellbores
- Curved from vertical to horizontal portion
- Longer, leading to more tortuosity and therefore, more gas slugs
- More solid producing due to high volume of sand used in fracking

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Challenges Facing Traditional Artificial Lift Methods

ESP

- Passing system through tight bend radius reduces system reliability, so limits to depth of system set
- Large gas slugs cause cavitation and eventual overheating and failure of downhole pumps
- Solids and debris erode ESP impellers
- Workovers are costly

Gas Lift

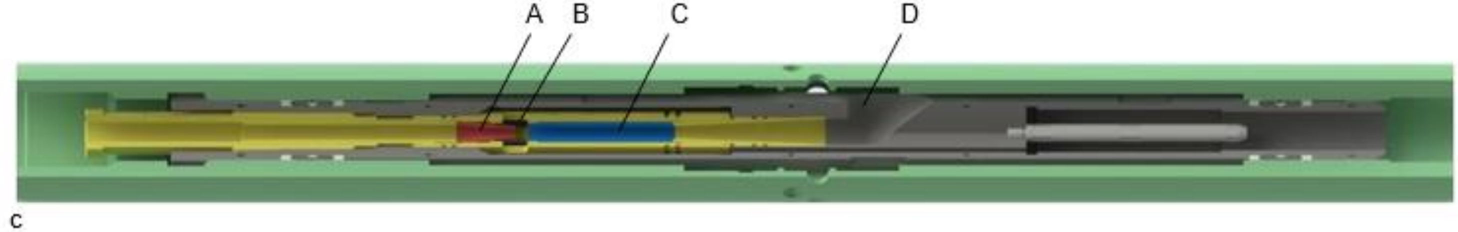
- Difficult to operate in small, closed systems featuring limited gas-storage capacities
- Generally not efficient in lifting small fields or leases
- Difficulty in lifting emulsions and viscous crudes
- Problems with dirty surface lines
- Safety concerns with high pressure gas
- Inability to effectively produce deep wells to abandonment

Rod Pump

- Deviated wells create friction between production tubing and rod string tending to wear holes in tubing
- Deep wells increases weight of sucker rods necessitating more power at the surface and increased rod failures
- Not designed to optimize production in applications featuring rapid rate decline

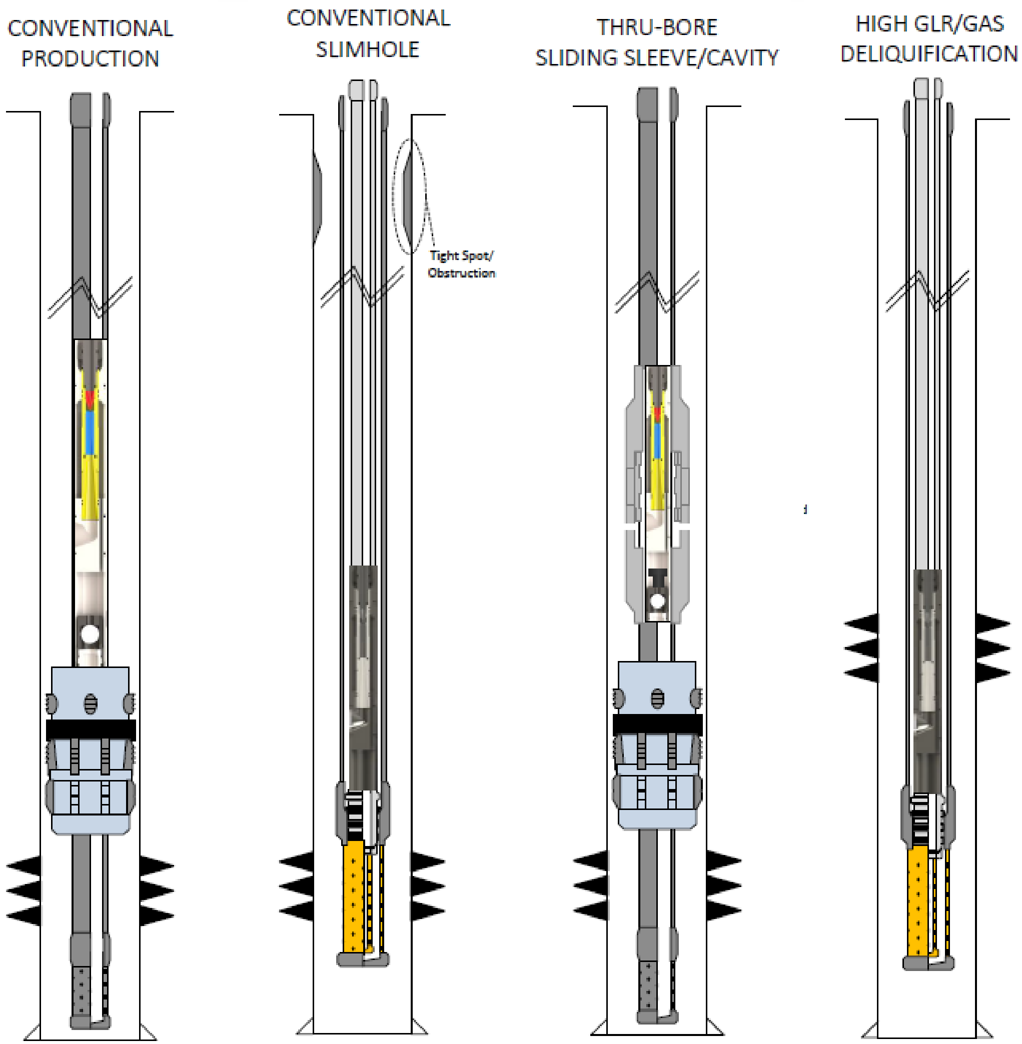
Enter Hydraulic Jet Pumps

- Provides an alternative artificial lift method more resilient to today's unconventional wells
- Functions according to the Venturi effect, utilizing the momentum of one fluid to move another. Drawdown brings formation fluids into jet pump and to the surface



- Consists of a nozzle, intake, mixing tube and diffuser, with a design that can be tailored to vertical, horizontal or deviated wells. Downhole jet pump is combined with a surface pump and power fluid system
- Requires minimal maintenance and optimization. When needed, can be performed without wireline or workover unit

Typical Jet Pump Completions



*In typical unconventional applications the jet pump is set in the wellbore between 30 to 70 degrees

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Typical Jet Pump Surface Arrangement

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Case Studies – Hydraulic Pumps Deployed

Case Study #1 – ESP

For a major Permian operator, a hydraulic jet pump was installed in a newly fracked horizontal well, and an ESP was installed in a new adjacent well under very similar conditions. Production rates and performance issues were compared

Case Study #2 – Gas Lift

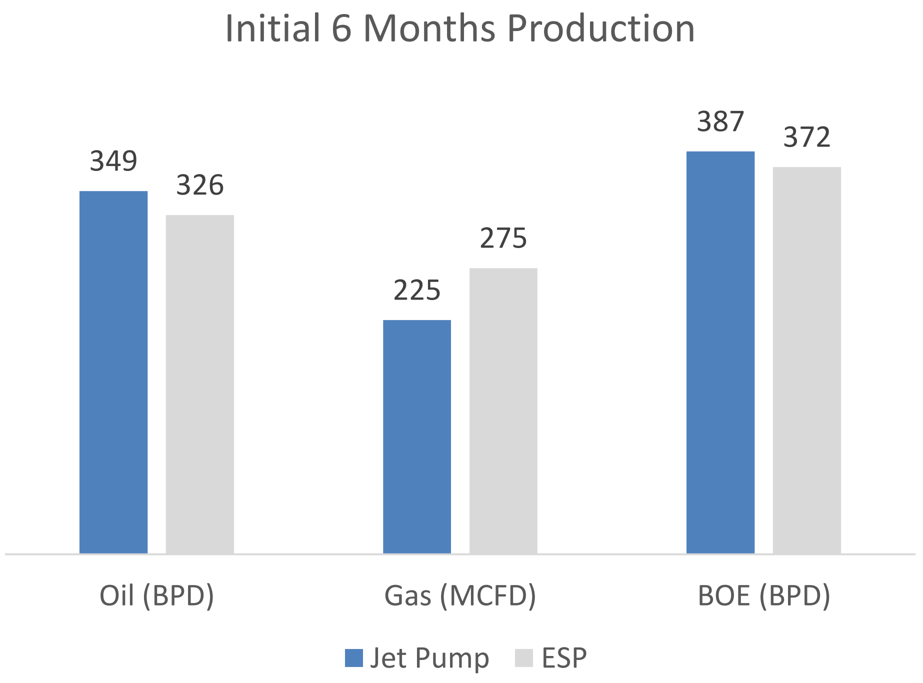
For an East Texas operator producing in the Wilcox formation, they had no electricity on site. Their gas lift operation was economically and operationally challenged. They tried a jet pump rental unit. Production rate and hp utilization were compared for 6 months before and after the transition

Case Study #3 – Rod Pump

For a major Eagle Ford operator, hydraulic jet pump system replaced a long stroke rod pumping unit. Data was compiled comparing average production over the six-month time period before and after the rod pump was replaced with the hydraulic jet pump system

Case Study #1: Hydraulic Jet Pump Handles Heavy Challenges in the Permian Basin

- Complications: Heavy solids, high gas production
- Test: A hydraulic jet pump was installed in a newly fracked horizontal well, and an ESP was installed in a new adjacent well under very similar conditions
- ESP: Experienced two failures; costing more than $300k in workover and equipment replacement
- Hydraulic jet pump: No failure; downtime limited to quarterly service with well back in production in 1-2 hours



Source: Production data from RS Energy

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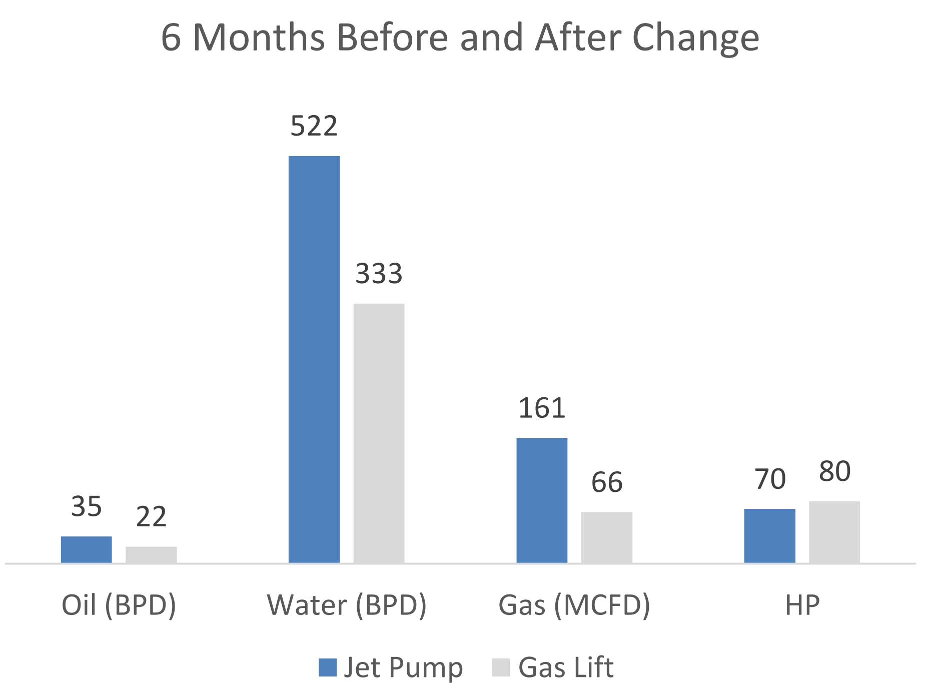
Case Study #2: Hydraulic Jet Pump Replaces Gas Lift

- Complications: Lack of electricity on location and gas lift system operating at full production capacity
- Gas lift: Site was experiencing economic and operational issues. Dependent on costly make-up gas to fuel compressors and lift fluid
- Hydraulic jet pump: Installed 180 hp natural gas-driven surface pump. Overall downhole and surface installation took less than 2 days
- Production: After testing period, an electric 125 hp surface pump was installed for permanent production. The production increase justified the CAPEX of bringing electricity to site



Source: Customer data

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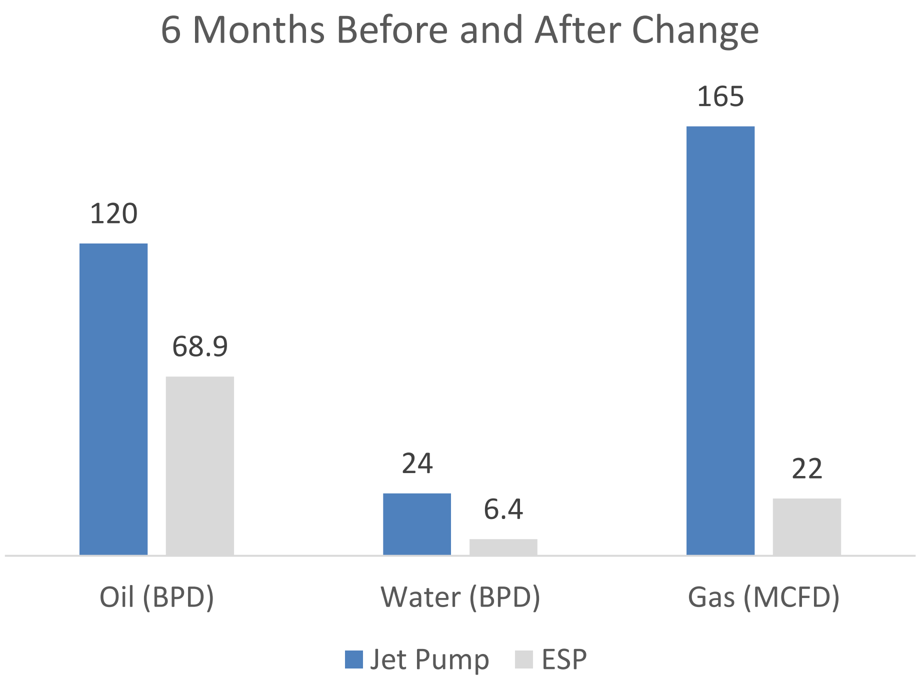
Case Study #3: Hydraulic Jet Pump Replaces Rod Pump in Eagle Ford

- Complications: Tight turns, long laterals, multiphase flow regimes, and steep decline rates
- Rod pump: Surface unit and downhole pump operating at max capacity. Due to rod/tubing wear, pump depth was limited to 8417' Measured Depth (MD) (1 DEG). At least one intervention performed in previous four months
- Hydraulic jet pump: Set at 8814' MD (45 DEG), thus increasing recoverable reserves. On surface, an 80 hp electric powered Hydra-Cell seal-less diaphragm pump was set with an ASME code power fluid vessel. 45 hp was utilized to lift the well
- Production: Jet pump produced substantially more oil and gas with marginally more water and utilized less HP



Source: Customer data

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Conclusions

Compared to electric submersible pumps, gas lift systems, and rod pumps, hydraulic jet pumps can deliver better artificial lift performance at lower overall cost over the life of an unconventional well operation

Advantages:

- Operate reliably at deeper depths
- New, more reliable surface pumping systems than traditional recips
- No moving downhole parts offers decreased risk of equipment failure
- More rugged and tolerant of abrasive and corrosive well fluids leads to better up time
- Issues can generally be fixed on the surface or by quickly bringing the jet pump to the surface, avoiding the need for numerous workovers or slick line services.

Thus saving considerable time and money for overall life of the well

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Thank You / Questions

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