



EXPLORATION & PRODUCTION

Jet Pumps Improve Bakken Shale Economics

Reliable, cost-effective option for early production of unconventional wells delivers significant savings for North Dakota operator.

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Jet pump systems can be modified to accommodate changing well pressures and flow rates, and the pump can be quickly retrieved, adjusted and redeployed without a workover rig. (Source: Weatherford)



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Overreliance on electric submersible pumps (ESPs) in shale wells can be detrimental to the bottom line. Many operators use ESPs to clean the wellbore after drilling and completing an unconventional well and then again later to provide artificial lift after the well stops flowing under natural reservoir pressure. However, during wellbore cleanup and early production the fluid is laden with sand and other solids that quickly damage ESPs and frequently cause pump failure. ESPs are also vulnerable to failure in gassy, waxy or corrosive conditions, which makes them ill-suited as an initial form of lift in unconventional plays such as the Bakken Shale.

Cost of ESP failures

The initial investment in an ESP system ranges from \$200,000 to \$400,000. Thereafter, each time an ESP fails, the cost of replacing the pump is significant since a workover rig is needed to pull the production tubing. Each ESP replacement averages between \$100,000 and \$300,000, including equipment costs and rig expenses.

Considering that an average shale well requires an ESP replacement between two and four times per year, equipment and workover costs can range from \$400,000 to \$1.6 million during the first year of production, according to Weatherford's historical data. At a time when operators must carefully manage their budgets, plan ahead and operate at maximum efficiency, such expenditures simply aren't feasible—and many companies are looking for more economical alternatives to produce their shale wells.

Jet pumps can deliver more reliable, cost-effective production in unconventional wells. Inspired by recent successes in replacing ESPs with jet pumps, a North Dakota operator enlisted Weatherford to investigate the viability of using jet pump systems to produce several of its Bakken Shale wells.

The operator had historically used ESPs for the majority of artificial lift before switching to rod pumping toward the end of the production curve. However, with high initial equipment costs and an average of about two to three annual pump failures per well, capex associated with operating ESPs was unacceptably high compared to the return on investment. The post-fracture flowback, a higher flow rate and harsh initial well conditions normally caused at least one ESP failure within the first three months of production. In some wells the operator had four ESP failures over the first three months of ESP lift in a single well. Combining the initial ESP installation and only one workover to replace a failed pump, capex for the first three months of production would average about \$450,000 per well.

Rigless solution

Jet pumps provided the operator with a more promising option. In a jet pump lift system the pump is deployed and retrieved using pressurized fluid or slickline, eliminating the need for a workover rig. As well conditions change, a technician can retrieve the jet pump, reconfigure it with a new throat and nozzle to adjust the flow parameters and redeploy the pump in as little as a few hours. By eliminating the need for workover rigs, jet pump systems significantly reduce labor, nonproductive time (NPT) and equipment costs.

Jet pumps have no moving parts, significantly decreasing the risk of equipment failure from solids-heavy, corrosive, gassy or waxy fluids. This makes the use of jet pumps ideal for recovering sandy post-fracture flowback from the wellbore. Because the pumps are hydraulically powered, there are no moving downhole parts. At the surface the power-fluid system uses a multiplex pump to pressurize and inject power fluid into the wellbore. The fluid travels downhole through the jet pump to the nozzle, which reduces the fluid pressure using the Venturi effect. This draws reservoir fluid into the pump throat, where the fluids combine. The mixture then transfers to the pump diffuser, where pressure increases to raise the comingled fluids to the surface.



Real-world successes, significant savings

The operator installed jet pumps in eight wells, which yielded significant savings over the first three months of production. The average expense for the first three months of production was \$41,500 per well, including downhole equipment costs and monthly surface equipment rental. The robust jet pumps handled the production with no NPT or failures, so no pump replacements were needed. By simply replacing ESPs with jet pump systems in the first lift stages, the operator estimated average savings of at least \$385,500 per well over those three months.

Because the majority of ESP failures occur during the first few months of lift and because the operator already owned significant ESP inventory, it chose to transition to ESP to lift the less solids-laden fluid that is typical of later lift stages. This enabled it to rotate its jet pump systems among other new wells to maximize capex savings.

Keeping jet pumps downhole longer

One of the most important cost-saving benefits is that jet pump systems can provide lift for several stages over the productive life of the well. For this reason, many Weatherford clients in the Bakken prefer to extend the benefits of rigless production by running jet pumps continually until eventually transitioning to rod pumps to handle final low-flowing production.

Upon initial deployment, a jet pump removes post-fracturing fluids to facilitate natural reservoir flow. Once reservoir pressure depletes and natural flow stops, that same jet pump system is used to transition the well to artificial lift, typically producing 1,000 bbl/d to 2,000 bbl/d.

As flow slows in later production stages, the jet pump can be adjusted to accommodate the changing well conditions by simply pulling the pump, resizing the throat and nozzle and redeploying the pump. This process is done at the well site and can be completed in a few hours with minimal equipment, saving the operator from investing time and capital to deploy a rig.

Rather than performing numerous workovers to change out lift systems over the life of the well, operators can save considerable time and money by keeping a jet pump system in place until reservoir energy is significantly depleted. When flow has slowed considerably—generally in the range of 200 bbl/d depending on a variety of well parameters, including flowing pressure—many operators transition their wells to small rod pump units. However, there is an even more cost-

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suited for these conditions, and it deploys directly into the jet pump bottomhole assembly unit, further avoiding the need for

tubing pulls and rigs.

Taking off like a jet

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After saving millions of dollars by deploying jet pump systems on eight wells, the Bakken operator is currently using the technology to lift 21 wells during early production and plans to expand the program to include a total of 60 wells. As this example shows, choosing the right form of lift at the right time based on reservoir characteristics and the production stage can substantially improve operational efficiency and profitability over the life of the asset.

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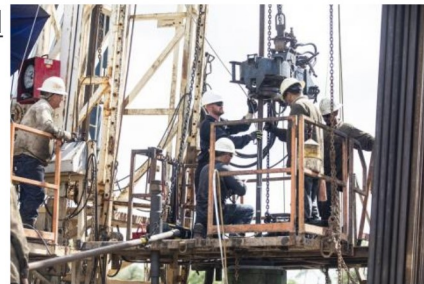
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