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How Multiphase Pumps Supplement Wells on Artificial Lift

Twin screw pumps are key for this operation.

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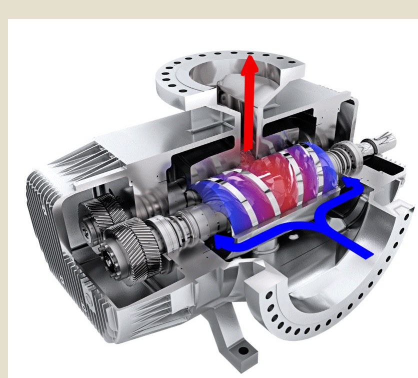
More than 5 million wells worldwide employ artificial lift systems. In North America, it is estimated that 90 percent of wells use artificial lift processes. Typically the technologies applied are pumped wells with rod or beam pumps and electrical submersible pumps (ESPs), or hydraulic and gas lift systems.

It is often necessary to install artificial lift systems in early production depending on the producing formation and expected reduction of the natural reservoir pressure. In unconventional production, including shale and tight formations, artificial lift is needed at the start of production to compensate for rapid decrease of the flowing pressure. The wellbore architecture is also complicated with deeper wells, deviated and long horizontal legs and multi-well entries.

Operators also strive for simplified gathering systems and pad production with minimum infrastructure, facility footprint and observing increasingly stringent emission and health, safety and environment (HSE) standards.

Production assumptions and predictions play an important role to satisfy stakeholder interests. More operators are looking at supplementing artificial lift with a multiphase

Image 1. Multiphase pump installed in a gathering system *(Images courtesy of Leistritz)*



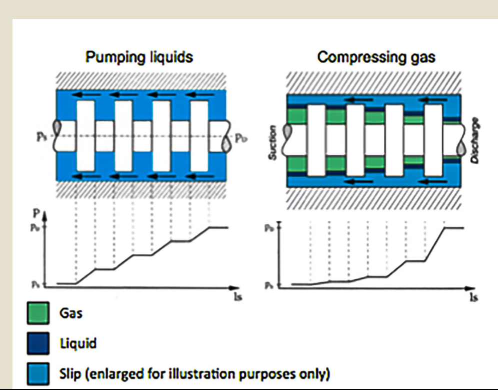


Image 2 (left). Twin screw multiphase pump. Image 3 (right). Pumping gas and liquids

Twin screw multiphase pumps are fixed displacement pumps where each pumping chamber forms when the two meshing screws rotate to transport a fixed volume from suction to discharge.

pump added to the conventional gathering system. This article will focus on the twin screw pump, which is a common pump design used for multiphase oil and gas transport and boosting. It is suited as a complement to a downhole pump or gas lift as it can handle a wide range of viscosities and gas volume fraction (GVF). The pressure boost is independent of pump inlet pressure, which allows the gathering pressure to drop in turn optimizing the produced flow and enhancing downhole pump or gas lift performance.

Twin screw multiphase pumps are fixed displacement pumps where each pumping chamber forms when the two meshing screws rotate to transport a fixed volume from suction to discharge. As shown in Image 2, the pump has two opposing sets of screw profiles moving the flow from suction at opposite ends of the screws toward discharge. The liquid part of the multiphase flow is necessary to compress gas. As the screws rotate, the centrifugal forces will cause the liquid phase to split from the gas phase and collect at the perimeter of the screw profile, in the annulus of the liner and the screw tips, and in the root of the profile.

As the flow reaches the discharge, the liquid phase is more defined, and a solid liquid slipstream will travel in the opposing direction of the main stream in the annulus formed between by the screws and the liner. This slipstream is a result of the backpressure buildup in downstream flow lines and separators.

When the slipstream backfills the next upstream pumping chamber, the liquid will compress the gas in the chamber. The backfill continues in the other upstream chambers, and as the liquid continuously fills the chambers, the gas is compressed. Equilibrium between gas and liquid pressure is reached, and the combined liquid-gas mixture will flow through the discharge port and continue downstream. As shown in Image 3, the pressure buildup with solid liquid is linear from chamber to chamber—however with gas it is asymptotic. Most of the gas (shown as blue) compression takes place in the last chamber just before discharge. The twin screw multiphase pump is a constant displacement machine; however with the liquid slip flow, it is a virtual variable displacement pump. Therefore, it can perform isothermal/isentropic gas compression. Unlike compressors, it can pump 100 percent liquids at any time.

The presence of liquid in the flow stream is critical for successful gas compression and to remove the heat of compression. At high GVF (98 to 99 percent), the integrity of the liquid phase is no longer stable. The liquid will foam, and the flow regime becomes turbulent. The slip flow is disrupted, and the pump loses its ability to compress gas and take away the heat, which could result in vapor lock. The result is fast, damaging heat buildup, and the pump must be shut down. To keep liquid at a minimum of 3 to 5 percent of inlet flow, a liquid recirculation system is included in the pump system (Image 4).

This system will allow the pump to operate at 100 percent GVF at skid inlet and absorb long gas slugs, mist flow and unstable flow regimes, which can occur when starting up and flowing a liquid logged gas that is capped well.

Multiphase boosting with twin screw pumps provides several advantages. By lowering the gathering pressure, there is less backpressure on manifolds, wellheads and downhole pumps. It also

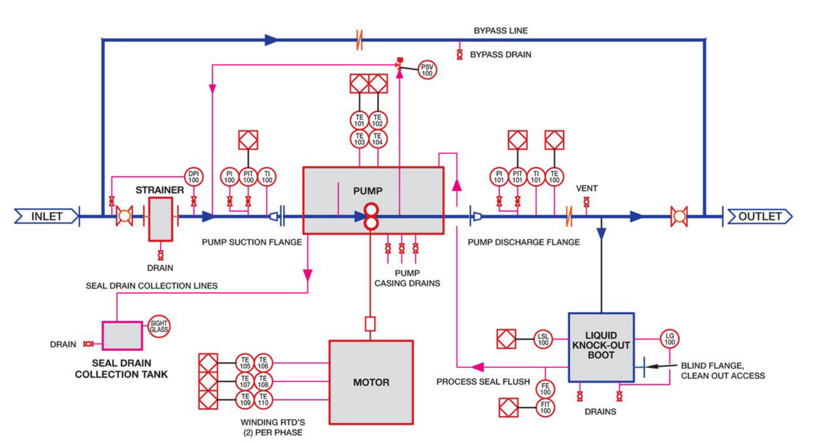


Image 4. Piping and instrumentation diagram with liquid recirculations system

lowers bottom hole pressure, improves well inflow and has higher liquid levels.

Improved downhole pump uptime results in steady plateau production and more reliable predictions and control. As the reservoir pressure declines, recovery and quicker depletion will delay well abandonment and improve economics. The deeper submergence of the ESPs and downhole pumps improve hydraulic performance resulting in lower differential pressure and improved net positive suction head (NPSH). The pumps operate at or above the bubble point, which improves gas handling ability and reduces risk of vapor lock and head loss.

Downhole pumps assisted by a multiphase pump also perform better with viscous oil, emulsions and in higher gas/oil ratio (GOR) formations. The lower backpressure on the well reduces power draw and electric motor load and reduces wear on rods, couplings and connectors. Damage from pounding can be avoided with the controlled constant backpressure created by the multiphase pump. The fewer well interventions and longer periods between service and overhaul of components reduce operating costs and costs from work over rigs. With gas-lifted wells, the risk of liquid loading and unstable tubing flow are reduced with the controlled low backpressure.

There are many advantages to using artificial lift with surface installed multiphase pumps. A "kidney loop" or bypass mode is a relatively easy operation and can be done with little or no production disturbance. Operators keyed on maximizing production from existing facilities have installed multiphase pumps with good results. ■

SVEN OLSON is senior consultant and former CEO for Leistritz Advanced Technologies Group. Olson holds a degree in process engineering and an MBA from the University of Lund in Sweden. For more information, visit leistritzcorp.com.