ADVANCING ARTIFICIAL LIFT

Sven Olson, Leistritz Advanced Technologies Corp., USA, explains how artificial lift and gathering systems can be optimised through the use of multiphase pumps.

The application of artificial lift in oil and gas production continues to grow as operators strive to maximise recovery and the use of existing facilities and processes, as well as accessing tight formations and low permeability shale assets. Drill centres and pad production are becoming very common as producers work to reduce facility footprints and minimise the environmental impact. However, along with the benefits of growing numbers of artificial lift installations also comes added complexity in producing an asset, which leads to increased operator cost exposure for well service and interventions. Today's trend for optimising production and total recovery is to further extend the outreach from a single pad, which results in the application of more deviated and horizontal drilling. This leads to complex well architecture with long horizontal sections, which makes lifting with conventional downhole products challenging, and in turn creates a whole new set of problems facing the operator. Depending on the specific production scenario of a formation, different artificial lift technologies are used. Figure 1 provides a depiction of a

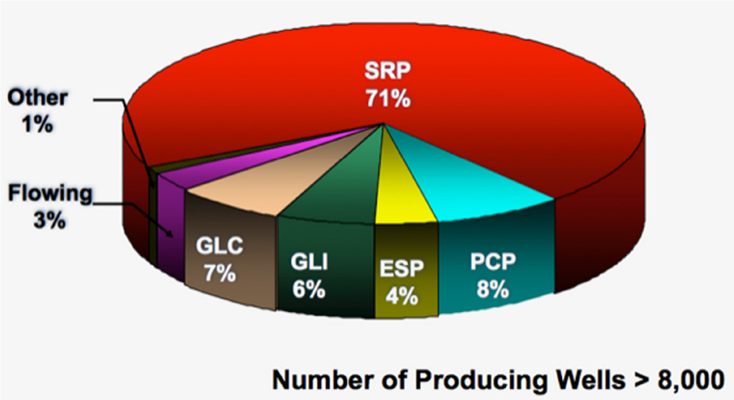

Figure 1. *Artificial lift technology distribution for onshore producing wells.*

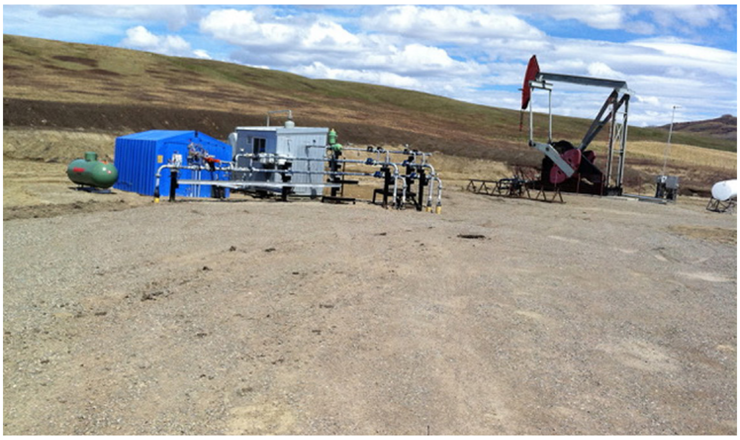

Figure 2. *Simple gathering system with a single multiphase pump.*

Figure 3. *Large gathering system with multiphase pumps.*

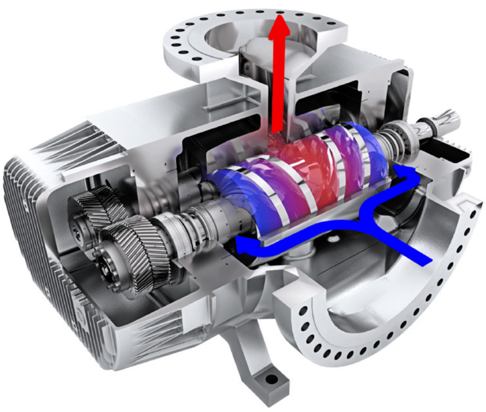

Figure 4. *Twin-screw multiphase pump.*

typical split of lifting alternatives for an operator producing 8000 onshore wells.

Over 5 million wells are on artificial lift worldwide; in North America alone, it is estimated that 85% of all wells use artificial lift. In onshore applications the SRPs (sucker rod pumps) dominate, however ESPs (electrical submersible pumps) or PCPs (progressing cavity pumps) are increasingly gaining ground. Other commonly used technologies include velocity strings, plungers, jet pumps and gas lift systems. Offshore, gas lift is by far the leading artificial lift technology, with mud line or downhole ESPs having some limited success, whereas onshore producers favour downhole pumps and SRPs.

This article will primarily deal with improvements to onshore artificial lift systems using different types of downhole pumps. However, offshore gas lifted wells can also substantially improve production and total recovery when multiphase pumps are used for reducing the backpressure on the well.

Artificial lift and multiphase pumps in gathering systems

Artificial lift is traditionally mentioned in connection with mature and low flowing wells. However, as seen with shale oil and gas developments, it is necessary to install artificial lift systems in early production depending on the formation and the predicted reduction of natural reservoir pressure. In unconventional production from tight formations, artificial lift can be required right from the start of production to offset the often rapid decrease in flowing wellhead pressure when it is unable to overcome the back pressure from the gathering system and the first stage production separator. Adding to the picture, the well configuration is also becoming increasingly sophisticated when deeper wells with deviated and long horizontal legs and multi well entries are produced. This development makes artificial lift essential for successful hydrocarbon recovery. However, at the same time, it also introduces new operational challenges and adds capital and operational costs.

Operators, therefore, strive for simplified gathering systems and pad production facilities with minimum surface infrastructure, facility footprint and increasingly stringent emission and HSE standards.

From the business side, especially in a depressed oil price market, production assumptions and predictions play an important role in satisfying investor and other stakeholder interests.

In this challenging environment an increasing number of operators are looking to supplement the existing artificial lift system with a multiphase pump tied into a conventional gathering system.

The workings of a multiphase pump

Multiphase pump technology has been in use for a number of years in oil and gas production around the world. This article will focus primarily on the twin-screw pump, which is the most common pump technology used in multiphase oil and gas boosting. What makes it especially well-suited as a supplement to a downhole pump or gas lift system is its ability to handle a wide range of viscosities, oil/water emulsions and gas fractions referred to as GVF (gas volume fraction). In addition, the differential pressure or pressure boost from the multiphase pump is independent of the inlet pressure. This feature is vital for lowering the flowing well head pressure, which in turn allows the gathering pressure to drop, thereby increasing the produced flow and facilitating the operation of the downhole pumps or gas lift system.

The twin-screw multiphase pump is a fixed displacement pump where a number of pumping chambers are formed when the two meshing screws rotate. As shown in Figure 4, each chamber transports a fixed volume of gas and liquids from inlet to discharge trapped in the chambers by the two opposing sets of screw profiles. In order to compress gas, the liquid phase of the multiphase flow pays a deciding role. When the screws rotate, the gravity difference between the gas and liquids will force the liquid phase to separate from the gas phase. The liquids will collect in the annulus formed between the liner and the tip of the screw profile and in the void close to the root of the profile. As the flow stream reaches the discharge, the liquid phase is more defined and becomes exposed to the pump backpressure. It results in a slipstream of liquid moving in the opposite direction of the pump flow in the above-mentioned annulus. Thus the opposite flow of liquid is entirely controlled by the backpressure created by the flow line system, separators and other process equipment downstream of the multiphase pump.

When the slipstream backfills the next adjacent pumping chamber the liquid will compress the gas in that chamber. The backfill continues with the other upstream chambers, and as the liquid continuously fills each subsequent chamber the gas becomes continuously compressed. When equilibrium between gas and liquid pressure is reached, the combined multiphase mixture will flow through the pump discharge and continue downstream. As shown in Figure 5, the pressure increase with only liquid is linear from chamber to chamber. However, with gas the pressure increase is non-linear. A majority of the gas compression takes place just before discharge in the last chamber (shown as blue). The twin-screw multiphase pump is in the family of fixed displacement pumps, yet the liquid slip flow turns it into a virtual variable displacement pump, which allows it to perform isothermal/isentropic gas compression. Contrary to a conventional compressor, the multiphase twin-screw pump, which is insensitive to the flowing density, can also handle 100% liquid at any time.

The re-circulation system

The liquid in the flow stream plays a critical role in sealing the screw profiles and removing the heat of compression, which is necessary for successful gas compression. At high GVF (98 - 99%) the stability of the liquid phase is no longer present; the liquid will foam and the flow regime can become turbulent. The backflow is disrupted and the pump can lose the ability to compress gas and remove the heat of compression, and possibly vapour lock. This can result in a fast heat build-up, which can be damaging and result in the pump being shut down. The liquid fraction needs to be kept at a minimum of 3 - 5% of inlet flow while a liquid recirculation system is included in the pump system, which can be seen in the P&ID shown in Figure 6.

The re-circulation system, which stores and re-collects liquids, allows the multiphase pump to absorb long gas slugs and operate with mist flow and unstable flow regimes. This system feature is necessary when starting up and flowing a gas capped well with little or no liquids reaching the pump. The liquid knockout and storage is an integral part of a multiphase pump package, which is built to handle different flow regimes as well as emulsions and high viscous crude oils. The separation efficiency is achieved using cyclonic separation and demister combined with cooling of the

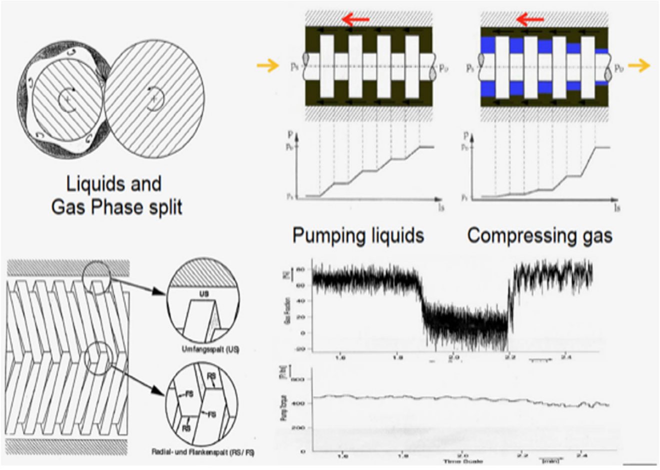

Figure 5. *Pumping gas and liquids.*

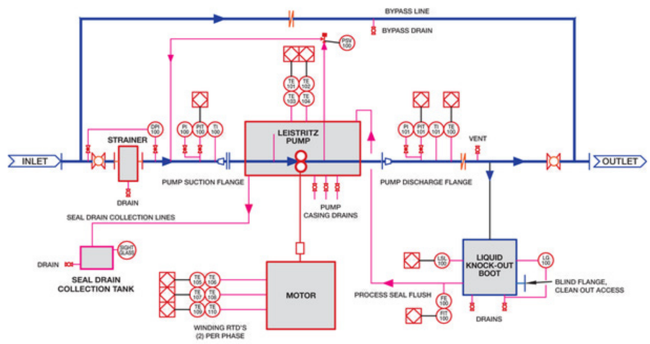

Figure 6. *P&ID with liquid re-circulations system.*

Figure 7. *Left: Fixed multiphase pump skid. Right: Portable multiphase pump.*

Well / Artificial Lift Method	P_{wh} before (kgf/cm²)	P_{wh} after (kgf/cm²)	P_{casing} before (kgf/cm²)	P_{casing} after (kgf/cm²)	Sub before (m)	Sub after (m)
CP-1464 / SRP	11	5	9,4	4,4	130	265
	➢ Increasing of the downhole pump submergence.					
CP-1461 / ESP	20	8	9,3	4	0	90
	➢ Reduction of the motor current – 10% (less DP required on ESP) and increasing of the ESP submergence.					

Source MPUR SA 2018

Figure 8. *Increased submergence of downhole pumps.*

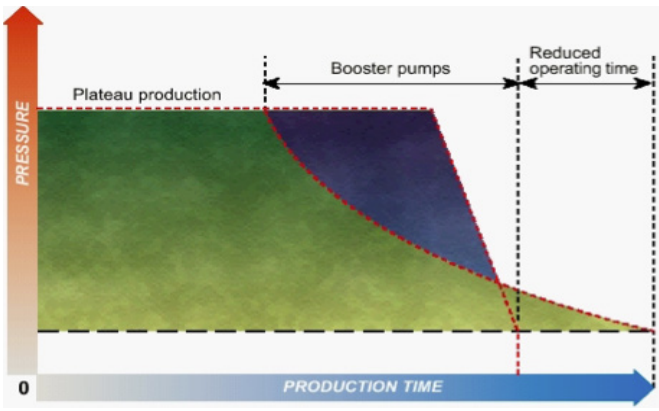

Figure 9. *Extending plateau production with the multiphase pump.*

liquids when necessary, including full automation and control of the liquid level for safe pump operation. The configuration of standard multiphase pump packages can be seen in Figure 7.

The benefits of combining an artificial system with multiphase pumping

Multiphase boosting with twin-screw pumps adds a number of advantages to a gathering system on artificial lift. Lowering the surface gathering pressure leads to reduced backpressure on manifolds, wellheads and downhole pumps. It also means lower bottom hole pressure, which results in better well inflow and subsequently higher liquid level in the well. It leads to deeper submergence of the ESPs and sucker rod pumps and significantly improves their hydraulic performance, resulting in lower differential pressure and improved net positive suction head. With the higher wellbore liquid level the pumps will operate at or above the bubble point, which improves the gas handling ability and substantially reduces the risk of vapour locking and head loss due to entrained gas. As shown in Figure 8, the higher liquid level brings a significant difference in submergence both for wells on ESPs and on SRPs. With less backpressure due to the multiphase pump, the reduced hydraulic work will also result in improved service life of the downhole pumps, less electric load on the ESP, and less wear and tear of rods, couplings and connectors.

A downhole pump operating on pump-off control will be on continuous service uptime and maintaining a steady plateau production thanks to the multiphase pump. This is achieved by optimising the wellhead pressure and tubing level by adjusting the pump inlet pressure through speed and flow control. The benefit for the operator is a more reliable production forecast and ability to better schedule service interventions. As shown in Figure 9, when the natural reservoir pressure declines over time, the multiphase booster pump maintains plateau production while adding to the total recovery with quicker depletion rate and providing overall improved economic returns.

With regard to flow assurance challenges, multiphase pump-assisted downhole pumps will perform more efficiently when handling viscous oil, oil/water emulsions and high GOR formations with entrained or free gas. A common challenge is maintaining constant flow and pressure in the test line during well testing. The multiphase pump installed downstream of the test separator is helping out in this process by controlling the flowing pressure using pump speed control independent of the back pressure from the first stage production separator. Also gas lifted wells, which can have a tendency to liquid load and create unstable flow especially with underperforming gas lift valves, will be supported by the reduced back pressure created by a multiphase pump.

Summary

Fewer well interventions and longer periods between service and overhaul of components are reducing operating costs and costs associated with work-over rigs. This, together with increased production and recovery are benefits of a multiphase pump-supported artificial lift system. Such installations, as part of the gathering system, can be done with little or no production disturbance as a 'kidney loop' or in a by-pass configuration to an existing gathering system. Drag skid and portable units are available for facilities with minimal infrastructure and the multiphase pump can be driven by either an electric motor or a gas engine. For operators and asset managers keyed in on optimising production from existing facilities on artificial lift, the multiphase pump offers a quick route to solid results and is driving a growing appreciation for this technology.