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Multiphase Pumps Handle Casing Gas

By Sven Olson

ALLENDALE, N.J.–A new concept is emerging where multiphase pumps can be used to handle annulus gas in wells in a more economical and environmentally friendly way.

Multiphase pumps can be applied to a single well or to a cluster of wells gathering associated gas coming up the annulus or with coalbed methane, where in both cases, the liquids from the production can be partially diverted through the pump assisted by forming the liquid seal in the pump necessary for transporting the gas. The result is a drawdown of the gas pressure at the wellhead, which leads to lower bottom-hole pressures and better inflow of liquids from the formation.

The production rate of oil and gas will increase, leading to a better total recovery and delaying abandonment of the well. Furthermore, the economics are more favorable with reduced facilities and less equipment, compared with the complexity of a compressor installation. Last, but not least, eliminating flaring or venting of gas to the atmosphere is a necessity in most oil fields today.

A twin-screw type of multiphase pump has some unique features. It is a constant positive displacement machine with each pumping chamber having a constant volume, which means any combination of gas and liquids can be pumped. It is possible to go from 0 to 100 percent gas in a fraction of a second passing a solid slug of liquid, and thereafter, go back to extended running on 100 percent gas. As the curve shows in Figure 1, a pump running with a high (85 percent) gas void fraction (GVF) suddenly receives a slug of liquid. The GVF drops to almost 0, and the liquid slug passes through the pump during a couple of seconds. Thereafter, the GVF

FIGURE 1

Slug Flow

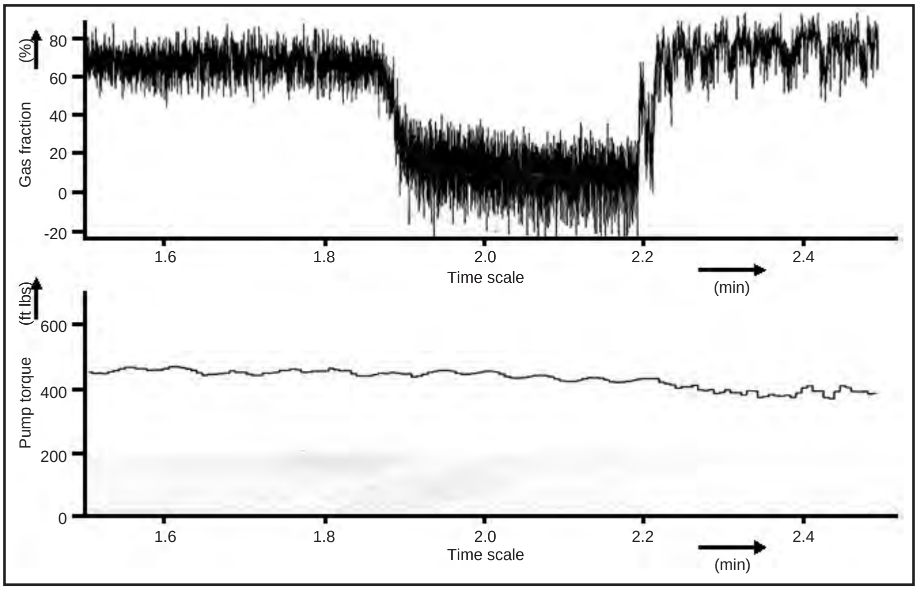


FIGURE 2

Cross Sections of Pump Screws

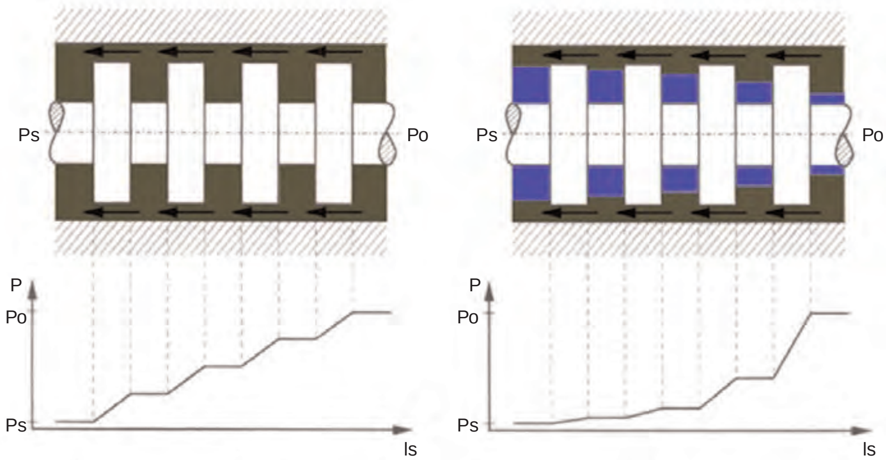
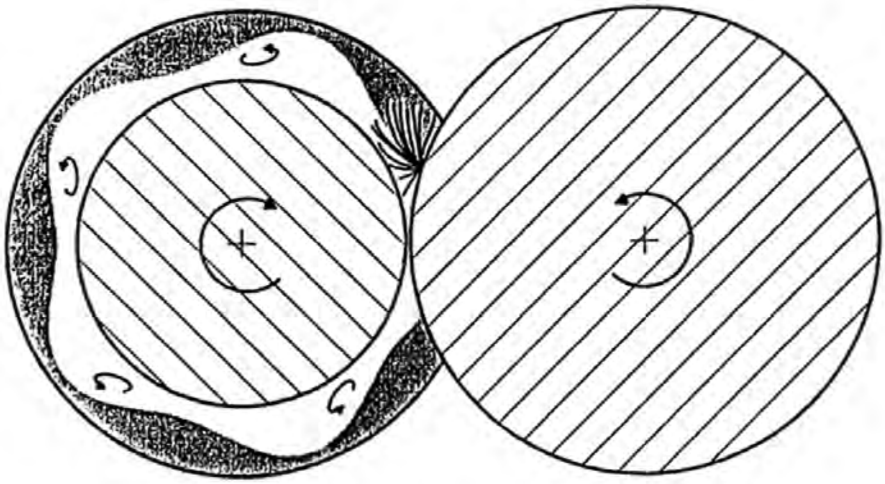


FIGURE 3

Liquid and Gas Phase Split



returns to the previous value. The torque required by the pump is shown in the lower curve, and as can be seen, the liquid slug has no influence at all on the pump or the driver.

So why is that? Figure 2 displays two cross sections of the pump screws. The same screw section can either transport the liquids (as can be seen on the left side) or gas (as shown on the right side), and of course, any combination of the two. What first happens is a phase split inside the pump, which occurs when the mixture of gas and liquid enters the inlet of the screws. With the rotation of the screws (Figure 3), the liquids will collect at the perimeter as a result of gravity forces and differences in density, just as the gases will follow in the pumping chambers along the center of the screws. When the liquids reach the highest pressure where the last chamber of the screw opens to the outlet, the backpressure will cause a flow-back of the liquids in a direction opposite to the gas flow.

The screws, which are running with annular clearance in the casing, leave enough room for the liquid to flow back (Figure 4). This flow-back, which is central in twin-screw multiphase pumps, will enter into preceding chambers upstream of the outlet and compress the gas trapped in these chambers. It is an isothermal form of compression. Very little heat will be generated, and it can be easily transported with the flow stream, eliminating any need for subsequent cooling, like with a compressor.

With this description, it is easy to realize the multiphase pump is a very universal piece of machinery and is ideally suited for oil and gas production. As the natural flow from a well with liquids and gases always varies and the phases are changing over the life of a reservoir, flexibility is essential for economical operations.

Marginal Well Production

In today's energy environment, more importance is placed on enhancing domestic oil and gas production from mature and marginal wells. In an October 2006 report, the Interstate Oil & Gas Compact Commission estimated that marginal wells accounted for 17 percent of domestic oil and 9 percent of domestic natural gas production from onshore fields. At last count, 400,000 producing oil wells and 300,000 producing gas wells in the United States are defined as marginal.

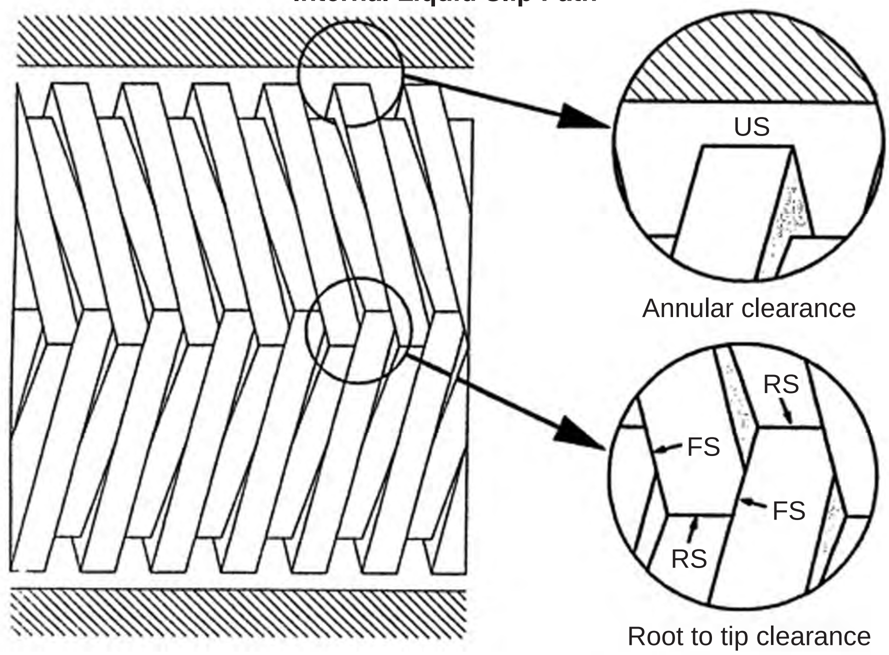
These oil wells produce 880,000 barrels a day with a total value of $17 billion-$20 billion, depending on oil prices. This is also the amount that does not have to be spent on oil imports, saving 7 percent on the nation's oil import bill. The numbers certainly point to the necessity of maintaining, and where possible improving, the production from marginal wells. Delaying well abandonment by continuously increasing the recovery from known and producing deposits is highly desirable and is getting higher on the political agenda.

The technology is picking up speed and a number of tools are available to the producer to assist in more efficiently handling casing gas, either as associated gas from oil production or from coalbed methane production.

In handling casing gas with compressors, the objective is to draw the gas from the casing, thereby lowering the flowing bottom-hole pressure, which improves the inflow performance of the well. In the past, the gas was simply vented, recombined or flared, or sometimes fed to a separate gas gathering system. Often with marginal wells, gas gathering is not economical and

FIGURE 4

Internal Liquid Slip Path



The skid-mounted casing gas multiphase pump package is compact, and has separate inlets for the gas from the casing and the liquids from the pump and tubing. The production stream passes through the pump, into a liquids collection boot, and then to the multiphase discharge.

does not allow for sufficient drawdown of the casing gas pressure. Simply tying the gas line to the liquid line does not really do anything to the gas pressure.

The gas, which is mostly wet and contains slugs of liquid, cannot be easily handled by a compressor. A compressor installation for casing gas is a complicated installation that requires a lot of auxiliary equipment such as separators, scrubbers and blow cases. The vessels need to have safety provisions such as pressure safety valves with vents or flares, and gas coolers to get rid of compression heat. Reliability suffers because of the complexity, the units are often noisy, and it does not take more than a liquid slug or very wet gas to shut down the entire unit.

New Alternative

A multiphase twin-screw pump offers a new and more reliable alternative. It is more environmentally friendly and operates quietly without flaring or venting to the atmosphere. Figure 5 shows the flow arrangement of a typical installation. The multiphase pump simply draws the gas from the well casing and recombines it with the liquids from the production stream, which also flows through the unit.

As part of the flow path, a recirculation system is arranged to support the pump in case the liquid is shut in for any reason. A volume equal to 4-5 percent of the total flow (gas and liquids) is diverted from an enlarged inclined pipe on the skid, which also traps the liquids coming with the wet gas stream. The liquids flow back to the low-pressure side of the pump to cool the mechanical seals and provide "seal fluid" for the screws as they compress the gas.

Typically, a rod pump will have less than 100 percent uptime and will stop for periods when the tubing level is insufficient and the load on the rod is too low. However during this time, the multiphase pump is still operating and transporting the casing gas. As mentioned, the liquids are necessary for the pump to move and compress the gas at all times. When the rod pump is stopped, the liquids are trapped and recirculated within the multiphase skid, allowing the pump to handle the gas for an extended time.

The differential pressure of the pump is self-regulating and independent of inlet pressure. When this pressure and the casing gas pressure are lowered at the same time by increasing the speed of the pump, the discharge pressure will be set by the pressure in the export line back to the battery like any positive displacement machine. This line is a true multiphase line, not only adding more liquids, but substantially more gas as well, to improve the overall production economy.

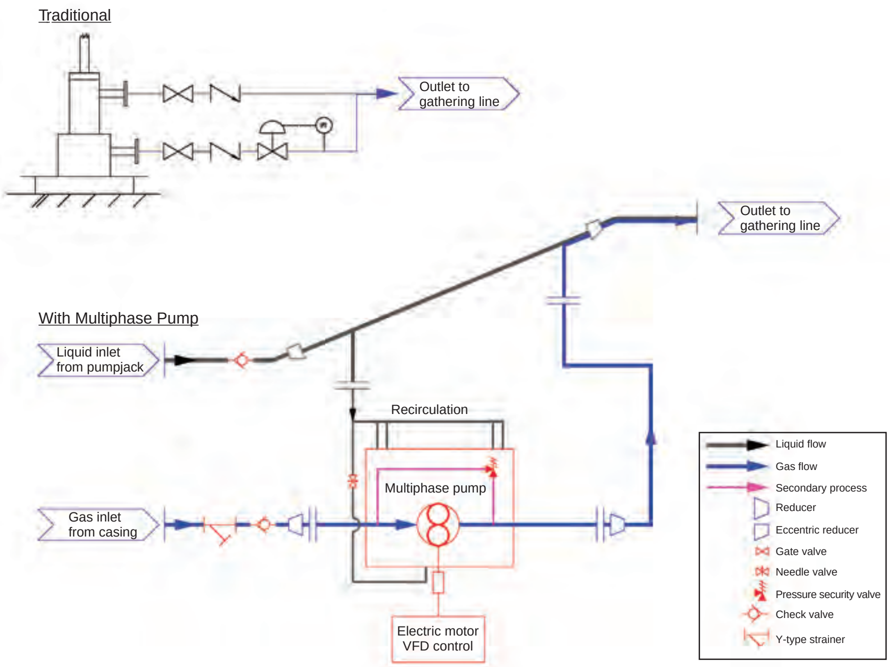
Additional Benefits

Several additional benefits have been observed. The gas adds extra lift and eliminates liquids surging, which causes havoc in the production separator. It also reduces the drag losses in the export line, lowering the load on the rod pumps. However, the main benefit with the multiphase pump is to lower the bottom-hole pressure in the well bore, which in turn, results in better inflow. A typical example has shown that lowering the casing gas pressure by half results in a 10-20 percent increase in oil production and a 60-80 percent increase in gas production.

The skid-mounted casing gas multiphase pump package is compact, measuring 10 feet long by four feet wide. It has separate inlets for the gas from the casing and the liquids from the pump and tubing, with the production flow passing through a liquids collection boot to the multiphase discharge outlet. The skid can be located close by the wellhead, and can be protected in an oil field-type shed to make the installation as nonintrusive as possible while also reduc-

FIGURE 5

Typical Flow Arrangement



The tie-in from the wellhead to the pump is shown here. In this case, the multiphase pump is enclosed in a nearby protective shed connected to the well-head by the gas and liquids lines, making the installation as nonintrusive as possible while reducing facility costs.

ing the facility costs.

In marginal and single-well pump installations, the economics are very sensitive to any deviation in expected returns. The multiphase pump unit can be easily relocated to another well if the analysis and evaluation of well productivity is not what was expected. The package is self-contained with alarms and necessary shutdowns, and it is flexible in capacity as a result of the variable frequency speed control of the multiphase pump.

One unit is operating in Canada and has shown very promising results. Several more are planned. The simple and rugged pump design is able to add the flexibility and reliability only a multiphase pump can bring.

The industry is in the "start phase" of contributing to enhanced marginal well production using multiphase pumps. Oil and gas operators now have access to an additional technology, which is easily justifiable both from the capital and operating cost sides, and at the same time, adds value to the production of domestic energy reserves. ❐

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Sven Olson is president of Leistritz Corporation, based in Allendale, N.J. With headquarters in Germany, Leistritz manufactures screw pumps for the oil and gas industry. Before joining Leistritz in 1986, Olson spent most of his career with IMO in Sweden. He was involved in testing and introducing multiphase pumping technology to North America, and actively participates in applying and promoting the technology in the oil and gas industry. Olson serves as an advisory board member of the Multiphase Pump Users Round Table sponsored by Texas A&M University. He holds a degree in process engineering and an M.B.A. from the University of Lund in Sweden.