HARTENERGY

2019 Artificial Lift Techbook

A supplement to

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Adding Value with Downhole Compression

Downhole artificial lift technologies improve gas production and recovery in liquid-rich gas wells.

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As gas wells mature, production tends to fall off, caused by declining natural drive energy from reservoirs. When the natural drive is too low to generate enough gas production at the surface, the well will normally be abandoned due to economic factors. Sometimes even before a gas well reaches its predetermined economic limit, the lower gas production reduces the gas velocity, which in turn decreases the liquid-carrying capability of the gas stream. The low liquid-carrying capacity makes liquids drop out of the gas stream and accumulate in the well to form a hydraulic column. This is called liquid loading. The hydrostatic pressure of the liquids causes the reservoir pressure to slow down or even stop gas production completely, eventually resulting in premature abandonment of the gas well. Industry estimates reveal that only about 60% of natural gas from reservoirs is recovered from conventional wells and only about 15% to 20% is recovered from unconventional wells.

Existing artificial lift methods for gas wells remove liquids in the vertical sections of the well or reduce the hydrostatic pressure of the liquid column. Current artificial lift technologies, however, cannot remove the liquids completely in both the vertical and horizontal sections of the well or increase reservoir drawdown.

Reliable downhole artificial lift

To address these challenges, Upwing Energy has developed a practical, robust and cost-effective downhole artificial lift system. The company's new Subsurface Compressor System (SCS) changes the pressure profile along the depth of a gas well (Figure 1). It provides both a suction effect to lower the intake pressure near the producing zones and a boosting effect to increase the discharge pressure downstream of the compressor. The lower downhole flowing pressure increases drawdown, facilitating the flow of gas from the formation into the wellbore to increase production (Figure 2). The higher discharge pressure from the compressor will overcome the pressure losses along the pipe and increase the wellhead pressure to flow the gas into the surface gathering system.

With both the suction effects and the boosting effects of the subsurface compressor at work, the well can produce gas from the formation under the lowest possible downhole pressures or even close to vacuum, while forcing the produced fluids uphole with enough push. This in effect increases production and delays well abandonment (Figure 3). With the delayed abandonment, the accumulated gas production from the well, and thus the recovery factor, will be highly improved.

The subsurface compressor also reduces liquid loading (Figure 4). With the increased gas production due to higher drawdown as well as the suction effects of the subsurface compressor, the gas velocities in the wellbore at the intake side of the subsurface compressor will increase tremendously. The higher gas velocities in turn will improve the liquid sweeping capabilities of the well in both the vertical and horizontal wellbore. At the intake side of the subsurface compressor, the lower pressure will promote the mass diffusion of the liquid molecules into the high-velocity gas stream. This further increases the liquid sweeping capabilities. Thus, both the higher gas velocities and lower pressures in the well will enhance the liquid

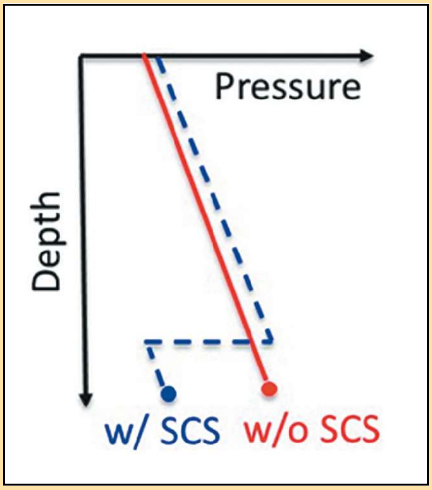


FIGURE 1

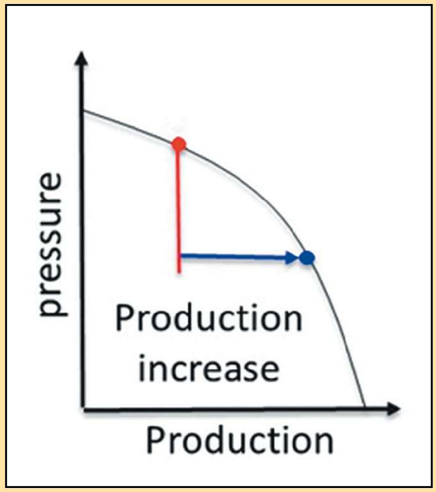


FIGURE 2

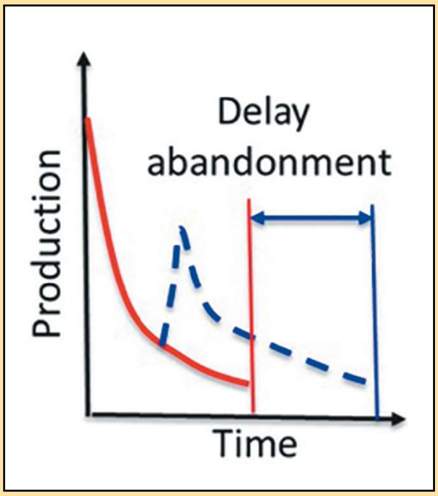


FIGURE 3

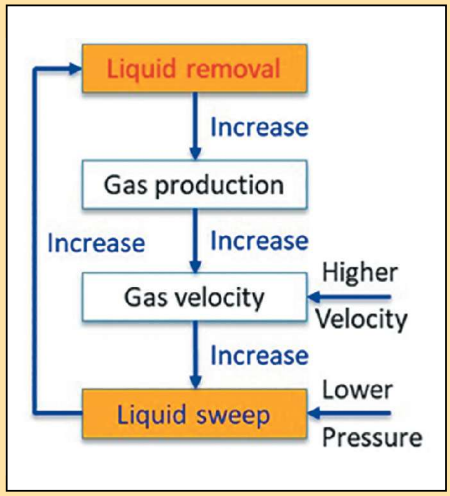


FIGURE 4

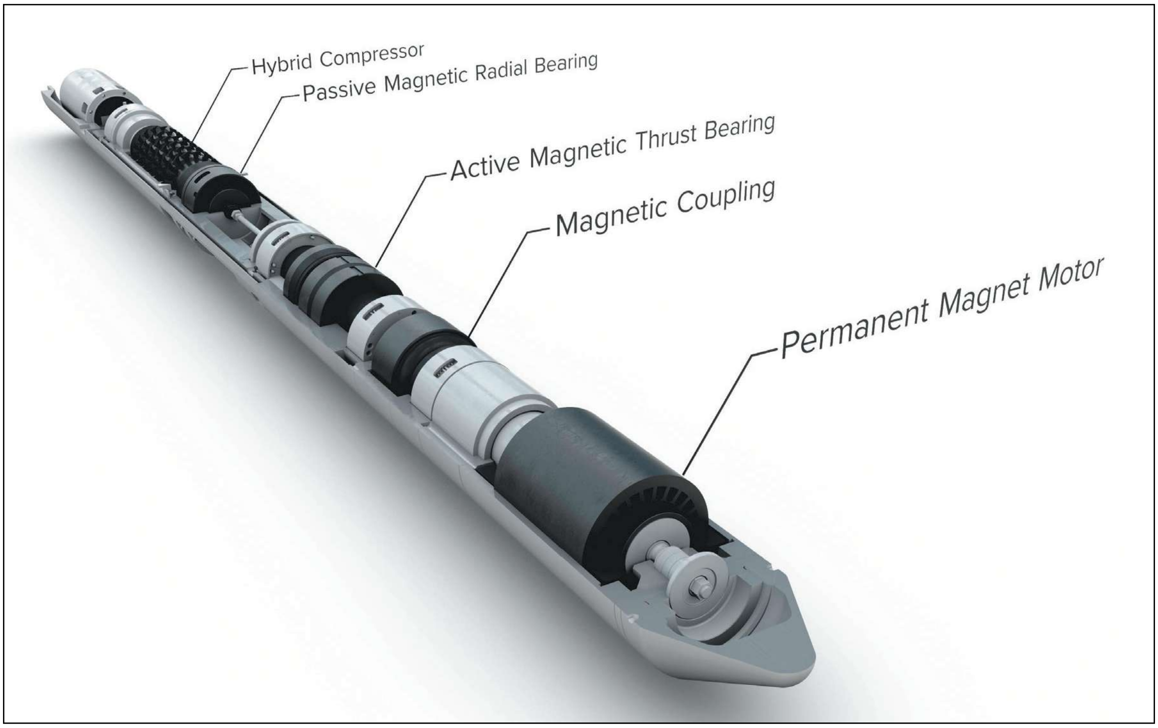
The Upwing SCS combines magnetic technology building blocks into a "protector-less" architecture for the harsh downhole environment. *(Image courtesy of Upwing Energy)*

removal from the well. With the liquids removed from the well, and the absence of the backpressure counteracting on gas reservoirs, gas production will further increase. The closed loop of the virtuous cycle of enhanced liquid removal (Figure 4) can only be enabled by the higher gas velocities and lower pressure generated by the subsurface compressor.

'Protector-less' architecture

The downhole portion of the subsurface compressor is composed of three modules, namely the hydraulic unit, bearing unit and motor unit.

The motor unit contains a permanent magnet motor as the prime mover of the subsurface compressor. To compress gas, the rotation speed of the subsurface compressor is set at 50,000 rpm, which is much higher than 3,600 rpm of a typical electric submersible pump to move liquids. The motor is filled with low-pressure inert gas and hermetically sealed from the downhole environment by an isolation can. More importantly, no downhole fluid or debris can get into the hermetically sealed motor unit, avoiding the electrical or contact bearing failures associated with such exposure.



Major system components of the Upwing SCS are depicted. *(Image courtesy of Upwing Energy)*

A pair of magnetic couplings is used to transmit torque from the motor unit through the isolation can to the magnetic bearing rotor. Using a magnetic coupling to transmit torque eliminates the need for a solid shaft, and thus no need for shaft seals to isolate the motor from the environment.

All seals are known to fail eventually. Seal failures will lead to the ingress of downhole fluids into the parts that cannot be exposed to the downhole fluids. This eventually causes multiple possible failure modes of the downhole rotating devices. To fundamentally eliminate all these failure modes, the best approach is to eliminate the protector containing the shaft seal, which is why the architecture is described as "protector-less."

The magnetic bearing unit is connected to the top of the motor unit. The bearing unit contains active magnetic thrust bearings and passive magnetic radial bearings to support the loads from the hydraulic unit. The most important advantage of using magnetic bearings compared to the traditional mechanical bearings is their reliability and efficiency for high-speed rotating devices. Since there is no physical contact between the rotors and stators of magnetic bearings, there will be no failure caused by introductions of foreign debris on the contact surfaces and efficiency loss due to frictions.

The hydraulic unit houses the gas compressor, which is designed to increase the pressure ratio of the discharge pressure to the intake pressure of the subsurface compressor. The compressor rotor is fully levitated by the magnetic bearings and spins at high speed without any physical contacts to the stationary part of the compressor.

Summary and status

Upwing's SCS increases gas production by decreasing bottomhole flowing pressure and causing higher reservoir drawdown. Effective drawdown can only be achieved by downhole compression near the perforations, where the gas is denser due to the higher downhole pressure. The effective drawdown increases the production rate significantly, which increases cash flow and net present value.

The SCS proof-of-concept field trials demonstrated an increase in gas production ranging from 30% to 58%. Gas well simulations with SCS installations have shown gas production increases ranging from 20% to 150%. In addition to better gas production, analysis shows that the SCS increases condensate production rates and improves condensate yield, particularly in horizontal liquid-rich formations, which positively impacts well performance and value. ■