VFD Technology for Beam/Rod Pumps, ESPs and PCPs

John Lesnick, Danfoss VLT Drives

New technology improves oil and gas production's reliability and efficiency.

At a time when the oil and gas industry is making headlines and documentaries about natural gas production are numerous, it is reassuring to know that an advanced variable frequency drive (VFD) pump solution is making oil and gas production more efficient and reliable.

To anyone driving in the Western U.S. and Canada, beam or rod-lift pumps are a familiar sight—with their unmistakable horse-head rocking up and down on the horizon. The pumps are a necessity of life for hydrocarbon producers, because inside most established wells, the pressure is too weak to lift the crude oil to the surface. Even when the pressure is high enough to bring fluids to the surface naturally, artificial lift pump technologies are used to boost production.

The Need for Efficiency

Efficient production is critical to David Ellis of Noble Energy. This independent, Houston, Texas-based energy company is engaged in worldwide oil and gas production and prides itself on innovation. Ellis was happy to hear about an innovative idea that could improve the productivity of the artificial lift used in his Oklahoma fields.

"We're interested in anything that produces more oil using less electricity," says Ellis. "Plus, anything that keeps our equipment running longer and more reliably is an idea we'll consider."

Ellis heard about the solution from his distributor, Randy Butler from Wilson, provider of pipe, valve and valve automation, fittings and artificial lift systems.

"We supply a lot of equipment to Noble Energy," says Butler. "So we know what works and doesn't work when it comes to increasing production and reducing mechanical failures." He knew Ellis would be interested in the new technology.

"The efficiency of an artificial lift is a factor of the volume of oil that it actually pumps divided by the volume it can theoretically pump," says Butler. "But in most artificial lift systems, you don't come close to the theoretical efficiency. That's because as the pump reduces the fluid level, the pump-off controller shuts the unit down. You don't want the pump running when fluids are low. Otherwise, shock loads, known as fluid pound, will damage the rod string.

When shutdown occurs, the pump stays off until fluid builds up in the wellbore. Then you can restart the pump. However, that on-off cycle hurts productivity. Plus it consumes a lot of electricity to restart the motor and get those heavy weights back in motion."

The Technology

The typical beam pump is driven by an electric motor with fixed frequency and voltage—so the pumps are either on or off. To avoid starts and stops, VFD solutions are sometimes applied to slow the pump to match the well's low productivity.

However, most VFDs have to be configured in a panel with an interface and pump-off controller board connected to an array of pressure and temperature sensors—a complex approach that often does not respond adequately to pump conditions.

Butler realized that the new drive, designed specifically for oil field applications, would be a perfect fit for Noble's Oklahoma production. Unlike standard pump-off controllers, it uses an integrated interface and a powerful algorithm that reduces the pump speed, maintaining and maximizing production while reducing energy consumption and mechanical stress. The system also provides warnings for pump off, paraffin buildup, gas pockets and other serious conditions.

"The VLT SALT controller does not normally stop the pump—it slows it down until the fluid levels have recovered," notes Ellis. "Because we can avoid the heavy amperage draw during restarts, we've been able to cut electric consumption about 20 percent. And we've increased oil production as much as 226 percent, because the system optimizes the pump."

On beam pumps, the drive varies the pump speed with each stroke to maximize efficiency. It goes a little slower on the down stroke to avoid bending the rod, then makes up the lost time by going faster on the upstroke.

"The [drive] uses a patented algorithm designed especially for artificial lift systems," says Butler. "In milliseconds, the drive responds to changes in torque, speed, viscosity flow, the affects of downhole temperature and pressure changes. But it doesn't need any sensors to monitor those conditions. It inherently understands the load characteristics and the conditions the pump is facing. Then the algorithm makes the appropriate adjustments automatically."

Applicable Pump Types

This VFD technology can be applied to all three types of pumps being used by Ellis, namely:

- Beam/rod pumps, which use a barrel, valves and plunger that fit inside the well to gather fluids and lift them to the surface
- Electric submersible pumps (ESP), which are immersed in the fluid and use a centrifugal impeller to propel the fluids to the surface
- Progressive cavity pumps (PCP), which use a motor with a stator and rotor, and the rotor-type auger that screw fluids up to the surface

On ESPs and PCPs, the controller can instantly detect gas pockets that could cause the pump to accelerate to dangerously high speeds—a condition known as cavitation. It slows the pump to let the gas pass, then returns to normal speed—and will repeat the process until the gas is eliminated.

It also has a unique sand-purge algorithm that runs the pump at full speed to clear sand from the bore hole before the pump seizes.

Ease of Installation

Besides improving pump performance, the system made installation easy. "I can cut external sensors, load cells, position indicators and pump cards," says Butler. "That's why a VLT SALT system installs in a quarter of the time required for traditional pump-off controllers. Plus, reduced electric consumption means smaller motors and transformers can be used. It's really a great solution for increasing efficiency and productivity."

Noble Energy's David Ellis agrees: "Across the board, I'm seeing oil production increases of 51 percent on the rod pumps and 187 percent and 226 percent on two wells with PCP pumps. Add that to longer equipment life and lower electric consumption, and I'd say that Danfoss' sensorless artificial lift solution is really worth its salt."

For the last 10 years, John Lesnick has been responsible for business development activities in several industrial segments including oil and gas with Danfoss. He has worked with a large number of users applying variable frequency drives and soft starters on applications in the upstream, midstream and downstream sectors of oil and gas. Over the last five years, he has managed the development of a Sensorless Artificial Lift Technology (SALT) control system that improves productivity and reduces cost. For more information, call 800-621-8806 or email salesinformation@danfoss.com.