BUILDING THE DIGITAL OILFIELD

Ari Huttunen, ABB, Finland, explains how oil producers are using modern motor control technology to achieve major profitability gains, in terms of higher oil flows and reduced pumping energy consumption.

Intelligent artificial lift methods, which support oil production operations by making proactive process adjustments using real time operating data from variable speed drives (VSDs) and sensors, are beginning to be more widely used in the oil industry. The tailored algorithms that can improve the artificial lift process also provide key enablers for achieving the digital oilfield concept, which will eventually see digital devices and communications networks used to optimise a wide variety of oil production tasks.

Higher output with less energy consumption

A common issue in oilfields is waste, which can be reduced cost-effectively through the use of intelligent artificial lift systems. This waste usually occurs in three main areas: from oil left in the ground; in electrical energy efficiency for running the pumps; and waste caused by unnecessary damage to equipment that is not being run correctly. Improved process management could, for example, provide a reduction in the number

of oil pump strokes and on-off cycles, cutting both energy demand and component wear.

As an insight to the economic benefits that intelligent artificial lift might offer, ABB generated drive testing data based on real-life customer sites at nine oil wells using rod pumps. The results showed there was potential to increase oil inflow by 50% – while also reducing pumping energy consumption by 30%. There were also cases where downtime due to maintenance and breakdowns was reduced by 70%. Although these results will not be applicable to every oil well, the data gives an indication of what is feasible with fairly little effort and investment.

Intelligent artificial lift via the drives is the logical starting point

Artificial lift (AL) methods, such as rod pumps, progressive cavity pumps (PCPs) and electric submersible pumps (ESPs), are used to increase the flow of crude oil from a well to improve production rates when the natural pressure is insufficient to push the oil to the surface. AL is today used in approximately 95% of the world's oil and gas producing wells meaning that of the estimated 1 million wells in the world, 950 000 or so are dependent on AL pumps for recovery. These pumps are run by motors, which are the driving force for all oil flow and movements in the AL process.

Figure 1. *Connecting artificial lift systems to digital communication networks and using real time data from variable speed drives and sensors helps to significantly increase production rates and reduce downtime.*

Figure 2. *Modern variable speed drives are capable of supporting intelligent artificial lift process control and protecting the equipment through remote monitoring.*

When these motors and pumps are managed and controlled by VSDs, intelligent artificial lift becomes possible and opportunities for improved insight and control of oil pumping start to appear, on several levels. This is because VSDs, which originally were only used for basic speed control on motors as an alternative to simple 'on-off' running, have developed over recent decades with oil industry-specific programmes built into them, giving operators and engineers valuable new opportunities for better process control.

Operators and engineers get insight as their first step to the digital oilfield

These developments mean that drives are becoming an important technology for the digital oilfield. Users, whether they are an operator in the field or an engineer supporting various operations, can benefit from powerful new insights into numerous aspects of their operations. This can be helpful in many ways, such as improving oil pumping based on the well conditions, optimising their energy use and protecting the pumps and equipment, through to remote monitoring and troubleshooting, which can be performed by experts even on the other side of the world.

Operators can obtain a better understanding of their processes based on digital data that is managed by, and sometimes generated by, the drive. This new set of eyes and ears to watch over and control the oil recovery process helps contribute to higher oil output and profitability, while also protecting against equipment breakdowns through early identification of trends and abnormalities.

Benefits across all pumping operations

Besides offering energy savings, higher oil production and reduced breakdowns, drives are also giving oil producers many other clear advantages for each of the most common pumps, such as rods, PCPs and ESPs, used in oil recovery. Quite simply, they offer an easy way to optimise specific pump criteria and operating parameters, resulting in the most profitable flow rates while also protecting the assets.

In rod pumps, for example, a modern drive makes it possible to automatically adjust the pump speed based on the inflow rate, to maintain a constant fluid level and therefore provide steady bottom-hole pressure. This results in increased inflow to the pump from the formation, giving higher production with reduced pump wear and tear. The drive can also automatically fine-tune and differentiate the upstroke and downstroke speeds to reduce the risk of malfunction and expensive damage to the rod pump.

Protecting pumps and people from damage and dirt

For PCP systems, protection against backspin is important to safeguard both equipment and people. This can be done through the drive so that, when a 'stop' command is given, the VSD will continue to control the pump until the rotating force created by the hydrostatic pressure of the oil is below a safe level. Similarly, for ESPs, the drive keeps operations running smoothly using a pump-cleaning action which helps the impeller shake off any residue that might cause an obstruction.

Energy optimisation for ESPs

ESPs, in particular, can also benefit from an energy optimisation function that adjusts the motor voltage and frequency relationship automatically according to the voltage/frequency curve setting in the VSD software. This function optimises the motor operation so that total energy consumption is minimised when the drive operates below the nominal load. The total efficiency of the motor and drive combination can be improved by up to 20% depending on load torque and speed. Consequently, this is a useful way to reduce energy consumption while maintaining motor performance.

Furthermore, optimisation, according to an optimal voltage/frequency curve, can increase the motor lifetime by decreasing its running temperature. Results from field operations indicate that a 10% reduction in current, results in a 5˚C reduction in motor temperature. Since ESP motors typically operate at the upper limits of their temperature tolerances this is a significant improvement. In the past, this current adjustment would be carried out manually by adjusting the tappings in the step-up transformer. With the drive software, the change can be made automatically without stopping the pump, reducing the risk associated with restarting.

Using VSDs with PCPs

The practical advantages of using VSDs in artificial lift installations are illustrated by two case applications.

Increased productivity for Oman's oil wells

A recent project in the Sultanate of Oman has seen more than 1500 oil-producing wells fitted with PCPs driven by VSDs in the search for a software-based solution to automate the processes and establish the possibility for remote operation.

Over the years, the well operation teams had faced some challenges with their PCPs, with 'pump-off' conditions, improper sand handling, rod over-speed, electric power outages and SCADA connectivity interruptions resulting in PCP failures and high production losses. Therefore, they considered ways to maximise the well production without risking the failure of the pump. Consequently, an automated control method was devised for monitoring rod torque, speed and pump intake pressure, while maximising production through a closed loop proportional/integral control.

The project has delivered increased productivity through intelligent and automatic production control. Reducing the need for human intervention for operation and maintenance has reduced HSE risks, while the start-up time reduction means more barrels of oil extracted. For a well with an average of 500 bpd of oil production, implementing the software has increased production by 17%.

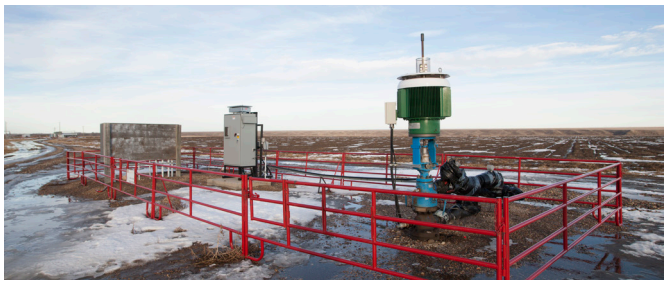

Figure 3. *Variable speed drives can help optimise the production according to the changing well conditions and protect both the equipment and the people using it.*

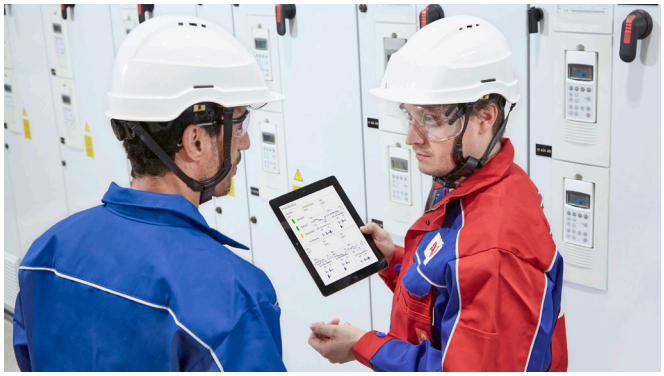

Figure 4. *Remote monitoring of the artificial lift systems enables faster and more precise resolution of operational problems happening in the oilfield.*

Reliable control for a permanent magnet PCP top drive motor

A VSD is at the heart of the large 85 hp MagnoDrive permanent magnet (PM) top drive motor developed by General Magnetic of Canada to drive PCPs. While a PM motor is initially more expensive than a comparable induction motor, it uses significantly less energy, allowing the initial cost differential to be offset early in its life cycle.

The main operational benefit of the MagnoDrive over a conventional PCP drive is that the speed and torque envelope is available throughout the entire speed range. This enables it to run full torque from 30 - 450 rpm, with approximately equal efficiency.

The vast majority of conventional PCP drives use AC induction motors. They have high efficiency levels from 70 - 110% of their rated speed, but outside those speed ranges there are significant challenges. PM motors are able to produce higher torque than the same size induction motors, providing greater operational efficiency.

It is the VSD component of the MagnoDrive that enables the motor to run at any speed and torque within its operating envelope. It is programmed to manage all possible situations, providing the advanced supervisory control that determines when to stop and start the motor, how fast it should go under varying loads, and how to most efficiently operate within any torque limits.

In addition to the energy consumption savings and the reduced greenhouse gases that result, there are other environmental and cost-of-ownership advantages of a PCP powered by a MagnoDrive. The advanced motor's direct drive operation removes the high maintenance hydraulic equipment, mechanical brakes, and speed reduction equipment, including gearboxes, belts and sheaves, required with conventional PCP top drives. The absence of these external moving parts reduces the general maintenance required to operate the MagnoDrive, makes it much safer for field operators and maintenance crews and makes it noticeably quieter in the field.

There is growing interest in the MagnoDrive concept within the industry, because operators and field engineers have found that the PM motor and VSD combination allows them to manage complex wells in a way that they could not before.

Remote condition monitoring – working at a distance to avoid problems

Besides simply helping to optimise daily oil pumping operations, today's drives also provide many other important benefits to artificial lift. Specifically, advanced connectivity now makes remote condition monitoring of the drives and the processes they are controlling possible. By using information coming from intelligent drives, engineers can get a faster and more precise understanding of operational problems, resulting in user benefits – including fewer costly surprise breakdowns in the field, quicker problem resolution and deeper analysis of data.

Eventually, using the facts derived from data analysis, decision-making can be improved with proactive trend spotting, which in many cases will identify potential problems before they become serious and costly disturbances, even in remote and difficult-to-access locations.

Digitalisation is going faster, one step at a time

VSDs have been using digital technology for decades and are now supporting intelligent artificial lift as it moves forward, based on the high level of data they can produce. This is providing a powerful and valuable new set of tools to increase productivity which any oil producer, oilfield manager or operator would be wise to explore.

Profitability, of course, is the real motivator. Today's new abilities to use digitalisation to get more oil out of a well, while reducing pump energy costs and breakdowns, is what makes this a genuine 'win-win' economic opportunity. Progressive oil companies are already seizing the opportunity as, step by step, the much-discussed digital oilfield begins to become a reality.