JULY / AUGUST 2008

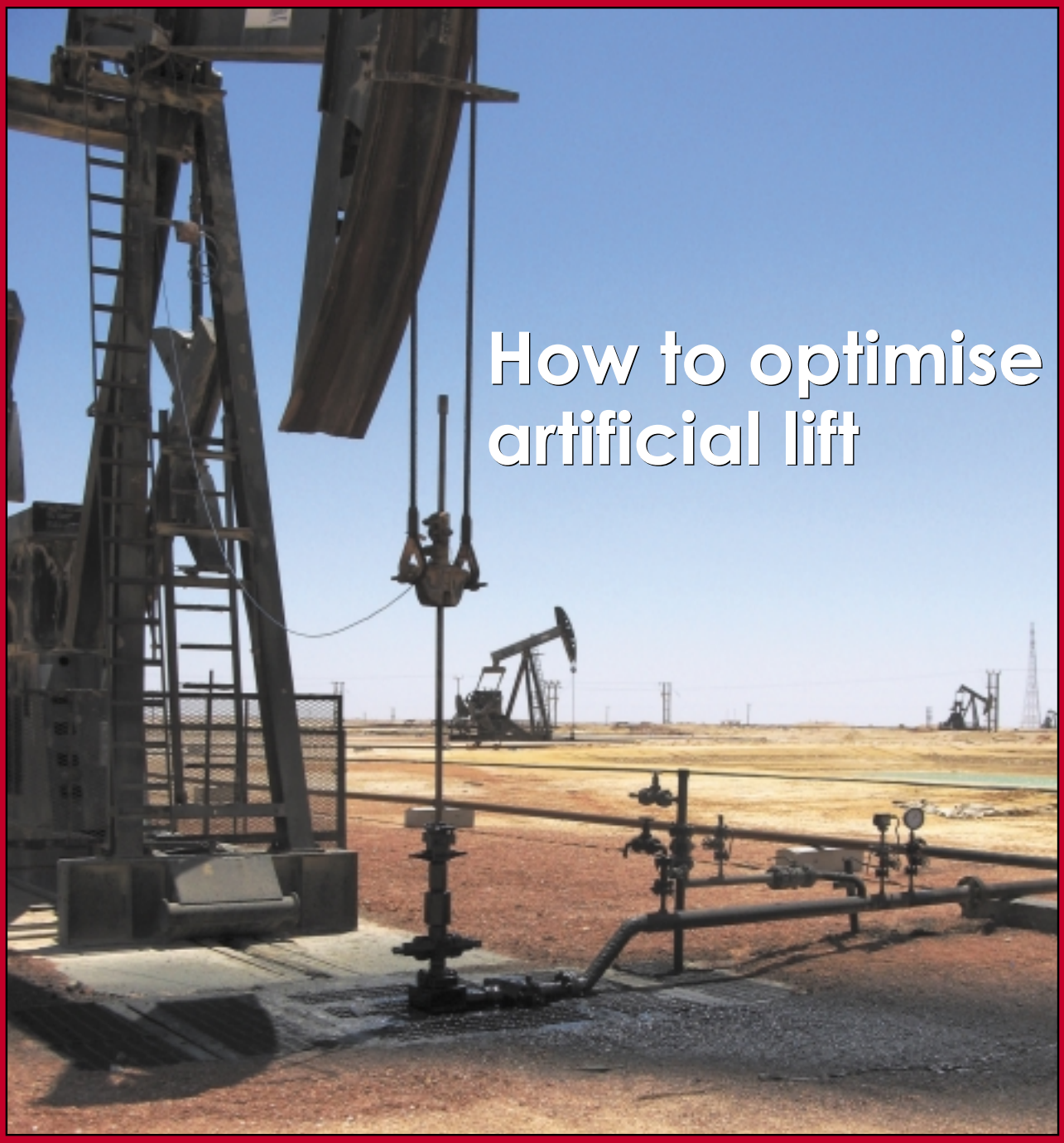
AOG

ASIAN OIL & GAS

Elephant hunting in the Arctic

Asian shipyards at full stretch

Slow and steady Q wins the race



How to optimise artificial lift

Optimising artificial lift with digital well integrity

The pressure to meet hydrocarbon production targets and maximise recovery within stringent safety and environmental regulations as well as the constraints of time and budget, grows daily. Here, Sensornet's **Neil Meldrum** and **Doug Walker** discuss how these challenges can be met by monitoring technologies and solutions with the precision to detect the smallest temperature variations; the speed to deliver timely interpretation of critical changes and events; and the reach to operate along the full extent of an asset, however remote or hostile, throughout the life of the field.

During a workover to install a gas lift system in an oil producer well in the Middle East, Sensornet, a global provider of advanced monitoring solutions, installed a digital well integrity solution to monitor and optimise well production. Distributed temperature sensing (DTS) data from across the production interval was used to enable better understanding of lift performance over time, resulting in a dramatic reduction in the requirements for traditional pressure gradient surveys. The measured inflow profile and depletion trend has proved invaluable in the design and placement of subsequent wells in the field.

Due to sub-optimal intervention, production and remediation planning, the operator had calculated that it was experiencing deferred production each year in excess of 270,000 barrels from the field. In addition there were gas lift operational issues that reduced the daily production and caused associated downstream problems due to slugging. With an immediate need to provide increased and improved production information to the production and reservoir engineering teams, the company deployed the Sensornet DTS acquisition system which provided an accurate flow profile along the length of the well to ensure events were detected immediately. This allowed the production and reservoir engineers to justify and utilise limited intervention opportunities and highlight viable solutions to rectify underperforming wells.

Middle East operators have embraced DTS technology as they look to optimise field development and maximise production.

The unmanned offshore location and small jacket size meant production logging and intervention operations were difficult to validate and a lack of communications and power infrastructure on the platform meant that limited permanent monitoring options were available. The DTS monitoring units have low power consumption and operate over a wide temperature range which enables them to be located in harsh environments, providing the ideal solution for locations such as this.

Digital well integrity

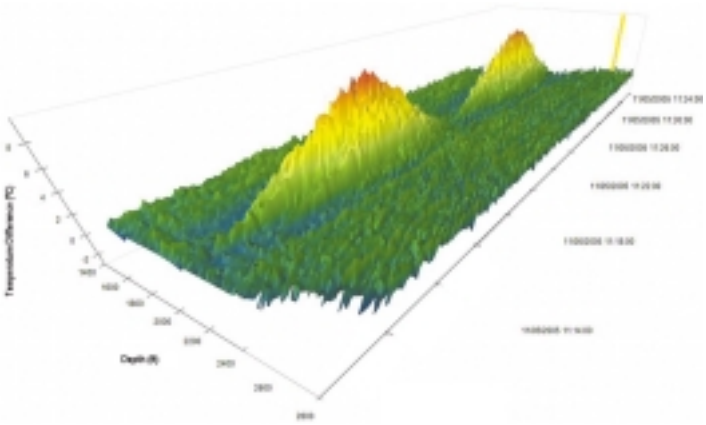
First established in the oil and gas industry for downhole well monitoring, DTS involves the installation of a fibre optic sensing cable into the well completion which enables the production engineer to maximise output and increase well integrity. The technology is permanently installed and is a non-intrusive, real-time and accurate monitoring system, which can also be used for other oil and gas applications such as refinery and transportation pipeline applications.

The system allows production and reservoir engineers to analyse underperforming wells and fully understand which sections of the well are producing in order to achieve a uniform

About the authors

Neil Meldrum is Sensornet's VP Europe, FSU and Africa. He has worked in the upstream oil and gas service industry for 20 years with global experience in land seismic data acquisition, well testing, intelligent well technology and permanent down-hole monitoring with both electronic and fibre optic systems. Meldrum has ten years' experience in product development and commercialising new wellbore technology, including Cidra's early fibre optic system introduction into oil and gas. He holds an MSc in technology & management in the oil and gas industry from the University of Aberdeen.

Doug Walker joined Sensornet as VP Asia early this year havin previously served as Baker Hughes' district manager for India and Bangladesh. With a BSc from Edinburgh University, he began his oil and gas industry career over 20 years ago as a wireline field engineer in the UK North Sea. He subsequently held account manager positions with Baker Hughes in Abu Dhabi, Norway, the Gulf of Mexico and Vietnam, later becoming the company's area sales manager for the north Asia Pacific area.



Through the analysis of temperature measurements, the DTS system can detect and locate minute changes such as these intermittent leaks in oil wells using FloQuest DTS visualisation and interpretation software.

stable flow. Condition monitoring along the entire completion identifies any problems or fluctuations of flow which can lead to slugging. This optimises the whole gas lift process to ensure a steady state or flow assurance. The distributed flow information provides a valuable input to the reservoir characterisation and resulting field development plan.

The system was permanently installed in the horizontal well on the outside of the tubing and was conveyed with the completion all the way to the toe of the well. The specially coated optical fibre is pre-inserted into protective metal tube layers where the outer tube diameter is typically 0.25in and encapsulated in an anti-abrasive plastic. At each tubing joint coupling a protector clamp holds the optical cable in place and provides a protective envelope for the cable while running into the well. This robust SureSight sensing cable was deployed to ensure years of operation without degradation or loss of signal performance. This provides continuous information on flow and temperature events, on the targeted zones, which will enable the operator to make informed decisions to adjust the stimulation program if required.

Installation of the digital well integrity solution was quick, efficient and ensured little interruption to conventional well deployment. Being permanently installed, the real-time, high-resolution system measures temperatures of at least 0.01°C and supplied accurate readings from approximately every metre along the wellbore from the surface to the toe, giving a thermal profile of the complete well. This provided flow and diagnostic information from initial well stimulation, start-up and production, along the 4.4km well length, which gave the production and reservoir engineering teams highly valuable information to better understand lift performance and effectively optimise well production and minimise operating costs.

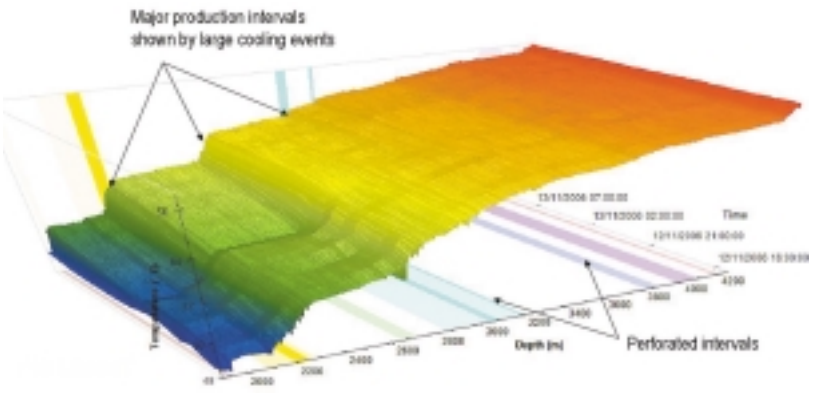
Any intervention into a production well whether to fix a gas lift system or mechanically change the completion configuration will result in deferred production. Minimising the intervention time is therefore clearly desirable. The DTS system was able to easily monitor, section by section, any changes in the gas inflow as it loses pressure and cools down entering the wellbore through the gas lift mandrills. The location of the gas lift mandrills is not an issue as the sensing solution is truly distributed along the completion.

During gas lift operation, cooling occurs as injection gas loses pressure entering the production string. This is clearly identified on the DTS profile. The time and location of cooling events allows the operator to determine which valves are operating, the sequence in which they are opening and even to detect if they are continuously injecting, or slugging. If there is a tubing or packer leak, the operator is quickly able to detect the precise location of the event and determine the most effective course of remediation. Without complete coverage it is possible to misinterpret well integrity issues, mistaking leaks for improper valve operation. The high resolution of the Sensornet acquisition unit, even at fast update rates, also allows intermittent valve operation to be detected.

During well start-up, the operator estimated it saved six hours' rig time, when the DTS temperature profile clearly detected a slugging faulty valve, allowing the component to be identified quickly and replaced immediately. Typically, if this digital well integrity system wasn't deployed, it would be extremely difficult to identify which valve is affected, so an operator would need to spend considerable time, cost and manpower to sequentially test each valve, requiring multiple slickline trips.

Any change in flow will have an associated temperature change. Because the system is truly distributed then any change of temperature, from the initial baseline trace, will be detected along any part of the wellbore. Temperature changes as small as 0.007°C can be detected. Intermittent changes will be detected, in real-time, because the DTS can scan the complete well length every 10-20 seconds. If required the system can measure to a range of 30km (eg 25km along a surface flowline and down into a 5km well). User defined alarms can be set up to continually police the wellbore for any changes. If an alarm is triggered then the production engineer can be alerted by text message or email.

Each DTS unit is an autonomous device that can be connected to up to 16 wells. A network connection allows the operator to access the DTS well data remotely. The DTS data is stored locally on the DTS or on a client SQL database. The client database can load and store raw and processed DTS traces that are accessed via windows or web applications. FloQuest DTS visualisation and interpretation



High resolution data captured across the production intervals using FloQuest software.

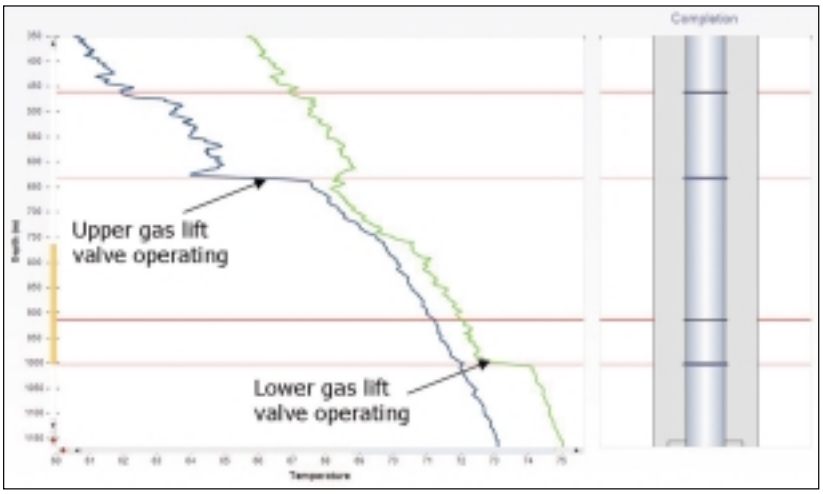
software provides the Operator with a tool to analyse the flow profiles and changes to production when combined with other petrophysical data (eg porosity, permeability and rock strength).

Leak detection

The implementation of an accurate and reliable monitoring system can also alert the operator to the presence of flow assurance issues which will not only minimise the amount of production lost but also prevent a major environmental or safety incident occurring. Accurate and early identification of problems allows the operator to schedule any intervention requirements with any possible planned maintenance downtime. Sensornet's pioneering range of cables can withstand extreme temperatures from cryogenic environments (–165°C) and those exceeding 700°C. By detecting the temperature change of the surroundings, the distributed temperature sensor not only detects the presence of a leak but can also pinpoint the location down to one metre.

In the event of a gaseous leak, the temperature drop due to the expansion (Joules Thompson effect) is instantaneous and can be considerable (liquid natural gas –120°C to –160°C, or for ethylene –110°C). The system provides measurements every ten seconds and such rapid detection is essential in the case of potentially explosive gases. In the effect of liquid leakage (eg oil or water) the temperature change is less pronounced and even more so along a horizontal well.

However, the key is in the sensitivity of the system which can detect changes as small as 0.01°C. Through the analysis of temperature measurements, the system not only detects leakage but with calibration and advanced interpretation algorithms, it can quantify leaks down to litre accuracy. Without complete coverage, it is possible to misinterpret well integrity issues, mistaking leaks for improper valve operation.



FloQuest visualisation software showing the completion diagram and location of gas lift mandrels alongside Sensornet DTS temperature traces.

Seeing is believing

The technology is still considered relatively new compared to conventional electrical and electronic technology, though it is quickly becoming an accepted sensing tool for monitoring the complete wellbore due to its passive sensing, field life longevity, and non-intrusive flow monitoring. The Middle East in particular has fully embraced this technology as operators in the region look to optimise field development and secure maximum production combining DTS with zonal isolation and remote flow control.

The benefits of this solution are obvious not only for the identification of issues in the reservoir throughout the lifecycle of a well but also for drilling in the future, as the construction of a robust reservoir model can dictate that a well may not be needed or may have to be relocated. Removing guess work and uncertainty can potentially saving millions of dollars to the operator through reducing or eliminating costly interventions, identification of potentially hazardous leaks and the unquantifiable cost of human life or the environment. ■