Optimised completions and production

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In conventional and unconventional reservoirs, there are several reasons for running a completion across the reservoir: to control sand production and/or to optimise inflow, control injected gas or CO2 in huff and puff treatments, and to prevent water production from long horizontal laterals. These are highly specialised subjects, and this is reflected in the range of control, optimisation and production enhancement technologies available as well as the ongoing focus on innovation in these areas, as Annabel Green, CTO of Tendeka, explains...

Inflow optimisation can be so fundamental to field economics that in the FEED phase, long before a Final Investment Decision (FID) is made, evaluation and screening of a potential reservoir or advanced completions takes place.

Detailed planning of the optimal completion configuration occurs throughout the execution phase. However, final configurations are often only determined once the Logging While Drilling (LWD) data becomes available and the completion is lying on the deck of the rig. This reservoir completion is then expected to provide the functionality required for the life of the well. While top-hole workovers are common practice during the well life, for reservoir completions there is no further opportunity to improve the functionality, or at least, that used to be the case.

Retrofitting advanced completions

Inherently, as fields mature, the range of production and recovery challenges increases or becomes more apparent. This can range from unwanted fluids being produced, differential depletion occurring, and hydrocarbons bypassed. On the flip side, innovation provides an increased range of solutions that can contribute to improved performance. Faced with such technical issues, there is now a growing trend towards retrofitting advanced completions into existing wellbores. This approach is not only aimed at improving production and optimising secondary and tertiary recovery projects, it can also be used to reduce well intervention requirements. Below is a selection of technologies that are enabling this trend:

- Advanced packer technologies that can compartmentalise the production zones
- Chemical solutions that can access the existing wellbore annulus and high expansion swellable and mechanical options.

As with primary reservoir completions, the range of technologies is increasing with the latest systems now offering fully intelligent completion functionality.

Smart wireless technologies

To combat the limitations associated with the use of conventional control lines, the development and deployment of wireless completions equipment is now becoming more prevalent (Figure 1).

From drill stem testing to multi-node intelligent completions, the shift from downhole equipment with no communication and/or actuation mechanisms to intelligent technology represents potentially huge efficiency and performance savings, as well as improved safety. However, these solutions tend to be targeted towards new field developments where there are currently limited options for replacement of failed equipment, or applications for existing wells, other than to conduct a complete workover.
For instance, there are a variety of digital oilfield solutions on the market today for topside applications, which can be integrated into existing fields to manage data and automate processes. Unfortunately, the same cannot be said for downhole solutions. The limited scope of intelligent equipment available does not address the needs of existing assets and can therefore demonstrate limited value. Without these retrofittable, dynamic downhole reservoir management systems, the full benefit of the digital oilfield is beyond the reach economically for many mature fields.

Well communication and data transfer
Tendeka, a global specialist in advanced completions and production solutions for the oil and gas industry, has developed a unique two-way Fluid Harmonics production telemetry system which can be applied to downhole devices for communication in all phases of flow from a well. The PulseEight system (Figure 2) provides a versatile wireless alternative to existing data transfer and actuation methods within both production and injection wells.

Downhole, the flow regime is diverted through an infinitely variable choke system which permits the manipulation of the available flow area with which to create a pressure response that can be observed at surface. These communications waves can be received and decoded by surface software examining the amplitude, duration and interval of the waves to deliver meaningful data from the tool.

A similar effect can be achieved at surface using a production choke for the reversal of the communication route. As this communication wave is contained within the normal flow stream, it is possible to achieve this level of communication without the need for additional downhole ‘jewellery’ such as signal boosters or repeater systems. This provides the ability for the entire system to have an elegantly compact configuration with limited downhole footprint (Figure 3). Additionally, surface equipment requirements can be reduced to almost zero by utilising existing pressure monitoring already in place which enables an easy to install solution.

Figure 2: Tendeka’s PulseEight device

Early development of the device focused on the need to address the significant challenges associated with ensuring Fluid Harmonics telemetry could be achieved in not only liquid flow but also gas, and all three phases of flow. Tool responses have been designed such that they can autonomously optimise the pressure response created downhole to illicit a robust surface signal. This has been demonstrated to be possible even within the changeable characteristics of ‘steady state’ flow regimes associated with any hydrocarbon production stream.

The PulseEight Wireless Gauge was first applied to a retrofit downhole pressure and temperature monitoring system. This significantly expanded upon the limited functionality of the traditional industry memory gauge by providing real-time data to surface. This has facilitated the capability of existing reservoir models to be simultaneously updated with the latest data in a timeframe that is unhindered by the need for well interventions to retrieve memory gauges to surface for download.

These benefits, coupled with the flexibility of the retrofit design, were exemplified over multiple deployments in the North Sea. This allowed valuable pressure and temperature monitoring to be regained in wells which experienced a failure of their permanent downhole gauge systems and wells which were never designed for gauge inclusion in the first place. In one example, declining reservoir pressure in a field had resulted in the requirement for more surface compression capability to drive production. It was therefore crucial that there was an accurate understanding of reservoir pressure and decline to meet contractual gas deliveries and achieve recovery targets. A long-term deployment of the gauge system secured the requisite information to facilitate these needs.

Reservoir to smartphone communication
The communication system capability has been further expanded to offer true cable-free access to wellbore data. A recent deployment of a flow control valve in an onshore well demonstrated the ability of the system to send data wirelessly from the tool all the way to a smartphone app.

In what is believed to be a world first, this wireless ‘reservoir to smartphone’ communication enabled easy access in almost any location with either cell phone or satellite link connectivity (Figure 4).
Through-tubing autonomous and wireless technology that projects, it can also be used to reduce well intervention wellbores. This approach is not only aimed at improving with such technical issues, there is now a growing trend solutions that can contribute to improved performance. Faced differential depletion occurring, and hydrocarbons bypassed. recovery challenges increases or becomes more apparent. Retrofitting advanced completions functionality, or at least, that used to be the case. completions there is no further opportunity to improve the required for the life of the well. While top-hole workovers are Decision (FID) is made, evaluation and screening of a potential production enhancement technologies available as well as the ongoing focus on innovation in these areas, as Annabel Green, from long horizontal laterals. These are highly specialised subjects, sand production and/or to optimise inflow, control injected gas or address the significant challenges associated with ensuring fluid production stream.

In conventional and unconventional reservoirs, there are several aspects. Moreover, the truly intelligent capability of modern tools and confidently advance digital oilfield operations by removing the need for traditional hydraulic or electric control lines. The elimination of these items can positively impact overall system costs whilst delivering an improved design from a safety aspect. Moreover, the truly intelligent capability of modern tooling sees the absolute need of surface data analysis for key trigger points in the well lifecycle to be mitigated, leaving engineering time to focus on more complex aspects of the reservoir’s production potential.

The future for this and other technologies should be to extend the operating envelope for intelligent completions and address its various applications. With advances in surface data analysis and autonomous completion tools, which can link both inter-tool and inter-well, should be considered as the next step for production optimisation over multiple wells and can deliver demonstrable value to both existing and new field developments.

**Production Enhancement technology**

In solving challenges of E&P companies with assets in unconventional formations, Tendeka has purposefully created a Production Enhancement product line around the needs of such operators. Tendeka works directly with E&P companies supplying all fracturing, acidizing, and EOR technologies along with engineered application and fluid field service support. Tendeka looks for ways to accelerate innovation by finding new methods for technology evaluation, such as the use of microfluidics to evaluate a new oil based relative permeability modifier for unconventional formations.

To maximise return on investment, reducing the time and cost to complete wells in unconventional shale plays is crucial, particularly given the increasing trend to pump more proppant per thousand feet as well as the associated increase in volumes of fracturing fluids.

One such way to reduce time and cost is during perforating in acid with plug and perf completions. This new patent pending process and technology eliminates the procedure of placing acid ‘after’ the guns are removed from the well. A spearhead acid stage is typically pumped prior to the main fracturing stage to clean cement debris and generally assist in reducing initial injection/fracture pressures. Taking a four well pad as an example, with 50 stages per well, with an average displacement volume of 250bbl and acid displacement time of 20 to 60 minutes per stage (based on pump-down method and rate), this would amount to over 50,000bbls of fluid and up to 200 hours of equipment time that could potentially be minimised.

The application of perforating in acid is not a new concept, but to date, its use has been limited in unconventional shale plays because of the corrosive properties of the hydrochloric acid (HCl) or urea-hydrochloride and the temperature limitations of urea-based products.

A new thermally stable Modified Acid™ system is now available to the market and is already in use by various North American operators. It shows far superior performance properties compared to hydrochloric or urea-based acids, without the extremely hazardous/negative exposure, transport, effluent, and corrosive properties associated with HCl. This system is a replacement for hydrochloric acid blends and can be utilised and exposed to perforating tools and wireline at high temperatures over long periods with minimal effect. This system allows operators to pump acid with the perforating guns and plug, reducing time per stage and saving considerable water per stage (a hole-volume per stage) where applicable.

In addition to the advantages of this system, it also achieves ultra-long-term corrosion protection on corrosion resistant
casing widely utilised in industry, such as P110. Casing integrity issues have been observed by multiple operators due to spearhead acid placement (hydrogen embrittlement). This system will provide corrosion protection well below the industry standard of 0.05 lb/ft² for up to 96 hours versus the usual six hours provided by HCl based systems, virtually eliminating the risks of casing integrity.

The chemical solution is part of a new portfolio of applications which aims to reduce water use and pumping time during completion operations in unconventional shale plays in the USA. Unique to Tendeka, the MajiFrac Solution (figure 5) also includes the company's field proven MajiFrac Composite Plug, which incorporates a pump down feature to minimise water by-pass, and MajiFrac HVFR which has superior performance in being able to carry proppant at higher loadings in produced water, due to its elasticity properties in produced water.

![The MajiFrac Solution](Image)

Figure 5: The MajiFrac Solution is the combination of a wide range of high-performance technologies and products

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