Intelligently Using Intelligent Completions

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Oil and gas producers and service companies have long been committed to recovering more hydrocarbons from fewer wells. This presents a significant challenge, and most in our industry will agree that innovative application of technology is key to addressing it. Today, however, the challenge is even more daunting: to produce more complex hydrocarbon resources economically while continuing to increase ultimate recovery.

In the past, a well's longevity could be prolonged by plugging it back and recompleting it in a shallower pay zone, continuing until all zones had watered out and the well was abandoned. However, engineers realized that in spite of their best attempts, recovery factors averaged only 30%, and often their response was to drill more wells.

Engineers sought new ways to improve recovery while drilling fewer wells using geophysical and reservoir information to guide well placement. More accurate, higher-resolution data reduced interpretation ambiguities and decision risk, and advances in drilling technology allowed wells to be steered into the most prolific portions of the reservoir. Most significantly, the shift from analog to digital data recording enabled integration of information from separate sources. This integration improved knowledge and allowed full field simulation, which in turn resulted in better reservoir understanding and more efficient field development plans.

From Knowing to Doing

Over time, several techniques have been employed to maximize early production and optimize financial returns. However, in the current environment, production rates alone do not define a good project.

Economically improving recovery is perceived as more difficult to achieve than just increasing production. Recovery is highly dependent on completion technology and reservoir management. Completion technology and reservoir management are more likely to succeed when applied on a fieldwide basis, and they both require substantial upfront engineering and investment. Despite the technical challenges, increasing recovery economically is essential to bringing the industry to a new level of success.

As we encounter more complex reservoirs, requiring multiple-zone completions, it is critical to have the capability to modify the downhole completion as production parameters change over the life of the well. The types of completions that can be modified to improve recovery are intelligent completions—combinations of downhole sensors and actuators, plus the software and systems integration to monitor and control individual sections of a well remotely.

In the first applications of intelligent completions, the focus was on single-well flow-control valves with limited monitoring. The economics of such technology limited its use to complex, often subsea, wells with high productivity. Over the course of a decade, however, about 1,200 zones now are producing through intelligent completions.

Advances in drilling technology now allow several reservoirs to be intersected by one wellbore and more well designs routinely include several laterals to achieve maximum reservoir contact. Both of these technologies will increase production from the well, but at the same time individual sections of these wells need to be managed independently. These wells require advanced monitoring and control to ensure that the value created in the drilling process is not lost during the production stage. With successful deployment of these technologies during the production stage—and a track record of system reliability—comes operating-cost reduction, making the more complex well architectures economical even in mature fields.

Tools For Progress

The reliability of completion tools has improved substantially over the years. Recent statistics show that the newest generation of gauges using electrical dry-mate connectors has better than 98% survival after 48 months. For this reason, more operators now run downhole pressure and temperature sensors systematically on their new wells.

The same methodology used to boost the reliability of downhole monitoring systems has been applied to flow-control valves. It involves specific focus on component qualification and testing, system integration, and training and service delivery standards. This focus has led to smaller sensors with better metrology that consume less power. New telemetry allows many individual sensors to be run on one cable, acquiring data at high frequency, and soon systems will use wireless telemetry rou-

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tinely. Both of these advances reduce the system cost significantly for downhole monitoring installations.

Similarly, the emergence of fiber-optic technology enables novel approaches. Distributed temperature sensing provides permanent and continuous temperature logging of wells all the way to the surface even under high-pressure/high-temperature conditions that exceed standard-gauge capabilities. When combined with the right software and flowrate measurement at surface, it is possible to determine accurate flow profiles and even derive zonal back allocations.

More recently, inflow-control devices (ICDs) have started gaining industry acceptance. These ICDs are integrated in the completion tubulars and allow control over the drawdown in each section of the well. In most cases, the reservoir is segmented with openhole packers with up to 15 segments per lateral. The use of ICDs to manage production by zone optimizes reservoir drainage, delays water or gas breakthrough, and improves ultimate recovery.

The next-generation ICD will be monitored dynamically and controlled actively, allowing real-time adjustment of the choke settings as reservoir performance changes over time. This operation will not require intervention. These systems will include the actual downhole flow control hardware, the monitoring system, and the logic to optimize well performance through a simple interface.

A Shift of Focus

These types of new technology will close the gap between recovery and economics, but only with the addition of a critical ingredient—people. Achieving this vision of economically improving recovery depends on people willing to embrace new technology and methods. For example, timely handling of enormous amounts of data became a requirement years ago with advances in seismic acquisition and well logging. Engineers and scientists will need to bring that understanding quickly to permanent monitoring and production control.

Effective application of intelligent completions requires efficient integration of data, disciplines, and technology, with the focus placed clearly on the reservoir. Decisions made on individual wells should always be made in the context of how the reservoir will be affected. With today's cross-disciplinary collaboration augmented by powerful dynamic models and seismic-to-simulation software, every decision can be played out to reveal its ultimate effect, before the die is cast.

This concept, which we describe as logging-while-producing, delivers continuous relevant production information to engineers. Intelligent cross-discipline workflows will simplify the decision process and make more effective use of investments in completions and reservoir management. Completions technology and reservoir management workflows must be united, for one cannot be implemented without the other if the goal of economically improving recovery is to be achieved. The solution is within our grasp. JPT