Variable choke adds versatility to completions

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AS THE WORLD'S demand for energy continues to increase, operators explore new ways to maximize cost-effective production from every well. Aiding them in their quest are intelligent well systems.

Encouraged by technical success and economic advantage, oil and gas companies are increasingly adopting intelligent well systems as accepted solutions in the completion engineer's tool box.

The increasing use of intelligent well technology is being driven by the availability of practical systems, strong reliability performance from installed equipment and the systems' demonstrated ability to improve the economics of marginal wells.

In addition to being more widely used on water and gas injection wells, the technology is being applied in three-, four- and even five-zone intelligent completions, as well as in an increasing number of ESP completions.

A recent development that has furthered the value of intelligent well systems is the commercialization of a remotely controlled, hydraulically actuated, variable downhole choke known as the HCM-A.

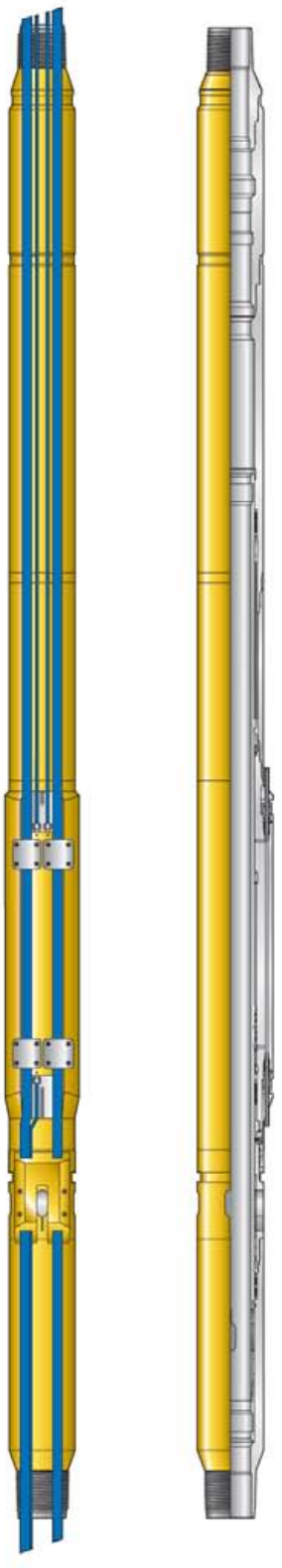
Baker Oil Tools has developed its InForce hydraulic intelligent well systems with various methods of intelligent flow control that include the use of remote controlled hydraulic sliding sleeves, fluid loss control valves and, most recently, the HCM-A hydraulic chokes. The chokes offer significant advantages over other methods in both flow control and reliability.

Since their first field installation in December 2003, the multi-position hydraulic chokes have been the fastest growing segment of the company's intelligent well systems business, according to the company.

GETTING BEYOND OPEN-CLOSE

During the 1990s, hydraulically-actuated control valves that could be shifted remotely were developed to selectively shut off or open zones without costly and risky intervention.

The company has been in the sliding sleeve business since 1997. Its first products were essentially modifications of old wireline sliding sleeve valves.



Baker Oil Tools' HCM-A infinitely variable hydraulic choke has been successfuly flow tested with over 300,000 lbs of sand at rates exceeding 25,000 bpd without significant choke wear or seal system damage.

However, improvements that made the valves able to shift easily and nearly instantaneously caused operators to see value beyond eliminating intervention and to improving recovery efficiencies.

It was that vision that led to the demand for the devices to go beyond simple open-close capabilities to act as adjustable chokes that could distribute injection, adjust pressure in various zones or control crossflows.

INFINITELY VARIABLE

The HCM-A combines the basic chassis from the company's HCM surface-controlled sliding sleeves with incremental choking technology. A balanced hydraulic piston opens and closes the choke.

A tungsten carbide choke assembly and J-mechanism selectively adjust the choke without the need for complex electronics downhole.

The HCM-A hydraulic chokes are infinitely variable, with the understanding that six intermediate choke settings between fully open and fully closed must be selected by machining a profile prior to tool installation.

Nodal analysis and reservoir studies help the operator and the company to determine the optimum settings for the chokes to achieve maximized oil production, reduced total water cut at the surface, improved final oil blend quality, sand control, avoidance of crossflow and consequent production losses, compliance with regulatory production restrictions, and production above the bubble point to avoid gas at the pump intake.

Input parameters for the nodal analysis include completion configuration, fluid properties, productivity indexes (PI), wellhead pressures, formation pressures, and ESP size/type.

An advantage of the HCM-A design is that the selection of the choke settings can be selected and changed in the field without the need of shipping back the tool for refurbishing.

This enables a well to be drilled, logged and possibly well tested before the HCM-A choke positions must be selected.

Erosion is a significant concern with all chokes and particularly those that are permanently installed.

The InForce HCM-A adjustable sliding sleeve can eliminate intervention and associated risks by providing multiposition choking for zonal control to help optimize production or injection. The sleeve has six standard choking positions ranging from 3% to 20% of the full tubing area plus full open and full closed.

The HCM-A's dual-stage choke configuration, with the seal system totally independent of the choke, provides superior erosion resistance so that any minor erosion imparted to the choke will not jeopardize the ability to isolate a given zone, according to the company.

Regardless of the amount of solids that flow through the tool, seal integrity is never compromised.

The HCM-A has been successfully flow tested with over 300,000 lbs of sand at rates exceeding 25,000 bpd without significant choke wear and without any seal system damage.

PROACTIVE MANAGEMENT

The additional functionality of a variable choke broadens the range of completion and production problems that intelligent well systems can solve to move operators toward their goal of proactive production management.

Intelligent well systems with variable chokes can provide access to zones below an electric submersible pump (ESP) by enabling fluid loss control during pump stoppages and changeovers.

They can also be used to commingle production from multiple zones through a single ESP, or to redirect flow to the secondary pump in a redundant ESP completion.

In many intelligent ESP applications, pump performance and life expectancy as well as production rates can be improved by balancing production from two or more zones.

Intelligent well systems with variable chokes can provide multi-zone flow control in offshore and deepwater applications.

The intelligent well systems can enable a single well to produce stacked pay zones when pressure regimes would not normally allow uncontrolled co-mingling.

In wells with commingled production, intelligent systems can shut in zones that begin to produce water or gas.

In addition, intelligent completions enable selective flow control in multi-zone sand control applications.

Some operators and/or host governments require selective production rate allocation when flow from multiple zones is commingled.

In these applications, flow control requires not only opening or closing a given zone, but also restricting flow from one zone relative to another. Variable chokes meet this requirement.

An intelligent well with a variable downhole choke can help manage water injection by distributing fluids among multiple injection zones.

Intelligent systems can also match well productivity or injectivity to optimize ESP performance.

When several reservoirs are produced from a single well, variable chokes enable intelligent systems to selectively manage each reservoir's production.

When applied in numerous wells throughout a field, these intelligent well systems can be part of a larger system of field-wide reservoir management.

CASE HISTORY

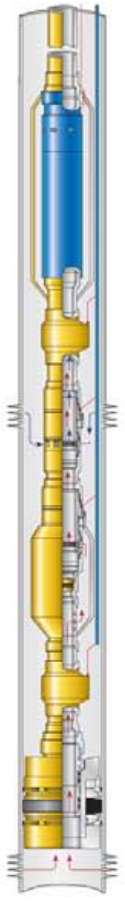
The first application of the HCM-A variable choke came in December 2003 in Ecuador, where an operator needed to accelerate production to meet delivery commitments to fill a newly constructed pipeline.

Achieving this objective meant that the wells would have to deliver commingled production from two zones with different pressures while complying with government regulations to monitor production separately from each zone.

After careful review of all available completion alternatives and systems, the operator selected an InForce intelligent well system as the best solution for the project.

Reservoir simulation and nodal analysis were performed to identify well candidates, simulate the effects and quantify the benefits of commingling two producing zones.

The project's overall cost was minimized by using as many currently available



The InForce HCM-A variable choke was first used in 2003 in a field in Ecuador to commingle production from two zones with different pressures while complying with government regulations to monitor production from each zone.

products as possible and by installing the intelligent well system while working over an existing completion.

Completion design and installation procedures were designed to be as simple as possible. Since the intelligent well systems would be installed in conjunction with ESPs, retrieving them easily was a key consideration during the design process.

The chosen wells had been produced previously using Y-tools with the ESP on the end of the tubing string.

The two producing zones had been separated by two production packers with mechanical sliding sleeves in each zone.

Production was alternated between zones by running wireline through the Y-tool to shift the sleeves.

The main drawback to this method was the constant requirement for intervention to shift the sleeves and the inability to assign production to each interval.

Intervention requires that the ESP be shut down temporarily, incurring service costs and lost production.

To solve the intervention problem while meeting proactive production management objectives, InForce intelligent well systems with multiple HCM-A chokes were installed under ESPs.

These systems provide full zonal control and real-time data monitoring, allowing the operator to monitor and optimize the production from each zone.

Permanent monitoring equipment installed below the chokes provides valuable real-time pressure, temperature and flow data.

Pressure and temperature are provided for each zone, while flow is provided for the lower zone only.

During the time that production is commingled, the flow rate and water cut from the lower zone can be viewed on surface, thus providing the production allocation required.

These systems also eliminate the need for intrusive well interventions that would have been necessary in a conventional completion.

To date, three InForce systems have been installed in the field with successful results.

Based on performance, at least four additional systems are planned for the same project. Additionally, three other operators are also starting their own developments with intelligent completions.

An early assumption about intelligent well technology was that it probably would make economic sense only in expensive wells, such as subsea wells, or in prolific reservoirs.

In practice, however, the company has installed intelligent wells in two land and two platform wells for every subsea installation.

In addition, two-thirds of intelligent well applications have been in producing wells that are artificially lifted and operated in what would be considered marginal fields.

The introduction of the HCM-A downhole variable choke has provided enough additional flow-control functionality to satisfy the needs of many, more complex applications.

As a result, the benefits of intelligent well systems can now extend to more complex production scenarios using the simpler, hydraulically controlled systems. ■