Intelligent Completions

Intelligent Sand Control in Deepwater

The providers of sand control equipment have been continuously challenged by the industry to develop new and innovative sand control completion systems to enable the completion of increasingly deeper, more difficult wells in a cost-effective way. The paper explains on single-trip multizone sand control system that gives operators the ability to complete, monitor and control multiple zones within wells, without mechanical intervention and minimising its associate risks & costs.

An intelligent completion enables the operator to monitor and control the reservoirs remotely in real time conditions, to significantly improve reservoir management. Wellbore intervention in deep water can be cost prohibitive on subsea wells. Intelligent completions can reduce operating expenses for deepwater projects by eliminating the intervention requirements. Since the majority of deepwater reservoirs require sand control, designing the sandface completion and the intelligent completion for maximum successful interface is important. The completion design will vary depending on the number of zones, or intervals, requiring control. Many early intelligent sand control completions were designed for two zones. Today, many operators are realising the need, and installing, completions designed for three or more zones. Moving this technology into the deep- and ultra-deepwater arena is the next frontier.

Intelligent Equipment for Sand Control Completions

The intelligent equipment involved includes a hydraulically controlled production sleeve for each zone, temperature and pressure gauges and sometimes flow meters. All components are connected hydraulically or electrically by hydraulic or I-wire control lines to controllers and monitors at the surface production facility; where changes in the reservoir are monitored and changes in the production sleeves' position are controlled. The control line must be routed through completion packers, tubing hangers, trees and incorporated into the flow line umbilical. The sand control completion equipment must be sized to allow a large enough Internal Dimension (ID) to allow a parallel and segregated production flow path.

Two-Zone Intelligent Sand Control Completion

Deepwater intelligent sand control completions were first installed in the Gulf of Mexico in the late 1990’s. They consisted of a two-zone intelligent completion (Figure 1) where the lower zone production flow was directed through the inside of a tubing string, or ‘dip-tube’, run across the upper zone and sealed between the zones (Clarkson et al. 2008). The flow was controlled by a shrouded hydraulic production sleeve placed just above the upper zone sand control completion. The upper zone production flow was directed in the annulus between the sand control completion and the dip-tube. The flow was controlled by another hydraulic production sleeve which opens to the annulus below the production packer and above the shrouded sleeve. Placing the hydraulic production sleeves above the sand control completion equipment allowed larger valve sizes which would not restrict flow due to flow area limitations. However, this technique is limited to two zones; any additional zones in the wellbore would be commingled to reduce the flow stream count to two. Accurate placement of the dip-tube and its production seals can be challenging in deepwater completions, especially with subsea trees. This has been accommodated with long-travel, sealing telescoping joints to ease space-out. The space-out adjustment is made while running in the well without pulling tubing back to surface. The telescoping joint is run in the stroked open position allowing a larger margin for error in space-out calculations. Also, long polished bore assemblies and accompanying seal assemblies can be used for the same purpose. These components are placed below any of the hydraulic or electrical connections; preventing flexing that would destroy the lines and wires.

Single-Trip Multizone Sand Control System

The advent of the generation IV single-trip multizone sand control systems designed specifically for high pump rate fracturing treatments has led to opportunities to efficiently complete more than two zones in deepwater wells (Figure 2). Generation IV multizone systems include mechanical sleeves within the screen assemblies for each zone. These sleeves are opened as each zone is treated and then closed to
provide zonal isolation and fluid loss protection. The mechanical sleeves are re-opened when desired to provide a production flow path for each zone.

Recent intelligent multizone sand control installations have been conducted in the Asia Pacific region near the South China Sea utilizing the generation IV multizone systems. Zone counts have run between three and six zones with a mixture of high rate fracture and pack treatments and high rate water pack treatments. These wells were completed with intelligent systems enabling monitoring and control of all of the zones individually. This completion design placed the hydraulic production sleeves within the zones themselves. Each zone's production flow was directed through its hydraulic production sleeve and into the production tubing; commingling with any other open zones. Placement of the sleeves within the zones means that the sleeves must pass through, and into, the sand control completion system. This limits the size and flow area of the sleeves; however, there is a great increase in the number of accessible zones. Seal assemblies designed to allow the wires and hydraulic lines to pass through are placed between zones.

The Asia Pacific wells were completed with both dry and subsea production trees. The subsea production trees were at water depths of less than 500 feet (152 meters). These were not deepwater wells. The intelligent completion space-out was conducted conventionally by locating the seals in their proper location then pulling enough tubing to install the space-out tubing and the tubing hanger. This method does not require a long-travel telescoping joint or long polished bore assembly as the seal assemblies are accurately placed. Mechanical shifters were placed at the lower end of the intelligent production tubing string to provide a means of opening the mechanical production sleeves of the multizone sand control system. As the shifters move through each sleeve it is opened, providing a pathway for production into the wellbore.

Completion brine in the wellbore during installation provided an over-balanced condition to the reservoirs while the sleeves are opened. This creates an opportunity for completion brine fluid losses to the reservoir while landing the production string. In these installations, the upper zone production sleeves were open while installing the tubing hanger and terminating the hydraulic and electric lines. To control the fluid losses, a polished seal bore and mating seal assembly were strategically placed so that they were mated while installing the tubing hanger.

**Next Step for Intelligent Sand Control Completions**

The next step in the evolution of intelligent sand control completions will be to enable the control of more than two zones in true deep- and ultra-deepwater completions. To accomplish this, the hydraulic production sleeves will need to be placed within the zones as in the recent Asia Pacific completions described above. However, the conventional space-out methods described are not feasible in deep- and ultra-deepwater completions; the water depth will require pulling thousands of feet of tubing to install the tubing hanger. The risk outweighs the reward. The margin for measurement and calculation error increases with the additional tubing lengths involved. The risk of damage to the hydraulic and electrical lines run to control the intelligent completion is greatly increased by the increased handling. The rig time spent pulling the tubing for the space-out is unnecessarily expensive. Incorporating long polished bore assemblies into the multizone sand control system to land the production seals is not feasible due to interference issues with the gravel pack service tools during deployment.

The solution is to adopt the method described early in the article where a long-travel, sealing telescoping joint is used to provide the ball park range of space-out results. The space-out adjustment would be made while running in the well without pulling any tubing back to surface. Since the hydraulic production sleeves are placed within the zones, the placement of this device must be between the hydraulic production sleeves and the production packer rather than below the sleeves. This means that the telescoping joint must accommodate a bypass of the hydraulic and electrical lines without causing damage to them. Development of long-travel, sealing telescoping joints with hydraulic and electrical feed-through capability is currently on-going within the service industry.

**Conclusion**

Two-zone intelligent sand control completions in deepwater wells have been run for the last 12 to 14 years. Intelligent sand control completions with more than two zones have been run in shallow water subsea wells for 5 to 10 years. The successful introduction of the developing feed-through long-travel, sealing telescoping joint technology, coupled with the generation IV single-trip multizone sand control system and future generation V system, will enable operators to complete, monitor and control more than two reservoirs remotely in real time conditions in any single deepwater wellbore. Accessing more reservoirs per wellbore will improve the economics for operators in deep- and ultra-deepwater completions.

(For references, please log on to www.oswindia.com)

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