First Deployment of Multizonal Intelligent Completion More Than Doubles Production from Shushufindi Well

System enables first commingled production in Ecuador compliant with regulatory requirements and reduces intervention costs by more than USD 1 million

CHALLENGE

■ Improve oil production in Ecuadorian brownfield.
■ Streamline completion installation and interventions.
■ Demonstrate accuracy and reliability of zonal monitoring and control to national regulatory authorities.

SOLUTION

Design and implement an integrated solution combining the IntelliZone Compact* modular multizonal management system, a REDA* Maximus* ESP system, and real-time data transmission and analysis.

RESULTS

■ Increased oil production 235%.
■ Reduced completion installation time.
■ Saved more than USD 1 million in intervention costs.
■ Conclusively proved feasibility of commingled production from two or more zones.

Restrictions on commingled production hampered productivity

Ecuador has several mature oil fields classified as brownfields, and the country is aggressively seeking to increase oil production. Discovered in 1969, the Shushufindi-Aguarico oil field uses artificial lift to produce from two main stacked reservoirs, which have different pressure regimes. Commingled production had not been an option in the past because the lack of independent measurement and flow control of each producing layer impeded reservoir management and petroleum accounting.

Dual concentric completions were historically used to produce both sands simultaneously, providing little flexibility and necessitating a separate ESP for each layer. This architecture increased the complexity, risks, and costs (including deferred production) of completion installation and interventions, including the scale removal and acid treatments typically needed in brownfields. ESP maintenance, repair, and replacement required pulling out the entire completion and exposed the formation to damaging well control fluids. Consequently, remedial measures were often postponed as long as one pump was operational, reducing productivity. In 2014, only 66 of 215 dual completions were active, representing 31% efficiency.

A solution was required that would

■ manage simultaneous production from two or more sands
■ provide zonal flow control and downhole monitoring of pressure and temperature in real time
■ enable back allocation of commingled production
■ accommodate artificial lift mechanisms such as ESPs
■ enable production testing without intervention
■ allow stimulation operations or chemical injection, as needed
■ expedite interventions, including ESP replacement
■ minimize formation damage during workovers
■ transmit data in real time from the field to the office.

Downhole flow control integrated with ESPs provided a viable solution

After studying the technical and economic feasibility of various options, Schlumberger proposed a four-well pilot with commingled production from the two sands. The IntelliZone Compact multizonal management system would be used to enhance well productivity and zonal control. This fully integrated system incorporates a multiposition flow control valve (FCV), a multiport packer for zonal isolation, and pressure and temperature gauges for annulus and tubing measurements.
Advanced simulation software is used to optimize settings; sophisticated models together with the gauge measurements enable monitoring of zonal flow contributions. Two IntelliZone Compact systems would be installed in the production tubing and a Maximus ESP system would be installed in a smaller concentric string above the producing zones, facilitating removal and preventing noise interference with the intelligent completion.

A multidisciplinary Schlumberger team took responsibility for obtaining regulatory approval for the design and for managing the entire project. Because of their past experiences with inadequate technologies, government agencies were understandably skeptical. Approval for subsequent wells hinged on the results of the first one.

**Operator more than doubled oil production and halved intervention costs**

The first installation was successfully accomplished, but formation damage resulted in a production rate lower than expected from the two zones. This presented an opportunity to demonstrate the benefits the IntelliZone Compact system brings to interventions.

The interventions included ESP removal and selective matrix stimulations, flow tests, and pressure buildups. The new system design enabled two operations to be conducted simultaneously (e.g., acid treatment in the upper zone and pressure buildup monitoring to determine the skin factor in the lower zone). Real-time monitoring helped maximize the effectiveness of the interventions (e.g., by indicating the need for further acid stimulation while the required equipment was still in place). The IntelliZone Compact system was unaffected by the multiple acid treatments. When the ESP was reinstalled, the FCVs isolated the productive zones, protecting them from completion fluid damage. Compared with dual-completion wells, intervention time was reduced by 17 days and costs by about 50%, or more than USD 1 million.

Real-time zonal monitoring and control have facilitated operational decisions for optimizing oil production by adjusting the FCV chokes. Production increased 235% on average—a total increase of more than 500 bbl/d—exceeding the customer’s expectations and all the selected KPIs. In addition, with the new system, the maximum number of zones that can be produced simultaneously in one well is no longer limited to two. Pleased with the outcome, the field operator and regulatory authorities approved the same completion design for the other three wells, and several more are scheduled.