Completion system cuts development cost by 60%

Harold Vickery and Christian F Bayne,
Baker Oil Tools

A ONE-TRIP MULTI-ZONE completion system was recently used by **Bohai Oil Corporation** to reduce development cost by 60%. The completion system was developed by **Baker Oil Tools** to address the potential of one-trip multi-zone gravel packing in The Peoples Republic of China's Jinzhou 9-3 (JZ9-3) Bohai Bay field.

Objectives of the project were to improve economic margins in development wells by maximizing efficiency and reduce rig time for completion operations.

Based on results of this project, Bohai Oil now credits the Baker Mini-Beta One-Trip Multi-Zone Gravel Pack system with helping cut completion time per well by up to 66% and total development cost for the JZ9-3 field by more than 60%.

The system, which was used to complete 30 of the 47 wells in the field, enabled the operator to individually frac pack or gravel pack four zones in as few as 2.4 days.

"Even with the relatively inexpensive costs in the Bohai Bay area, using the Mini-Beta system resulted in saving more than $2.5 million in rig time for the wells that were completed during this project," said **Liang Yue Liu**, Design Manager for Bohai Oil. The savings figure was based on rig time valued at $40,000 per day.

As a result of the success of this project, Bohai Oil awarded the completion of all 186 wells in its SZ36-2 Bohai Bay field to Baker Oil Tools. To date Phase 1 of the SZ36-2 Project has been completed with similar results to those achieved on the JZ9-3 project.

JZ9-3 field was a near ideal application for one-trip multi-zone system.

IDEAL APPLICATION

The JZ9-3 development offshore China provided an ideal application for the one-trip multi-zone system. The ability to complete several wells with similar characteristics within the same project presented an excellent opportunity to optimize efficiencies.

The Jinzhou 9-3 oil field is located in the northern offshore area of Liaodong Bay, approximately 53 km from Jinxi City and approximately 28 km from Haiku.

The field was discovered in 1988. Prior to beginning development in 1997, a 3D seismic survey had covered all the area, and six appraisal wells had been drilled.

Seismic interpretation indicates that the Jinzhou 9-3 structure is a long and narrow mono-anticline controlled by a large fault. The large fault unfolds in the northeast direction as a boundary fault.

The structure is 17 km long and 2.5 km wide, for a total trap area of 36 sq km. A northwest fault divides the whole structure into an eastern part and a western part. The western part, the main target for development, comprises an area of 32.5 sq km.

Six oil-bearing layer groups and one gas-bearing layer group have been found in the field. The first and second oil layer groups are the most widely distributed. The third and fourth layer groups have the second highest distribution and are developed mainly in the east area of the field. The fifth, sixth, and seventh layer groups are relatively limited in extent.

The first and second oil layer groups of the main oil formation and the third and fourth layer groups are of two separate oil and water systems. The oil/water interfaces for the two systems are 5,578 ft (1,700 m) and 5,775 ft (1,760 m) below sea level. The first and second layer groups are controlled by structure, while the third and fourth are controlled by both structure and lithology.

The oil layers of the fifth group are estimated to overlap and be composed of many small sandstone bodies, with connectivity controlled by lithology.

An accurate assessment of oil/water interface in this layer group remains unclear.

The sixth layer group contains a gas/oil and an oil/water contact. The gas/oil interface is 5,889 ft (1,795 m) below sea level, and the oil/water interface 5,915 ft (1,803 m) below sea level. This oil layer group is controlled by structure.

The seventh layer group is a gas formation controlled by lithology and structure. The overall reservoir has a wide range of physical properties.

In general, the porosity varies between 27% and 31%, with permeability ranging from 100 to 500 millidarcies. There is a good relationship between porosity and permeability.

SELECTING THE COMPLETION

The reservoir layers in the Upper Guantao and Lower Ming are of similar pressures and will decline at very similar rates.

The individual zones in the production wells are commingled from the time the wells are brought on, with the ability to be isolated should water breakthrough occur.

Since all the zones were of similar pressure, this allowed the perforation of all zones at the same time without any cross-flow problems between zones.

Once this parameter was established, a one-trip multi-zone gravel pack system was determined to be the most efficient completion for the project.

COMPLETION SYSTEM

The Mini-Beta system combines field-proven Baker crossover tool technology with one-trip multi-zone expertise to allow multiple producing intervals to be gravel packed or frac-packed with a single trip into the wellbore. Each interval can be treated individually while maintaining complete zonal isolation during all steps of the treatment.

The new system can be used with multiple zones of varying length and with gravel placement treatments that can be pumped either above or below fracture pressures with large volumes of sand.

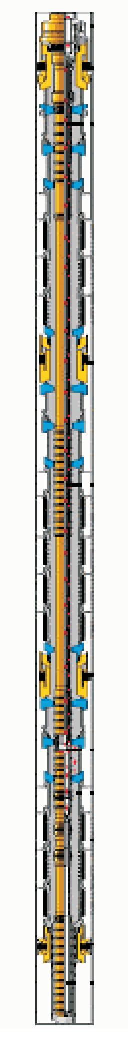
In addition to multiple producing intervals, the system is particularly well suited for areas where the producing formation is layered and subsequently difficult to treat as one complete producing interval.

Modifications from previous one-trip systems eliminated some general limitations of those systems and resulted in a system that supports a variety of gravel-packing applications. The addition of a seal bore below the isolation packer but above the gravel pack port eliminates the need to close the gravel pack sliding sleeve while the isolation packer is being set.

This also eliminates problems that might be encountered with a sliding sleeve that would not hold positive pressure during packer setting.

The overall length of the assembly around the isolation packers was shortened so the distance required between zones could be as short as 28 ft compared to 45 ft previously.

At the same time, the isolation packers themselves were modified to increase the differential pressure rating so they could be used in higher-rate fracturing applications. The crossover port was also made more robust to accommodate higher rates and higher sand concentrations.



Mini-Beta One-Trip Multi-Zone system

The older system had a relatively small concentric string of tubing that was used to "extend" the crossover port to the surface. In the new system, the tubing swivel at the top of the service tool string was modified to allow the concentric string to have a larger inner diameter, reducing friction pressures at higher pump rates.

OPERATING PROCEDURE

After the well has been perforated and a gauge ring has been run through the perforations, a sump packer is set on depth, either with wireline or on drill pipe. The multi-zone assembly is then picked up and run into the well; it is latched into the sump packer once it is on depth.

The top gravel pack packer is then set hydraulically. After testing the top packer, the service tools are released from the assembly, moved uphole and positioned mechanically (with weight indication), where each isolation packer is set hydraulically and tested immediately.

The service tools are then lowered back to the lowest zone, positioned mechanically, and the gravel placement treatment for that zone is pumped, either below or above fracture pressure.

Since there is not a squeeze position, the treatment is pumped in circulate position with the annulus closed. This allows the annulus pressure to be monitored throughout the entire treatment.

As soon as sand screenout has occurred, the service tools are positioned in reverse, and the excess sand is reverse-circulated from the wellbore.

This configuration places the crossover port and an evacuation port between a single set of seals and allows excess sand slurry to be reversed from the tubing without placing any pressure on zones below or above the zone being treated.

If desired, the gravel packed zone can be stressed to assure proper gravel placement prior to moving the tools to the next zone to be treated.

As the tools are moved uphole, each zone is treated as desired. With each zone totally isolated from all other zones, each zone can receive the type of treatment, and at the appropriate pressure, for which it is most suited, without consideration of the other zones in the well.

Once all zones have been treated, the service tools are pulled from the well, the upper completion string is run and the well is placed on production.

ONE TRIP VS STACK-PACKING

The process of stack-packing multi-zone completions was implemented during the 1990s as a method of completing three or more zones within the same wellbore using high-pressure/high-pump-rate tip screen-out frac designs.

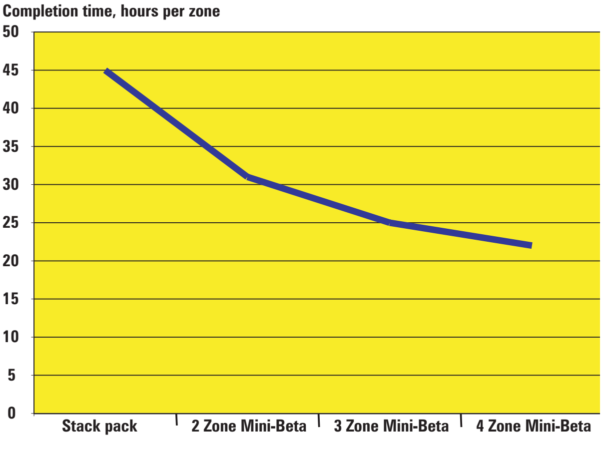
In a stack-pack, completion operations for each zone are usually carried out sequentially. The lowest zone is perforated, completed and isolated.

Then the operations are repeated for the next higher zone, and so forth. Stack-pack completions can become quite time consuming because they require a number of different trips into the wellbore.

A comparison of the one-trip Mini-Beta system to the stack-pack type completion used early in the development of the JZ9-3 field emphasizes the efficiency achieved with the one-trip system.

Previous experience had shown that a stack-pack would take 3.83 days for a 2-zone well, 5.80 days for a 3-zone well, and 7.77 days for a 4-zone well.

Actual average times, Bohai Bay project



Using the one-trip system yielded average time savings of 1.15 days for a 2-zone well, 2.99 days for a 3-zone well, and 4.28 days for a 4-zone well.

Even with the relatively low costs in the Bohai Bay area, using the one-trip system resulted in an overall savings of over $2.7 million and 68 rig days for the 30 wells that were completed and/or gravel packed. ■