ESCALATION IN THE EAST

Radmir Gaynetdinov, Maria Novikova, Reza Rastegar, and Stephen Forrester, NOV, explore the need for the development of multistage fracturing in the eastern hemisphere.

Advances in horizontal completion methods in the past decade have driven the development of technologies that can better stimulate the entire horizontal interval, leading to more production from the reservoir. Multistage fracturing, however, did not gain significant traction in the eastern hemisphere, and saw only limited technological development, due to limited availability of multistage fracturing technology, a shortage of experienced field personnel, and little interest in large-scale application of the technology. Furthermore, increased lateral length often meant production was not homogeneous across the lateral, highlighting the need to implement a method of more effectively stimulating the lateral's entire length. This article explores how National Oilwell Varco's (NOV) proprietary multistage fracturing technology was used to address this need in a uniquely challenging environment in the eastern hemisphere.

Case study

Challenge

An operator in Eurasia decided to use a new horizontal multistage fracturing technique to improve the initial production (IP) of wells in an oilfield. Reservoir rock was largely sandstone with low-permeability shale, and hydrocarbons were trapped in anticline structural traps. Previous directional wells in the field had underperformed with lower-than-expected IP and quick declines. Significant technical, geological, and capital investment risks, often including the necessity (and availability) of a coiled tubing fleet, required any alternative solutions to be extremely cost-effective. To explore the viability of the multistage fracturing technique, the operator designed a pilot project in the field to compare potential improvements in operational efficiency and IP rates.

Methodology

The multistage fracturing technique the operator selected was a combination of the Burst Port System™ (BPS) and a cup-to-cup selective isolation tool. The BPS is a casing sub with built-in nozzles designed to open at pre-determined absolute pressure, which is set at surface before running in the well. The system utilises engineered disks that are designed to rupture at a very specific pressure. The rupture disks are designed with an atmospheric chamber, which is a feature of this tool that ensures that higher stimulation pressures can be achieved while also enabling the opening of all the nozzles when the pumping commences. Running the BPS requires no specialist personnel or equipment to install and make it up with the casing. However, stimulating the system using stimulation straddle tools can only be done with a qualified NOV field engineer operating the equipment.

The cup-to-cup selective isolation tool is a cup packer system that straddles a BPS for a selective fracture treatment. The cup-to-cup BHA, which can be configured for a variety of operations with a full or half straddle, uses durable cups to provide isolation of the fracture treatment and allow multiple stages to be treated in a single trip. A mechanical casing collar locator enables accurate engagement, making it easy to locate the BPS in the casing string. Additionally, memory gauges above and below the lower cups record passive monitoring of isolation and provide valuable post-stimulation data.

This modular system allows for combinations of packers and cups in varying arrangements, enabling the distance between the cups to be changed depending on zone length. Importantly, the cup-to-cup selective isolation tool can be run on a rig with a workstring, addressing the challenge of cost and availability of coiled tubing units.

The operator designed a pilot project to test the BPS and cup-to-cup system, with the goal of performing a multistage fracturing job in a group of sidetracked wells to determine the benefits and drawbacks of the system. Previous wells in the field were completed with openhole liners up to 1000 m (3281 ft) and with 200 m (656 ft) of horizontal sections using openhole packers and fracturing sleeves with dissolvable balls. The BPS is applicable in both openhole and cemented completions. The system with cup-to-cup tool could not only potentially provide a faster fracturing cycle time, but also facilitate the use of standard casing cleaning equipment by not causing restrictions in the casing. The BPS and cup-to-cup tool also removes the need for mill-out operation as required after completion with ball and seats.

It was decided to complete the initial pilot wells with cemented liners and with 5 - 7 BPS tools through the reservoir. Focus was placed on how the casing strings were assembled and how the tools were spaced out to ensure fractures were going to be initiated at the desired depth. A marker joint was installed below each tool within the casing string to engage with the collar locator in the cup-to-cup BHA, and care was taken that the absolute bottomhole pressure inside the casing did not exceed 80% of the designed burst pressure during operations. The stimulation jobs were designed with very high proppant concentrations, presenting potential challenges of seal washout and debris around the BHA.

Figure 1. *The BPS features a casing collar with built- in nozzles designed to rupture at pre-set absolute pressures.*

Results

Despite the operational challenges, the system performed as designed and the pilot wells were successfully stimulated. In wells where four or more stages were completed, the flow rates were three to four times that of wells with fewer stages, and continual effort was made to further optimise the number of stages within the horizontal section. The use of the combined BPS and cup-to-cup technology resulted in the following improvements:

- Eliminated the need for a coiled tubing fleet; the system was run on a workstring with the use of a rig.
- Eliminated the need to clean out the liner after all the stages.
- Eliminated the intake of kill fluid after flushing the liners.
- Brought wells to stable production shortly after completing the fracturing jobs.

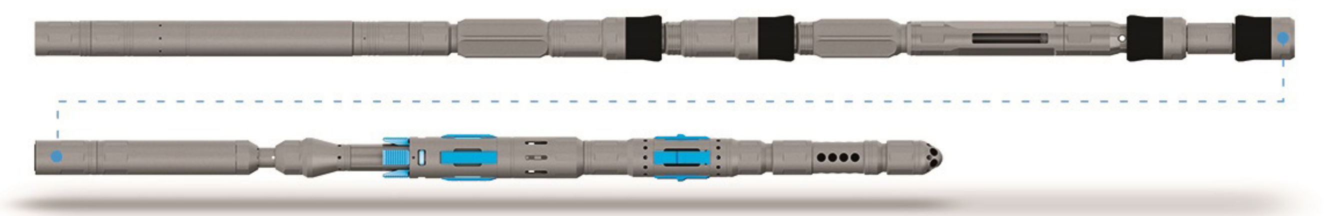

Figure 2. *The assembly of the cup-to-cup tool.*

Additional case studies

Additional work in the field began after the pilot project was completed. Two additional sets of wells were planned for stimulation with the combined systems, using cemented liners through the reservoir section as with the pilot wells. Stage spacing was optimised over the pilot wells by shortening the distance between zones to approximately 25 - 37 m (82 - 121 ft). Despite the challenging downhole environment, the presence of a workstring BHA downhole enabled a more accurate engagement with the BPS and resulted in better than expected production, peaking at 225 m^3/d.

After the first set of wells, the operator continued the use of the BPS and cup-to-cup tools in the second set of wells to further improve production and performance. The horizontal section length was increased, and a larger bit was used to drill the reservoir section. The liners were again cemented for zonal isolation. The planned zones were treated via two fracturing jobs, and two fracturing fleets were employed for the project. All fracturing jobs were completed as planned without issues, with stimulation time being reduced even further. A fluid production rate of approximately 300 m^3/d was achieved in the second set of wells.

Overarching results

The results of the pilot and initial wells indicated that the combination of the BPS and cup-to-cup tool was a success. The starting productivity and three-month cumulative production from the first trials were almost two times greater than those seen in a conventionally completed well, which in the region was often seven stages, and the productivity from the second trials was even greater than that of the first. Additionally, the production performance was nearly three times higher than that of conventionally completed well in the same area. This proved that production rates directly and positively correlated with the number of stimulation zones and that reducing the distance between zones did not negatively impact fracturing success. The results prompted the operator to consider increasing the number of treated zones in newly drilled and sidetracked wells to as many as 15 zones, with continued use of the BPS and cup-to-cup system for selective treatments.

As implementing the BPS and cup-to-cup system allowed the operator to significantly improve their production, the project proved that these technologies were viable alternatives to traditional completion methods in the region. By eliminating the need for a coiled tubing fleet, the operator was also able to complete the project at a far lower cost. To drive further increases in production and performance and the application of multistage fracturing technology, NOV continues to develop its multistage BPS and cup-to-cup tools. New equipment sizes, such as 146 mm (5 ¾ in.) BPS and cup-to-cup tools, are being developed for more diverse applications. Additionally, upgrades to the performance of the equipment itself will allow broader implementation in the global market.

Conclusion

Completion tools are changing the way wells are completed, particularly in the eastern hemisphere. The BPS and cup-to-cup tool are one such example, saving operational time by eliminating the need for both two wireline trips for every stage and explosive charges. The practice of hydraulic fracturing is evolving, and tools like the BPS that allow selective stage treatments – rather than single-stage treatments done in order from the toe to the heel – will redefine the norm as increased implementation makes clear their distinct advantages. Additionally, tools like the BPS that allow selective refracturing of stages, which involves secondary hydraulic fracturing of underperforming zones, will grow in importance as cost-efficiency remains a major concern.

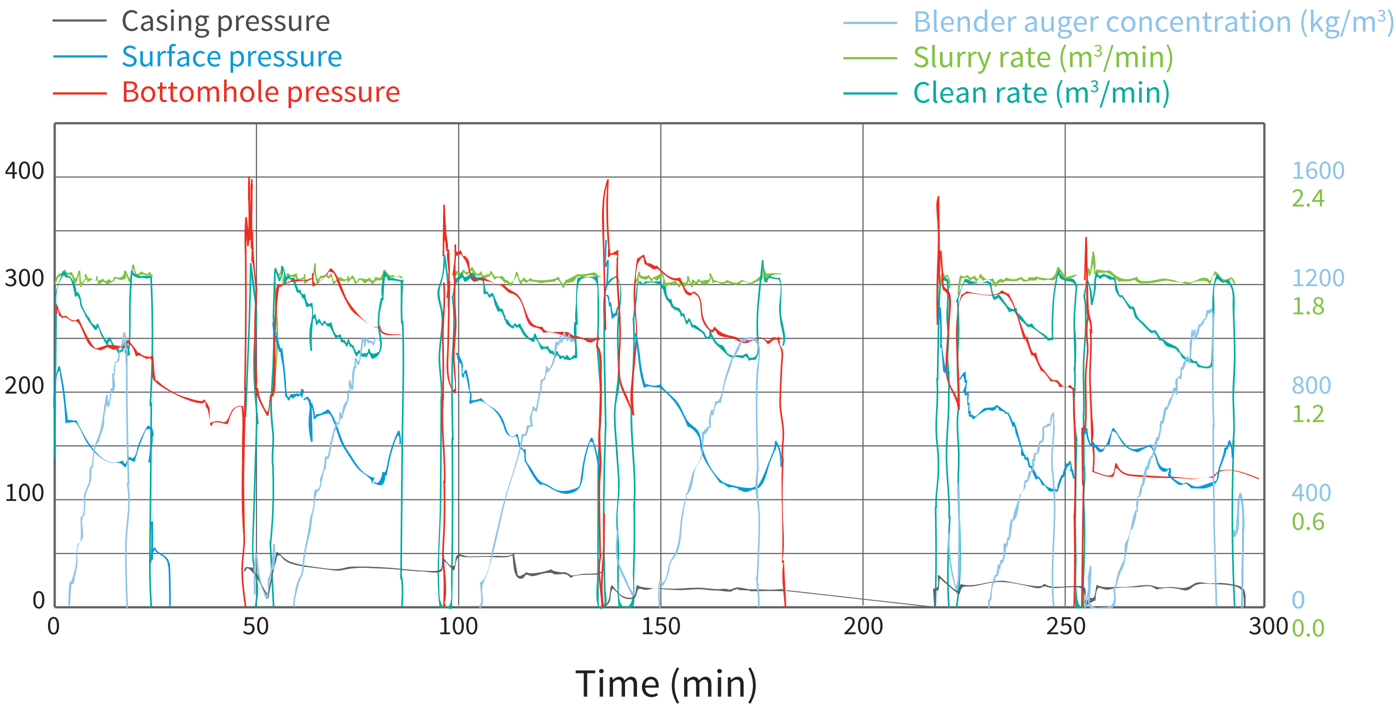

Figure 3. *This graph provides a summary of multistage stimulation using the BPS and cup-to-cup tools, demonstrating the consistency and effectiveness of the system.*