Sequenced refracturing boosts production, EUR without drilling

Operator improves recovery in previously completed laterals through use of sequenced refracturing technique.

With constrained oil prices, unfavorable market conditions and reduced budgets, many shale operators today are actively investigating viable alternatives to the mass drilling and completion campaigns of recent years.

Costs associated with drilling, casing, cementing, perforating, setting and milling out bridge plugs, and fracture stimulating dozens of stages along a 1.2-km to 3-km (4,000-ft to 10,000-ft) lateral typically range from $6 million to $20 million, depending on the play and placement of the well. On the other hand, refracturing an existing horizontal wellbore—reopening established fracture networks and/or accessing previously unstimulated zones—typically costs from $1 million to $2 million. Refracturing, therefore, represents an economically attractive option for improving well performance and return on investment.

The rationale for refracturing lies primarily in the well-known fact that optimization of the completion process in every unconventional play has been gradual. Literally thousands of existing wellbores in good reservoir rock were originally fractured with substandard practices, especially those completed early in development. In addition, many initial completions suffered damage of various kinds that caused production to decline more rapidly than usual. Thus, numerous opportunities exist for operators to reenter declining or depleted shale wells and apply more effective techniques.

One emerging approach for boosting recovery in a previously completed lateral combines rigorous candidate selection and completion modeling with an innovative sequenced refracturing technique using a proprietary new diversion material.

**Candidate selection, refracturing strategies**

Economically successful refracturing operations require a systematic candidate selection workflow. Key factors in evaluating the post-refracturing production potential of a well or group of wells include reservoir quality and heterogeneity, original completion characteristics, initial well performance, changes in rock and reservoir properties, proximity to offset wells, decline rates, current production, and stress and depletion profiles along the lateral at the time of proposed restimulation.

Some wells are simply not good candidates for refracturing. Even when selected wells appear viable, specific goals and completion strategies can vary in significant ways. Candidate wells with sufficient remaining volumetric potential tend to fall into one of three categories.
First, wells with damaged completions usually exhibit high IP rates followed by rapid declines. Damage may be due to aggressive drawdown, settling of proppant at the bottom of fractures, or overflushing of proppant away from the wellbore, all of which inhibit fracture conductivity. Second, wells with sub-optimal completions tend to show good IP followed by slower declines. Substandard completions may be the results of inadequate proppant volumes or excessive spacing between perforation clusters. A third type of refracturing candidate is the parent or first well produced in a pad, where interference with subsequent in-fill wells—due either to pressure communication or asymmetric fracture growth—may have a negative impact on production.

For each candidate type, a different refracturing strategy may be necessary. For example, a “reconnect” strategy seeks to reopen existing fracture networks and restore fracture connectivity with the wellbore. A “restimulate” strategy strives to increase stimulated reservoir volume (SRV) by adding new perforations and fracturing new zones of high-quality rock. A “recover” strategy combines these two approaches to refracture a depleted parent well before stimulating offset wells by modeling the group as a system and taking into account potential interference.

Finally, advanced completion modeling software enables operators to simulate various refracturing scenarios, engineer appropriate completion designs for each strategy and optimize treatment parameters. For any refracturing strategy, success depends largely on finding a reliable, cost-effective method of isolating existing fracture networks and reopened zones from new, previously unfractured areas.

FIGURE 2. Encana used BroadBand Sequence refracturing to increase oil and gas recovery from wells in the Eagle Ford and Haynesville plays. (Source: Schlumberger)
Sequenced refracturing with diversion

To maximize the productivity of initial completions in unconventional reservoirs, Schlumberger developed the BroadBand Sequence fracturing service (Figure 1). To date, more than 4,500 sequenced fracturing treatments have been performed in the U.S., Canada, Argentina, Mexico, Saudi Arabia, Oman and China. Within the past year, a handful of early adopters also have begun applying this innovative technique to refracture declining shale wells at a fraction of the original cost.

To establish connectivity between the wellbore and undrained reservoir volumes, sequenced refracturing alternates the pumping of fracturing stages of different sizes with the concentrated pills or slugs of a proprietary new blend of degradable particles and fibers. The first fracturing stage initiates fractures in zones of lower formation stress. Next, a composite pill is pumped downhole, temporarily isolating initial fractures and diverting the subsequent treatment—pumped under higher pressure—to zones of higher stress. Additional sequences of fracturing fluid and pills initiate even more fractures. Thus, sequenced fracturing stimulates a larger number of perforation clusters, boosting total SRV and associated production.

Blending degradable particles of multiple sizes with degradable fibers, this unique composite fluid overcomes the limitations of traditional chemical diversion methods and fluids containing particles alone. Fibers prevent dispersion or settling of particles in the wellbore, ensuring the material remains highly concentrated downhole. The size and amount of components are optimized to create a temporary low-permeable plug using minimal material. Larger particles pass through the perforations but not the existing fracture entrance. Incrementally smaller particles accumulate to further reduce permeability.

Field tests show these temporary plugs can withstand temperatures from 38 C to 204 C (100 F to 400 F) and a pressure differential of up to 3,700 psi for a period long enough to complete a typical stimulation treatment. Afterward, all particles and fibers completely degrade within a few days without additional intervention, opening the zone for production. To stimulate a longer section of wellbore, the number and size of alternating fracture treatments and composite pills can be increased, along with pump rates, as needed. This, then, is how the new sequenced fracturing technique applies to refracturing operations, in which the entire lateral is open for treatment.

Refracturing increases production, recovery

To accelerate production and increase EUR in declining wells, Encana decided to evaluate the sequenced fracturing technique to refracture candidate wells in both the Eagle Ford and Haynesville shales. Candidates were selected based on quality of the reservoir, completion and production history, and location relative to nearby wells.

Since perforations were still open along thousands of feet of lateral, use of mechanical bridge plugs or inflatable packers was not appropriate in either case. Both wells were completed in continuous pumping operations, alternating fracturing stages with composite pills to promote diversion along the lateral.

Sequenced refracturing led in both cases to significant increases in production (Figure 2). In the Eagle Ford well, oil production increased from about 50 bbl/d to 650 bbl/d, while flowing pressure increased from 250 psi to 5,000 psi. In the Haynesville well, gas production increased from 2,832 cu. m/d to 142,000 cu. m/d (100,000 scf/d to 5 MMscf/d), while flowing pressure increased from 1,500 psi to 6,000 psi.

Early days

The application of sequenced fracturing with diversion to refracture existing horizontal shale wells is growing. Initial results—like the two wells above—are very promising. Since few operators have significant experience with refracturing of any kind, many are proceeding with caution, learning as they go. Every refracturing operation is different. Success depends on holistically integrating workflows for reservoir evaluation, candidate selection, completion design with effective technology enablers, treatment execution and production management. Done properly, refracturing a good candidate well or group of wells can substantially boost production, increase EUR and ensure solid return on investment at a fraction of the capital expense required to drill and hydraulically fracture a whole new lateral. 

Refracturing represents an economically attractive option for improving well performance and return on investment.