Case Study

StackFRAC HD system outperforms cased hole in vertical wells

United States, Permian Basin
StackFRAC HD System

Background

The Permian Basin consists of several stacked pay zones and is one of the top five resource plays in the United States. Two of the target formations are the Wolfcamp shale and Bone Spring (together referred to as the Wolfbone) in the Delaware Basin of West Texas. The Wolfcamp shale extends through the Permian Basin, acting as both a source rock and a reservoir. It is estimated that the Wolfcamp shale contains 3 billion bbl of oil. The Bone Spring, located above the Wolfcamp formation, is a thick sequence of interbedded sandstones, carbonates, and shale at depths ranging from 6,000 to 13,000 ft. Production comes from both the sand and carbonate layers of the Bone Spring.

The shale and carbonate layers of this unconventional trend act as barriers to fracture growth, making well completions a challenge for operators. While horizontal completions in the shales are in the initial stages and have yet to be proven, operators are successfully exploiting the reserves through vertical wells. Figure 1 illustrates the Permian Basin, and specifically, the formations in the Delaware Basin that are the focus of this case study.

Even though this is a mature exploration area, completion of the thick shale intervals requires investigation into new methods and technologies to access the remaining hydrocarbons that are more challenging to exploit. Thus far, two vertical completion methods have been predominantly utilized in the Wolfcamp and Bone Spring formations to gain access to hydrocarbons: open hole multi-stage systems (OHMS) and the conventional cemented liner, plug-and-perf (CLPP) method.

Challenge

An operator working in the Wolfbone wanted to effectively complete vertical wells while keeping costs low. Initially, the operator used the standard cemented liner plug-and-perf stimulation method; however, it encountered problems with wireline guns and had issues while fishing plugs, resulting in additional time and labor costs. The operator was also looking to exploit the higher porosity and permeability of the sandstone layers, as well as any natural fractures present.

Solution

The operator chose to run the Packers Plus StackFRAC® HD open hole system in its vertical wells since it had successfully used it in other, predominantly horizontal, unconventional plays. After several wells were completed with StackFRAC HD systems, stimulated, and put on production, the operator conducted a 30-, 60-, and 90-day production analysis, as well as a time and cost comparison of the two completion methods to determine a long-term solution for completing vertical wells in this unconventional play. Twelve vertical wells completed with StackFRAC HD technology were compared to 44 plug-and-perf wells in Reeves County, Texas.

Production was studied in two different categories: overall production and production by area. Overall production examined vertical wells completed by the operator using a similar stimulation design but a different completion method. Production by area removed any location bias by looking at two areas separately: the Core and the Worsham areas. The Core area is centrally located in the basin where the majority of the activity has taken place, and the Worsham area is located deeper in the basin with better porosity.

Results

Overall cumulative production from the vertical wells completed with StackFRAC HD technology was up to 36% higher than the plug-and-perf wells (Figure 2). When the wells were broken out into the Core and Worsham areas, the results were quite different. In the Core area, the StackFRAC HD wells produced only up to 9% higher than plug-and-perf wells (Figure 3). However, in the Worsham area, StackFRAC HD wells outperformed plug-and-perf wells by 64% after the first month, and this trend continued after 3 months, with an 88% production difference between the two completion methods (Figure 4).

It should be noted that both areas have virtually identical gross and net pays, average porosity, water saturation, and other measurable geological reservoir parameters. However, the Worsham area performed better than the Core area when completed with StackFRAC HD open hole technology. One possible reason for this would be increased natural fractures in the Wolfcamp. The higher mud weights required and more/larger gas flares recorded in mud logs, combined with higher gas oil ratios and flowing pressures, indicate that very small but pervasive natural fractures were likely created during hydrocarbon generation in the Worsham area of the Wolfcamp. These natural fractures significantly increase average permeability, and thus, increase production.

Unlike cemented completions, StackFRAC HD open hole technology retains connectivity of natural fractures to the wellbore. After fracture flowback, results for the StackFRAC HD wells displayed higher flowing pressure and significant oil production within the first 24 hours; whereas CLPP wells had lower flowing pressures and no oil production for 5 to 6 days. The quicker appearance of oil production may be attributed to unstimulated natural fractures that were not filled with cement.

Although the natural fracture system in the Core area is not as extensive as the Worsham area, StackFRAC HD wells still performed better than CLPP wells, albeit by a smaller margin. Additionally, the Worsham area is considered to be a more reliable comparison of production results than the Core area, since the stimulation parameters in the former are more similar between the two completion methods that were analyzed. The Core area was completed prior to the Worsham area while operators were still determining the optimal stimulation design.

StackFRAC HD and plug-and-perf capital costs were determined to be approximately equal, but there were benefits from completing the wells quicker with the StackFRAC HD system. A time comparison analysis shows that completion time was reduced from 4 days with the plug-and-perf technology down to 2 days with the StackFRAC HD system, saving the operator 20% on stimulation costs.

The operator was initially concerned that using an open hole system in vertical wells would not achieve proper zonal isolation, due to fracture geometry causing crossflow between stages. However, tracer logs displayed multiple fracture initiations in a single stage and isolation at the packers, which mitigated the operator’s concern regarding uncontained vertical height growth when using an open hole system in a vertical well completion.

Therefore, the results show that the StackFRAC HD open hole multi-stage system is a viable, long-term solution for completing vertical wells in stacked pay compared to the traditional cemented liner, plug-and-perf method.