Unconventional diagnostics for unconventional wells

New fracture flow diagnostics help operators elevate fracture performance.

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In recent years, the Permian Basin has been the most prolific shale play in the U.S. Production in this area increased to 3.8 MMbbl by 2019, representing almost 70% of the whole U.S. production growth from 2011 to 2019, according to the International Energy Agency. The impressive aspect of this achievement is that the growth has not stopped. On the contrary, the Permian is expected to continue growing and is estimated to achieve up to 5.8 MMbbl by the end of 2023.

Such growth doesn't come easy. Significant advances in drilling, completing and multistage fracturing will continue to drive production increases. But evaluating the performance of fracturing programs and the wells they deliver is key to optimizing resources and ensuring maximum return on investment (ROI). Conventional diagnostic, such as production logging tools, can't provide all the insights required to ensure the operator is achieving the best returns. This article focuses on the challenges faced when assessing unconventional reservoirs in terms of production and TGT's new Fracture Flow diagnostic tool that evaluates the flow performance of hydraulically fractured wells stage by stage.

Pushing the boundaries

Operators have been drilling aggressively and pushing the boundaries of hydraulic fracturing beyond conventional standards compared to other plays. The drilled length of lateral sections has been constantly boosted, adding more footage as well as more production stages. The ultimate objective is to penetrate deep into the target formation, increasing the area of contact with the specific reservoir or formation, therefore making the well, its completion and the reservoir one dynamic production system.

Champions of this approach include a Houston-based operator that recently drilled such a well at the Wolfcamp Formation. The completion included a lateral section of more than 17,900 ft running through the Spraberry Formation. The completed well had a total measured depth exceeding 24,500 ft with a custom-

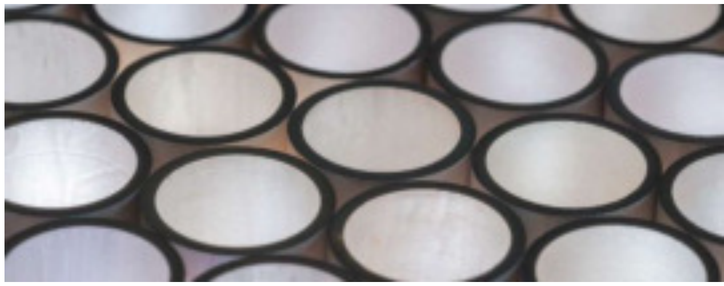

FIGURE 1. Fluid and gas moving through a reservoir generate acoustic noise. Inside TGT's Chorus sensor is a highly sensitive piezoelectric hydrophone that converts acoustic pressure waves into an electric charge. (Source: TGT)

ized completion design and fracturing treatment. The completion included more than 50 stages and sand was pumped along more than 2,200 ft of the reservoir to increase the well productivity.

These extended laterals have been engineered to optimize production performance and leverage improvements in drilling, fracturing treatments and completion designs. The operators have overcome a number of well construction challenges and have quickly moved up a steep learning curve.

Like the challenges encountered with well construction, the Permian Basin faces its own challenges. Following such an extensive multistage hydraulic fracturing program, the wells are brought onstream at high IP rates. But most of these extended-lateral producers tend to decline dramatically over a very short period. To help combat this challenge and many others, TGT has developed a number of application-specific diagnostic products using its True Flow System to quantitively evaluate flow dynamics throughout the entire well system—from the reservoir to wellbore and the dynamic interplay between the two.

When talking about a hydraulic fracturing job, the importance of the program design prior to execution is well-known. During this phase, sophisticated software is utilized to model and optimize the fracturing program, taking into consideration multiple variables. These variables include formation properties, lithology, depth, mechanical stresses and other parameters

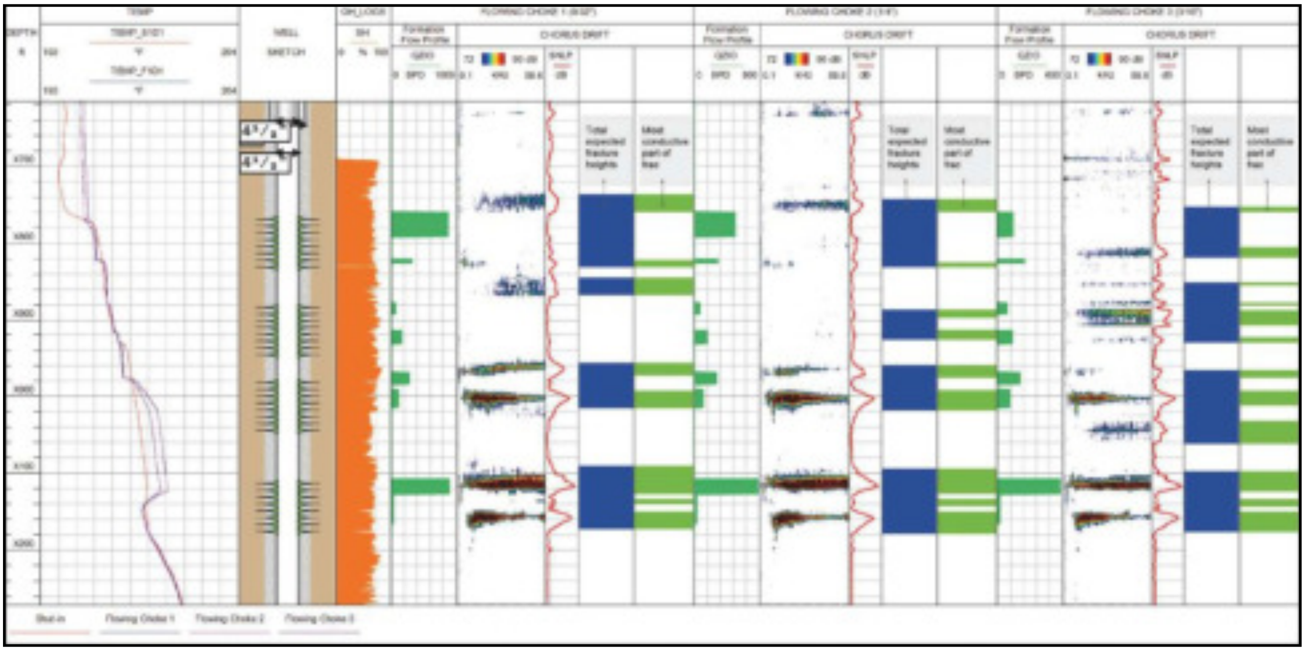

FIGURE 2. Fracture Flow diagnostics compare fractured intervals (blue) to main producing intervals (green) at different choke sizes to evaluate the true effectiveness of hydraulic fracturing programs and maximize well performance. (Source: TGT)

that can affect the final outcome. Another important consideration is the formulation of the hydraulic fracturing fluid. This fluid normally comprises sand (or proppant), gels (foam or sleek water) and additives that are pumped downhole following the job design to prop open the induced fractures and maximize the extension of the fracture in terms of length, height and aperture as well as the integrity of the fractured conduit itself, so hydrocarbons can flow unabated.

Evaluating fracture inflows

TGT's diagnostic Fracture Flow is able to locate and evaluate fracture inflows and quantify inflow profiles in hydraulically fractured wells. The product is delivered by the company's analysts using the True Flow System, which combines several technology platforms—Chorus (acoustic), Cascade (thermal), Indigo (multisense) and Maxim (digital workspace)—to acquire, interrogate and analyze the acoustic spectra and temperature changes generated by the hydrocarbons or any other fluid flowing from the reservoir through active fractures and into the completion (Figure 1). This diagnostic capability goes beyond conventional flow measurement techniques that generally stop sensing at the wellbore and are therefore unable to quantify flow within the reservoir itself.

The Fracture Flow product extract shown in Figure 2 represents the diagnosis of a hydraulically fractured oil producer with greater than 80 degrees deviation. The reservoir has a gross thickness of about 1,200 ft and is fully cased.

The operator's objectives in this case were to evaluate the post-fracture performance of three zones and compare the effectiveness of fractured stages by assessing the production contribution from each fractured interval, identify crossflow or behind-casing communication, and increase production efficiency by identifying the optimum production choke for this well system.

The results revealed by the Fracture Flow analysis revealed that the fractured intervals (Figure 2, blue coding) were not contributing fully to production in their entirety. Furthermore, it identified the active zones and where the main production was coming from (Figure 2, green coding). Fracture Flow revealed that only 62%, 59% and 56% of each zone was actually producing at the outset. The Fracture Flow analysis also indicated there were no crossflows among the three zones, which was another key finding from an integrity perspective. Thirdly, the Fracture Flow diagnostic program helped determine the optimal choke size required to ensure the fractured zones were contributing at the maximum rate.

TGT works in close collaboration with operators using Fracture Flow to help them reach their frac evaluation objectives, locate effective fracture inflows, quantify inflow profiles and assess the effectiveness of fracture programs, helping to optimize future programs and maximize ROI. E&P