

PRECISION- ENGINEERED PROPPANTS

Don Conkle, CARBO, USA, describes the development of a precision-engineered proppant and reviews its performance.

When pumping is underway, downhole tools and assets can often be subject to the erosive impact of proppant. Irregular shaped and sized proppants are often manufactured with a range of imperfections that actually serve to reduce conductivity and strength. Throughout the years, the properties of man-made proppant have improved incrementally. However, the oil and gas industry long required a technological step-change for deeper, high stress and high production wells.

CARBO's expertise within materials science and manufacturing enabled it to develop a more conductive and more durable proppant technology that significantly improves overall fracture conductivity (or space to flow), resulting in reduced erosion, enhanced production, increased recoverable reserves and greater returns for the operator.

Smoothly does it

The high smoothness of the improved proppant technology reduces drawdown across the fracture face, allowing hydrocarbon production to flow through the pack with increased ease. When the smoothness of the product works in conjunction with its enhanced durability and strength, well performance decline curves are flattened, making it well suited for operators desiring higher estimated ultimate recoveries.

Shale wells typically decline rapidly, and as production falls off and flowing pressure declines, the fracture begins closing on the proppant with increasing pressure. A study in the Eagle Ford compared productivity curves in 24 wells, half of them propped with sand and the other with sand and higher-strength ceramics tail-in. As stress on the proppant reached approximately 7500 psi, the advantage of ceramic proppant became clear. A significantly steeper decline occurred in

the productivity index of the dry gas wells propped with sand after 180 days of production versus the ceramic tail-in wells, known as the PI Rollover. In Utica dry gas wells, companies are starting to blend sand and CARBO's KRYPTOSPHERE ceramic, starting with 100 mesh and progressing to 40/70 ceramic, 30/50 ceramic, and finally tailing in 35 mesh.

Precision-engineered microstructure

In addition to exceptional smoothness, the ceramic's precision-engineered microstructure translates into a stronger, more spherical, more uniform proppant. These features work together to create additional space in the fracture for hydrocarbon flow as well as a more uniform flow path. The reduced flow path minimises the pressure drop due to non-Darcy flow effects across the fracture, which further enhances overall conductivity, flow rates and ultimate recovery. The proppant is more resistant to cyclic loading and acids and significantly less erosive on frac pumps and downhole tools. These benefits translate into increased completion tool life, reduced rig downtime and overall cost-savings for the E&P operator. The design makes it well suited for the production enhancement demands of deepwater Lower Tertiary, high-stress wells and other wells with these stringent conditions.

The ceramic is able to provide value in a range of varied well types. In order to offer a more tailored solution approach, KRYPTOSPHERE HD technology was specifically engineered for offshore applications and very deep well applications, while KRYPTOSPHERE LD was developed for onshore applications and moderate to deep wells. Both versions feature vastly improved levels of conductivity, strength and durability,

being able to deliver more than twice the baseline conductivity of bauxite-based, high-strength proppant exceeding 14 000 psi closure stresses.

Engineered for conductivity

As an ultra-conductive, high-density ceramic proppant, the HD technology was initially engineered to solve the production and completion challenges for a Gulf of Mexico Lower Tertiary development. At the time, there was no proppant available on the market capable of addressing the high closure stresses (ranging from 12 000 to 20 000 psi), which were common in this region. The HD ceramic works to achieve higher production and estimated ultimate recovery (EUR), maximising the operator's return on investment.

The LD technology is engineered to have the same characteristics as the HD technology – mono-sized with exceptional strength, durability and smoothness – providing high conductivity across the entire range of low to high stress well conditions. It significantly exceeds the conductivity of existing low-density proppant and reduces costly wear-and-tear on pressure pumping equipment, ultimately providing higher production and EUR. In addition, the LD technology provides higher conductivity, improved proppant transport and increased propped fracture volume compared to intermediate-density and bauxite ceramics (Figure 1).

Case studies

Gulf of Mexico

All super major E&P companies operating in the Gulf of Mexico have now utilised KRYPTOSPHERE HD. It has been deployed for deep, high stress wells. One company has reported that the HD ceramic is enabling a multi-fold increase in tool life. Production results are exceeding clients' expectations and the wells are proving to be prolific. Clients are also realising a substantial reduction in completion equipment wear-and-tear, resulting in lower risk and cost.

The HD ceramic was also employed with SCALEGUARD technology in a tailored solution for a major E&P operator in the deepwater Gulf of Mexico's Lower Tertiary. This technology is the first production enhancement technology in which scale inhibiting chemicals are infused into a ceramic proppant. This technology provides a controlled release of the scale inhibitor, resulting in long term protection against the formation of common oilfield scales. The technology is designed to safeguard the entire production network – from the fracture through the wellbore to the subsea/surface processing equipment – without compromising fracture conductivity, thereby protecting the operator's entire asset. In this well, the HD technology was the base proppant for SCALEGUARD technology. In one of the largest and deepest jobs for the proprietary technologies to date, both technologies were utilised in this application, as a solution to maximise both conductivity and the treatment of scale.

Utica Shale Play, USA

CNX Resources, a leading Appalachian basin producer, successfully employed the LD technology at a depth of approximately 13 500 - 14 000 ft. Under these deep and challenging conditions, this technology was selected for its better economics, strength, improved proppant transport and increased propped fracture volume. The LD technology eliminated the need for gel and cross-linked fluids, leading to a reduction in overall completion cost. Initial production from the first well using the LD technology was prolific, flowing more than 61.9 million ft³/d of natural gas in a 24 hour period and making it one of the highest producing wells in the Utica. By integrating the LD technology into CNX Resources completion design, CNX Resources was able to achieve the completion efficiency that allowed it to showcase three of the top ten dry Utica well results at that time.

Prevention of fines migration

In a unique application, KRYPTOSPHERE has also been used by a pre-packed screen (PPS) manufacturer as the internal media within its slotted liner/screen design. The PPS is deployed to prevent fines migration associated with hydrocarbon production. The technology was selected due to its uniform, single-mesh-size, creating more uniform pore throats and more space for hydrocarbon flow.

Integrating technology to enhance production

In order to build the most optimal solution for a variety of different well challenges, KRYPTOSPHERE has been designed to serve as the base ceramic technology, or to be otherwise integrated, with a range of additional technologies to enhance proppant functionality, such as flowback/fines control, pack integrity and frac fluid clean-up. The ceramic works in conjunction with resin coating technology, proppant pack consolidation and relative permeability modification products. In the realm of production assurance, it can be employed with SCALEGUARD as previously highlighted, but also with SALTGUARD, which inhibit salt, and other GUARD family of inhibiting technology in development. For fracture evaluation, KRYPTOSPHERE is manufactured with an in-built inert tracer, enabling users to track the whereabouts of the proppant downhole at all times.

Conclusion

Oil and gas operators can increase their production and recovery rates for the life of their wells by identifying the optimal balance of contact and conductivity for the reservoir, and building it efficiently to lower total finding and development costs per boe. Commercialising technology that lowers the operator's cost to produce oil and gas is a necessity in today's challenging environment, in which every fracture must be optimised. There are many further opportunities for these ultra-high conductivity proppant technologies to be deployed around the globe, and future deployments in the Middle East, South America, North Africa and the North Sea are expected to be underway in 2018. ■



KRYPTOSPHERE LD



Standard low-density ceramic proppant

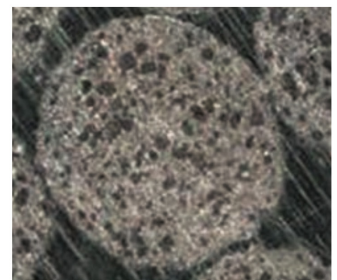


Figure 1. KRYPTOSPHERE LD technology has a very low internal porosity which creates a proppant with high compressive strength and durability.