THE AMERICAN OIL & GAS REPORTER®
DECEMBER 2007
The "Better Business" Publication Serving the Exploration / Drilling / Production Industry

Proppants Improve Well Performance

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Ever since operators began pumping diesel to hydraulically fractured wells more than 50 years ago, service companies have been searching for better ways to keep the fractures open using a variety of proppants–from walnut hulls to sand. As companies learned more about the process, the question became how to carry the sand farther into the formations. The ongoing development of lightweight, crush-resistant synthetic proppants has increased the potential productivity of the fractured well bores, according to the experts.

In the early 1960s, studies examining the relative conductivity of an open fracture versus a proppant-packed fracture concluded that conductivity benefited from the presence of a single layer of scattered proppant called a partial monolayer, says Harold Brannon, senior adviser, fracturing, for BJ Services. But he adds that creating a partial monolayer in field applications was been unachievable until the development of ultralightweight proppants (ULWPs).

"In the early days, proppants were so heavy that they would settle out without getting adequate coverage," Brannon explains. "By placing a partial monolayer, we can cut costs and achieve a much better conductivity."

BJ Services began using a manufactured ultralightweight proppant in 2003 called LiteProp™ 125, according to Brannon. He says it has a nominal specific gravity of 1.25 grams/cc, compared to 2.65 for sand and even higher for ceramic or bauxite proppants.

"We have pumped more than 3,000 wells globally as we gain more experience in both the laboratory and in the field," he notes. "The ultra lightweight allows the proppant to be transported farther into the hole. We are now developing proppants with near-neutral buoyancy. That provides much better coverage of created fractures, which is directly tied to well productivity."

The ability to place the ULWPs, some with half the density of sand, deep into the fracture produces a greater effective frac length and higher conductivity for significantly better production, according to Brannon.

Earlier this year, BJ Services introduced LiteProp 108, a thermoplastic nano-composite with improved strength, improved sphericity and lighter weight. It has a nominal specific gravity of 1.054g/cc. Brannon says LiteProp 108 is designed to withstand 225 degrees Fahrenheit and 6,500 psi of closure stress.

"One of the real keys is not having to use gelled fluids," he states. "Polymers create damage within the formation. This uses only slick water with a little friction reducer."

Brannon explains that conductivity is measured by the permeability of the formation multiplied by the width of the fracture. He says LiteProp 108 maintains the width of the fracture with a slight deforming of the proppant, but without embedding into the formation.

LiteProp™ 108, an ultralightweight thermal plastic nano-composite manufactured for BJ Services by Sun Drilling Products, has a nominal specific gravity of 1.054 g/cc and is engineered to withstand 225 degrees and 6,500 psi of closure stress.

"LiteProp 108 has tremendous potential," he exhorts. "We have been using it with extraordinary performance. One of the first wells on which the technology was used was near Farmington, N.M., in a deeper Dakota formation. A typical well in that area produces 500 Mcf of gas a day and then declines to about 200 Mcf/d after a month on production. That well using LiteProp 108 came in at 3.4 million cubic feet a day. It has been four months now and it is still producing 2.9 MMcf/d."

Brannon says BJ Services has done similar work in the Niobrara formation in northeastern Colorado. "We pumped the material with VaporFrac™, which is a high-quality foam, with a similar type of stellar results," he adds. "Wells are producing two to four times more."

BJ Services is also using its lightweight proppant materials in gravel packs, according to Brannon. He points to a successful horizontal gravel packing project for Petrobras in offshore Brazil. "These wells have 3,000-foot horizontal holes with huge washouts at the heel where the wells make the turn," he comments. "We have completed multiple wells using LiteProp 125 with 100 percent packs of the well across the 3,000-foot horizontal hole. It is revolutionizing the applications by incorporating the same neutral buoyancy mechanics."

Game-Changing Technology

Sun Drilling Products Corp., headquartered in Belle Chase, La., manufactures LiteProp 108 for BJ Services. Douglas P. Heller, president, chief executive officer and chairman of the board for Sun Drilling Products, calls LiteProp 108 a "profound invention."

"The ability to create a partial monolayer is a game-changing technology," Heller remarks. "LiteProp 108 is near-neutral buoyancy. It is light, very hard and not brittle. The bead will deform to some extent, so it will not chip or break. And it is nonabrasive. Prior to LiteProp 108, conventional proppants such as sand and ceramics were notorious for being abrasive in the flow-back through the tubing."

But perhaps the biggest benefit, according to Heller, is the ability to place the ultralightweight proppant in a partial monolayer with slick water. "It goes everywhere the water goes. It will not settle; it is overcoming the laws of physics for settling," he claims. "While this technology is more expensive than sand, it is totally different. The economic benefits far outweigh the cost. It will open new basins for drilling activity."

BJ Services is marketing LiteProp 108 in the United States, but Heller says Sun Drilling Products is marketing the same product itself outside the United States, especially in Canada, under the name FracBlack™. At the same time, Sun Drilling Products continues to work toward expanding the technology's application envelope.

"At present, the application limits are 225 degrees F and 6,500 psi closure stress, but that is not to say we will not have a new material a year from now," he remarks. "This is a niche market. But in the new age of resource plays, it will have a huge payoff for operators.

"Our plant is going round the clock," Heller adds. "We have gone from the laboratory to full-blown scale up in a short time and are just now hitting stride. There is huge demand, and we are expanding to meet it. We are expanding our plant in Louisiana, and we are looking for an additional plant site in Texas."

Improved Production Rates

Halliburton also is testing a new plastic-based ultralightweight proppant that has a specific gravity of 1.08g/cc, reports Ron Hyden, stimulation group manager in production enhancement. "We have tested it in trial jobs in the Rockies, the Permian Basin and Oklahoma with a significant improvement in resulting production rates," he claims. "We are testing it in temperatures of 200 degrees or less and less than 8,000 psi closure stress."

The as-of-now unnamed lightweight proppant is designed for a partial monolayer, according to Hyden. "This deforms," he says. "It does not go away. Even in deformation, it keeps the crack in the reservoir rock open."

Hyden states the porosity of a propped fracture created with Halliburton's new ultralightweight proppant is designed to be in the range of 80 percent. The porosity of a fracture propped with conventional proppant pack is only about 40 percent. He says that companies are often driven by trying to create a lightweight proppant, but that is not the whole story of the success of a proppant.

"Even if it is a perfectly matched proppant to the fluid density at one condition, it will float or sink at a different reservoir condition," he explains. "You still need some chemistry to keep the proppant suspended across the fracture height. You need a fluid with properly designed viscosity to evenly distribute a partial monolayer of ultralightweight proppant to increase conductivity.

After more than two years of testing and tweaking its lightweight proppant, Hyden says Halliburton expects to roll out the technology in the first quarter of 2008.

Meanwhile, Halliburton is rolling out a new product called Horizon gravel, which is a synthetic lightweight material for horizontal open-hole gravel packs, according to Harvey Fitzpatrick, sand control product group manager.

"Horizon gravel has a lower density than normal quartz gravel, which allows a better efficiency of transport," states Fitzpatrick. "We can successfully pump a longer lateral and successfully pack it at a lower rate."

The ability to pump at a lower rate is critical, according to Fitzpatrick, because

Halliburton is testing a new plastic-based ultralightweight proppant with a specific gravity of 1.08 g/cc in trial applications with temperatures to 200 degrees and up to 8,000 psi of closure stress. The proppant in this jar has been suspended in fluid for several days with no settling.

it reduces the friction pressure. Too much pressure, of course, creates the possibility of fracturing the formation during the return flow. "You jeopardize the pack if you fracture the formation," he says. "Horizon gravel provides an extra safety factor."

Fitzpatrick says his company is preparing for open-hole horizontal gravel packs in deepwater wells in Brazil in which they have to stay within a narrow pressure window between the reservoir pressure and the frac pressure to successfully complete the wells. Horizon gravel allows Halliburton to "pump at a lower pump rate and still pack a longer lateral," he relates.

Statoil also has had success using Horizon gravel in open-hole gravel pack operations in horizontal wells up to 3,120 feet in length in the Norne satellite field in the North Sea, Fitzpatrick adds. "These wells had three or four sections that the operator wanted to control independently," he says.

To enable separate control of individual pays in these completions, intelligent components and packers were run inside the screen assembly, while swellable packers were installed with the screen assembly. The swellable, open-hole packers were included in the gravel pack screen assembly to provide the necessary zonal isolation in the open-hole annulus. Improved transport with the Horizon gravel allowed packing past the tight clearance around the Swellpacker™ isolation systems, Fitzpatrick says.

"Three wells were completed successfully using this method, enabling Statoil to recover more reserves," he notes, "Lightweight gravel packs are definitely not inexpensive, but the cost of gravel is not material in these types of wells. Horizon gravel offers ways to successfully place gravel packs in wells where they have not been able to otherwise be done."

Ceramic Proppant

Once upon a time, the conventional thinking was that ceramics should only be used on high-pressure or deep wells, but that is not the case at all, according to David Gallagher, vice president of global marketing and sales for CARBO Ceramics. "Ceramics can be used as a proppant on any well that needs increased conductivity. It has broad applications," he remarks. "If an oil and gas operator believes that increased fracture conductivity would add to the economic value of his reservoir, ceramic proppant should be considered."

Gallagher cites industry statistics as "testimonial" to the increasing role of ceramic proppants. "Ceramics represented less than 10 percent of all proppant pumped 10 years ago, but today ceramics account for about 20 percent of all proppant pumped. This is remarkable considering that the total amount of proppant pumped in the same time frame has tripled," he continues. "This clearly shows the growing embracement of ceramics as a value-enhancing investment."

The characteristics of ceramics include their resistance to crushing and near-perfect sphericity, leading to higher flow capacity. Gallagher says lightweight ceramic proppants are being used with increased frequency in slick water fracturing projects.

"Ceramics have stood the test of time," he claims. "Because of their strength, quality, and roundness, ceramic proppants bring more economic value to the reservoir, which is demonstrated by their expanded share of the slick water fracturing market."

Sand has been the primary proppant used in the Barnett Shale and other unconventional shale gas plays, but Gallagher says his company's lightweight ceramic proppants have been pumped in two field trials in major shale plays.

"What the operator is looking for is the best combination of strength, conductivity, transportability and economic value–precisely what the newest lightweight proppant, 40/80 CARBOHYDROPROP®, should bring to the market," he points out. "The technology has the proven ability to increase conductivity. We are making more inroads into shale. There will certainly be an increased use of ceramics, not only in these plays, but in any reservoir where increased conductivity accelerates productivity or enhances ultimate recovery."

Engineered Air

Potters Industries Inc., an affiliate of PQ Corporation, manufactures lightweight, crush-resistant glass beads for a variety of applications. "You can buy a bucket of spackle in a hardware store and it feels empty when you pick it up because the spackle mix contains hollow glass beads," explains Robert Flanagan, an account manager for Potters Industries. "It is the same concept that explains why an eight-pound bowling ball is the same size as a 16-pound bowling ball. It is engineered air."

If glass beads can be used in spackles and other commercial products, why not as a proppant? They are, according to Flanagan. Potters Industries became involved in the oil and gas industry with fine-grade and coarse-grade glass beads designed for drilling mud applications to act as a lubricant and reduce friction and torque within deviated holes.

"The solid glass spheres act as tiny ball bearings to reduce friction and reduce differential pressure," Flanagan explains. "The beads are a transparent, solid soda lime glass, free of pits and excess air bubbles. They are chemically inert and do not effect the chemical characteristics of the mud system."

Building on the success of glass beads as a drilling mud additive, the technology is now moving into the well stimulation market. "Glass has several advantages over sand as a proppant material, including flowing into the cracks and crevices better. We have used both solid

With the ability to increase conductivity for accelerated productivity and enhanced recovery, ceramic proppants such as the ones shown here from CARBO Ceramics account for 20 percent of all proppants being pumped today–up 200 percent from a decade ago.

beads and hollow beads as a proppant," Flanagan continues. "Glass beads are more expensive than sand, so they are not the first thing operators reach for, but they also offer capabilities that sand cannot match."

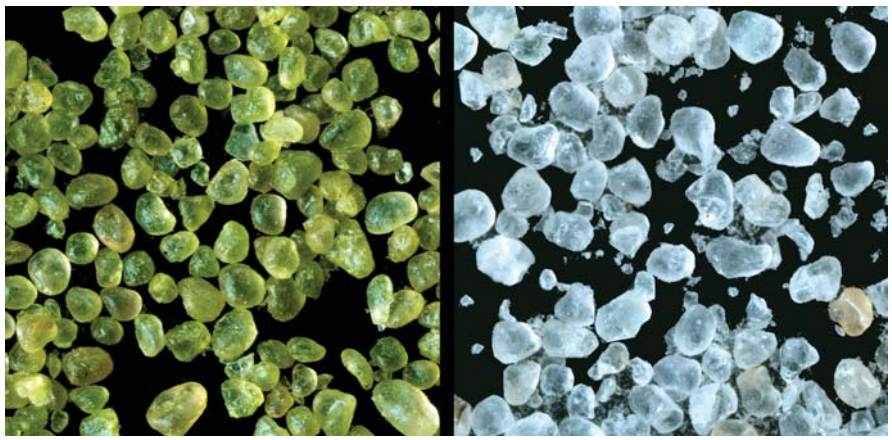
He says Potters manufactures a solid glass bead with a specific gravity of 2.5 and a lightweight hollow bead with a specific gravity of 1.1g/cc. He says the 1.1 hollow beads can withstand a closure stress of 8,000 psi, while the regular solid glass beads can withstand in excess of 30,000 psi closure stresses.

"It is up to the operator and service company to determine what type of strength is needed," Flanagan adds. "Operators may want their carrier fluid a little lighter, so it can get into the fractures better. We even had one chemist looking at putting hybrids together, mixing two or three materials to make a proppant."

Flanagan believes interest in using glass beads as a proppant is growing because of the spherical nature and the strength of the beads. "They have a ball bearing effect," he contends. "They roll over one another, and there is no breaking off. The beads are not all the same size, either, for better penetration into various sizes of cracks and fissures. They range from 50 to 250 microns."

Resin Coated Sand

Houston-based Hexion takes a unique approach to building a better proppant. Rather than using alternate materials, the company is improving the performance of conventional proppants through engineered coatings that enhance their physical properties, according to Bill Kemp, sales and marketing manager for Hexion's Oilfield Technology Group.



Resin coating gives conventional sand proppants enhanced properties, including improved fracture flow capacity, minimal fines generation and migration, crush resistance, and flow-back prevention. Shown here is a comparison of fines generated by Hexion's Prime Plus™ resin coated proppant (left) versus northern white frac sand (right) at 6,000 psi closure stress.

"We provide resin coated proppants–both sand and ceramics–used in oil and gas hydraulic fracturing," explains Kemp. "The resin gives the proppant improved properties. It can also keep the proppant from flowing back."

As an example, Hexion's Prime Plus™ resin coating provides superior fracture flow capacity compared with uncoated and tempered resin coated proppants, Kemp claims. "It offers the least fines generation and migration available in waterfrac proppants, the highest crush resistance, and Hexion's partially cured Stress Bond™ technology to prevent proppant flow-back," he reports.

Resin coated proppants are a small percentage of the total proppant market, but Kemp says they are growing quickly. "Resin coating makes for more conductivity, higher flow rates, and more productive wells," he comments. "The greater the conductivity of the propped fracture, the greater the treatment's return on investment that is realized."

Noting that sand is the least expensive proppant material, Kemp claims that adding a resin coating to conventional grades of sand offers benefits on par with more expensive synthetics. "You can get many of the same advantages for less cost. That is why resin coated sands are a growing segment of the business," he states.

Resin coated sand is being used in a variety of oil and gas applications, including the Barnett Shale and Fayetteville Shale plays, according to Kemp. "We are seeing growing demand from several operators in Barnett Shale wells in the Fort Worth Basin," he concludes. "Operators who have used resin coated proppants in these applications are seeing improved results over uncoated sands and ceramics." ❐