Reshaping Sand Control

Shape Memory Polymer Foam ‘Remembers’ Original Size to Conform to Wellbore

> After Baker Hughes chemists proved the unique, scientific properties of the shape memory polymer foam material, Bennett Richard (left) and Mike Johnson helped take it from the lab table to the rotary table.
How the GeoFORM™ conformable sand management system using Morphic™ technology works

When the polymer tube is taken to a temperature above its glass transition temperature, it goes from a glass or hard plastic state to an elastic, rubber-like state. For the Baker Hughes 2 3/8-in. totally conformable sand screen, the polymer tube is constructed with an outside diameter of 7.2 in. The tube is taken to a temperature above its glass transition temperature where it becomes elastic. The tube is then compressed and constrained to a diameter of 4.5 in. While holding this constraining force on the tube, it is cooled below its glass transition temperature, which locks the material at the new reduced diameter, essentially freezing the tube into this new dimension. Once downhole, the material springs back to its original 7.2-in. diameter.

In a perfect world, hydrocarbons would flow unencumbered—and sand free—from the reservoir into the wellbore like a river toward an open sea.

For as long as man has dug or drilled into the earth, whether searching for drinking water or for heating oil, he has struggled to keep his bounty free of sand. Today, sand migration continues to plague drilling operations worldwide, causing reduced production rates, damage to equipment, and separation and disposal issues. In short, sand is an ever-present, costly obstacle to oil and gas production.

Baker Hughes has been helping operators reduce the serious economic and safety risks of sand production for decades through deployment of sand management systems—including screens, inflow control devices and gravel packing. All have the same goal: to keep sand from entering the well along with the hydrocarbons without affecting production. But even gravel packing, the most widely used and highly effective sand control method, has its drawbacks.

In gravel packing, sand, or “gravel” as it’s called in the industry, is pumped into the annular space between a screen and either a perforated casing or an openhole formation, creating a granular filter with very high permeability. However, sand production may occur in an unconsolidated formation during the first flow of formation fluid due to drag from the fluid or gas turbulence, which detaches sand grains and carries them into the wellbore. These “fines” will then lodge in and plug the gravel pack, increasing drawdown pressures and decreasing production rates.

Now, after years of research, Baker Hughes has engineered a totally conformable wellbore sand screen from shape memory polymer foam that has the industry rethinking sand management: the GeoFORM™ conformable sand management system using Morphic™ technology.

This advanced material can withstand temperatures up to 200°F (93°C) and collapse pressures up to the base pipe rating while allowing normal hydrocarbon fluid production and preventing the production of undesirable solids from the formation.
Foam vs. metal
How do you convince a customer who has run metal screens downhole for years to give something made of foam a chance?

That was the big question that Baker Hughes scientists and engineers faced as they developed a brand new technology never before used in the oil field.

“When we first started researching this, the properties of the materials were a scientific novelty,” says Mike Johnson, sand management engineering manager for Baker Hughes. “Usually, you bring a technology into the oil and gas industry from another industry—from something that’s already in use. In this instance the science and technology were developed within Baker Hughes.

“It definitely has some major advantages over what is currently offered in the area of sand control. Compared to other products in openhole applications, it provides a stress on the formation that’s unachievable with today’s sand control technology to prevent sand from moving initially.”

“Oddly enough, I thought this was going to be a difficult sell,” says Bennett Richard, director, research for the Baker Hughes completions and production business segment. “But, every time our customers have toured our research center and seen this product, they’ve immediately grasped the concept and seen the benefits.”

Richard explains how the technology works: “Shape memory polymers behave like a combination of springs and locks. The behavior of these springs and locks is dependent upon what is called the glass transition temperature. A polymer below a certain temperature is locked in position and acts as a glass or hard plastic. If you take it above this glass transition temperature, it starts to act as a spring and becomes more elastic like rubber. For our 2 7/8-in. screens, we construct a polymer tube with an outside diameter of 7.2 in. That tube is then taken to a temperature above its glass transition temperature where it becomes elastic. The tube is then compressed and constrained to a diameter of 4.5 in.

“While holding this constraining force on the tube, it is cooled back down below its glass transition temperature, which locks the material at the new reduced diameter. The process essentially freezes the tube into this new dimension. Once downhole, the material ‘sees’ its coded transition temperature again and ‘remembers’ that it’s supposed to be a bigger diameter and tries to spring back to its original 7.2-in. diameter.

The material composition is formulated to achieve the desired transition temperature slightly below the anticipated downhole temperature at the depth at which the assembly will be used.”

The totally conformable sand screens are currently manufactured in two sizes—2 7/8-in. for 6-in. to 7.2-in. openhole applications and 5½-in. for 8½-in. to 10-in. openhole applications. The screens come in 30-ft joints made up of four 6-ft screen sections (tubes) and can be run in any openhole application where metal expandable screens, standalone screens and gravel packs would be used.

The possibility of performing multiple openhole completions with sand control efficiency close to that of ‘frac and pack’ treatments but with limited equipment and personnel is very appealing.”

Giuseppe Ripa
Sand control knowledge owner, Eni exploration and production
“Some materials, such as rigid polyurethane foam, are hard but very brittle,” Johnson says. “In addition, conventional polyurethane foams generally are made from polyethers or polyesters that lack the thermal stability and the necessary chemical compatibility for downhole applications.”

The GeoFORM sand management system, created at the Baker Hughes Center for Technology Innovation in Houston, is an advanced open-cell foam material designed with two key attributes for openhole application: reservoir interface management and filtration.

Johnson explains, “It is generally accepted that particulates less than 44 micrometers can be produced from the well without erosion damage to the tubing or surface equipment, so the GeoFORM material matrix was designed to allow less than 3 percent total particles to pass, with 85 percent of those particles being 44 micrometers or less.

“An openhole completion filtration media permeability should be at least 25 times the permeability of the productive reservoir to avoid productivity restrictions. If the reservoir has a permeability of one darcy, the GeoFORM sand management system would require a permeability of 25 darcies to prevent productivity impairment.”

Because it is an entirely new material, the mechanical properties, chemical stability, permeability, filtration characteristics, erosion resistance, deployment characteristics and mechanical tool design of the GeoFORM sand management system were tested extensively before a field trial on a cased-hole remediation well in California in October 2010.

“In order to fully understand the properties of the new material and its potential application window in the downhole environment, the material was aged in various inorganic and organic fluids for extended time periods and at varying temperatures up to 248°F (120°C),” Johnson says.

“The totally conformable screen outperforms every screen that Baker Hughes has ever tested for plugging or erosion resistance—the two main problems with sand control completions,” Richard says. “I’m sure there’s going to be a formation material that we find at some point that will plug it, but we’ve always been able to plug the other screens we’ve tested over time, and we have never been able to plug this material in laboratory tests.”

The first field trial in an openhole sand control application was successfully run in December 2010 for Eni in the Barbara field in the Adriatic Sea. Giuseppe Ripa, sand control knowledge owner for Eni exploration and production, says, “The possibility of performing multiple openhole completions with sand control efficiency close to that of ‘frac and pack’ treatments but with limited equipment and personnel is very appealing.

“Moreover, there is the possibility to develop short (1 m) unconsolidated silty layers where frac and pack is mandatory for fines control and production efficiency but the treatment is not feasible,” Ripa says. “This aspect is very attractive in deepwater developments where multiple sand bodies must be completed in one horizontal or highly deviated well in order to be economical through less rig time being consumed.”

The GeoFORM screens are being manufactured at the Baker Hughes Emmott Road facility in Houston at a rate of about 2,500 ft (762 m) per month. Justin Vinson, project manager for the sand management system, says, “The product portfolio will be expanded in 2011 to include more sizes, different temperature ranges and a through-tubing remedial application.”