Matt Offenbacher, AES Drilling Fluids, USA, discusses the advantages of leveraging promising chemical technology from the past to inspire new solutions for today.

Building Better Mousetraps

While it is up for debate whether he actually said it, Ralph Waldo Emerson is attributed with the quote: "Build a better mousetrap, and the world will beat a path to your door." As the unconventional market demands cost-saving innovation, companies are seeking the next great idea to further lower costs and improve performance.

One can imagine any number of revolutionary chemistries in a research lab, but the greatest impacts for today's market build upon the promising technology of the past that failed to mature or never found the right application. Innovative reinvention of these building blocks has resulted in millions of dollars saved through faster drilling, reduced losses and elimination of casing intervals.

Mixed metal hydroxide (MMH)

From their introduction nearly 30 years ago, MMH systems offered exciting fluid properties: low pump pressures, excellent hole cleaning, and resistance to lost circulation all with highly favourable health, safety and environmental profiles. While MMH demonstrated promise, limitations quickly became apparent. Improper treatment or contaminants irreversibly disrupted the MMH network, resulting in a near-instantaneous collapse of suspension properties, which transformed the shear thinning fluid and gave it water-like characteristics. One failed system in the field was sufficient to eliminate MMH as an acceptable fluid option for most operators.

An MMH system works through the charge interaction between MMH crystals and clay platelets. This charge interaction facilitates its unique properties where at high shear, viscosity remains relatively low, while at low shear, viscosity is high (Figure 1).

MMH technology always demonstrated great potential but addressing the drawbacks appeared insurmountable as the industry returned to generic systems. Ultimately, the discovery of an inhibitor package enabling MMH systems to tolerate a wide variety of contaminants revitalised a once dormant technology. With the introduction of the EnerSEAL MMH system, it is possible to address challenges that benefit from MMH properties without the potential failure mechanisms that limited widespread adoption.

Figure 2 compares a conventional MMH system against EnerSEAL with 0.25 lb/bbl lignite contamination. Note the dramatic reduction in rheological properties for the conventional system. It is this stability that opens mixed metal hydroxide technology to new applications.

EnerSEAL is well suited for challenging hole-cleaning scenarios, including milling and large diameter deviated wellbores. Another key benefit is the limited turbulence at the wellbore face to reduce washout in poorly consolidated or salt formations. In lost circulation scenarios, the high viscosity at low shear limits fluid invasion as EnerSEAL enters narrow fractures and thickens (Figure 3).

Direct emulsions

Historically, direct emulsion systems were employed to drill depleted, loss-prone regions by reducing the mud weight below that of water. These systems feature a water-continuous phase with a dispersed oil phase, typically diesel or mineral oil that reduces the overall density of the fluid. A stabilising surfactant maintains the dispersion to prevent separation of the two immiscible phases.

Direct emulsion applications, such as those in depleted reservoirs, were cost-sensitive. The inclusion of an expensive non-aqueous phase made utilisation unattractive even with the opportunity to mitigate losses. In many projects, a few wells employed a direct emulsion system, only to revert back to drilling with water as a cheaper option.

Direct emulsion systems faded into the background with periodic requests and a similar adoption and abandonment cycle for depleted reservoirs and other loss-prone formations. The Permian Basin presented a unique challenge where a direct emulsion system would help with density control, but in this case as a saturated salt system to drill through a salt section.

While the concept remains, the surfactant chemistry to address these concerns required further development. Surfactants feature an oil-soluble tail end and a water-soluble head which lowers the surface tension between the insoluble phases. In the old freshwater systems, plenty of free water made identifying properly soluble surfactants a simple task. With a saturated salt system, new surfactant chemistry was required to ensure fluid stability (Figure 4).

Extensive testing of a number of surfactants and surfactant blends led to the development of the EnerLITE direct emulsion system, enabling simultaneous density control and salt inhibition. The system enables the elimination of a casing string isolating a salt formation layer, helping reduce drilling time, material costs, and waste volumes. This also removes the necessity of earthen pits, which are prohibited in many areas.

Low clay systems

As laterals extend further, the window between drilling equivalent circulating density (ECD) and fracture gradient narrows in key formations. Customers continue to investigate the potential for longer and longer wells as rig capabilities and drilling optimisation improvements make the

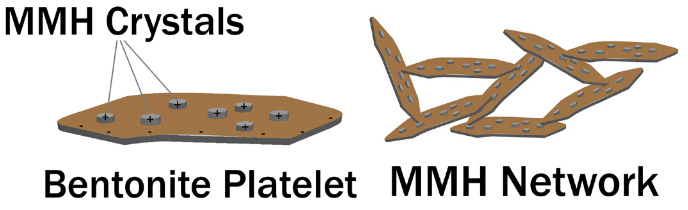

Figure 1. *Left: MMH crystals adhere to the bentonite platelets by ionic exchange in which the naturally occurring cations on bentonite are exchanged with MMH. This forms a strong association on the face of the clay platelets. Right: The MMH complex entangles a network of clay platelets. The electrostatic charge maintaining the network readily breaks with shear. This is what provides the unique rheological properties of MMH systems.*

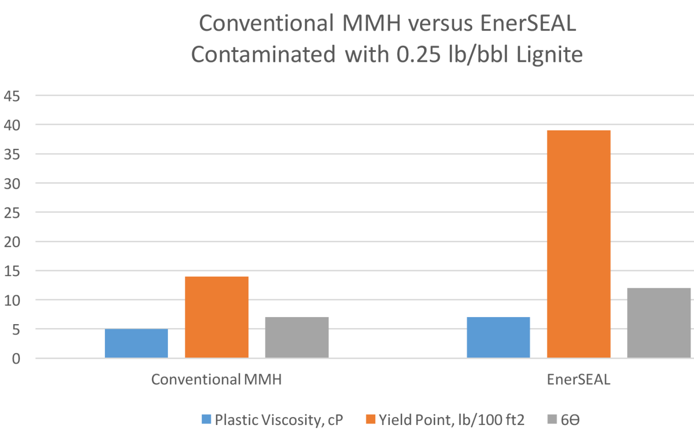

Figure 2. *Conventional MMH versus EnerSEAL rheology at 120˚F with 0.25 lb/bbl of lignite.*

Figure 3. *EnerSEAL enters the low shear region of a fracture network, thickening and slowing or eliminating losses.*

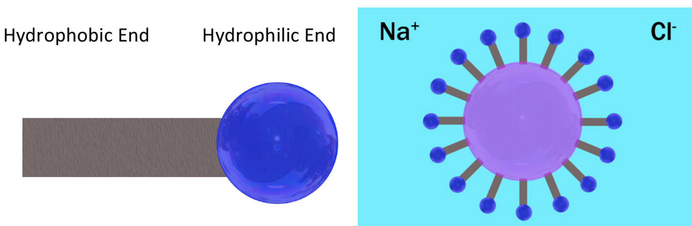

Figure 4. *Left: A surfactant features a hydrophobic (oil-loving) tail and a hydrophilic (water-loving) head. Right: The new approach with the EnerLITE system was to feature a surfactant that created a stable dispersion of oil in saturated brine versus older freshwater systems.*

concept a potential reality. To improve hole-cleaning in longer laterals, many rigs have upgraded pumps to 7500 psi. This accounts for the friction pressure loss across a longer drill string and wellbore, but the fracture gradient of the formation remains the same. Lower ECD becomes more critical as elevated pressure requirements draw closer to the strength of the formation.

In the offshore market, clay-free and low-clay systems boast minimal ECDs, particularly as they relate to the temperature variations between the seabed and downhole. While the unconventional market does not face these conditions, minimising organophilic clay additives aids to lower ECDs through a reduction in overall solids within the system. Introduction of polymeric viscosifiers provides sufficient rheology for hole-cleaning without the elevated plastic viscosity found with excess clay additions.

The EnerREACH low-clay system was developed with a new viscosifier to provide the necessary suspension and control ECDs where necessary – customised to the demands of the land market. Key design elements include contaminant tolerance, compatibility with base fluids, and system reuse before dilution. This technology was designed to account for the demands of land with inspiration from offshore.

The toolbox

Last year, a technology company called Juicero, which had raised over US$120 million to produce a machine that squeezed fresh juice from individual packets, closed its doors. During a product review, it turned out that hand-squeezing the packets made the same quality juice – in less time. The machine was a classic case of a solution looking for a problem.

There is not one single fluid solution for all of the drilling challenges. It is essential to have the right tools in the toolbox for any number of requirements and optimise system properties for well conditions. Information is critical to identify the best available option. From there, laboratory testing, hydraulic simulation, and a mud programme define the best properties and contingency plans.

Execution remains key

Delivery with the right people determines success or failure for any new system. This includes training, a commitment to customer service, and experience.

A few years ago, the United States government spent millions of dollars to re-develop a material code-named FOGBANK. The exact purpose of FOGBANK is classified, but it is a material used in nuclear weapons. It seems that over a number of years, anyone who knew how to produce the material retired or left and nobody within the government knew how FOGBANK was manufactured. After tens of millions of dollars, the government was able to re-learn what it once knew.

Leveraging the knowledge and experience of prior accomplishments with new technology of today is essential to avoid repeating the same costly mistakes of the past. Drilling fluid systems only succeed with the combination of proper skills and the focus to deliver. The dynamic nature of fluid property maintenance for well conditions requires competence and foresight. In the Utica, the AES VERT system exhibits the reliability of a quality invert emulsion system to drill wells approaching 30 000 ft with 20 000 ft horizontals in less than 20 days. The only way to achieve this is for best practices to be standard practices with experience carried over to every well.

Summary

A look towards fluid solutions of the past has inspired new solutions for today. Research will continue on 'blue-sky' innovation, but reviewing promising technologies and addressing their unsolved issues proves an effective pipeline to added value for customers. These technologies continue to deliver when matched with the right applications and the right people in the field to ensure success.