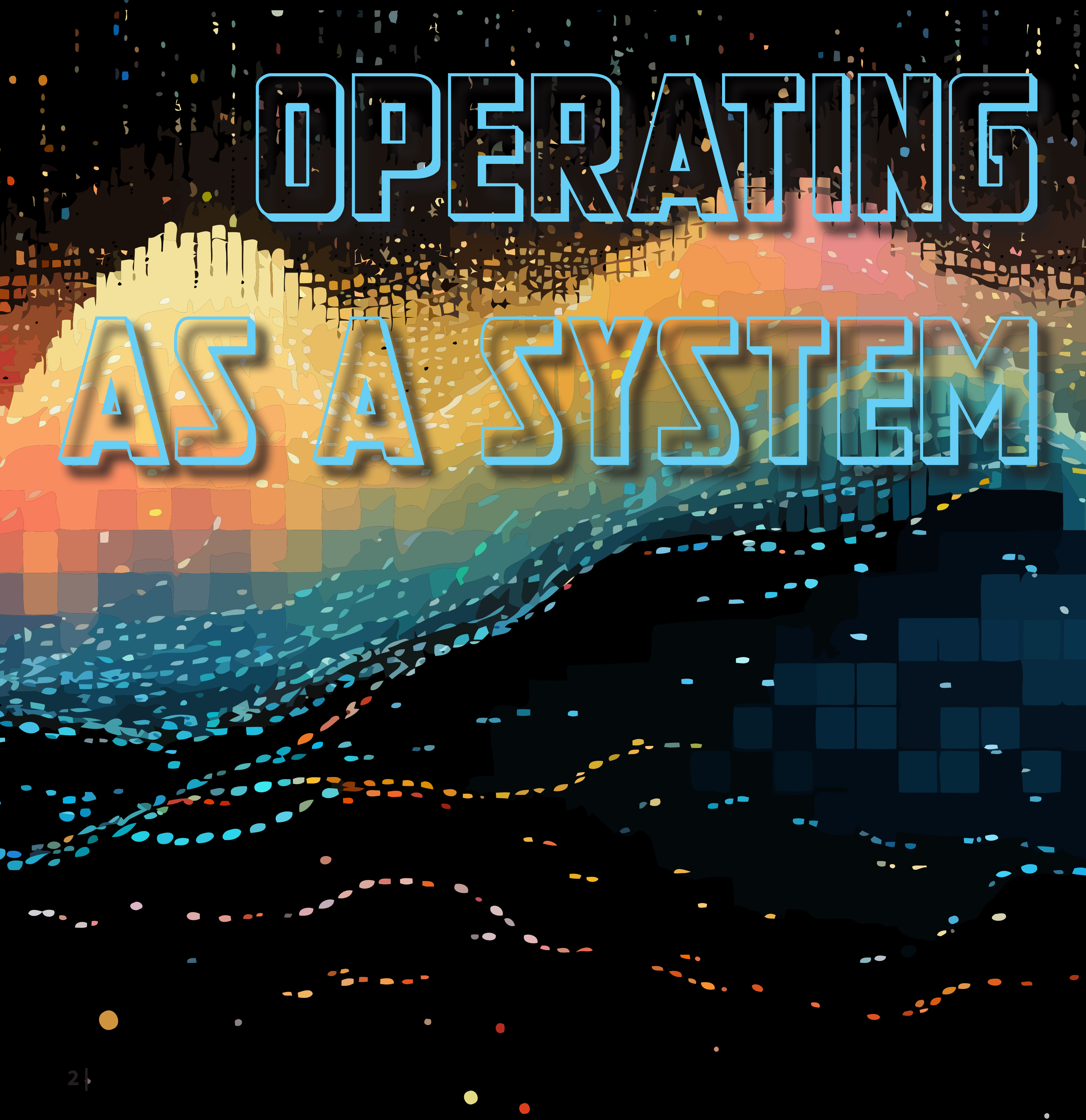
# OILFIELD TECHNOLOGY

MAGAZINE | JANUARY/FEBRUARY 2024

# OPERATING AS A SYSTEM



**Matthew Offenbacher and Richard Toomes, USA, AES Drilling Fluids,** describes how identifying and optimising drilling fluid interactions can transform the entire drilling process.

Drilling fluids interact with the entire drilling system. As the lifeblood of well delivery, identifying and optimising these interactions transforms the entire drilling process as laterals extend further and the drive for efficiency continues. Automated measurement, modelling and trending, and a variety of chemical solutions must come together to deliver the perfect wellbore – time and again.

Factory drilling requires perfect execution across multi-well campaigns. A major failure in a project of 10 record-breaking wells undermines the gains achieved by the other nine in the form of drilling time, completion scheduling, and the net present value of the oil and gas produced. Longer laterals present the opportunity to reduce the number of wells required to deliver a project, but they face narrower engineering tolerances and greater demands on equipment performance.

Drilling fluid performance requires greater consistency in treatment to stay within these narrower tolerances. As lateral length grows, friction pressures across the drill pipe increase. Inconsistencies in rheology and density create larger fluctuations across the system, creating pressure variances that may induce fractures or wellbore collapse. In shorter wells, these variances prove less consequential and typically go unnoticed.

Continuous measurement systems provide regular trends for rheology and density, highlighting the issue and encouraging changes in behaviour at the rigsite to smooth these fluctuations. In one case, automated measurement revealed density fluctuations of more than 0.7 lbm/gal. Real-time monitoring allowed the entire drilling team to observe and prioritise better mixing practices to lower the fluctuations to 0.2 lbm/gal.

Real-time monitoring tools also facilitate trend comparison to pre-well hydraulic models to capture deviations from expected values. As trends exceed modelled thresholds, models can be modified and tested to identify the cause of the variance. This allows for on-the-fly corrections or adjustment to the drilling or drilling fluids programme. New machine learning tools are being developed to accelerate identification of issues at the earliest possible stages. This prevents minor deviations from becoming catastrophic events.

With new generation rigs featuring 7500 psi circulating systems, hole cleaning in long 8.5 in. or smaller reservoir sections is achieved through turbulence and pipe movement. Invert emulsion systems are maintained with lower rheology to sustain turbulence while suspending weight material. Many record-breaking wells are drilled with good maintenance practices using conventional invert emulsion systems. Flat rheology systems designed for extreme offshore environments may facilitate slightly lower circulating pressures, but hydraulic simulation and economic evaluation is recommended to determine if such systems deliver in a specific well environment.

The Newtonian rheological profile of unviscosified brine promotes turbulence to convey cuttings. Viscous sweeps provide supplemental hole cleaning. To limit residual polymer remaining in the system, which retains solids and limits turbulence, a new shear-degrading additive was developed. The additive provides suspension of cuttings but breaks down during additional circulation as it remains in the system. At higher density, where

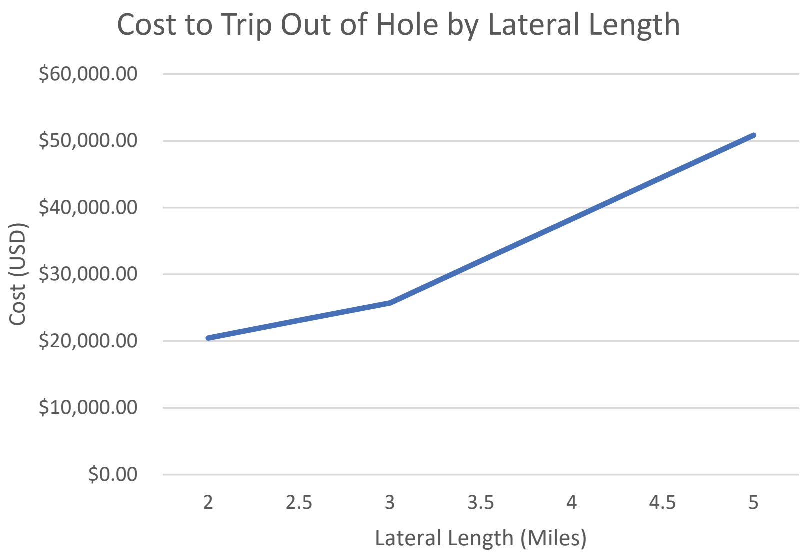



**Figure 1.** *Cost to trip with the ability to rack back pipe at 3350 ft/h vs 1400 ft/h laying down drill pipe once derrick capacity is exceeded at 25 840 ft.*

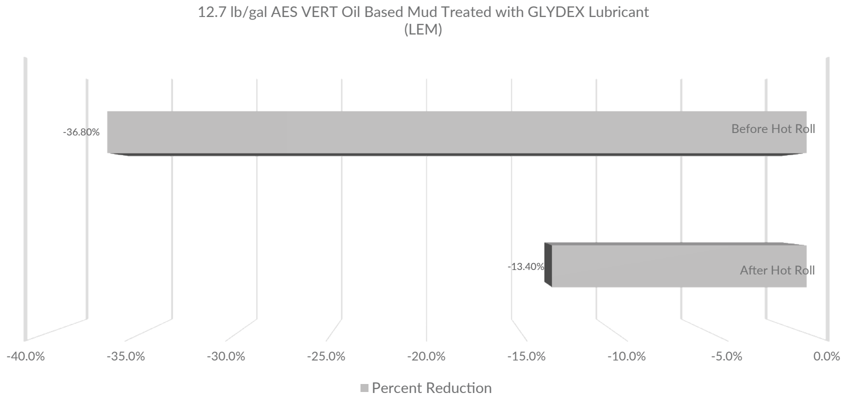



**Figure 2.** *LEM results of GLYDES OBM lubricant, demonstrating sustained coefficient of friction reduction after hot roll exposure at 250°F.*

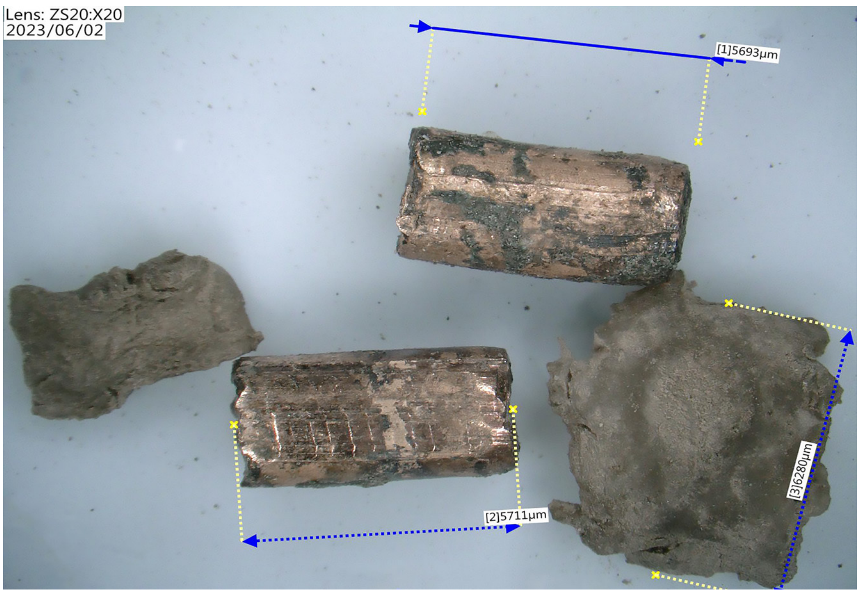



**Figure 3.** *During sample preparation for XRD/XRF analysis, visible chunks of metal and elastomer are observed in a sample as part of a failed tool investigation.*

clear fluid is uneconomical and a weighted system is required, polymers provide suspension.

Throughout the drill string, energy is lost through friction and drilling dysfunction. Lubricant additives offer improved drilling performance through more energy at the bit and the potential to improve drill pipe life. Drill pipe value and cost, which are often amortised over a five-year period by pipe suppliers, continue to rise as on-bottom drilling efficiencies and elevated torque both drive pre-mature pipe wear. Extreme pressure lubricants, which create a film to protect metallurgies as two surfaces come into contact, have the potential to offset the acceleration of drill pipe wear in such demanding drilling environments.

In most extended reach projects, invert emulsions are preferred due to their inherent lubricity. For challenging wellbore trajectories, a supplemental lubricant may remain necessary. Historically, invert emulsion lubricants have been viewed with scepticism. Many products were available with laboratory measurements that failed to deliver sustained torque reduction in the field. Advances in chemistry have transitioned invert emulsion lubricants from temporary, unsustainable additives to practical options. Effective torque modelling, directional surveillance, and new lubricant options, open up the possibility of indentifying the correct application to benefit from invert emulsion lubricants and quantify the benefit.

Water-based drilling fluids provide a lower-cost alternative in some applications. These fluids, particularly freshwater and clear brines, increase rate of penetration as high spurt loss limits dilational hardening effects.

Water-based lubricant chemistry continues to advance, leveraging new developments to reduce overall friction between surfaces and extend pipe life through extreme pressure properties. Several field studies show water-based lubricant torque reduction matching or exceeding the lubricity of invert emulsions.

Wellbore quality is a function of many factors, including directional control, wellbore stability, and hole cleaning. Where hole cleaning is primarily a function of circulation rate and pipe movement, wellbore stability is a function of proper density selection and fluid-formation interactions.

A lower density is preferred to minimise the risk of losses, but stabilising a collapsing wellbore is likely to require a higher density than using the correct one initially. Data analytics platforms featuring offset density maps and associated issues provide critical information to deliver the correct density the first time. Additional overlays of geologic hazards, such as nearby wells and faults, provide a more complete picture of risk for this assessment.

Clear, water-based fluids are preferred for their higher rates of penetration as they limit dilational hardening near the bit. High spurt loss fluids require aggressive solids removal but limit the ability to seal fractures or permeable streaks. Supplemental sweeps of graphite or sulphonated asphalt are used to plug microfractures and create a wall cake. Unlike a filter cake, which forms as fluid leaks into a permeable formation, a wall cake is characterised as material embedded into impermeable shale. This material smooths the wellbore and improves overall lubricity during trips. A single-sack solution was developed to simplify these sweep treatments. If a clear fluid needs to be converted to a full mud system, the single-sack option facilitates rapid mixing.

Limitations to downhole weight impact traditional directional tool control, making rotary steerable systems (RSS) often the preferred choice for extended reach laterals. Continuous rotation improves hole-cleaning and smoother well trajectories improve torque, but only if the RSS remains drilling ahead. Some early implementations of RSS revealed that drilling gains were offset by delays due to tool failures. In these failure events, trips near total depth prove more expensive when pipe length exceeds rack capacity in the derrick, requiring each addition stand to be laid down and picked back up from ground level. Figure 1 shows the cost to trip out of the hole assuming a spread cost of US$80 000 per day and a maximum derrick capacity of 25 840 ft of drill pipe by lateral length with an assumed vertical section of 10 000 ft. Note the inflection in cost due to the extra rig time to lay down stands.

Failure mechanisms remain subject to speculation, but fluids are naturally a part of any conversation. It is not uncommon for the directional company to blame the drilling fluid while lacking the fluid knowledge to properly make such a claim. Similarly, the drilling fluid company has limited understanding of tool function and potential failure mechanisms that could occur from drilling fluid components. Without a clear root cause, incentives to improve tool reliability are lacking.

Drilling fluid companies now have many of the tools to improve these investigations for true failure analysis. First and foremost, a robust quality control system is essential to verify and validate that drilling fluid products meet stated specifications. When there is no evidence of a product issue, automated drilling fluid measurement provides a supplemental data set of rig behaviours and activities. Density fluctuations from poor mixing and rheology spikes – or the lack thereof – are presented alongside drilling data. Any inconsistencies can be addressed or, as in many cases, the investigation can pursue another route. In this way, automation provides a third party to align rigsite activity with speculation on a root cause.

In the laboratory, new detection methods using x-ray fluorescence (XRF) and x-ray diffraction (XRD) characterise materials found during tear down of a failed tool. XRF differentiates common drilling fluid components from elements not found in traditional drilling fluid additives. XRD complements elemental analysis of XRF by identifying crystalline structures of mineral-based materials. This helps to determine if the source is natural, such as from a formation or a natural drilling fluid product or if it originates from drilling equipment. In many cases, the plugging material is composed of materials such as titanium, manganese, and iron, indicating that something within the tool itself is failing. Between real time information and advanced laboratory work, a new conversation can take place for the next generation of reliable RSS.

## Conclusion

As drilling limiters are approached with today's latest technologies, performance barriers will be broken by seeing the drilling operation as a system. Wherever system interactions occur, there is potential for both dysfunction and resolution to push technical limits even further. Because drilling fluids touch nearly everything in the drilling system, no one single product or concept materially changes outcomes. The future is in identifying these relationships and eliminating inefficiencies through automation, modelling, and advanced chemistries for not only efficient drilling fluids, but efficient wells.