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Drilling towards decarbonization: Sustainable fluid solution for Vietnam

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Abstract

Embarking on a journey toward sustainable drilling practices, an operator in Vietnam faced the challenge of drilling high-pressure/high-temperature (HP/HT) wells through a reactive formation. In pursuit of environmental excellence and emissions reduction the operator collaborates with Baker Hughes to develop a tailored drilling fluid solution. Key objectives of sustainable drilling fluid design included maintaining downhole stability, ensuring wellbore integrity, and meeting environmental regulations.

A multidisciplinary team developed a tailored drilling fluid solution comprising the PERFLEX™ high-performance water-based drilling fluid system in combination with the PYRO-DRILL™ water-based drilling fluid. This paper will highlight the solution supported by additional WBM additives, exceeded expectations, enabling the operator to drill the well 14 days ahead of plan, resulting in estimated savings of $4.2 million USD. The drilling operation resulted in a reduction of emissions by 21%, contributing to the operator's sustainability targets. The successful execution of the drilling operation demonstrated the efficiency and reliability of the HPWBM fluid program, contributing to reduced operating time, lower costs, and minimal environmental impact compared to previous drilling campaigns. This case study underscores how high-performance water-based mud systems can optimize drilling operations, reduce waste, and provide an economical approach to drilling HP/HT wells in Vietnam, aligning with sustainability and carbon reduction goals.

Keywords: Water based mud (WBM); Sustainability; Carbon out; High performance; High temp and high pressure.

1. Introduction

Drilling fluids, also known as drilling muds, are critical components in the drilling process for oil and gas wells. These fluids serve multiple functions:

- Cooling and Lubricating the Drill Bit: Drilling generates significant heat due to friction, and drilling fluids help in dissipating this heat and lubricating the drill bit to enhance its lifespan.
- Carrying Cuttings to the Surface: The fluid carries the rock cuttings produced by the drill bit to the surface, preventing them from accumulating at the bottom of the well and causing blockages.
- Maintaining Wellbore Stability: Drilling fluids help to stabilize the wellbore by providing hydrostatic pressure, preventing the collapse of the formation.
- Preventing Formation Fluids from Entering the Well: By exerting pressure, drilling fluids prevent unwanted fluids from the surrounding formations from entering the wellbore, which could cause blowouts.
- Forming a Filter Cake: When drilling fluid filters into the formation, it forms a filter cake on the walls of the wellbore, which helps to prevent further fluid loss and stabilize the well.

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2. Types of Drilling Fluids

- Water-Based Muds (WBMs): These are the most used drilling fluids. They consist of water and various additives to enhance performance.
- Oil-Based Muds (OBMs): These fluids use oil as the base fluid and are used in conditions where WBMs are ineffective, such as in highly reactive shale formations.
- Synthetic-Based Muds (SBMs): These are like OBMs but use synthetic oils, offering environmental and performance benefits.
- Pneumatic Drilling Fluids: These include air, mist, foam, and aerated fluids and are used in specific applications like depleted formations or when minimal formation damage is required.

3. High-Performance Water-Based Muds (HPWBM)

High-Performance Water-Based Muds (HPWBMs) are an advanced type of water-based drilling fluids designed to enhance the performance and mitigate the limitations of conventional WBMs. The key features and components of HPWBMs include:

3.1. Key Features

- Increased Inhibition: HPWBMs are formulated to prevent the swelling and dispersion of reactive shales, which can cause wellbore instability. This is achieved by using advanced inhibitors such as amines, polymers, and glycols.
- Enhanced Lubricity: To reduce friction and torque during drilling, HPWBMs often include lubricants that improve the fluid's lubricating properties, making it more comparable to oil-based muds.
- Improved Rheological Properties: HPWBMs maintain optimal rheological properties, which means they have the right viscosity and gel strength to carry cuttings to the surface efficiently, even under high temperatures and pressures.
- Better Temperature Stability: These fluids are designed to remain stable at high temperatures, preventing degradation and loss of function during deep well drilling.
- Environmentally Friendly: HPWBMs are more environmentally friendly compared to OBMs and SBMs. They are less toxic and easier to dispose of, reducing environmental impact.

3.2. Components

- **Base Fluid**: Water is the primary component, which can be fresh water, seawater, or brine, depending on the drilling requirements.
- **Clay/Shale Inhibitors**: Polymers like polyacrylamide, KCl, glycol, and amines help prevent shale swelling and dispersion.
- **Viscosifiers**: Materials such as bentonite clay or polymers like xanthan gum are added to increase the viscosity of the mud, aiding in cuttings transport.
- **Fluid Loss Additives**: Polymers and other chemicals like starch or polyanionic cellulose (PAC) reduce the loss of fluid to the formation by forming a thin, low-permeability filter cake.
- **Lubricants**: Additives like graphite, glass beads, or special polymers reduce friction between the drill string and the wellbore.
- **Weighting Agents**: Materials such as barite or hematite are added to increase the density of the fluid, helping to control formation pressures.
- **pH Control Agents**: Chemicals like lime or caustic soda are used to maintain the desired pH level of the drilling fluid, ensuring optimal performance of the additives.
- **Surfactants**: These help to reduce the surface tension of the fluid, improving its ability to carry cuttings and maintain wellbore stability.

3.3. Advantages of HPWBM

- Reduced Environmental Impact: Being water-based, these fluids are less harmful to the environment and easier to dispose of compared to OBMs and SBMs.
- Cost-Effective: Although HPWBMs are more expensive than conventional WBMs, they are generally cheaper than OBMs and SBMs, providing a cost-effective solution for challenging drilling environments.
- Enhanced Drilling Performance: By mitigating common issues such as shale instability and high friction, HPWBMs improve overall drilling efficiency and reduce non-productive time (NPT).

- Versatility: HPWBMs can be tailored to meet the specific needs of various drilling conditions, making them suitable for a wide range of applications.

4. Case Study

4.1. Background

An operator in Vietnam required a cost-effective drilling fluid for high-pressure/high-temperature (HP/HT) wells drilled through a reactive formation with narrow fracture windows.

4.1.1. The drilling conditions called for a fluid solution that

Remained stable at downhole temperatures of nearly 140°C (284°F). Possessed a mud weight of up to 15.0 ppg (1.8 sg) to maintain wellbore integrity in the high-pressure reservoir. Helped ensure a high rate of penetration (ROP) without risks of bit balling, gelation, or barite sag. Delivered a high-quality wellbore to facilitate long logging runs (more than 9 days per section), without the need for separate wiping trips

In addition, environmental regulations in the region called for a water-based mud (WBM). The operator was not confident that a cost-effective WBM could be found for this challenging drilling application. But based on their successful working relationship with Baker Hughes over the past several years, the operator approached the serv service provider to develop a solution.

4.2. Developing a full drilling fluid solution

A multidisciplinary Baker Hughes team comprising of Drilling and Completions Fluids, Drilling Services, and Completions, Intervention, & Measurements worked closely with the operator to develop the optimal drilling fluids strategy. Over the course of six months, the team conducted more than 200 pilot tests and dozens of laboratory X-ray diffraction and dispersion tests to measure formation/fluid interactions and shale reactivity—all of which helped optimize the drilling fluid formulation before deploying it downhole.

Based on this testing, as well as performance from the previous three years of field operations, the team proposed the PERFLEX™ high-performance water-based drilling fluid system in combination with the PYRO-DRILL™ water-based drilling fluid as an environmentally friendly alternative to oil-based mud (OBM) systems for the HP/HT drilling campaign.

For added formation protection and superior ROP, the team recommended other WBM additives as part of the overall drilling fluid strategy: MAX-GUARD™ PLUS, which limits clay hydration and plasticity to lower bit-balling risks PENETREX™ ROP enhancer, which reduces torque and drag to increase drilling rates and efficiency. LATILUBE™ additive, which improves lubricity SULFATROL XCEED™ and KEM-SEAL™ for fluid loss control in HP/HT environments MAX-SHIELD™ sealing polymer to improve wellbore stability.

4.3. Executing with efficiency

The operator agreed with the proposed fluid formulation and drilling commenced on the next HP/HT well. Based on the comprehensive lab and pilot testing results, the drilling fluid was initially formulated with 40% PERFLEX and 60% PYRO-DRILL, with the other additives added as needed.

During drilling, the Baker Hughes fluid experts closely monitored the fluid properties and drilling parameters at the rig site. Daily pilot tests on the rig informed any changes to the drilling fluid formulation, ensuring that the condition of the mud matched the requirements of that day's drilling operations. Any proposed changes were discussed at daily meetings with the operator and communicated with the rig crew to ensure seamless fluid alterations without any logistical delays.

At a measured depth (MD) of 2535 m (8,317 ft) into drilling the 12 ¼-in. section, the well was displaced from the 40/60 PERFLEX/PYRO-DRILL formulation to a 100% PYRO-DRILL fluid to save drilling costs and boost performance. One week prior to this changeout, the Baker Hughes team and the operator thoroughly reviewed the pilot test results and agreed on a final changeout procedure to minimize delays or errors.

Drilling continued smoothly to TD with the 100% PYRO-DRILL formulation. The PERFLEX mud mixture used previously was retained at surface as a reserve mud, if required.

4.4. Delivering the well with seamless performance

The drilling operation proved that the PERFLEX/PYRO-DRILL combined fluid treatment was the optimal WBM for this well. The fluid allowed drilling to proceed smoothly and safely to TD, without any problems related to bit balling, wellbore integrity, gelation, or barite sag.

The average ROP exceeded operator expectations through the high-temperature section, reaching greater than 15 m/hr. As a result, the well was drilled 14 days earlier than the initial plan, saving the operator an estimated $4.2 million USD.

A 10-day wireline logging operation through the high-temperature 12 ¼-in. section proceeded smoothly, without a wiper trip, and confirmed that the hole was in good condition. With this confirmation, the casings and liners were run and set smoothly in all sections, allowing well production to commence ahead of schedule.

The operator confirmed that the comprehensive WBM fluid program, managed by the multidisciplinary team of Baker Hughes drilling fluid specialists, delivered this well with far greater efficiency and reliability than previous well construction projects. The operator reached their targeted production goals in far less time, at lower costs, and with minimal environmental impact compared to previous drilling campaigns.

5. Conclusion

High-performance water-based muds represent a significant advancement in drilling fluid technology. By combining the environmental benefits of traditional WBMs with enhanced performance characteristics, HPWBMs provide a viable alternative to oil-based and synthetic-based muds in many challenging drilling environments. This is an example of how our high-performance water-based mud systems optimized drilling time, reduced mud wastes, and provided an economical approach to drill a HP/HT well. Less operating time and disposal reduces drilling costs while helping the customer meet their sustainability and carbon reduction goals.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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