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Mechanical Specific Energy and Rig Sensor Data: A Novel Approach to Lubricant Evaluation

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Abstract

Rig sensor data, including mechanical specific energy trends, reveal a new approach to characterize lubricant performance in real-time. Traditional laboratory and field observation methods failed to distinguish sustained torque mitigation between different additives due to equipment limitations and variations between wells and drilling conditions.

The new approach leverages wellsite data sources and physics-based drilling concepts to identify lubricant contributions to drilling efficiency. Collaborative efforts between the operator and drilling fluids company identified new metrics for performance contributions not observed through traditional laboratory screening techniques.

The industry relies upon laboratory testing to assess lubricant performance at low torque conditions using instruments with limited accuracy. Once a lubricant is qualified for field trial, torque trends are monitored with additions for comparison. In many cases, the reduction in torque is then offset by increased weight on bit to increase rate of penetration, resulting in a return to elevated torque. A physics-based approach uses mechanical specific energy to capture the reduction in energy loss across the drilling system at a given drill rate. This method revealed that seemingly indistinguishable lubricant additives as observed in the lab produced dramatically different results in the field.

This paper compares traditional and new evaluation methods using wellsite data from a drilling campaign in the Permian Basin. The authors will discuss how a comprehensive approach to the drilling system can facilitate future evaluation of fluid additives or other equipment as potential limiters.

Introduction

Drilling torque remains a persistent challenge as well complexity and length continue to grow beyond the capacity of available equipment. Excess torque and mitigation methods are under constant scrutiny to maximize drilling performance and minimize associated costs. Lower torque offers many benefits:

- Higher rate of penetration
- Improved directional control and utilization of lower-cost mud motors for steering
- Extended lateral capability
- Increased pipe life
- Lower hard-banding replacement costs
- Reduced pipe inspection frequency

Optimizing current drilling systems provides savings without significant changes in drilling equipment and rig design. Improving lubricity of the drilling fluid is a primary method to generate these savings, but consistent and reliable evaluation techniques are lacking.

Lubricant Evaluation in the Laboratory

Laboratory lubricant evaluation includes compatibility testing and coefficient of friction reduction measurement. In select cases, the film strength is measured. The testing process is iterative, with candidate selection based upon performance comparisons between products. This requires repeat tests in high volume and limits the practicality of test conditions that reflect downhole drilling environments.

Compatibility Testing

Compatibility testing confirms the lubricant candidate does not induce adverse effects on the drilling fluid. The complex chemistry of fluid mixtures can lead to unpredictable results without upfront evaluation. Performance variables include base fluid composition, pH, temperature, salinity, hardness, and solids (Farnum, Toomes, and Offenbacher, 2023). In whole drilling fluid, rheology and fluid