Nano-Graphene Engineered Lubricant for Drilling Fluids

Vickneswaran Veloo,
Scomi Chemicals, Malaysia

Abstract

Scomi together with the technical partner had developed series of nano graphene engineered product in mass production scale, one of the latest product that had been field trial successfully in the region is a graphene enhanced product that provides superior lubricity and thermal stability to the water based drilling fluids. It is a blend of proprietary fluids engineered with nano graphene, where graphenes will penetrates into microscopic pores of the tubular metal, crystalized in layers under high pressure, forming a protective film to improve lubricity, prevent bit balling, improve BHA's life span, improve ROP, and most important of all improving fluids' thermal stability.

Laboratory performance test with EP/Lubricity Tester indicated 70-80% torque reduction on a water based salt polymer mud system, compared to conventional lubricants of only 30-40% reduction. The product had been field trial in a HTHP onshore well with temperature up to 176°C (349°F), and hard formation reducing the bits' life span to only 2-3 days. During the field trial, it's noticed that 2-3% of the product had improved ROP 125%, actual reaming torque reduction of 20%, bit's life span increased >75%, fluids loss reduction of 30% with 40% polymers concentration reduction compared to planned mud formulation. The improvement in drilling performance and bits' life span had significantly reduced operator's operational time and cost. Graphene itself has superior mechanical properties such as tensile strength of 130 gigapascals, weight of 0.77 mg/m^2, Young's Modulus of 0.5 TPa, specific strength of 4.7 – 5.5 x 10^7 N.m/kg, melting point of 4510K. Obviously graphene will be a very robust material for drilling and exploration activities. Considering material cost, application methodology, as well as HSE concerns, nano graphene has chosen to be suspended in the surfactant based carrier fluids prior introduced into the drilling fluids. And thus the product limitation will based on the limitation of the carrier fluid instead of graphene material. This graphene enhanced lubricant is biodegradable, thermally stable up to 300°C, suitable for moderate salinity drilling fluids up to approximately 140,000 mg/l of chloride content.

The lubricant forms a lubricating film known as tribofilm by both physical adsorption (i.e. physisorption) and chemical adsorption (i.e. chemisorption) which involves physical and chemical changes of both solids and lubricant molecules that are influenced by tribological conditions. The chemical reaction leading to boundary lubrication is initiated by temperature, pressure or mechanical contact (shearing forces and drilling).

The lubricant is designed to find areas of high friction, shear or pressure and its effective concentration is high at the point of friction. The carrier fluid is formulated to facilitate migration of protective nanoparticles to the metal surface. The lubrication mechanism is controlled by chemical structure of nano materials and their ability to form a strongly bonded protective film on the rubbing surfaces. The film is stable at extreme pressure and temperature. The nano graphene will invade into the microscopic spaces and chemically bonded to the metal surface, allowing the tubulars to tolerate extreme heat, and abrasions. Upon high pressure and temperature, the lubricant containing nano graphene gets crystallized in layers, causing the tubular surface shear and slide easily, thus lowering the friction coefficient. The crystallized nano graphene layers also prevent direct contact between metal surfaces, hence minimizing metal wear. The nano graphene coating also prevent oxidation, where the nano particle will displace the rust and carbon varnishes. They also change the morphology and surface characteristics of metal surface, creating a self healing friction barrier. The nano graphene coating also balling of the "fines" onto the metal surface, preventing bit balling and allowing the bit to freely cut the new formation. Once the nano graphene film is formed on the metal surface, it doesn't depends on the carrier fluid, it will remained on the metal surface disregard fluids contamination such as water and solids that might affect the carrier fluid. This differentiate the product

from other liquid or solids type of lubricants where its depletion rate is low and also low dosage is required.

In one of the PTTEPI Myanmar onshore block drilling campaign, the reservoir section consisted of sand interbedded with shale is classified as hard formation, causing slow ROP and consumed several bits during the reservoir drilling in the first few wells. In order to reduce client's operating cost and improve ROP, Scomi has offered PTTEPI the graphene enhanced lubricant solution and after performing a comprehensive laboratory test..

With the success of the first field trial on nano graphene engineered drilling fluids, Company is in the midst of developing series of graphene enhanced product to cater more challenging drilling and production conditions.