Abstract

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Masters of Science (Msc)

Tribology study in deep downhole drilling processes: Influence of contact pressure and sliding speed on friction under Newtonian and Non-Newtonian Lubrication.

Drilling processes are complex and costly processes. Mechanical friction is predominant as the limiting factor in attaining high recovery rate of target recoverable oil resources. As a result it is of essence to reduce the cost incurred as a result of mechanical friction by putting in place the methods to minimise the friction encountered during drill string/casing and drill string/formation contact. However to best perform this, laboratory simulation of the conditions and / understanding of the mechanisms found in downhole, in particular, deep and ultra-deep downhole is a necessity.

The work presented herein simulates the drill string/casing and drill string/formation or rock contact under aqueous and non-Newtonian lubrication. Furthermore contact pressure and drilling speed were varied under the two later mentioned lubricant. Following the running in method, the results depicted a decrease in friction coefficient as load or contact pressure was increased. This was observed both when the steel/steel contact (simulating drill string/casing contact) and when steel/sandstone rock (simulating drill string/formation contact) were simulated. Increasing speed increase perturbations in the coefficients of friction, and has no direct effect on the mechanical friction in comparison to observations in the case when the when load was incremented at low speed ranges. However, as the speed increases the friction coefficient for steel to steel contact reduced significantly. The latter invalidates the universality third law of friction, which state that friction is independent of speed. Offset of

the steel pin, meant that the pin encountered new and fresh/hard asperities and hence increases the vibration. Thus to better control this was concluded that load allowance and measurements thereof is to be made when designing drilling strings for deep downhole drilling. In addition the incorporation of the bentonite particles into the drilling mud increased the friction for steel/steel contact due to two-body abrasion which becomes the prevailing mechanism on the entrainment of the bentonite particles between steel pin and steel disc.

For steel/sandstone contact the friction decreased on the entrainment of bentonite particle. This was attributed to the microstructure and porosity of the sandstone disc. Furthermore and important for lubricant design, the water to bentonite ratio was tested. The result for the latter testing showed that friction increased with increased water concentration in the bentonite mud. This means that the overall performance of pure water lubricant in comparison with bentonite mud was found to be poor. Thus addition of bentonite mud at certain concentration for specific drilling contact, can either increase friction or decrease friction and consequently it was found advantageous to use bentonite particles under drill string/formation contact depending on the hardness of the formation. The porosity seemed to reduce the tribofilm, making it difficult for smooth and good friction reduction since the charged lubricant is lost in filling the pores. Upon visual observation the tribofilm thickness for when sandstone was lubricated with bentonite was slightly thicker than in the case when water as a lubricant was used. Though for different sandstones the rock porosity increased friction, it was assumed that with time the worn material and the bentonite particles quickly works to fill the pores that were initially taken to be gas filled. The microstructures of the contacting materials and their abrasiveness strong influence the drilling friction.