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Fluid Circulation Effects on Torque and Drag Results, a New Take on an Old Subject

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Abstract

The hydraulic effects on torque and drag modelling have been thoroughly studied in the past, yet their interpretation still causes a lot of misunderstandings and confusions. Historical models disregard the circulation effects and focus on the fluid mass by employing buoyancy forces based on Archimedes principle. On the other hand, the reference model including the fluid circulation effects, introduced by R. F. Mitchell in the 1990s, consists in computing the forces due to internal and external fluids along the drill-string. The first type of models called Archimedes method directly produces an effective tension, while the second one generally called pressure area method produces a true tension that must be further transformed to get the effective tension. These different forms of tensions add even more confusion.

By returning to the basic equations of the fluid effects on the drill string, an equivalency between Archimedes and pressure area models has been found for the case with no circulation. Furthermore, with the same principle, an Archimedes-like model is deduced for the case of fluid circulation, where the effects of fluid pressures, frictions, and flows could be more easily interpreted. These two hydraulic models, after implementation in a true stiff-string 3D model enable then to fairly compare the two approaches in terms of forces applied on the structure.

The comparison of this Archimedes formulation with pressure area model gave sensibly the same results for various scenarios, proving the equivalency of the two approaches even with the case of circulating fluid. In addition to the model-to-model comparisons, torque and drag results are compared to field experiments at different depths. Flow rate was varied while reciprocating the drill string up and down, and the hook load was recorded for each flow rate and each tripping direction. The model-to-data comparisons showed a good agreement between the theoretical results and experimental data.

An advanced Archimedes method with all fluid circulation effect has been developed. By tackling the problem of circulating fluid in the drill string using two different approaches and proving their equivalency, a better understanding of the hydraulic effects can be achieved, which in terms can help settle the possible debates and confusions that might arise by drilling engineers.