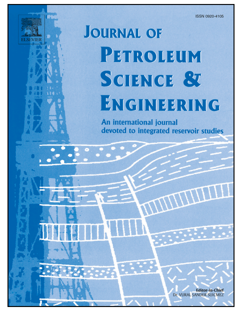

Theoretical modeling of Positive Displacement Motors performance

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Theoretical Modeling of Positive Displacement Motors Performance

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ABSTRACT

Positive Displacement Motor (PDM) has been used extensively in directional and horizontal drilling operations. To the best of our knowledge, there is no reliable analytical model to predict the performance of PDMs. Based on motor geometry; each PDM has its own unique performance that is experimentally obtained by manufacturers using water as a testing fluid. These experiments are not only costly and time-consuming, but also with conditions that do not represent the actual down-hole conditions.

The key to improve the prediction of motor performance is to, accurately; determine the flowing cross-sectional area of PDM. This paper uses Nguyen et al. (2014) model for calculating flow area of a multi-lobe progressing cavity pump, in addition to two developed analytical models for predicting the actual performance of a multi-lobe PDM. A sensitivity analysis was performed to optimize motor geometry to maximize motor torque. The developed models were validated using experimental data from a single 1:2-lobe and multi 2:3-lobe PDMs. The results revealed that when the stator lobe number is greater than five, torque is maximized if the dimensionless motor geometry is zero. The flowing cross-sectional area is reduced when the stator lobe number is higher than four lobes. However, the flow rate is always higher when the stator lobe number is increased. The results also showed that it is not recommended designing a PDM which has the stator lobe greater than twelve. Furthermore, model validation showed that the proposed model predicts the actual multi-lobe PDM performance with average percent error of less than 6% when differential pressure across the motor is 300 psi or less. The results of this study are not only important for manufacturers to optimize PDM design, but also for operators to improve the performance and efficiency of PDMs.

INTRODUCTION

There are two types of downhole mud motors, namely Positive Displacement Motor (PDM), and Downhole Turbine Motor (DTM). The PDM has been the most common motor in the United States with about 99% of the total footage drilled in the United States (Li et al., 1998). A PDM is a hydraulically driven down-hole motor, which drives drill bit without rotating drill-string and uses the Moineau principle (Moineau, 1932). Moineau design composed of two helical gears, one inside the other, where the rotor rotates around its longitudinal axis in parallel with the stator axis. The internal gear always has one extra lobe than the external one. The rotor is designed so that all the lobes of the rotor are constantly in contact with the stator. As the drilling fluid is forced into the motor, fluid hydraulic power drives the rotor in an eccentric rotation, which is then transferred into concentric rotation through a universal joint assembly, which is transferred to drill bit.

A basic PDM is composed of the following parts: sealed bearing assembly, adjustable housing and drive shaft, power section, and dump sub (Cougar Drilling Solutions Handbook, 2012). The sealed bearing assembly carries all radial and thrust loading, where the sealing is used to deliver maximum flow to drill-bit. The adjustable housing connects the stator to the bearing assembly housings, and houses the drive shaft assembly. The power section converts hydraulic power from