# ABSTRACT


Title of Document: EXPERIMENTAL AND NUMERICAL STUDIES OF DRILL-STRING DYNAMICS

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A drill string is the transmission component of rotary drill-rig system used for mining petroleum and natural gas resources. The drill-string system is essentially a long slender structure whose length can be in kilometers. Additionally, the drill-string is subject to discontinuous forces from interactions with the wellbore, which can cause erratic torsion oscillations and stick-slip motions. Here, a unique scaled experimental apparatus has been constructed to understand the dynamics of one section of the drill-string subjected to stick-slip interactions with an outer shell. In both the experimental and modeling efforts, the drill-string system is studied as a slender rod with large discs on either end, with the bottom disc being enclosed within a shell, which is representative of a borehole. The experimental setup allows for studies of stick-slip interactions between a drill-string like system and an outer shell, unlike the prior studies. A series of careful experiments are conducted with special attention to parameters such as the drive speed, the mass imbalance, and the nature of contact between the bottom disc and the outer shell. The experimental results indicate that the rotor motions can be divided into different phases, with each phase being characterized by its own unique features that include bumping, sticking, slipping, and rolling characteristics. In order to gain insights into the drill-string

dynamics, reduced-order models have been developed inclusive of a novel drill-string wellbore force-interaction model that can account for stick-slip behavior. Both the experimental observations and model predictions are found to be in agreement, in terms of the system dynamics. Furthermore, parametric studies have been conducted and the findings are presented in the form of experimental and numerical simulation results, and the qualitative changes observed in the dynamics are discussed. These findings suggest that the drill-string curvature and contact friction plays an important role in determining the present of erratic motions. This dissertation effort provides clues to how the drive speed can be used as a control parameter to move the system out of regions of undesired dynamics and how the drill-string motions can be influenced to keep them close to the borehole center.

# EXPERIMENTAL AND NUMERICAL STUDIES OF DRILL-STRING DYNAMICS

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Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2011

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