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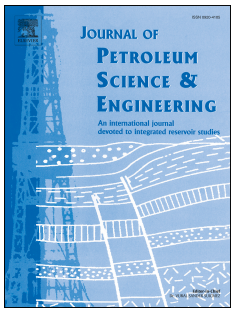

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Investigation on Bit Stick-Slip Vibration with Random Friction Coefficients

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Abstract

Torsional vibration of a drillstring, bit stick-slip in particular, is investigated with a simplified single degree of freedom (DOF) model in this paper. The friction in the bit-rock interaction is modeled as random, and the motions in stick and slip stages are treated separately. In the stick stage, it is treated as in static equilibrium. A single point or a range of points, at which the stick stage is completed and the slip stage is started, are determined depending on deterministic or random static friction coefficient assumed respectively. In the slip stage, the response at a time instant becomes a spreading area centered around the means due to the randomness of the kinetic friction. By assuming the random kinetic friction as White noise, the probabilistic distribution of the responses with displacement and velocity is calculated with the numerical path integration (PI) technique. For verification purpose, Monte Carlo (MC) simulation is also conducted. Also due to the randomness in friction, the time instants leaving the slip stage, or entering the stick stage, become random. Comparison between PI and MC shows that results from the two methods are in good agreement. In addition, parametric studies on damping, rotary speed, weight on bit, drillstring length and different combination of pipe and collar are conducted for both deterministic and random cases.

Keywords: Drillstring; Bit stick-slip; Path Integration; Random friction coefficient; Probability; Parametric studies

1. Introduction

Drillstrings are critical components of drilling in the oil and gas industry. The drillstring may experience three types of vibrations during drilling operation, namely axial vibration, torsional vibration and lateral vibration, or their combination. Stick-slip is a severe format of torsional vibration with apparent detrimental effects on the drilling system. It happens when the rotation of the drillstring is slowed down (or even stopped) and then suddenly increased when the torque overcomes the anti-torque from the rock cutting and friction. Under this situation, the rotary speed and torque on the bit may be several times larger than those on the surface (Kriesels et al., 1999), causing high cyclic stress within the drillstring and premature failure of drilling components (Christoforou et al., 2001). The rate of penetration (ROP) could be drastically decreased as well by the stick-slip (Kamel and Yigit, 2014). It is reported that stick-slip happens in as high as 50 percent of drilling time.

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