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Axial Force Transfer of Buckled Drill Pipe in Deviated Wells

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Abstract

Axial force transfer is an issue in deviated wells where friction and buckling phenomenon take place. The general perception of the industry is that once drill pipe exceeds conventional buckling criteria, such as Paslay-Dawson, axial force cannot be transferred down-hole anymore. This paper shows that, even though buckling criteria are exceeded, axial force transfer could be still good if drill pipe is in rotation. On the contrary, there exists sliding operations where lockup is observed, due to buckling, even though standard buckling criteria are not exceeded. This paper is intended to show and explain how axial force is transferred down-hole in many simulated field conditions: sliding, rotating, with or without dog legs. These new results have been obtained from an advanced model dedicated to drill string mechanics successfully validated with laboratory tests.

This paper will show applicable results for practical well operations where axial force transfer is an issue. These results will enable to give some guidelines to help the drilling engineer to select cases where conventional buckling criteria should be used cautiously. Indeed, simultaneous torque-drag-buckling calculations show that tubular can tolerate significant levels of compression, enabling to provide weight transfer to the drill bit, even though drill pipe is buckled. Others examples, in contrast, show that standard buckling criteria cannot predict the occurrence of buckling that may cause tubular lockup while tripping in the hole.

The applications of these results are numerous for all deviated wells such as horizontal or extended reach drilling wells. This paper should contribute to reduce unpredictable lock-up situations and improve axial load transfer performance.

State of the Art

Introduction

Axial force transfer is generally an issue in highly deviated wells, such as horizontal and extended reach drilling wells, where drag friction is significant and buckling may occur, leading sometimes to lock-up. These challenging wells are characterized by a long horizontal departure (HD) relative to the vertical depth (TVD) of the well. The horizontal departure to vertical depth ratio (HD/TVD) from which axial force transfer becomes critical is approximately 4. Resulting from excessive friction and/or buckling, operations such as mud motor sliding, tubulars and completion running, or transferring weight on bit while drilling, become very difficult. The axial force transfer issue comes from an insufficient tubulars weight in the vertical or low deviated section of the well to run the drill string in the long deviated hole. To overcome this problem, drilling engineers utilized sometimes drill collars or heavy weight drill pipes above drill pipes to push the string downhole. For a given coefficient of friction (μ), it is practical to define the critical angle ($Inc_{gravity}$), that is the angle for which tubular can no longer move down hole due to its own weight. This angle depends on the friction coefficient (μ) and takes the form:

$$Inc_{gravity} = \tan^{-1}\left(\frac{1}{\mu}\right) \quad (1)$$

For example, a coefficient of friction equal to 0.3 gives a critical angle around 73 deg. That means that if the inclination is greater than 73 deg., tubulars need to be pushed in the hole to start a downward motion.