SPE 116029

Drill Pipe Stress and Cumulative Fatigue Analysis in Complex Wells Drilling: New Approach in Fatigue Optimization

A. Sikal, DrillScan, J. Boulet, VAM Drilling, S. Menand, H. Sellami, Ecole des Mines de Paris

This paper was prepared for presentation at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

Abstract

In the today high-cost and complex drilling environment, the importance of drillstring failure issue has dramatically reappeared, in spite of many manufacturing and materials improvements. Most drillstring failures are due to fatigue, resulting from repeated cyclic bending loads and stresses in tensile or buckled drill pipes. Fatigue prediction is usually based on the cumulative fatigue damage model from Hansford and Lubinski as defined in API RP7G. This model, based on S-N curves, a failure criterion and a damage accumulation rule, initially requires a calculation of the drillpipe stress caused by bending when rotated in a dog leg. This bending stress calculation, key point of the cumulative fatigue damage model, is usually made by assuming that the curvature of the drill pipe is the same as the dog leg. However, this paper shows that this strong hypothesis may lead to major under-estimation of the cumulative fatigue damage. Moreover, the stress distribution within a drill pipe may be completely different depending mainly on the position of the drill pipes along the drillstring and the wellbore architecture and tortuosity.

The cumulative fatigue damage model as defined in API RP7G has been implemented in an advanced torque and drag model, which enables to track any given point of the drill pipe while drilling, such as the transition zone, the tool joints and the drill pipe body. For the first time, it has also been possible to fully track variation of stresses at a given point in the drill pipe. Based on drill pipes S-N curve available in the literature and actual drilling data, this paper shows and compares results of fatigue damage calculations as obtained from the conventional way (strong hypothesis on the contact) with results obtained from advanced torque and drag model that make no assumptions about the contact.

This extensive study as presented in this paper has never been done in the past. This advancement should probably lead to minimize the risk of drillstring failures in complex wells by a better monitoring of stresses in drill pipe.

Introduction

Drill pipe failures are still responsible for rising costs in drilling industry. In spite of many research studies carried out to mitigate this issue, it continues to occur with high frequency. Many drill pipe failures analyses have shown that fatigue accounts for the majority of drillstring failures.

Fatigue is a cumulative and non-reversible phenomenon, resulting from repeated cyclic bending loads and stresses in tensile or buckled drill pipe. Fatigue occurs even if the cyclic stress is much lower than the static strength limit of the drillpipe material.

Fatigue prediction is based usually on the Cumulative Fatigue Damage model (CFD), introduced by Hansford and Lubinski in API RP7G[1]. This model allows determining the life duration of the drill pipe based on S-N curves, damage accumulation rules and a failure criterion. However, it requires calculation of the drill pipe stress in the wellbore, which is the key point in fatigue prediction. Bending stress calculation has first been performed by Lubinski in case of rotated drill pipe subjected to tension, and Paslay suggested improvement by studying the case of compression. Lubinski/Paslay model is based on strong hypotheses on the contact between drill pipe and wellbore, and assumes the axial load to be known.

The aim of this paper is to address a new approach to assess the bending stress in the drillpipe. This methodology allows implementing the Cumulative Fatigue Damage model as defined in API RP7G, in an advanced torque/drag and buckling model[2,3,4], which allows tracking any given drill pipe while drilling.

The principle of the approach is to assess:

- Drill pipe stress history while drilling
- Stress distribution within drill pipe in order to determine the most critical zones according to fatigue damage
- Drill pipe Cumulative Fatigue Damage