IPTC 12737

Development and Application of a BHA Vibrations Model

J. R. Bailey, SPE; E. A. O. Biediger, SPE; S. Sundararaman (ExxonMobil Upstream Research Company), SPE;
A. D. Carson, SPE; W. C. Elks, SPE; F. E. Dupriest, SPE (ExxonMobil Development Company)

This paper was prepared for presentation at the International Petroleum Technology Conference held in Kuala Lumpur, Malaysia, 3–5 December 2008.

Abstract

A dynamic model of a drilling bottomhole assembly (BHA) has been developed using a lumped parameter, frequency-domain approach. The model is used within the operator's workflow to redesign assemblies to improve lateral stability, reduce tool damage, and mitigate vibrationally induced bit and BHA dysfunctions. This paper describes the model and the results of an eight well study conducted to validate its usefulness in predicting vibrational behaviors in the field.

The simplicity of this modeling approach is contrasted to the complexity of some of the finite element approaches. However, field data suggests this deterministic approach provides reasonable prediction of the dominant field behaviors. The model has been implemented in a graphically sophisticated design tool that can easily be used to compare the behaviors of several alternative BHA configurations simultaneously. The presentation format also allows the user to understand the key design elements that are causing the vibrational behavior, as well as the relative impact of changes that might be considered. The comparative, or relativistic, modeling approach allows the user to predict the best BHA for a particular drilling application. However, it is also structured to support the operator's rate of penetration (ROP) management process by allowing rapid redesign based on real time observations of field behaviors. The graphical displays and parameter plots have been discussed in a previous publication.[1]

The details of this dynamic modeling methodology will be described with reference to a field case study to outline the approach. In this method, vibrations mitigation is posed as a design problem rather than purely an analytical one. The operator is uniquely positioned to view the drilling dynamics problem at the overall systems level, with the BHA comprised of components from various vendors and with drilling operating parameters determined at the rigsite. This modeling tool can be applied to both BHA redesign and drilling surveillance.

Introduction

The operator has developed a computational BHA design tool, Vybs™, to mitigate drilling vibrations caused by lateral bending dynamics near the bit. Drilling operations are known to be frequently impacted by drilling tool vibrations, particularly in the stiffer bottomhole assembly ("BHA") portion of the drill string. Many prior investigations in this area have concluded that lateral BHA dynamics may be the most significant vibration mode to be addressed. Several studies of lateral vibrations have been reported in the literature, including but not limited to the following references: Dareing,[2] Mitchell and Allen,[3] Payne,[4] Spanos and Payne,[5] and Chen.[6]

The Vybs model has been designed to characterize the vibration tendency of a BHA and to facilitate comparison of design alternatives. Some BHA's may be characterized as "good" and others as "bad" from a vibrations design perspective, and the solution is deeper than simply seeking to identify and avoid the critical speeds of a given design. During the course of drilling operations, flexibility is needed to operate over a range of rotary speeds (RPM) and weight on bit (WOB) values. Furthermore, there are tangible benefits from developing a simplified approach to BHA dynamics modeling. These include broad applicability, ease of use, minimized computing demand, and rapid turnaround of new designs based on real time field observations. While simplicity is desired in some ways, sufficient complexity is still required to accurately predict dominant field behaviors. Comparative studies of predicted and actual field behaviors are necessary to confirm the adequacy of the method. After describing the model basis in some detail, this paper will demonstrate overall agreement with data from one field application. The interested reader is referred to a prior paper[1] for four additional case studies.

The model is an engineering tool that supports the decision making process related to BHA design and selection, with an objective to mitigate lateral dynamic vibrations and BHA-induced stick-slip. Importantly, the tool enables the development of best practices for BHA design and thus can be used as an instructional device. To facilitate this approach, the software is