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PDC Bit Steerability Modeling and Testing for Push-the-bit and Point-the-bit RSS

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Abstract

The footage drilled with rotary steerable systems (RSS) has increased significantly these last few years, due notably to the highly complex wells drilled today. Moreover, high requirements about borehole quality are needed to optimize drilling performances, running completion tools or increase the quality of formation evaluation.

Rotary steerable systems can be classified in two types according to the steering mechanism: point-the-bit and push-the-bit. Whatever the type of steering mechanism, both tilt and side force are applied on the bit. Although bit tilt is predominant in point-the-bit system, bit side force is the main factor that affects hole deviation in push-the-bit system. There have been many controversies in the scientific and industrial community regarding the deviation mechanisms involved in these two systems. To react to this controversy, a full-scale drilling bench has been developed to test drill bits in push-the-bit, point-the-bit or hybrid push-point mode. This new facility enables to apply any coupled tilt-side force on the bit to reproduce the RSS mechanisms.

This paper is intended to show results of this experimental campaign. First, the role of the side force and of the bit tilt in the deviation process have been fully differentiated and measured . Then, these results demonstrate that the bit steerability for a same given side force is strongly affected by the tilt applied on it. At last, one shows that borehole quality is not only affected by the bit design itself but also by the tilt-side force combination These experimental results presented in this paper have been validated with a software that enables to reproduce the hole deviation every inch drilled. The results of this paper should also contribute to improve bits selection for RSS in order to drill a smooth and uniform borehole.

Introduction

This paper presents the results of a 2-years joint industry Research & Development project between Total, Schlumberger, Varel, DrillScan and Mines ParisTech University. The aim of this project was to test in the laboratory the directional behavior of drilling PDC bits submitted to various side forces and bit tilt angles, as encountered in any directional system, and especially RSS. These tests have enabled to measure the bit steerability in push-the-bit, point-the-bit and hybrid push-point configurations for many bits and gauge designs, and thus to better understand the deviation mechanism involved according to the amplitude of the bit tilt and side force applied at the bit.

State-of-the-art

Definition

The directional behavior of any drilling system depends mainly on:

- The directional system: RSS, Bottom Hole Assembly (BHA) rotary, Steerable Motor;
- The rock formation: hardness, anisotropy [1,2] , dip angles …;
- The drilling bit characteristics (cutting profile, gauges): steerability, walking tendency [3,4].