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How the Bit Profile and Gages Affect the Well Trajectory

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Abstract

The importance of wellbore deviation is well recognized by the drilling industry. An analysis of the directional behaviour of a drilling system must include the directional characteristics of the drilling bit. A comprehensive analysis of the directional behaviour of PDC bits is presented in this paper, including the effect of bit profile, gage cutters and gage length. Numerical simulations as well as laboratory tests have been carried out in order to better understand the mechanisms of PDC bits deviation and to evaluate the most important parameters affecting the directional behaviour of PDC Bits.

The analysis of the directional behaviour of PDC bits presented in this paper shows that each part of the PDC bit (bit profile, active and passive gages) plays a major role on the walking tendency and steerability of the bit. A quantitative evaluation of the contribution of these factors on the well trajectory (inclination and azimuth) is given.

A full-scale directional drilling bench was built to measure, for the first time, the walking tendency and the steerability of PDC bits. The results obtained demonstrate that the bit profile, the gage cutters and the gage length have a significant effect on the walking tendency and on the steerability of the PDC bits. A 3D theoretical rock-bit interaction model was developed to reproduce the drilling tests results.

Introduction

The oil and gas industry relies greatly on directional drilling to develop petroleum reserves in environmentally sensitive areas or in restricted surface areas through an increasing number of multilateral, horizontal and extended reach wells. To drill and control the deviation of these becoming more complex wells, many directional systems can be used. Depending on the well characteristics, one can select a rotary Bottom Hole Assembly, a steerable mud motor or more recently a Rotary Steerable System. Whatever the system used, the drill bit has an influence on the directional behaviour of the drilling system. This paper enables to define the contribution of the different parts of the PDC bit on its directional behavior (steerability and walking tendency) and their impact on the well trajectory.

Background

Theory

The directional behaviour of PDC bits is generally characterized by its **walk tendency** and **steerability**. The walk tendency or bit turn is a concept well known by the drillers and a natural phenomenon existing in any rotating cutting drilling heads. From this walk tendency, Ho[1] introduced for PDC bits the walk angle, which is the angle measured in a plane perpendicular to the bit axis, between the direction of the side force applied to the bit and the direction of the lateral displacement of the bit (figure 1). The walk angle quantifies the intrinsic azimuthal behaviour of the PDC bit. When the lateral displacement of the bit is on the left of the side force, the bit has a left tendency. If the lateral displacement is on the right of the side force, the bit has a right tendency. A neutral bit means that the lateral displacement is in the same direction than the side force. Considering this definition, according now to the surface position, when we are in a building phase, if the bit goes to the left, then its tendency is left; if it goes to the right, then its tendency is right. Now, if the bit is going to the left while dropping, its tendency is right; if it goes to the right, then it has a left tendency. At last, it is