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Classification of PDC bits According to their Steerability

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Abstract

With the emergence of rotary steerable systems, the technical issue concerning the bit design for a specific directional application has reappeared. Today, a bit must be specifically designed for use with a particular directional system : rotary bottom hole assembly (BHA), steerable mud motor or rotary steerable system (RSS). The reason is that the bit must have the ability to respond properly and rapidly to a side force applied by the steering system in order to initiate a deviation as requested. To do so, the bit must have a predetermined steerability compatible with the directional system in order to provide the optimum dog leg potential.

The new generation of directional drilling systems differentiates “pointing the bit" from "pushing the bit". As a consequence, the bit directional response is a key factor that operators and directional drillers need to know to make the good adaptation between the bit and the BHA. However at the moment, there is no standard method that can propose a way to classify bits according to their steerability and walking tendency.

Based on a comprehensive analysis of the directional behavior of polycrystalline diamond compact (PDC) bits (numerical simulation, pilot and field tests), a simple methodology has been developed in order to define and evaluate the steerability and the walking tendency of PDC bits. This methodology is used to classify the PDC bits defined with their IADC bit profile codes.

As the PDC bit steerability is mainly a function of the bit profile, the gage cutters and the gage pad, some design recommendations are given concerning these three parts. For each IADC bit profile code, the bit steerability and the walking tendency is estimated through some formulas linking only the heights and lengths of the cutting profile. Some guidelines are also given about the gage pad length and gage cutters characteristics in order to achieve improved steerability.

This simple method based on geometrical criteria enables to estimate quickly not only the PDC bit steerability, but also the maximum dog leg potential achievable by the PDC bit, when coupled with the steering system.

Introduction

It is well recognized today that the directional behaviour of a drilling system is a complex coupling between the bit directional responsiveness and the mechanical behaviour of the directional system, but one also bears in mind a possible rock formation effect[1] (anisotropy). This paper is focused on the directional behaviour of PDC bits, characterized by their walk tendency and steerability.
After having noticed in a previous paper[2] that the bit steerability and walking tendency were mainly a function of the bit profile, gage cutters and gage pad characteristics, we propose in this paper to use a simple methodology to classify PDC bits defined with their IADC bit profile codes (figure 1). This methology is based on a recent study on the directional behavior of PDC bits based on theoretical models, numerical simulation, as well as pilot and field trials[3].

Background

Definition

The directional behaviour of a PDC bit is generally characterized by its **walk tendency** and **steerability**. To quantify the walk tendency, Ho[4] 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[2]. The walk angle quantifies the intrinsic azimuthal behaviour of the PDC bit.

The bit steerability (*BS*) corresponds to the ability of the bit, submitted to lateral and axial forces, to initiate a lateral deviation. The bit steerability can be defined as the ratio of the lateral drillability over the axial drillability :

$$BS = \frac{D_{lat}}{D_{ax}} \qquad (1)$$