OTC 19991

Improving Rotary-Steerable Borehole Quality Using Innovative Imaging Techniques

Junichi Sugiura, PathFinder Energy Services

This paper was prepared for presentation at the 2009 Offshore Technology Conference held in Houston, Texas, USA, 4–7 May 2009.

Abstract

Borehole quality of point-the-bit rotary steerable systems (RSS) has been well documented in the industry. This type of system, using an extended passive-gauge polycrystalline diamond compact (PDC) bit and/or a full-gauge near-bit stabilizer to tilt the bit, is known to produce high-quality borehole due to the extra lateral stability added to the lower part of the bottom-hole assembly (BHA), below the RSS deflection unit. Yet, extended-gauge PDC bits and full-gauge stabilizers are not suitable for every drilling environment, and a push-the-bit system may be more applicable in certain formations.

On the other hand, borehole quality of push-the-bit RSS has not been extensively discussed in the past, partly because the PDC bit gauge length and profile are directly related to the directional response of the tool, and different gauge lengths may be used based on the application. This type of system may lack lateral stabilization between the bit face and steering unit, depending on the type of bits used and the steering mechanism. To increase the lateral stability and borehole quality of the system, in-depth analysis of PDC bit (gauge type and length) and BHA design is required.

This paper describes the results of extensive downhole drilling tests conducted on a push-the-bit RSS. The controlled tests were conducted using various PDC bits drilling through different formations. Improvements in stability and borehole quality have been examined using vibration data and a unique near-bit 2-D/3-D caliper image. Visualization of the borehole, using 3-D caliper images and their spectrum analysis, reveals that borehole quality is highly dependant on the BHA components below the RSS steering unit.

The test results show that progressive testing with innovative imaging techniques can systematically improve the performance of push-the-bit RSS and produce a better understanding of the interaction among the bit, formation, and RSS steering unit. Proper use of these techniques helps during the development of a field where troublesome formations are encountered and poor borehole quality leads to high torque and drag which limits the drilling performance.

Introduction

Poor hole quality causes tight borehole, packing off, high torque/drag, stick-slip, degraded logging-while-drilling (LWD)/wireline log quality, unpredictable directional performance, and consequently problematic casing runs. There was initial recognition of the "crooked hole" problem in the early 1950's.[1,2] This "crooked hole" was repeatedly observed by drillers for decades in forms of "tight hole" and very high torque/drag even without aid of modern LWD tools. Advancement in LWD imaging technology can now allow engineers to identify 3-D borehole oscillation issues and oscillation frequencies while drilling.

Borehole oscillation

In 1951, MacDonald and Lubinski first expressed the precise definition of so-called "crooked hole" or "spiral hole" and provided a "crooked-hole" formula for the maximum drift size with a given bit and collar combination.[1,2] Since Lubinski's study (58 years ago), significant progress has been made in understanding the oscillating or cyclic nature of persistent borehole problems.[3-6] Mechanical calipers obtained from wireline logs and acoustic standoff calipers from LWD logs have accelerated this understanding of borehole oscillation problems. The use of such equipment is no longer the only way to detect 3-D borehole problems, such as borehole oscillation.