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Bit Selection Using Mathematically Modeled Indices Deliver Significant Improvement in Directional Drilling Performance

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Abstract

Despite the development of models describing Fixed Cutter (FC) bit performance, selection is still made on the basis of visible, geometric features. Optimal selection is complicated further by the large variation in characteristics of cutting structures, in combination with a diverse range of gauge lengths and geometries.

A set of performance indices is presented for FC bits. These are derived from a sophisticated mathematical model and describe performance in terms of Rate of Penetration (ROP), Durability, Stability, and Steerability. Once the relative importance of each index is established, the optimal bit for the application can be selected.

Due to the growing diversity of directional tools, a specialist interface for Rotary Steerable Systems (RSS) is also presented. This software incorporates logic regarding tool operation and trajectory requirement, and assesses these against key characteristics of the bit including length, profile, gauge, cutting structure, and sidecutting capability. The software will list bits ranked by decreasing suitability.

Bits can now be modeled routinely and described in terms of their technical interaction with the drilling assembly and the formation. Selection on the basis of modeling and this interaction is novel and valuable, and will provide consistent selection and improved performance.

Performance summaries are documented for global RSS applications. Use of the software lead to optimal bit design selection. Some of the designs selected had not been considered suitable from prior visual review. The designs delivered excellent performance in terms of both footage and penetration rates. In addition, they were accurately matched to the specific RSS utilized, enabling the system to efficiently deliver the required directional control.

Introduction

Offshore drilling in West Africa poses several drilling challenges which have limited drilling performance and build rate capabilities in directional applications. The extremely soft sandstone and shale lithologies in the vertical intermediate section are prone to erosion and hole enlargement with high hydraulic energy. Hole enlargement reduces deflection forces for commercial Rotary Steerable (RS) tools as well as mud motors, which significantly decreases build rate capabilities and limits directional plans and capabilities. The associated hole enlargement in the vertical section creates a drilling environment that is subject to increased risk of lateral vibration (bit whirl), which even in soft formations is capable of catastrophic damage to BHA components and the bit cutting structure. This, in turn, results in reduced drilling performance and increased drilling costs.

Compromising mud flow and hydraulic energy in these soft and fast drilling sections increases risk of loading the hole with cuttings, increased ECD, and stuck pipe. As depth increases, formation integrity and CCS increase, which helps to improve directional response. This is because the increased Weight on Bit (WOB) provides flex to the BHA and improves control. However, in many of these applications high hole angle, limited drilling parameters, and interbedded lithologies (with high compressive strength variability), combine to increase risk of torsional vibration. Aside from mechanical damage to the