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Powered Rotary Steerable Systems Offer a Step Change in Drilling Performance

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Abstract

Drilling horizontal gas wells at an average TVD of 12,500 ft in Saudi Arabia has always been very challenging owing to harsh drilling conditions. These wells are drilled in southern Ghawar field. Subject formations include bands of Lower and Middle Triassic and Upper Permian, composed of dolomite, shale, silt stone, and anhydrite formations. The main challenges in drilling these formations are slower penetration rates and difficulty in sliding with conventional motors in both the build and lateral sections.

This paper describes a step change in drilling performance using powered rotary steerable systems (PRSS) technology that led to record directional runs through difficult Khuff sections.

With the PRSS assembly, the company was able to drill both vertical and curve sections in one run, maximize ROP, and increase footage per bit run while meeting directional requirements. PRSS successfully kicked off from vertical and improved ROP up to 192% compared to conventional motor ROP in deep gas drilling. Significant improvements in ROP resulted in saving multiple bit trips in 12-in., 8 3/8-in., and 5 7/8-in. hole sections.

Introduction:

Figure 1 shows the stratigraphic view of Ghawar field in Saudi Arabia. The late Permian Khuff A, B, and C stacked carbonate reservoirs are the main gas-producing zones at depths of 10,000 to 12,000 ft. Formations encountered are well recognized for providing a harsh and hard drilling environment. Steerable motor drilling is a relatively inefficient process, with associated problems in the area ranging from trajectory control in unstable formations to slow penetration rates, pipe sticking, and slide drilling. Conventional steerable motor drilling requires sliding of the bottomhole assembly to steer the well path; therefore, drilling becomes slower and potentially more problematic. Rate of penetration (ROP) is impacted as a result of wellbore friction, plus BHA and drillstring components tend to hang up. Also, while drilling the Khuff wells, high mud weights are required to balance the formation pressures. Drilling formations with different reservoir pressure increases the tendency of the drillstring to stick to the permeable formations, hence giving rise to differential sticking, which in turn gives rise to sliding difficulties.

Conventional Well Profile and Casing Design

Two different types of casing designs are used while drilling these deep gas wells, namely “K1” and “K2”. Figure 2 shows the comparison of the casing designs.

In the conventional K2 well profile, 13 3/8-in. casing is set from surface to 30 ft into Base Jilh dolomite. A typical well profile calls for vertical drilling of about 800 to 1,000 ft with a performance motor and an aggressive polycrystalline diamond compact (PDC) bit. The bit is then pulled out of hole and the build section is drilled with a steerable motor bottom hole assembly at a planned 4° to 4.5° dogleg severity. The 9 5/8-in. casing is planned and set at about 70° inclination into Khuff C carbonate. On average, 3 bit trips are required to drill the 12-in. build section. After setting 9 5/8-in. casing, personnel use a rotary assembly to clean out cement and drill the shoe track. 8 3/8-in. single or dual laterals are drilled in the Khuff-C reservoir,

In a K1 design, 9 5/8-in. casing is set 30 ft into Base Jilh dolomite formation. The build section is drilled in 8 3/8-in. hole size to Khuff-C carbonate with a 7-in. liner run. 5 7/8-in. single or dual laterals are drilled in the Khuff-C reservoir layers.