Micro-flux control, E-C D continuous circulation valves allow operator to reach HPHT reservoirs

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MANY TIMES, WELLS drilled in challenging environments encounter high costs, their targets aren’t reached, and they often end up being abandoned. HPHT wells fall in this category, and, in offshore Egypt, this was the rule. After several attempts, with advanced techniques being tried, Eni’s foreign affiliate decided to use a combination of the company’s continuous circulation (CC) valves, Eni Circulation Device (E-C D) and the Micro-Flux Control (MFC) method. At Eni, the combination of CC with the precise measurement and control of the flow and pressure from the well, within a closed loop through a rotating control device (RCD), is called Eni-Near-Balanced Drilling (ENBD).

With this new drilling method, for the first time, a well in the HPHT area reached all targets.

Facing the typical kick-loss scenario, these wells incurred significant nonproductive time (NPT). The goal with E-C D was to avoid pressure and temperature fluctuation by keeping the annulus as stable as possible, and the MFC provided a clear picture while managing the bottomhole pressure.

Previous attempts were made using just the RCD, followed by a continuous circulation system. Later on, the E-C D valves were used with the RCD on other wells. Even though improvements were seen, they were not enough to ensure reaching the final targets. It was only when the MFC method was added that success was achieved.

INTRODUCTION

Exploratory wells can be challenging due to the inherent uncertainty about downhole pressure limits, pore and fracture pressures, and formation surprises that are not clearly mapped from seismic. In difficult environments, many wells are abandoned before reaching target.

A closed-loop managed pressure drilling (MPD) method is now providing a significant step change in drilling performance. For the first time, pore and fracture pressures can be determined very accurately and safely while drilling. As a consequence, the mud weight can be properly adjusted and managed, avoiding loss circulation, stuck pipe and low ROP. The industry loses an enormous amount of time trying to solve these problems, which very often leads to the misunderstanding that the well’s technical limit has been reached, and the well gets abandoned unnecessarily.

WHAT ARE THE BENEFITS?

Depending on the well, interrupting circulation for a connection creates problems that can be severe. When circulation is interrupted (pumps off), there is a pressure reduction downhole that can cause influxes or stability problems. The more these effects are present and combined on a well, the more significant the challenge and the more benefits the well should enjoy by using a CC method to drill.

Use of heavy drilling fluids with very high barite content can lead to barite sagging. In horizontal or highly deviated wells, keeping the well clean is always a challenge. In high-temperature wells, the temperature change at the bottom can be significant when circulation is interrupted for some time.

With a CC system, a steady-state condition is maintained downhole so the formations do not suffer pressure oscillations. Hole-cleaning improves, and the ability to pump out of the hole for extended intervals usually means the string can be moved until it is inside the previous casing, thus reducing the chance of problems in open hole.

THE E-C D SYSTEM

This system is composed of E-C D subs that are positioned on top of the stand. Only the stands that will be positioned inside the portion of the well for use of CC need to have the subs. An E-C D manifold is installed on the rig floor; close to the stand pipe manifold, diverting flow from the stand pipe manifold directly to the E-C D sub.

A hose connects the E-C D manifold to the E-C D sub on the rig floor, allowing a connection to be made without the need for significant change from a normal connection. The diversion of the fluid from the top drive to the side entry of the E-C D sub is independently managed by the E-C D manifold.

E-C D subs have a working pressure of 5,000 psi, though a 7,500-psi version is under development.

Figure 1: The ECD sub has a working pressure of 5,000 psi, though a 7,500-psi version is under development.
Having conceptualized Eni-Near-Balanced Drilling (ENBD) in 2005, even before the first MFC well was drilled in August 2006, the company waited until each individual component – E-CD and the MFC – reached maturity before using them in combination.

The first well selected to prove the concept and benefits was the most challenging environment Eni had in its portfolio at the time. Knowing the system will be exposed to harsh and severe conditions, it was a wise decision to wait until the initial learnings were implemented.

To give an idea of the experiences to date, the E-CD tools independently have accumulated more than 1,200 working days over seven challenging wells, including one extended horizontal at 5,650 m, two HPHT wells, and one complicated deep sidetrack. Mud weight has ranged from 1.06 to 2.23 SG (8.80 to 18.6 ppg), with flow rates up to 950 GPM and pressures of 5,000 psi. More than 3,000 DP connections have been made with a current reliability of 97% to 100%, depending on the severity of the environment – HPHT, flow rate, drilling fluid conditions, pressure, etc.

From the MFC side, the system has been used on more than 26 wells, drilled more than 110,000 ft of exploratory and development wells with depths from 1,000 ft to more than 20,000 ft. It has been used on land, jackup, platform and floater, covering all possible rig scenarios with mud weights ranging from 9 ppg to more than 18 ppg, using water, oil and synthetic based fluids, including formates.

With these solid individual tool performances, the ENBD system was ready to be deployed on a jackup rig. As a direct result of the success of the system’s first well in a challenging environment, the ENBD system is currently operating on a semisubmersible rig offshore Libya, with very good results.

**OPERATIONS DESCRIPTION**

Well operations for the first well are divided into two distinct periods. First with only E-CD valves, and the second period when the ENBD system was used, involving both the E-CD and MFC. As it was possible to compare events made while drilling well sections before and after using the ENBD, its value was clearly demonstrated. This comparison was very important to demonstrate – since it was the first well where Eni would use the MFC – the benefits of using the ENBD system, compared with the E-CD valves alone or just drilling the well conventionally.

Once drilling resumed in the 8 ½-in. section, with the belief that the mud weight window would be a little wider, with the MFC still offline, two more kicks were detected by the rig, being detected conventionally. The 9 ¾-in. liner was run, but the MFC was still kept offline due to the concern of surface back-pressure. This concern is fairly common with other companies using the MFC for the first time, as they were not familiar with its improved accuracy and well control capabilities.

The MFC was rigged up during the 10 5/8-in. section but remained offline until the 9 ⅝-in. liner was run. During this period, two kicks were reported by the rig, being detected conventionally. The 9 ¾-in. liner was run, but the MFC was still kept offline due to the concern of surface back-pressure. This concern is fairly common with other companies using the MFC for the first time, as they were not familiar with its improved accuracy and well control capabilities.

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**8 ½-IN. SECTION**

With the MFC offline at the beginning of the 8 ½-in. section, 17 days were needed to drill 29 m when two kicks were detected conventionally, with 13 days of NPT recorded dealing with these two events. After bringing the MFC online, it took another 17 days to drill 408 m and reach section TD. Of these 17 days, five days...
were lost tripping to fix the LWD, which had stopped transmitting to surface. No kicks or losses were detected.

On one occasion, the rig detected 15 bbl lost from the pits, but the MFC did not show any downhole losses. One hour was spent by the rig trying to identify the cause of the losses. After nothing was identified, drilling resumed, and confidence in the MFC accuracy started to increase. Before running the 7 5/8-in. liner, a dynamic FIT was performed.

It is believed that most of the kicks detected before bringing the MFC online were likely due to the limitations of conventional well control systems and their detection capability, and interpretation of the recorded parameters. What was observed was most probably gas expanding close to surface, and that was interpreted as a kick.

Many times, the gas at surface was not due to an influx but simply connection gas or ballooning, which the MFC clearly differentiates.

5 7/8-IN. SECTION

The targets were four sands that would be evaluated for the first time, as none of the previous wells reached the planned TD. By now the rig crew was comfortable with the ENBD system and taking immediate actions. On one occasion, it took less than one minute for the crew to shut the well in after receiving information of an influx detected by the MFC personnel (Figure 2).

A closed-loop MPD method can help to determine pore and fracture pressures accurately and safely while drilling. This allows the mud weight to be properly adjusted and managed, avoiding loss circulation, stuck pipe and low ROP.

Upon detection of losses, immediate action was also initiated by the rig, pumping LCM in an attempt to fix the problem. On one of the first loss events detected, the rig decided to bypass the MFC because of concern that the surface back-pressure being applied was making things worse. As the ENBD system uses the CC valves, there was no need to apply back-pressure during the connection to compensate for the loss of friction. Application of back-pressure would be used only if there was a problem with the mud pumps and circulation was interrupted, which did not occur.

The combination of the two approaches proved very successful, allowing the company to reach the targets of an exploratory well after previous failed attempts. It was proved here that the ENBD can successfully drill the undrillable.

By comparing events before and after the system was brought online, the benefits were clearly demonstrated, both technically as well as economically. Acceptance by the rig crew was very quick. The rig decided to use the system more and more, not just for drilling, taking full advantage of the flexibility and options available to control the pressure and identify downhole events.

With the success of this well Eni decided to use the ENBD system on a floater rig for the first time, offshore Libya.

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CONCLUSIONS

Many different tools and drilling methods are available to address the issues of challenging wells, and Eni decided to combine a continuous circulation valve with the micro-flux control to bring, for the first time, the ENBD system to a challenging offshore well.

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