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Optimizing Wellbore Construction with Managed Pressure Drilling (MPD) and Managed Pressure Cementing (MPC)

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SUMMARY

Managed Pressure Drilling techniques have been gaining acceptance in recent years overcoming the drilling challenges related to pressure while attempting to minimize formation damage. For wells with a narrow margin between the pore and fracture pressures, the challenge does not end when the drilling has concluded. After total depth has been reached, addressing the surge/swab effect while tripping and running casing without MPD can create the pressure scenarios that led to using MPD in the first place. The surge/swab pressures for small hole sizes can be extreme and may result in influxes or hole instability on the trip out to pick up casing. Running casing in the hole, in many instances, can result in hydraulic fracturing of the formation as the casing nears or enters the open-hole section. The magnitude of the losses and additional stresses within the rock may prevent getting the casing to bottom. After the casing is in place, the ECDs from the cementing process may easily exceed the fracture pressures, which could result in losses, poor zonal isolation, and remedial cement repair. The overall well construction process has been optimized with the successful implementation of MPD and MPC.

Introduction

Managed Pressure Drilling (MPD) techniques have been gaining acceptance in recent years overcoming the drilling challenges related to pressure while attempting to minimize formation damage. For wells with a narrow margin between the pore and fracture pressures, the challenge does not end when the drilling has concluded. After total depth (TD) has been reached, addressing the surge/swab effect while tripping and running casing without MPD can create the pressure scenarios that led to using MPD in the first place. The surge/swab pressures for small hole sizes can be extreme and may result in influxes or hole instability on the trip out to pick up casing. Running casing in the hole, in many instances, can result in hydraulic fracturing of the formation as the casing nears or enters the open-hole section. The magnitude of the losses and additional stresses within the rock (caused by the surge/swab) may prevent getting the casing to bottom. After the casing is in place, the ECDs from the cementing process may easily exceed the fracture pressures, which could result in losses, poor zonal isolation, and remedial cement repair.

More recently, Managed Pressure Cementing (MPC) has also been implemented to finalize the wellbore construction phase by closely monitoring and adjusting the bottom hole pressures (BHP) as needed while running the casing and cementing.

The overall well construction process has been optimized with the successful implementation of MPD and MPC; these techniques have minimized or eliminated the problems encountered not only while drilling but also that would continue during the cementing phase if neither MPD nor MPC had been used.

What is MPD?

MPD has been defined by the IADC MPD/UBO committee as “an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure profile accordingly.” The goal of MPD is to avoid a continuous influx of formation fluids to the surface with any influx incidental to the operation safely contained and managed using an appropriate process. In other words, MPD can be described as ECD management. MPC can similarly be described as managing the ECD during the entire cementing operation, including tripping out and running casing.

MPC

The main advantages of MPD are to optimize the drilling process to obtain better control of the ECD within the encountered pressure limits, especially when drilling in narrow pressure windows, to minimize non-productive time (NPT) related to lost circulation and kicks and, therefore, to reduce drilling costs and provide a safer operation. After the wells reach their final depth, the challenge often continues and consists of performing and providing an optimum zonal isolation while still managing the bottomhole conditions. Just like MPD, the objectives of MPC are to improve the zonal isolation process and results by cementing the well without inducing losses or having formation influxes and to eliminate remedial jobs.

Similar to conventional drilling, it is a common practice to increase the cement density to avoid any formation influx, and in some cases, losses would be induced as a result of having an ECD that is greater than the fracture pressure, leading to poor cement jobs and not providing adequate zonal isolation. By applying MPD techniques to the zonal isolation process, a lower mud density is used in MPC because the lighter mud weight used during drilling is still in the wellbore and will be displaced during the cementing operation of pumping the cement slurry and spacers. Applied surface back pressure (SBP) is adjusted accordingly to control and maintain the wellbore pressures within the operating limits (i.e., pore and fracture pressures). As a result, zonal isolation is improved by eliminating or minimizing fluid losses and formation influxes during the cementing operation.

The integration of both cementing and MPD automated data acquisition control systems, along with the use of multiple fluids with different densities and rheological properties, were the primary hurdles encountered when implementing MPC in the first wells. The MPD automated control system was modified to facilitate the data integration and the use of different fluids during cementing operations in which MPC is implemented. The automated MPD system can calculate the ECD at any point in the wellbore when circulating the cement slurry and spacers.

System Description

A basic automated MPD system includes the data integration, enabling the well to be maintained within the required operating window. The integration begins with data acquisition from the data system of the rig, surface instrumentation from the MPD chokes, rotating control device (RCD), flow meters, and real-time downhole LWD/MWD information. This data can be collected from third parties with many protocols, such as WITS, Profibus, Modbus, and OPC, with WITS level 0 being the most common. The purpose of this data gathering is to ensure that a constant ECD is maintained at all times with this simple equation:

$$SBP = \text{desired ECD} - \text{hydrostatic pressure} - \text{friction pressure} - \text{surge/swab pressure} \quad (1)$$

The cement real-time parameters are sent to the MPD system throughout the process (Fig. 1); OPC communication transmits data to the MPD data acquisition and control system where ECDs are calculated, and applied SBP are determined to maintain the pressures along the wellbore within the operational window, adjusting the operational parameters accordingly. The MPD control system can also send the readings from the mass flow meter back to the cementing operator; these readings include flow rates and densities out, enabling the cementing operator to monitor the operation in real time and to have a more precise measurement of the returns at surface.

Figure 1 MPC Process

Case Study

The wells considered for this case study are located in the Paradox basin in the southeastern quadrant of Utah. The target in this area is an organic-rich dolomitic shale and production is achieved by the intersection of natural fractures in the rock. The complexity of the geology, including folding and

faulting of the formations, results in countless challenges while drilling this shale and geosteering is fundamental to stay within the pay-zone. Additionally, variations in pressures within these fault compartments have also become a major challenge. Typically, offset wells in the area had been drilled with a 14.5 ppg mud weight which was swapped to 17.5 ppg hematite system when landing the lateral.

MPD optimizes the drilling process by having control of the ECD, determining the actual pressure limits, reducing non-productive time (NPT) associated to lost circulation and kick events, and therefore, reduces drilling costs and provides a safer operation. The main objectives of implementing MPD on this project were to minimize fluid losses and avoid damaging the reservoir.

An MPD automated system was required for these wells due to the extremely narrow drilling window available, being as low as 40 psi. The MPD strategy to drill the lateral section consisted of using a static underbalanced drilling fluid and maintaining a constant ECD above pore pressure, meaning that the mud weight was lower than what was used in conventional drilling. The equipment required to apply MPD techniques in this tight environment included a 2,000-psi rotating control device, MPD autochoke and control system, rig pump diverter system, data acquisition system, drillstring floats and subs [Non-Return Valves (NRV)] and pressure while drilling (PWD).

Once the well was being drilled with MPD, the difficulty was to execute and achieve an effective zonal isolation with conventional cementing considering the narrow pressure window available. The objective of using MPC was to improve the zonal isolation process; the wells have been cemented without inducing losses or having formation influxes. Several wells have been successfully and safely drilled and cemented using MPD and MPC techniques. As a result, the drilling operation is not only optimized but the gap in the well construction process is minimized by improving the zonal isolation and eliminating remedial cementing jobs afterwards. Cement bond logs have also confirmed the success of MPC.

Planning, engineering, and communications are key elements of a successful implementation of MPD and MPC operations, improving and facilitating the optimization of the overall process, beginning with drilling and ending with the zonal isolation phase.