Underbalanced Drilling and Managed Pressure Drilling – Two Methods for Optimising Drilling

a report by
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Introduction

The difficulties experienced when using conventional overbalanced drilling (OBD) methods have encouraged operators to seek other techniques. Two such techniques are underbalanced drilling (UBD) and managed pressure drilling (MPD), since both have shown success in optimising the drilling process. These two methods, if applied properly and in the appropriate circumstances, also benefit the reservoir when compared with conventional overbalanced techniques.

Background

UBD was initially adopted to resolve drilling problems, but it soon became evident that this technique could also minimise reservoir damage. As originally conceived, UBD included techniques that were fully underbalanced with influx to the surface, as well as methods called 'low-head' and 'at-balance' drilling in which the bottomhole pressure was kept marginally above or approximately equal to the reservoir pressure. These techniques later became designated by the term MPD. This terminology was eventually adopted by the International Association of Drilling Contractors (IADC) and MPD became a separate designation from UBD.

In spite of its many benefits, UBD has not been embraced by the industry as widely or as readily as might have been expected. This reluctance has been due in part to additional equipment rental costs compared with conventional drilling, and in some cases regulations limit flaring or production while drilling. Moreover, there can be resistance to new technologies as they require additional effort to learn and implement, and there is a perceived risk of failure when implementing new technologies compared with using more familiar methods.

Definitions

In 1994, the Alberta Energy Utilities Board Interim Directive defined UBD operations as follows: "When the hydrostatic head of a drilling fluid is intentionally designed to be lower than the pressure in the formations being drilled, the operation is considered under-balanced drilling."[1]

More recently, the IADC has defined MPD as "an adaptive drilling process used to precisely control the annular profile throughout the wellbore. The objectives are to ascertain the downhole pressure-environment limits and to manage the annular-pressure profile accordingly."[2]

Some debate still remains in the industry as to what constitutes UBD and MPD and whether one is a subset of the other. Many would agree that all drilling – from conventional overbalanced to foam or air – can be considered a form of 'managed pressure' drilling, as the pressure must be controlled or 'managed' for safe drilling. Therefore, MPD may be too vague a term to describe exactly where it is applied in practice, and the expression can cause confusion among those new to the industry.

If one accepts UBD and MPD as separate entities, a pragmatic approach may be to define where each is primarily used and for what purpose. Exceptions will always exist; however, this article proposes that the differentiation between UBD and MPD be made based on whether the target bottomhole circulating pressure is intentionally maintained below the pore pressure throughout the openhole section (UBD), or equal to or marginally above pore pressure for all or most of the openhole section (MPD). An added proviso is that the objective of MPD is to preclude influx from the formation during the drilling operation, while the opposite occurs with UBD.

Each technique has its place, and the best applicable solution will depend on the problems anticipated. MPD cannot match UBD in terms of minimising formation damage, allowing characterisation of the reservoir or identifying productive zones that were not evident when using OBD; however, when the objective is to mitigate drilling problems, MPD can often be as effective as UBD, with the added advantage of being more economically viable. MPD is also preferable where wellbore instability is a concern, where there are safety concerns due to high H_2S release rates or where there are regulations prohibiting flaring or production while drilling. Both techniques have been applied in many types of formations containing different types of reservoir fluids and wells and in different hole sizes. However, these criteria are not inherent limitations; rather, it is the formation pressures, stability, production potential and other factors, when evaluated from a technical and economic standpoint, that determine whether a candidate is a good prospect.

Comparison

MPD is used primarily to resolve drilling-related problems, although some reservoir benefits also may be achieved. This is not surprising, as any effort to decrease the degree of overbalance, and thus reduce the impact of drilling fluid on virgin formations, will usually

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result in some positive reservoir benefits. UBD, on the other hand, has long been employed to provide solutions to both drilling- and reservoir-related problems.

MPD is often seen as easier to apply compared with full UBD operations. In non-reservoir sections, MPD design requirements often determine that a simpler equipment package will satisfy safety considerations for the well. The day rate would therefore be reduced compared with using full underbalance.

Equipment requirements for both operations vary depending on the design parameters of the project. In many instances, the same equipment set-up will be necessary for both UBD and MPD methods. The distinguishing difference is that for an MPD set-up, fluid influx is not typically expected during drilling; instead, it is used as a contingency measure or when a higher pressure zone exists that will produce to the remainder of the openhole section while the system is overbalanced.

When the margins between pore and fracture pressure are very narrow, some level of automation has been sought in MPD to help to provide quick response to changes in downhole conditions. While the vast majority of MPD operations – where the drilling margin is wide – will not require such 'fine' control, in some sectors where the pressure margin is narrow this degree of control will be beneficial when it is implemented with sufficient redundancy, safety and system controls in place. Eventually, as the MPD system proves reliable, it could also be utilised to enhance control of the target bottomhole pressure during UBD operations.

Addressing non-productive time (NPT) is a major focus for both MPD and UBD. NPT associated with kicks, wellbore breathing and lost circulation will have an immediate impact on rig time and its associated cost, and can also lead to additional costs associated with lost mud, lost circulation materials, additional casing string(s), stuck pipes and unplanned sidetracks. Any of these can directly affect a project's financial viability.

An added benefit of MPD and UBD has been an improvement in safety due to the more detailed planning and procedures required for their implementation. These systems allow for readily identifiable influxes in a controlled environment compared with conventional operations, which is of particular benefit for MPD in high-pressure, high-temperature (HPHT) wells.

Some UBD projects have not realised the reservoir production gains that were expected and this has often resulted in a reduced interest in using UBD. However, when reviewing the data from many wells, it becomes evident that one of the reasons that improvement did not meet expectations is that, although many wells have been classified as UBD, in reality underbalanced conditions were not maintained – some portion of the drilling was underbalanced, but overbalanced conditions often occurred or were intentionally used for tripping and/or completing the well. This reduces or even eliminates any productivity gains from UBD, so in many instances appears that UBD has had little or no impact on reduction of formation damage and improved productivity. A key to productivity improvement is the mitigation of formation damage throughout the drilling and completion phases.

An additional reservoir-related benefit of UBD that should not be overlooked when compared it with MPD and OBD is the opportunity it provides for reservoir appraisal. It is possible to conduct comprehensive reservoir evaluation (well testing) during drilling via a properly executed UBD job that has been designed for reservoir fluid inflow throughout, along with proper equipment, metering and data acquisition. The acquired data are integrated and used in reservoir simulators designed for the UBD process to estimate permeability, reservoir extent (if there is sufficient time to see this response), reservoir pressure, point of information (PI) or fracture properties of the zone(s) drilled.[3]

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Conclusion

Technical specialists gauge a well's success in different ways. Drilling specialists view a well as successful if it reaches target at or below the dry-hole Authorization for Expenditure (AFE). Geology and reservoir specialists classify a well as a success if valuable information about the drilled formations is obtained and these formations are productive. The asset team/manager wants the well to provide the information required, be highly productive and be drilled under budget. When properly implemented, UBD and MPD have proved that they can satisfy all these drivers. Both can address drilling problems and reduce the NPT typically associated with conventional drilling and, where the primary drivers are reservoir related, UBD is the best option. However, one should not choose one method over the other solely based on subjective considerations; the technical and economic comparison of all solutions should be performed, and a decision to 'do what's best for the well' should be taken depending on the merits of each technique. ■

1. Alberta Energy Utilities Board Interim Directive 94-03, "Underbalanced Drilling", July 1994.
2. Schmeigel K, "UBD Techniques Optimize Performance", *Hart's E&P*, October 2005.
3. Ansah J, Shayegi S, Ibrahim E, "Maximizing Reservoir Potential using Enhanced Analytical Techniques with Underbalanced Drilling", paper SPE 90196 presented at the 2004 Society of Petroleum Engineers (SPE) Annual Technical Conference and Exhibition, Houston, TX, 26–29 September.