MPD techniques address problems in drilling Southeast Asia's fractured carbonate structures

By Ken Muir, Weatherford

DRILLING CARBONATE STRUCTURES in Southeast Asia is often problematic due to the incidence of severe and total losses commonly encountered in highly fractured, cavernous limestone formations. Many wells have been abandoned or taken much longer than the budgeted timetable, resulting in significant cost overruns. Cement and various formulations of LCM (loss of circulation material) are typically used to cure the losses, but usually with short-term effect, resulting in more cement being required and further delays. Examples where cement was pumped in excess of 30 times on a single well, often resulting in a significant reduction in ultimate well productivity, are common.

To address the problems inherent in drilling these fractured carbonate formations, managed pressure drilling (MPD) is rapidly becoming the technique of choice. The areas most affected include Indonesia and East Malaysia, where pressurised mudcap drilling (PMCD) is the main technique used, but a simpler form of returns flow control is also employed successfully in Vietnam to divert gas while drilling, without the need to close-in the well.

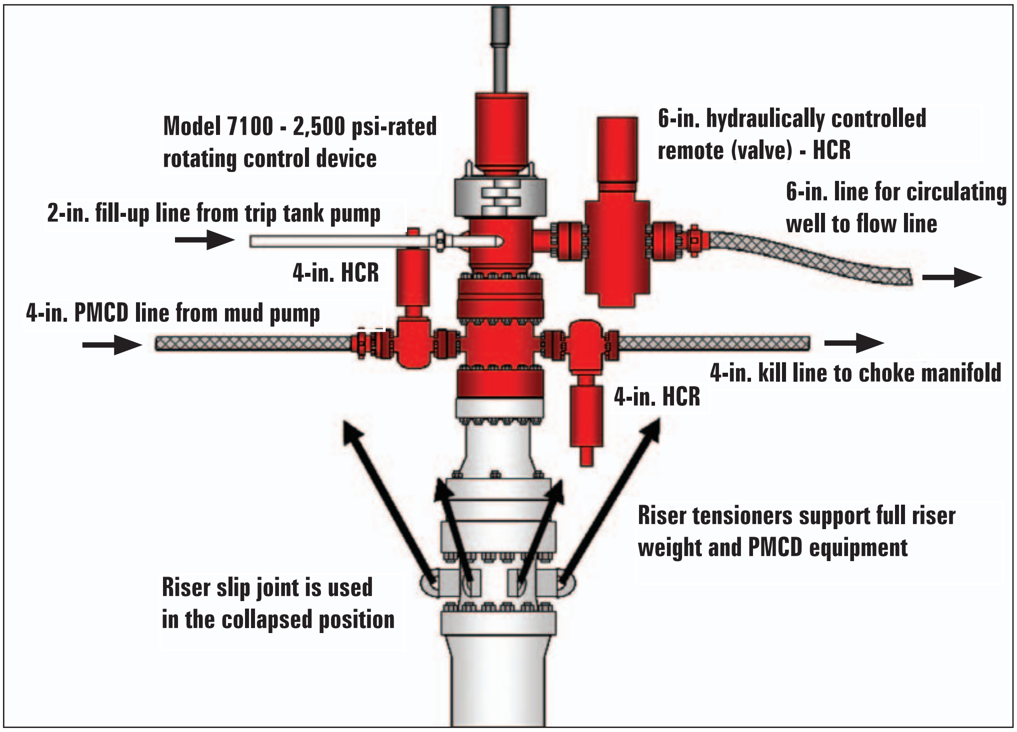
MPD TECHNIQUES

MPD comprises a range of techniques, including simple flow control of returns while drilling, through PMCD to constant bottomhole pressure (CBHP). The techniques differ with respect to flow control philosophy but have 2 key features in common in that they all use a rotating control device (RCD) to seal the top of the annulus and they all maintain the well in a balanced or overbalanced condition. With MPD, there is no intention to drill underbalanced. The reservoir pressure may be balanced by a combination of hydrostatic pressure, friction pressure (ECD) and backpressure (choke), but MPD is not an underbalanced technique intended to deliver production enhancement. MPD is primarily a technique for eliminating nonproductive time during drilling operations, and it regularly delivers significant cost savings, especially in the high-cost offshore market.

In Southeast Asia, the technique used is predominantly PMCD, where a viscous, weighted or unweighted fluid is used in the annulus with the intention of delivering a hydrostatic column in the range of 100-200 psi below the reservoir pore pressure. The net result is a closed-in pressure on surface reflecting the 100-200 psi differential. This modest surface pressure represents the "P" in the PMCD technique. Fluctuations in the surface pressure are used to monitor 3 factors:

- Gas migration in the annulus – in which case fluid is injected into the annulus at a pre-calculated rate and volume to re-inject the gas back into formation.

- Pore pressure increase as drilling proceeds into the reservoir – the annulus fluid weight can be progressively increased to keep the surface pressure within the acceptable range for the RCD or surface equipment.



Above: This schematic illustrates the pressurised mudcap drilling (PMCD) rig-up on a floating rig. The technique is being used in Southeast Asia's fractured carbonate structures.

- Fracture plugging – If the formation heals or partly heals itself due to the cuttings packing-off in the fractures, then PMCD may no longer be possible and operations revert back to conventional drilling.

OFFSHORE MPD

Offshore MPD operations commenced 3 years ago and have now been performed by 12 different operators in Indonesia, Malaysia and Vietnam. Upwards of 30 separate operations, including multi-well development campaigns and short single-well exploration projects have been performed. MPD has also been performed across the full range of offshore rigs, including jackups, semi-tender rigs, semisubmersibles and a multi-well campaign using a drillship, with another drillship in the planning stage. Normally PMCD is used to control losses in the reservoir of gas wells; however, troublesome limestone sections in the upper wellbore can also be drilled efficiently using this technique.

The simplest operations can be performed from jackups or tender rigs with a surface BOP, where the RCD is installed directly on top of the annular preventer. The difficulty with PMCD on floating rigs is how to apply a closed, pressurised system to a floating drilling system with marine riser and telescopic joint designed for very low-pressure containment. In fact, the earliest MPD operations in Southeast Asia were from a semisubmersible rig, and one of the longest running PMCD operations has been performed on the SEDCO 601 semisubmersible, which has actively employed the PMCD technique since 2004.

On floating rigs, the riser slip-joint is used in the collapsed and locked position with an adapter from the slip joint top connection to a mud flow cross, surmounted by the RCD. The slip joint is not actually required to accommodate rig heave because the RCD handles all rig movement while drilling, yet the slip joint remains in use because the riser attachment points and other utilities are normally on this joint. Because the slip joint remains in use, this becomes the weakest pressure rating point in the system, with a maximum rating of 500 psi. Both slip joint packers can be energized to provide redundancy, and there is a low risk of failure due to the lack of movement.

Another design factor to be considered is the loading on the slip joint inner – outer barrel locks, which also accept significant loading when the annulus is pressurized. In most floating rig applications to date, a safe working limit of 300 psi has been imposed on the annulus pressure, leaving a 200-psi safety margin. The mud logging service should be employed to monitor the annulus pressure in addition to their normal standpipe pressure monitoring function, so that alarms can be set and monitored continuously.

Different RCDs are employed in offshore PMCD operations, often depending on operator preference, but influenced by factors such as static and dynamic pressure rating, lower flange connection, and single or dual seal element capability. Nonfloating rig operations with the RCD immediately above the annular preventer have the greatest pressure capability and normally use a dual seal element RCD with 2,500 psi capability for rotating and stripping. The pressure rating for this unit doubles to 5,000 psi in the static mode, giving a large operational safety margin, but it should be clear that the RCD is not intended to replace the BOP as the primary well control device. In reality, most operations are performed towards the lower end of the pressure rating, although operations using very light annular fluid resulting in annulus pressures in excess of 1,400 psi have been performed without difficulty.

The rig-up employed for offshore PMCD operations is a development area with several techniques used as the technology matures. The initial method was to drill normally until unsustainable losses required the rig-up of PMCD equipment. This was the slowest method, often requiring 8-12 hours of rig time to convert to PMCD. An alternative method used was to rig-up the RCD and mud cross without the RCD bearing, but with a drilling nipple installed in the RCD clamp. The mud return flowline was attached to the drilling nipple for conventional drilling, but this again required several hours of rig time to rearrange for PMCD when serious mud losses occurred.

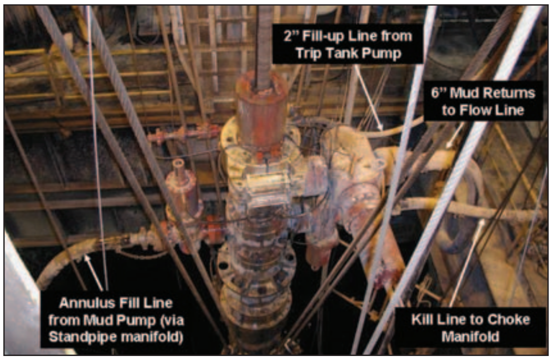
Ultimately the best solution is to fully rig-up the system at the start of the section requiring PMCD, including installation of the bearing assembly. During conventional drilling, returns are taken through a 6-in. hose from the RCD side outlet back to the rig flowline. Once serious losses occur, the flowline is isolated using a hydraulically operated valve, and PMCD commences with annulus injection through a dedicated line. With a properly trained crew, this changeover takes only a few minutes. Other lines commonly connected to the PMCD system are a 2-in. line from the trip tank pump for hole fill during trips and a bleed-off line to the choke manifold to remove any gas that does reach the surface. It is often easier to bleed-off small amounts of gas at surface than to bullhead this gas all the way

A PMCD rig-up on semisubmersible. The earliest MPD operations in Southeast Asia were from a semisubmersible rig.

back down the well and into the formation.

MPD TRAINING

A vital component for all offshore MPD operations is training. Even the most experienced drilling personnel have very little knowledge of MPD operations; therefore training is required for everyone involved, including operator drilling supervisors and engineers, rig crews from supervisor level down to derrickman or mud system operators, and even service company personnel such as mud loggers and mud engineers. Training is often provided by the specialist MPD company and is normally performed both onshore for non-rotational personnel and offshore for rig crews. Training is augmented by a practice of holding regular short safety and instructional meetings during operations. Very few offshore rig personnel have any experience of using an RCD, so training in the operation and handling of this equipment is invariably required to minimize the time needed to safely replace the seal element while maintaining annulus pressure. MPD engineering and procedures are also normally provided as part of the specialist MPD company service, including well site supervision during MPD operations.



PMCD is seen in operation on a semisubmersible rig.

MPD ENGINEERING & PROCEDURES

Each project involving MPD requires drilling engineering based on the well profile and reservoir pore pressure. Factors to be considered include:

• PMCD surface equipment design: Systems should be designed to permit conventional drilling until losses are experienced (losses may not occur). The system should allow a quick and simple change to PMCD and back to conventional drilling, as required.

• Annulus fluid design: Calculate the weight of the annular fluid (typically 0.2 ppg less than formation pressure) to comply with the pressure capability of the surface pressure control equipment. Check mix fluid availability. Calculate anticipated surface pressure.

• Required pump rates: Use the annular velocity required to stop gas migration and to force gas back into formation. Calculate fluid volume required.

• Calculate an influx height and volume: Calculate the height of the influx for a given annular pressure increase and derive the volume to pump per 100 psi increase in annulus pressure.

A key decision point is when to change from conventional drilling to PMCD. Clearly PMCD can only be performed when the formation will accept all the cuttings and fluid pumped into the well. This decision point is controlled by a decision chart that normally provides 3 clear alternatives:

• Losses are below the drilling pump rate – continue to drill.

• Losses are approximately the drilling rate – perform an injectivity test.

• Total losses – make an immediate change to PMCD.

PROBLEMS

Operations have generally been successful during offshore MPD, except where the reservoir pore pressure during exploration activity is lower than anticipated and too low to support the annulus fluid column. In this situation, the fluid level drops, and the operation, if sustainable, becomes a floating mudcap operation. This requires a lot more fluid and eliminates the ability to monitor downhole conditions via fluctuations in the surface pressure. Alternatives such as aerated fluid and environmentally friendly salt water foam are about to be tested to solve this particular problem.

Other problems encountered relate to rigging-up of unfamiliar equipment on the rig, although this has now been resolved by performing a detailed rig survey a full 3 months prior to the start of operations. This survey confirms the lifting gear specification, connection types and sizes; length of hose runs required and related considerations, to eliminate any surprises that may delay operations.

While PMCD allows a well to reach TD relatively easily, the problem of how to pull out of a well remains. It can still require considerable time to kill prior to pulling safely out of the hole. To address this problem, operators are increasing their use of full bore casing valves like the downhole deployment valve (DDV). The DDV isolates the lower wellbore and allows the drillstring to be recovered, logging to be performed and completions run, without having to kill the well. The combination of these 2 technologies (PMCD and DDV) promises a step change in fractured carbonate reservoir drilling efficiency.

Another offshore PMCD constraint relates to the availability of suitable RCDs with dual seals, high pressure rating and the ability to accept up to 6 5/8-in. drillpipe. Previously the maximum drillpipe capability in this specification was 5 in., which imposed limitations on high-volume gas well design. The latest Model 7800 RCD satisfies all of these requirements and permits larger bore gas wells to be delivered.

CONCLUSION

Offshore MPD is rapidly increasing in popularity because it regularly eliminates drilling nonproductive time and thereby reduces costs in the increasingly expensive offshore market. MPD activity levels in Asia Pacific are increasing every month as successes are discussed within the operator community. Operators seek fractures to deliver productive gas wells, therefore the best wells are often the hardest to drill, but equally deliver the greatest advantage from MPD. Equipment has frequently been rigged-up but not used if fractures are not encountered, however the time saving available from one well normally covers the cost of the MPD service over a multiwell program. At least one drilling manager can be quoted as saying, "I will never drill a carbonate structure again without some form of MPD."

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