Introduction to Offshore; Managed Pressure Drilling

Peter Aird, C.Eng.

Session 2.1: MPD Feasibility & Candidate Selection for Offshore well’s.

www.kingdomdrilling.co.uk

Digitally signed by Peter Aird
DN: cn=Peter Aird,
o=Drilling,
ou=Deepwater,
email=kingdom_drilling@msn.com,c=GB
Date: 2016.01.22 14:11:17 Z
Section outline

- Planning & feasibility methodology and well candidate selection for adaptive MPD via;
  - Alternative adaptive methods
  - Offshore MPD well’s candidate selection process
    - IADC selection toolkit
      - MPD Adaptive technology variations
    - Case study example(s) of candidate selection.
      - West Africa, North Sea, Greenland.

*Note: To designate preferred methods for any project’s well’s section(s) to be drilled, a ‘Candidate selection process’ should be used.*
MPD is increasing applied to wells that cannot be drilled conventionally without incurring significant loss/waste, key factors are;

- Deeper more challenging target depths
- Compartmentalised Reservoir pressures
- Narrow pore ($P_p$) and fracture ($P_f$) pressure window

To MPD or not to MPD?

Managed pressure drilling candidate identification model was part of a project conducted by TAMU that researched CSM model, flow diagrams, CSM thesis, well databases and CSM software.

George Medley, Signa Engineering. In “MPD Candidate Identification: To MPD or Not to MPD,” presented at the 2010 SPE/IADC Managed Pressure Drilling & Underbalanced Operations Conference, Mr Medley detailed a model developed as part of a research project at Texas A&M University (TAMU). One of his co-authors is TAMU’s Dr Jerome Schubert.

The candidate selection model seeks to identify critical steps in the process and provides the theory on MPD.

Further, Mr Medley said, it provides guided options and helps determine candidacy using hydraulic analysis. MPD, Mr Medley said, is a virtual godsend to the industry, when properly applied.
“It’s filled a real gap in the technology that has allowed us to drill wells that were undrilled and to improve performance on wells that were drillable,” he remarked.

To begin the process, Mr Medley recommended **defining objectives** and **collecting a variety of data** – on wells, geology, equipment and design.

He urged that **drilling problems be understood relative to the objectives**.

Finally, learn the variations on the theme of MPD because there are several different types.

The candidate selection software draws from several databases of MPD wells drilled.

- The first, developed by Signa, breaks the MPD well data down by MPD variation, i.e., constant bottomhole pressure, dual gradient, pressure mud cap control drilling and so on.
- **At Balance with Smith** developed a second database that details wells by rig type.
- Finally, the database from **Secure Drilling** (now part of **Weatherford International**) also analyzes rig type, as well as project type (development, exploratory, HP, HPHT, etc).
Not all projects need MPD

- Some projects simply require;
  - Changes, improvement in casing design
  - Revisiting pressure and wellbore stability problems, recognition, analysis and solutions
  - Change of mud system and rheology used
  - Better selected managed and operated equipment
  - Training and development of people involved

- The challenge is what, when, how, why and where to draw the line in regards to **Convention or not?**
When Pore / Fracture pressures Converge?

- Adaptive MPD solutions could simply be;
  1. Use a drilling fluid with lowest APL
e.g. Optimal rheology for desired well operations
  2. Change Azimuth of a directional well to
     optimise wellbore stresses
  3. Change the drillstring/wellbore geometry
  4. Change drilling parameter to increase or
decrease annular pressure effects.
  5. Control surface choke pressure on the well’s
     system.
  6. Put a ‘bloke on a choke’.
Statoil’s HPHT Offshore development drilling conclusions

1. Continuous circulation
2. Wellbore strengthening

3. Managed pressure drilling

Other methods?
1. Casing while drilling
By maintaining a continuous circulation flow, the circulating pressure and balance, ECD, can be set at the optimum to control the well and maximise bit RoP, the static mud density can be reduced as can the fluid loss into the producing formation. With steady state pressure, temperature and mud flow, throughout the drilling of the pay zone, the chances of exposing a cleaner, undamaged production formation are greatly enhanced. Generally, the higher production rate will be very worth while.
The CCS was first used commercially on the successful re-entry and deepening of the Port Fouad Marine Deep 1 (PDMD1) well in the Mediterranean, offshore Egypt. This exploration well, operated by Eni affiliate Petrobel, had been drilled and suspended above the objective after encountering hole problems related to narrow differences between pore pressure and fracture pressure gradients. Before installation on the Maersk Endurer jackup, the system was tested by Eni on the Pergemine 7 land rig drilling the Monte Enoc 10 well in Val d'Agri field in southern Italy. There, it performed satisfactorily.

PFMD1 was successfully re-entered, and 402m (1,319 ft) of 8½in. hole were drilled with uninterrupted circulation to 4,991m (16,375 ft), where a 7-n. liner was run. Rotating BOP equipment was installed, and 5 7/8-in. hole was drilled to TD at 5,244m (17,205 ft), continuously pumping mud to both the drill pipe and the annulus. MWD/LWD/PWD tools recorded formation data and real-time ECD measurements in both hole sections. Re-entering and deepening the PFMD1 well, using continuous circulation, was a great success. The system demonstrated remarkable reliability in its first commercial field application, making 522 connections while drilling and tripping with no interruptions to circulation nor additional rig time attributable to mechanical failure.
The CCS has proven to be a safe, reliable system that allows operators to successfully drill complex offshore wells and wells with narrow pore pressure/fracture pressure gradient windows that were previously difficult to drill, time-consuming and expensive. It can also be used with Closed Hole Circulation Drilling to drill reservoirs, where formation damage and impaired production can be reduced, maintaining continuous circulation and controlling the EMW overbalance. The system has proven to be safe and reliable to operate, and has successfully achieved its programmed drilling objectives.
1. Wellbore Stress Augmentation raises fracture initiation pressure.

2. Fracture Propagation Resistance fracture initiation pressure unchanged, but stable fracture propagation range is extended.

3. Combination of 1 & 2
Wellbore strengthening?

Acceptable WSM
Large, Tough and Granular

Proprietary Graphite Blend
Marble
Nutmegs

Unacceptable WSM

Product that work others that don’t!

https://www.slb.com/~media/Files/resources/oilfield_review/ors11/win11/03_stabilizing.pdf
Other Adaptive Methods?
'Casing While Drilling' technology, is related to drilling using ‘Casing’ instead of ‘Drill Pipe’. The casing transmits the required mechanical cutting forces and the hydraulic energy to the rock, while simultaneously casing the wellbore. The earliest know instance of casing drilling was in Russia in the 1930's.* According to Tesco Corp, over 1000 sections and 3 million feet have been drilled with casing by Dec 2008.** There are two techniques available in the drilling industry for casing while drilling.
One major problem with casing-while-drilling technology is that no open-hole logging can be performed. Once drilled the hole is cased and no open-hole sections remains. This can be disadvantageous when reservoir sections are to be drilled with casing. But the advantage of being able to case a section of unconsolidated reservoir outweighs the lack of open-hole logging. Most of the formation evaluation can also be performed through the casing.
Offshore ‘MODU’ CWD
CWD- Advantages

- Reduces a number of trips, and the associated drilling trouble time
- Gets casing to depth through problem zones formations.
- Reduces drilling problems associated with surge and swab, lost circulation, and differential sticking.
- It improves kick control and allows using higher density mud.

Deep Water Shallow Water Flow
- Washed out top hole Section
- Casing erosion

Solution: Run Liner While Drilling
- Hole protected
- Liner at desired position

Open Requirements: Immediate cementing Option (Cement through motor or new method to be designed)
- >= 20” DL tool sizes
- Liner hangers (current max.=16”)

Fractures with Highly Different Pore Pressure Causing
- Downhole blowouts
- Downhole kicks

Solution: Run Liner While Drilling
- Kick / loss control
- Hole protected
- Liner at desired position

Open Requirements:
- Immediate cementing option (Cement through motor or new method to be designed)
IADC MPD Selection Toolkit
The candidate selection software draws from several databases of MPD wells drilled. The first, developed by Signa, breaks the MPD well data down by MPD variation, i.e., constant bottom hole pressure, dual gradient, pressure mud cap control drilling and so on. 

At Balance with Smith developed a second database that details wells by rig type. 

Finally, the database from Secure Drilling (now part of Weatherford International) also analyses rig type, as well as project type (development, exploratory, HP, HPHT, etc).
IADC MPD candidate selection

1. **Work scope definition**, purpose, goals, objectives
2. **Recognise** offsets and gather all relevant data
   1. Well’s, geology, Equipment, and design.
3. **Analysis and Identify**
   1. **Why, when, how things failed, and what exactly went wrong**
4. **Determine and Evaluate** viability of each option
   1. QHSE, Loss Time, Cost, contingent options
   2. Process, systems, equipment, people to be used
   3. How to best prevent failure from resulting/recurring
5. **Hazop / Hazid** analysis, prioritization and risk association
6. **Approve method(s)** to use
7. **Drill section (s)** and manage ‘adaptive change’
8. **Commend and Correct** i.e. translate & sustain learning.
Candidate selection Outline (2)

1. Recognise, analyse and identify purpose.
2. Determine and evaluate data that exists.
3. Perform plan, design, engineering and operability analysis
4. Select the preferred method(s)
   Optional
   1. Assess and assure economic viability
   2. Tender, select and recommend equipment
   3. Perform Hazops, Hazids operability analysis
1. Work scope definition

- Discuss project importance of clear and aligned work scope definition
  - When this needs to be done
  - Why it is fundamentally important
  - Impact (Problems/risks presented) if not implemented efficiently and effectively
2. Recognition, information gathering

- Discuss current process of labelling drilling’s problems
  - Openly honestly truthfully?
- How to best learn from failure?

- Vs utilising a Manging Lost Time $MLT^{TM}$ approach
3. Analysis and Identification

• **Group Discussion**
  – How do we currently as an industry learn from wellbore drilling failures and things that then go wrong?
  – How can the management and control of safety and operational aspects be changed and improved?
4. Determine / Evaluate methods

- Present and discuss IADC MPD screening tool.
  - Excel sheet as provide by IADC
5. Hazop, Hazid, Risk management

• Present TRM Hazard/Risk management process,
  - i.e. A Simple 5 step risk management process that we evolved within Kerr McGee UK in 2007 when delivering ‘best in class’ wells repeatedly until company was sold.

• Discuss the benefits learned from this simplified approach vs software alternatives and other risk register processes that then ‘lie on a book shelf’.
The table illustrates a simplified guide for choosing MPD variations for given ‘pressure conditions’ and ‘equipment limits’.

It may be noted with caution that the table below broadly serves as a guide for selecting an MPD method or variation, under different observed conditions.

After choosing the MPD variation and method, performing a detailed candidate selection process is recommended. This helps in understanding the utility of MPD for a given project and assists the operator in making a better judgment.

<table>
<thead>
<tr>
<th>Observed conditions</th>
<th>Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow Pressure window – LP equipment at the surface CBHP CCS</td>
<td>CBHP, CCS</td>
</tr>
<tr>
<td>Narrow Pressure window – HP OK at surface ABP</td>
<td>ABP</td>
</tr>
<tr>
<td>Severe lost circulation zones. No possibility for CBHP</td>
<td>PMCD</td>
</tr>
<tr>
<td>LP &amp; HP zones. Zone not too deep for the subsea pump</td>
<td>DGD</td>
</tr>
<tr>
<td>LP &amp; HP zones. Enough rig space for 2 muds &amp; separation Mud Diution</td>
<td></td>
</tr>
<tr>
<td>LP Zones</td>
<td></td>
</tr>
<tr>
<td>Special needs requiring a closed system.</td>
<td></td>
</tr>
<tr>
<td>Threat to Health, Safety and Environment HSE</td>
<td></td>
</tr>
</tbody>
</table>

• Note:
  – Different geology, pressure regimes, rig space, equipment setup and availability, conditions and objectives of operation, and other considerations often demand a different variation or method from options shown.
MPD Adaptive technology variations

RCD Only

Conventional BOP Stack

Kick/Loss Detection

Conventional BOP Stack
MPD Adaptive technology variations

MPD Block Diagram
MPD Adaptive technology variations
MPD Adaptive technology variations

Conventional BOP Stack

Dual Gradient Seafloor Pump

Seawater or other fluid

RCD (optional)

SS BOP Stack
MPD Adaptive technology variations

- Controlled riser mud level
- SS BOP Stack

- Mud Line Pumping (riserless)
- System would incorporate a SS BOP if used below surface rag
- RCD
- With or Without RCD
MPD Adaptive technology variations

Dual Gradient / Mix Fluid w/Gas

Concentric Riser
Or Booster Line(s)

Dual Gradient / Mix Fluid w/Liquid/LGS

Concentric Riser
Or Booster Line(s)

LGS = Low Gravity Solids

SS BOP Stack

RCO
MPD Adaptive technology variations

Floating Mud Cap

Pressurized Mud Cap

BOP Stack RCD or Annular

Fluid Level
MPD Adaptive technology variations
Say “Yes to the dress”

**Rules of thumb** Candidate well -SIGNA 2006:

- MPD best deployed where Drilling problem(s) cannot be solved with conventional techniques that result in well’s impossible to drill:
  - Cyclic problems *e.g.* *kicks and losses*
  - surge and swab effects out with safe operating regimes
  - narrow pressure windows in complex geologies
  - High flat time or non-productive drilling time
  - When QHSE concerns exist
  - No viable casing size option approaching TD
MPD aims at staying between the Pp and Fp window similar to the conventional method of drilling. However, MPD uses an additional array of equipment that gives better control of the WBP and provides better information of downhole conditions.

This info and control of WBP, helps in making better decisions and in navigating through tougher pressure conditions. MPD is a better way using physics to meet the desired ends.

The UBD and MPD operations have a fundamental difference, the same difference that UBD and conventional operations have. The WBP is deliberately maintained less than the Pp at least at one point of the open wellbore for UBO, encouraging an ‘influx’ of fluids in to the wellbore. This controlled influx of underground fluids is not considered as a ‘kick’. The containment of these fluids is only at the surface in the form of flaring the gases and/or diverting the fluids into a pit.

For conventional and MPD operations, the objective is to stay above the Pp, at any point of the open wellbore, during the entire drilling operation. Any influx that occurs if the WBP drops below the Pp is termed as ‘kick’, even if it can be contained quickly and safely. Uncontainable influxes/kicks may result in dire consequences like blowouts.

With the additional array of equipment in MPD operations, it is easier and safer to perform a few drilling operations that cannot be performed with conventional drilling.
8 Commend, Correct & Learn

• In the context of MPD well candidate selection, further discuss
  – how organisational and individual learning currently is managed and controlled within drilling operations
  – How can learning be further improved, translated and sustained?
Case study – candidate selection

1. **Group exercise**
   - To be provided on day of course.
     - IADC MPD book Pages 275-282

2. **Candidate selection case study examples.**
   1. Offshore UK (*Extreme HPHT*)
   2. Offshore Greenland (*Deepwater Arctic*)
   3. Offshore Africa (*Carbonate drilling problems*)
Questions – Candidate selection

1) What steps are viewed necessary in a candidate selection process

2) What, Why is essential data required to be able to properly conduct a reasonable MPD candidate assessment

3) What are the essential equipment components for successful implementation for standard MPD

4) What optional equipment may be needed?

5) Define and describe how a MPD HAZID should be conducted.

6) Define and describe how MPD Hazop(s) and risk assessments are conducted.
Debrief, Questions

Session 2.1: MPD Candidate Selection for Offshore well’s.