UTILIZING MANAGED PRESSURE DRILLING (MPD) TECHNOLOGY TO MITIGATE DRILLING PROBLEMS IN HPHT EXPLORATION WELLS

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Special dedication to both of my parents, Md Khalid bin Hasim and Hayati binti Abdul Hamid. They are truly my pillars of strength, who always believe in what I do. I also dedicate this thesis to my brothers, Mohd Haziq, Mohd Zulhilmy and Mohd Hazwan for their continuous support and motivation.

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ABSTRACT

Managed Pressure Drilling (MPD) is a relatively new technology that has improved some old ideas of Underbalanced Drilling (UBD). The main aim of MPD discussed in this study is to avoid continuous influx of formation fluids to the surface by maintaining a state of effective overbalance. Nowadays, most of the remaining resources around the globe might only be located in harsh reservoir environment such as deepwater and high pressure high temperature (HPHT). This kind of situation also represents real threats to most drilling contractors, if conventional drilling methodology were applied. However, with MPD capability, it allows them to drill through the "un-drillable" formations, helps to reduce non-productive time (NPT) and overcome drilling problems such as narrow pressure window, kick-loss scenarios, low rate of penetration (ROP), loss of circulation, and failure to reach target depth (TD). These problems can be avoided if wellbore pressures are controlled, maintained and managed in more efficient way. However, in order to mitigate those challenges, implementing the right tools, techniques and necessary rig modification are crucial. In fact, during the MPD operation, controlling the wellbore breathing, and identifying the upper and lower limit of pore pressure were the main issues and concerned, which are also discussed. Lastly, conclusions are drawn and future recommendations are suggested in this study. In offshore Malaysia, MPD is proven to be a successful operation, while managed to drill through the HPHT condition, narrow pressure window, reach deeper target, control kick issues and minimize wellbore fatigue stress. Cross referencing with drilling contractors, and conducting verbal interview with drilling personnel are also recommended for furthering the study area.

ABSTRAK

Penggerudian tekanan terurus (MPD) adalah teknologi yang baru yang telah ditambahbaik daripada idea yang lama seperti penggerudian dibawah imbangan (UBD). Tujuan utama MPD yang dibincangkan di dalam kajian ini adalah untuk mengelakkan kemasukan cecair formasi yang berterusan ke dalam permukaan dengan mengekalkan keadaan imbangan yang berkesan. Pada masa kini, kebanyakan sumber yang tinggal di serata dunia hanya boleh dijumpai di dalam persekitaran takungan yang payah seperti laut dalam dan suhu tinggi tekanan tinggi (HPHT). Situasi ini juga memberi ancaman yang hebat kepada kebanyakan kontraktor penggerudian, jika kaedah penggerudian konvensional diguna pakai. Walau bagaimanapun, dengan kemampuan MPD, ia membolehkan mereka untuk menggerudi formasi "yang tidak tertembus", membantu mengurangkan masa tidak produktif (NPT), dan mengatasi beberapa masalah penggerudian, seperti tingkap tekanan yang sempit, senario tendangan-kehilangan, kadar penembusan yang rendah (ROP), kehilangan edaran, dan kegagalan untuk mencapai kedalaman sasaran (TD). Masalah-masalah ini boleh dielakkan jika tekanan lubang telaga dapat dikawal, disenggara dan diurus dengan cara yang lebih efisien. Akan tetapi, untuk mengatasi masalah-malasah tersebut, perlaksanaan alat-alat dan teknik yang betul, serta pengubahsuaian pelantar adalah perkara sangat penting dan perlu dititikberatkan. Malah, semasa operasi MPD dijalankan, pengawalan pernafasan telaga, dan mengenal pasti had atas dan bawah tekanan liang merupakan isu utama yang perlu dikhuatiri, dan juga telah dibincangkan. Akhir sekali, kesimpulan telah diputuskan dan cadangan untuk masa hadapan juga dikemukakan di dalam kajian ini. Di luar pesisir pantai Malaysia, operasi MPD telah terbukti berkesan, di mana telaga yang berjaya digerudi adalah berkeadaan HPHT, tingkap tekanan yang sempit, berjaya mencapai sasaran yang lebih dalam, mengawal isu tendangan dan mengurangkan tekanan keletihan telaga. Selain, rujukan secara menyeluruh, mengendalikan temubual bersama kontraktor dan kakitangan penggerudian juga dicadangkan untuk penambahbaikan kajian ini di masa hadapan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AD	-	Air Drilling
AFP	-	Annular Friction Pressure
API	-	American Petroleum Institute
APWD	-	Annulus Pressure While Drilling
ASM	-	Along String Measurements
ATR	-	Above Tension Ring
BP	-	Back Pressure
BHA	-	Bottomhole Assembly
BHP	-	Bottomhole Pressure
BOP	-	Blow Out Preventer
BSP	-	Back Surface Pressure
BTR	-	Below Tension Ring
CBHP	-	Constant Bottom Hole Pressure
CCS	-	Continuous Circulation System
CCV	-	Continuous Circulation Valve
CPD	-	Control Pressure Drilling
DAPC	-	Dynamic Annular Pressure Control
DFC	-	Dynamic Flow Check
DFIT	-	Dynamic Formation Integrity Test
DGD	-	Dual Gradient Drilling
DWOP	-	Drilling Well on Paper
E-CD	-	Eni Circulation Device
ECD	-	Equivalent Circulating Density
EKD	-	Early Kick Detection
ENBD	-	Eni Nearbalanced Drilling
ESD	-	Emergency Shutdown
FG	-	Fracture Gradient

FIT	-	Formation Integrity Test
FMCD	-	Floating Mud Cap Drilling
FP	-	Fracture Pressure
H_2S	-	Hydrogen Sulphide
HAZID	-	Hazard Identification Study
HAZOP	-	Hazard and Operability Study
HP	-	High Pressure
HT	-	High Temperature
HPHT	-	High Pressure High Temperature
HPHT-hc	-	High Pressure High Temperature *Hors Catégorie* (beyond classification)
HSE	-	Health, Safety and Environment
IADC	-	International Association of Drilling Contractors
ID	-	Internal Diameter
LCM	-	Lost Circulation Material
LMRP	-	Lower Marine Riser Package
LOT	-	Leak-off Test
LWD	-	Logging While Drilling
MD	-	Measured Depth
MFC	-	Microflux^{TM} Control
MGS	-	Mud Gas Separator
MODU	-	Mobile Offshore Drilling Unit
MPC	-	Managed Pressure Cementing
MPD	-	Managed Pressure Drilling
MWD	-	Measurement While Drilling
NCS	-	Norwegian Continental Shelf
NPT	-	Non-Productive Time
NRV	-	Non-Return Valve
OBD	-	Overbalanced Drilling
PCSB	-	PETRONAS Carigali Sdn. Bhd.
P&ID	-	Process & Instrumentation Diagram
PD	-	Power Drilling
PFD	-	Process Flow Diagram
PLC	-	Programmable Logic Controller

PMCD	-	Pressurized Mud Cap Drilling
PP	-	Pore Pressure
ppg	-	Pound per Gallon
PWD	-	Pressure While Drilling
RCD	-	Rotating Control Device
ROP	-	Rate of Penetration
RPCD	-	Riser Pressure Control Device
RPM	-	Rotation per Minute
RT	-	Reduction Tool
SPE	-	Society of Petroleum Engineers
TD	-	Target Depth
TVD	-	True Vertical Depth
UBD	-	Underbalanced Drilling
WDP	-	Wired Drill Pipe

CHAPTER 1

INTRODUCTION

1.1 Research Background

Although the term managed pressure drilling was not launched until 2003, the history of MPD and MPD equipment dates back to the 1930s when the first rotating heads where described in the catalogue of Shaffer Tool Company in 1937 (Hannegan, 2011). These rotating heads are quite similar and based on much of the same principle as the modern rotating control devices (RCD) in use today. In the beginning, RCD where used for air drilling and underbalanced operations, but over time the industry understood how they could use this equipment to control and manipulate equivalent circulating density (ECD) and from the 1970s RCD equipment was used to control ECD and more effectively control the pressure in the well (Nas, 2010). The technology used today combines new technology with older principles and techniques to manage common drilling problems.

The first example of offshore managed pressure drilling was seen in the 1970s in Gulf of Mexico. MPD in the form of mud cap drilling and pressurized mud cap drilling were developed throughout the 1980s and 1990s. Rehm et. al. (2008) described that development over the last decades have been within the use of precise control of surface backpressure to compensate for ECD, application of constant bottomhole pressure, continuous circulation systems, various dual-gradient systems applicable for deepwater and ultra-deepwater, and various types of down-hole valves.

MPD operations have been conducted offshore from both fixed installations such as jack-up rigs and production platforms with surface Blow Out Preventer (BOP), and floating installations such as, semi-submersibles and drill ships with both surface and subsea BOP (Hannegan, 2011). Bjørkevoll et. al. (2010) has mentioned, on the Norwegian side of the North Sea, managed pressure drilling has been used successfully both for production drilling in depleted reservoirs and for exploration wells from jack-up rigs. In areas where the weather conditions are quite calm, such as in the Mediterranean Sea, South East Asia and in deepwater fields outside the west coast of Africa, MPD operations has been performed successfully for several years (Nas, 2010). This development seems to continue, bringing MPD technology into new areas and integrating it more and more in the operations. Even though there are challenges associated with MPD, the drilling contractor and big players in the industry seem to be determined to solve the challenges and take the technology into the future by utilizing MPD to mitigate problems and hazards through implementing the right tools, techniques and necessary rig modifications to the next level.

1.2 Problem Statement

As a result of many of the easy prospects offshore has already been drilled, nowadays operators and drilling contractors are focusing on the more challenging environments such as extreme water depths, thorough depleted formations and high pressure high temperature (HPHT) wells. As mentioned earlier, much of the remaining resources around the globe might be located in HPHT environments, while that kind of situation represents real challenges to most drilling contractor, if conventional drilling methodology were applied. Thus, to be able to increase the recovery in older fields, new wells needs to be drilled, but the problem in older field which have been producing for several years is that the formation pressures decreases. Both pore and fracture pressure decreases as the reservoir is being drained, making the operational window for drilling narrower and harder or near impossible to drill. Furthermore, drilling in challenging environments with different drilling hazards causes a lot of non-productive time (NPT), i.e. time where the rig is not drilling. The result of NPT and high rig costs is a lot of money spent on nothing productive.

Evidently, most (if not all) of HPHT drilling prospects are not economically viable using conventional drilling methods with conventional drilling equipment. The main reason for that are excessive costs caused by narrow pressure window, riser gas problem, early kick and formation influx, lost circulation, wellbore instability and stuck pipe, in which most of them may cause high amount of NPT and a lot of well control issues. All of drilling-related issues mentioned above have one thing in common – they can be avoided if wellbore pressures are controlled, maintained and managed in more precise way. Thus, in order to solve the challenges associated with challenging environments and narrow pressure window and high percentage of non-productive time, there is in particular one drilling method many operators have been looking towards for the last decade, and that is MPD with its variations.

1.3 Research Objectives

The main objectives of this research are:

i. To discuss the potential of MPD in mitigating drilling hazards and problems in HPHT exploration wells through MPD tools, techniques and technology, in comparison with conventional drilling method.

ii. To discuss the current MPD technology, planning, approach and operation pioneered by drilling contractors throughout the operation based on recent successful experiences of MPD.

1.4 Scopes of Study

This study covered the following aspects:

i. HPHT well issue associated with narrow pressure window and drilling problems which makes the conventional drilling is relatively undoable.

ii. The focus is solely on technical aspects when discussing MPD technology in mitigating drilling problems, rather than commercial aspects.

iii. Benefits and implication of MPD in HPHT wells which based on proven case study.

iv. Reliability of technology existing today and the experiences gained up to date with MPD implementation in HPHT wells.

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