PROCEEDINGS
JOINT CONVENTION BANDUNG (JCB) 2021
November 23rd – 25th 2021

Application of Managed Pressure Drilling Successfully Navigating Narrow Drilling Window Enabling Opportunity for Offshore Depleted Reservoir

Insan Faza[1], Ali[1], Fikri Irawan[1], Andry Prasthio[1]
[1]Weatherford

ABSTRACT

Extending field productivity within the reservoir which is currently facing natural decrease from virgin pressure is common challenge in mature field development. The depleted reservoir changes formation properties such as pore pressure and fracture pressure when the drilling window becomes narrower promotes further challenges.

As the reservoir pressure window becomes narrow, implementation of conventional drilling technique may induce common drilling problems, such as loss circulation, kick, differential sticking and so on. An alternative method known as Managed Pressure Drilling (MPD) which actively controls the annular hydraulic pressure while drilling, making connections, and tripping operation was implemented in this operation.

At the beginning of the 8.5in. section, extensive drilling window of 6.33ppg observed based on the subsurface information and preliminary study. The challenges appear when the well had just been drilled in less than for 2,300ft where the drilling window significantly reduced to 0.93ppg as a result of pore pressure ramp up. Meanwhile, fracture pressure point decreases at the same section which result in narrow drilling window of the 8.5in hole. At this condition, the utilization of conventional drilling methods promotes high risk of inviting undesirable conditions such as loss and kick. Without MPD implementation, it is considered impossible to reach target depth successfully.

Weatherford MPD system computes precise ECD model based on real-time drilling parameters and downhole condition. Surface Back Pressure is exerted during pipe connection to keep the well overbalance until target depth achieved.

This paper describes MPD utilization as unconventional method to overcome drilling hazard related to pressure depletion and extend technical limits for prolonged and developed field. The publication is expected to unlock further advancement in Indonesia developed field with similar approach by other operators.

Keywords: Narrow pressure window, managed pressure drilling, equivalent circulating density.

INTRODUCTION

Drilling a new well is a crucial step toward boosting oil and gas recovery. However, for some depleted fields, drilling of new wells is difficult due to constrained operational drilling window. This is due to the field's production history and is especially linked to formation pressure depletion.

The difference between the highest pore pressure gradient and the lowest fracture gradient determines the operational drilling window of each section. The operational drilling window has a different value at each depth of the wellbore.

All producing oil and gas fields will experience pressure depletion issues. This factor will determine the economic conclusion of that area. The use of conventional drilling techniques in places where these difficulties exist promotes higher risk of causing kicks and losses. It is necessary to drill a well by maintaining the bottom pressure within the pressure drilling window. Managed Pressure Drilling (MPD) is the fit-to-purpose drilling method to complete this objective. By utilizing MPD technique, the bottom hole pressure is consistently and accurately adjusted to remain above the pore pressure and below the fracture pressure during drilling and connection.

MANAGED PRESSURE DRILLING

MPD is a drilling method used to accurately regulate annular pressure in order to prevent influx entering the wellbore. MPD equipment develop a closed-loop drilling system to manage the annular pressure profile by exerting Surface Back Pressure (SBP) to easily manage the bottom hole pressure while drilling, pipe connection, or even running completion string *(Agustinus, 2016).*

Distinctive to conventional drilling, the determination of bottom hole pressure using MPD includes one additional factor as explained in the equations below.

$$BHP_{static} = HP + SBP$$

$$BHP_{dynamic} = HP + AFP + SBP$$

BHP_{static} = Bottom Hole Pressure while no circulation

$BHP_{dynamic}$ = Bottom Hole Pressure while circulation

HP = Hydrostatic Pressure Mud

AFP = Annular Friction Pressure

SBP = Surface Back Pressure

MPD EQUIPMENT

Rotating Control Device

Rotating Control Device (RCD) is an equipment which is installed above the annular BOP or riser, depending on the type of BOP set on the well. While drilling, RCD will seal the annulus surrounding the drill pipe to produce a closed and pressured annulus system. The primary function of the RCD is to enable closed-loop system through a dual sealing element installed inside the RCD Bearing. RCD installed in this project is RCD Marine Series to align with its offshore shallow water operation. The RCD Bearing can be installed directly into RCD housing without any man riding operation on the BOP area. The RCD is completed with three primary outlet with two side outlet sized 7-1/16in. for return line and emergency fill up line as well as one outlet sized 2-1/16in. for injection, trip tank line and bleed off line.

MPD Automatic Choke Manifold

MPD manipulates the bottom hole pressure by applying additional pressure at the surface, which is referred as SBP. The SBP is generated when the flow through the MPD manifold is restricted by a surface choke. The MPD Automatic Choke manifold system is capable to change the proportion of choke opening based on the desired SBP set point. When the requisite SBP is higher, the choke will be closed until the required SBP is reached. When the requisite SBP is lower, choke system will perform the opposite action. The MPD Manifold is completed with two chokes sized 3in. that can be utilized separately or simultaneously depending on the operation necessities.

MPD Automatic Choke Manifold enables to detect loss and kick within seconds, making it a reliable tool to mitigate loss and kick to be handled promptly and minimize catastrophic well control related issue. MPD Automatic Choke manifold system is completed with Coriolis Flow Meter for flow detection capability. It can measure accurate flow out rate, mud density and returned temperature. All of these data then combined with drilling parameters from WITS and installed surface sensors to be analyzed by the MPD control system in real time to deliver annulus pressure management during drilling operation.

MPD OPERATION

Preliminary MPD simulation was completed in advance prior to drilling commencement. This study was used to simulate actual MPD condition in order to obtain the optimum mud weight design and SBP range. Drilling parameters such as RPM, WOB, ROP, mud rheology and well trajectory were simulated in order to acquire the optimized ECD. According to the MPD simulation, 13.66ppg mud and 150 psi SBP would be applied at a depth in 8.5in. section where the estimated depleted pressure regime.

According to the geological data modeling, extensive drilling window of 6.33ppg was expected at the beginning of the 8.5in. section. The difficulty arises when the drilling operation reached 2,300ft below the last casing shoe where the drilling window drastically reduced into 0.93ppg due to the pore pressure ramp up and decrease of fracture pressure gradient in the same hole section as illustrate in Figure 5. Depleted formation occurs in the same section because production operations have proceeded in that location for many years, resulting in pore pressure and fracture pressure drop at certain layer. The combination of these two factors results in an extremely narrow pressure window. To successfully drill this well, ECD needs to be controlled precisely within the drilling window by utilizing MPD technique.

MPD equipment such as RCD, MPD Automatic Choke manifold system, and accessories were pre-installed before the 8.5in. section. Then fingerprinting and familiarization were performed to personnel involved, such as essential rig contractor team, mud engineer, wireline crew, and drilling supervisors, on how MPD works were performed. The system SBP resulted by flowing at drilling rate to MPD Automatic Choke manifold system with choke at fully open was measured to be 33psi.

Existing mud weight set in the wellbore at 10.83ppg. At the beginning of 8.5in. section, drilling commenced conventionally without exerting SBP while circulation or pipe connection because of extensive drilling window. MPD system were activated in EKD mode to detect unwanted kick or loss to minimize aftermath impact.

The mud weight was then increased periodically prior to the estimated depth of depleted zone. At this depth the mud weight used was 13.66ppg. It was decided to proceed drilling the sequential depth without additional SBP while drilling as the ECD generated shall be overbalance and exceed the safety margin. However, during pipe connection, the MPD Automatic choke system applied 150 psi SBP in the annulus to maintain ESD above the pore pressure and allowing drilling to continue safely and effectively until the TD was reached.

The objective of the CBHP technique is to prevent and control hydrocarbon migration to surface by using the mud density as near as possible to the pore pressure. In some cases, the mud density is designed in slightly underbalanced condition; in other cases, it is designed at balanced condition. The mud design will be adapted with the drilling window profile and will be limited by formation strength, fracture leak-off point, and equipment specification *(Dharma D.S., 2016).*

During drilling, the ECD was observed from MPD real-time bottom hole pressure model (generated by MPD software platform) in conjunction with the PWD sensor readings installed in the BHA. Both of these technology controlled independently. The ECD was monitored during dynamic and static condition i.e. pump off. During no circulation, the annulus friction pressure would disappear and MPD system anticipated this condition with the exertion of SBP.

The basic principle of having a back-pressure pump diverted across an MPD choke at surface is that the pressure loss created at the choke is directly transmitted to the annulus, since there is full column of fluid at all times. Hence even though the flow from the back-pressure pump does not pass downhole, but through the surface line on the rig, the pressure in the annulus is still able to be manipulated as required *(Zein, J., 2016)*. The MPD Automatic Choke system will adjust the choke opening to build pressure along the surface line, which will be delivered to the bottom hole pressure through the annulus.

MPD connection proceeds according to the illustration in Figure 3. The ECD value was maintained at 13.95ppg during static conditions. The flow from drill string gradually decreased at the same time the back-pressure pump is increased gradually to compensate friction pressure lost. Simultaneously, MPD Choke will adjust the choke opening until the required SBP is achieved according to the pressure schedule. When the mud pump is completely shut off and the desired SBP has been reached, the drill pipe connection can be initiated.

Reverse procedure is in place after the connection, prior to continue drilling. The flow from drill string will be gradually increased while the back-pressure pump rate decreases at the same time. Drilling to be resumed safely while the MPD system monitors the parameters until the target depth is achieved.

Conclusions

Hydrocarbon extraction from the reservoir that have been producing for years result in pore pressure depletion. In this particular field, the decline lead to reduction in pore pressure and fracture pressure of certain layer. While at the non-producing layer, both of these pressures remain constant. This event ultimately caused the narrow pressure window existence within one drilling section which will lead to kick and loss drilling hazard. The used of MPD technique allows drilling operation to overcome this challenges by maintaining bottom hole pressure within the pressure window. MPD is proven to be successful in drilling wells with narrow drilling window until the target depth is safely achieved.

Acknowledgements

The authors would like to express their appreciation to Weatherford management for their permission to publish these results and all valuable contributors of Indonesia MPD team.

References

Zein, J., Irawan, F., Hidayat A.M., et al. “Case Study-Constant Bottom Hole Pressure of Managed Pressure Drilling Utilization to Maintain Wellbore Instability in East Java Drilling Operation, Indonesia”, Presented in Asia Pacific Oil & Gas Conference and Exhibition (APOGCE) 2016 in Perth, Australia, 25-27 Oct 2016. SPE-182212-MS.

Agustinus, K., Zein, J., Irawan, F. et al. “Managed Pressure Drilling Application to Deploy Lower Completion Safely and Efficiently in Static-Underbalanced Well”, Presented at Offshore Technology Conference Asia held in Kuala Lumpur, Malaysia, 22–25 March 2016. OTC-26713-MS.

Dharma D.S., Hidayat. A.M., Irawan F., “Enhance ECD Management using Sub-Based Uninterrupted Circulating System Application”, Presented in Abu Dhabi International Petroleum Exhibition and Conference held in Abu Dhabi, UAE, 7–10 November 2016. SPE-183132-MS.

Figure 1: RCD Installed on BOP

Figure 2: MPD Automatic Choke Manifold

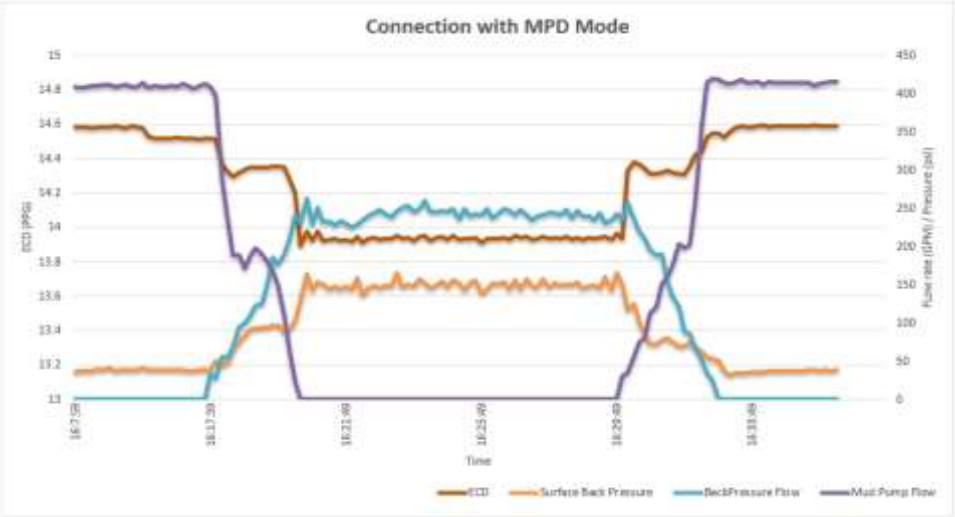

Figure 3: Ramp Pump Schedule during Connection with MPD Mode.

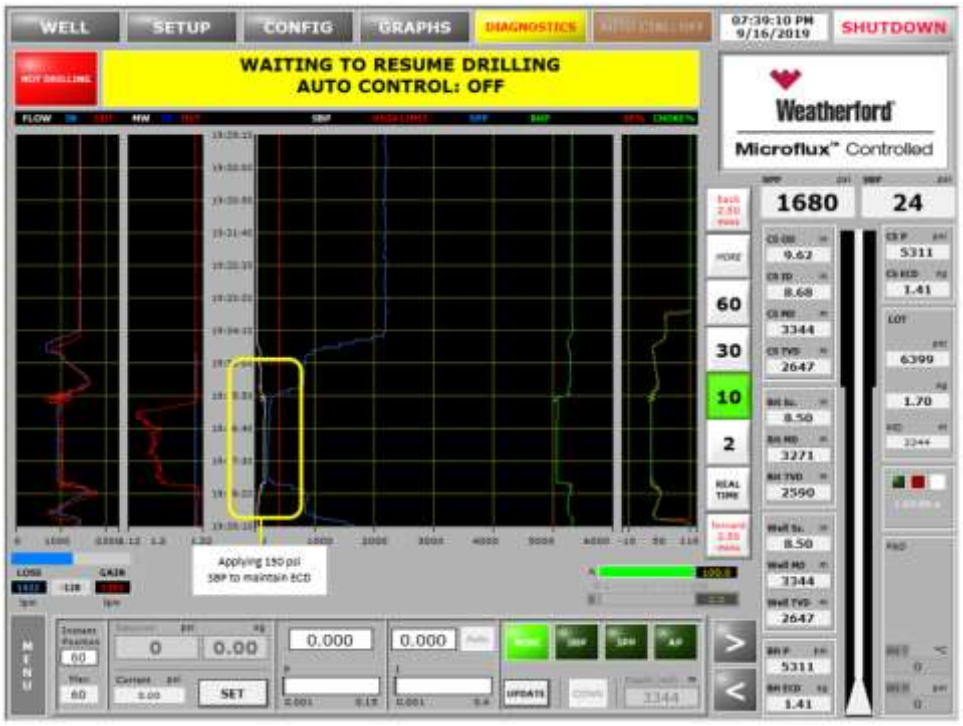

Figure 4: Applying SBP during Connection to maintain ECD.

Figure 5: Drilling window of 8.5in. hole section.

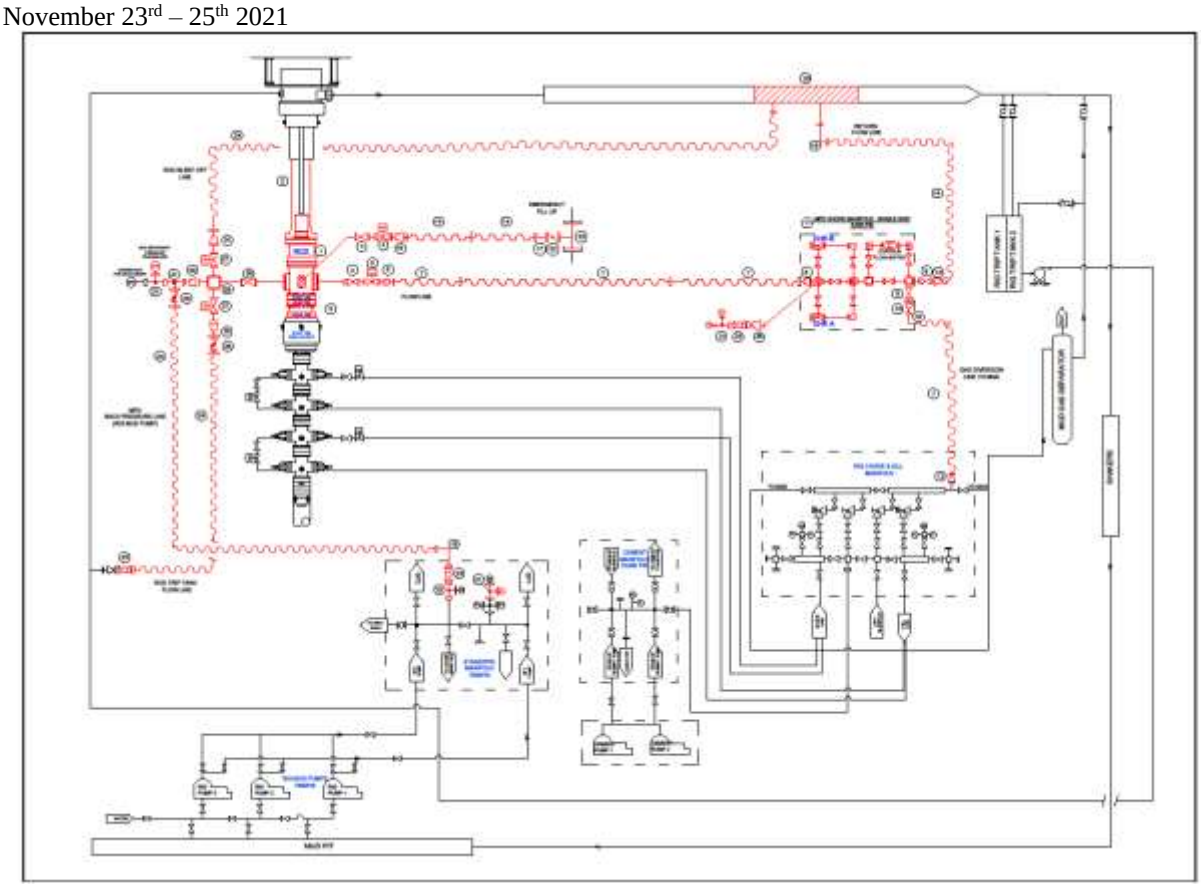

Figure 6: Piping and Instrumentation Diagram.