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Drilling Optimization by Using Advanced Drilling Techniques in Buzurgan Oil Field

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Abstract

Efficient and cost-effective drilling of directional wells necessitates the implementation of best drilling practices and advanced techniques to optimize drilling operations. Failure to adequately consider drilling risks can result in inefficient drilling operations and non-productive time (NPT). Although advanced drilling techniques may be expensive, they offer promising technical solutions for mitigating drilling risks. This paper aims to demonstrate the effectiveness of advanced drilling techniques in mitigating risks and improving drilling operations when compared to conventional drilling techniques. Specifically, the advanced drilling techniques employed in Buzurgan Oil Field, including vertical drilling with mud motor, managed pressure drilling (MPD), rotary steerable system (RSS), and expandable liner hanger (ELH), are investigated and evaluated through case study analyses, comparing their performance to that of conventional drilling techniques. The findings indicate that vertical drilling with mud motor exhibits superior drilling performance and wellbore verticality compared to conventional rotary drilling bottom hole assemblies (BHA) for drilling the 17 ½" hole section. MPD systems employed in the 12 ¼" hole section demonstrate safe drilling operations and higher rates of penetration (ROP) than conventional drilling methods. Rotary steerable systems exhibit reduced tortuosity and achieve higher ROP when compared to mud motor usage in the 8.5" and 6" hole sections. Lastly, investigations of expandable liner hanger cases reveal subpar cement quality in the first case and liner remedial work in the second case, highlighting the successful implementation of ELH techniques in the offset field. Overall, this paper highlights the advantages of utilizing advanced drilling techniques in Buzurgan Oil Field, showcasing their ability to mitigate drilling risks and enhance drilling operations when compared to conventional drilling approaches.

Keywords: drilling optimization, rotary steerable system (RSS), manage pressure drill (MPD), expandable liner hanger (ELH).

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1- Introduction

As firms continue to expand their drilling operations in existing oil and gas areas across the globe, the optimization process is still considered to reduce drilling time and associated cost per each well [1]. Problems like pipe sticking, overflow, mud loss, hole cleaning, and wellbore instability take up about 20% of all rig time which result in Non-Productive-Time (NPT). So, a small change to the NPT could save a lot of money. Because of these, the drilling is optimized to reduce cost and NPT, in addition improving drilling performance and safety. Optimization of drilling is a method that relies on optimized well design, computer software, unconventional drilling techniques and experienced personnel [2].

Prediction of penetration rate (ROP) is important process in optimization of drilling due to its crucial role in lowering drilling operation costs. This process has complex nature due to too many interrelated factors that affected the rate of penetration [3]. Horizontal wells are of great interest to the petroleum industry today because they provide an attractive means for improving both production rate and recovery efficiency. The great improvements in drilling technology make it possible to drill horizontal wells with complex trajectories and extended for significant depths [4]. In this modern period, engineering techniques were utilized in every field; consequently, a great deal of technological advancement was observed, especially in vertical and directional drilling technologies, such as the development and application of mud motor in vertical hole drilling and rotary steerable system technology to optimize drilling operations [5].

Non-productive time (NPT) and operational problems may enhance operational expenses due to downhole pressure uncertainty and circumstances. Managed Pressure Drilling (MPD) provides cost-effective solutions for problematic wells with narrow windows [6].

Cemented liner and liner hanger installation need the greatest care and attention. Conventional liners have had problems with top consistency, packer/hanger pre-set or fail to set, shoe and cement integrity. An expandable liner

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hanger system (ELH) allows rotating and reciprocating of the liner while passing throughout a high dogleg zone. Rotation while cementing improve cement quality. High torque expandable liner hanger facilitates washing and reaming down operations in difficult sections and helps run the liner to the optimum depth [7].

1.1. Study area

The area of study is Buzurgan Oil Field. This Field is located south-east of Iraq near the Iraqi-Iranian borders, about 60 Kilometers to the south-east of Al-Emara City, the center of Missan Governorate. The structure elongates from the northern-west to the southern-east, consist of two-dome, the southern dome is larger and higher than the Northern dome. From top to bottom, the strata drilled in Missan oilfields include Tertiary Upper Fars which is mainly clay interbedded with sand, Lower Fars Formation is complex and consists of five members; Mb1, Mb2, Mb3, Mb4 and Mb5 with lithology thin to thick and massive anhydrite interbedded with shale and salt, as well as the formation pressure is abnormal with 2.2 g/cc Expected Pressure coefficient. Then the formation consists of Tertiary Jeribe Fm. to Cretaceous Nahr Umr Fm. Cretaceous Mishrif carbonate reservoir is the main target interval in Buzurgan oilfield, the Mishrif is divided into 7 pay zones, namely MA, MB11, MB12, MB21, MB22, MC1 and MC2.The main pay zone is MB21. The common well design type drilled in buzurgan oil field is horizontal well profile [8]. Fig. 1 shows a well structure in buzurgan oil field.

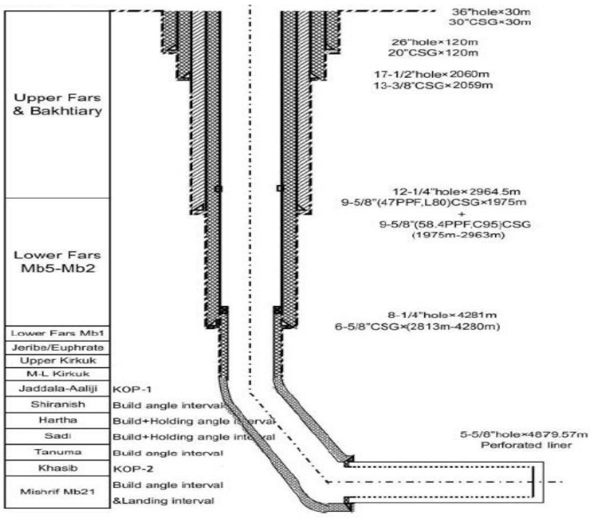

Fig. 1. BUCS-86H Well Structure [8]

1.2. Drilling Risks

The main Risks expected for drilling horizontal oil well in Buzurgan field are:

a. Lower drilling performance and wellbore verticality issues when drilling long 17 ½” vertical hole section with conventional rotary bottom hole assembly (BHA).
b. Water and gas overflow, losses and wellbore stability in 12.25” hole section.
c. Flow gas in 8.25” or 8.5” hole in ALIJI formation, mud loss in JADALA formation, stuck and wellbore instability due to sloughing shale specially tanuma formation.
d. Lower rate of penetration, wellbore tortuosity by using mud motor with sliding mode in 8.5” hole section.
e. Lower cement bonding quality and job failure of conventional 7” casing liner.

2- Workflow Steps

The workflow to achieve the objectives of this paper is to demonstrate the technical solution to mitigate drilling risks by using unconventional and advanced drilling techniques as follow:

2.1. Mud motor effectiveness

Demonstrate the effectiveness of mud motor to solve the lower rate of penetration in 17.5” hole section by drilling performance comparison with rotary conventional drilling BHA by using excel sheet.

2.2. Manage pressure drill (MPD) effectiveness

Demonstrate the effectiveness of manage pressure drill(MPD) technique case study to solve the flow gas, loss, drilling performance and stuck in 12.25” by comparison with normal drilling operation, then discuss implementing this technology to treat downhole problems in 8.25” or 8.5” hole section.

2.3. Rotary steerable system (RSS) effectiveness

Demonstrate the effectiveness of the rotary steerable system (RSS) field applications to solve the lower ROP and wellbore tortuosity in 8.5” hole section by comparison with PDM by using excel sheet.

2.4. Expandable liner hanger (ELH) effectiveness

Demonstrate the effectiveness of 7” expandable liner hanger (ELH) technique to solve the lower cement bonding quality and job failure reduction by postanalyses two cases study.

3- Hypothesis

3.1. Mud motor in vertical hole drilling

Drilling vertical hole with motor often doubles or triples the penetration rate compared to standard rotational methods. Mud motors work with most drilling fluids. While drilling wellbore between 17 ½" and 26" in diameter, motors may increase penetration over rotary techniques, maintain a vertical wellbore, and reduce drill collar twisting off. vertical hole drilling with motor may be cost-effective when appropriately constructed. It has found widespread use in both directional and conventional drilling. Fig. 2 depicts the fundamental design of a positive displacement motor. The stator is a rubberized component having a spiral, helical channel. Motor choice is dependent upon well specifications [9].

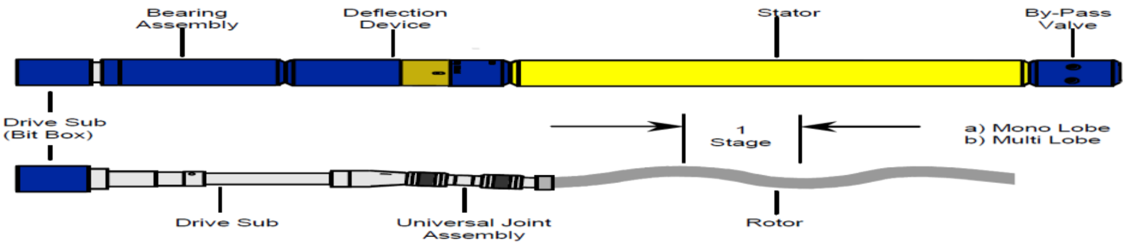

Fig. 2. Positive Displacement Motor (PDM) [9]

3.2. Managed Pressure Drill (MPD) technique

It is an adapted drilling technique used to adjust the annulus pressure inside the wellbore with greater precision. The goals are to define the pressure environmental constraints and regulate annuals fluid pressure correctly. That may involve controlling choke pressure via an enclosed and pressurized mud returning. Managed Pressure Drilling will often prevent wellbore flow [10]. Constant bottom-hole pressure (CBHP) describes ways to modify or decrease circulation friction loss or equivalent circulating density(ECD), maintaining BHP within a pressure window. Margin is between limits. Low margin is pore pressure and wellbore stability; large margin is differential stuck, lost circulation, and breakdown pressure [11]. Fig. 3 explains this technique.

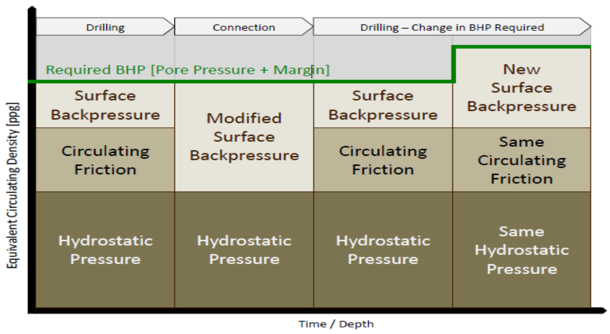

Fig. 3. MPD Constant Bottom Hole Pressure Technique [12]

a. MPD equipment

The main MPD part is rotating control device (RCD) which is primarily responsible for diverting the upstream mud out from the borehole to the MPD choke manifold in the meantime ensuring an effective sealing between the drill string and the wellbore. MPD utilizes a RCD to keep the annulus sealed from the atmosphere. Trying to apply an enhanced compound rubber sealant to the drillstring creates a reliable seal while allowing the pipe to move vertically.

If the RCD bearing assembly has to be replaced during operation, Drill String Isolation Tool (DSIT) is used as a backup.

Other essential part of MPD is Automated MPD Choke Manifold which manages wellhead pressure by adjusting flow restriction. which helps keep a nearly steady bottom hole pressure under both dynamic and static conditions. The stated choke is a semi-automated choke that can regulate pressures by manually adjusting points on the control unit and keep pressures regardless of upstream flow conditions so that pressure, mud loss and kick can be controlled and detected accurately. Fig. 4 below shows choke manifold parts.

Two-phase separators are necessary for the safe handling of gas in field. Separator must be capable of circulating invasion or gas to the surface while handling the plan flow rate and gas rate during the design phase [13]. The MPD layout is shown below in Fig. 5.

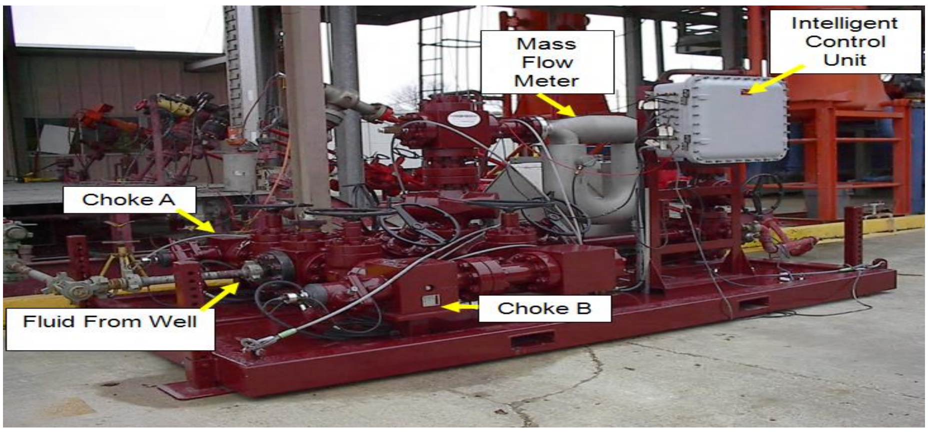

Fig. 4. MPD Choke Manifold System [13]

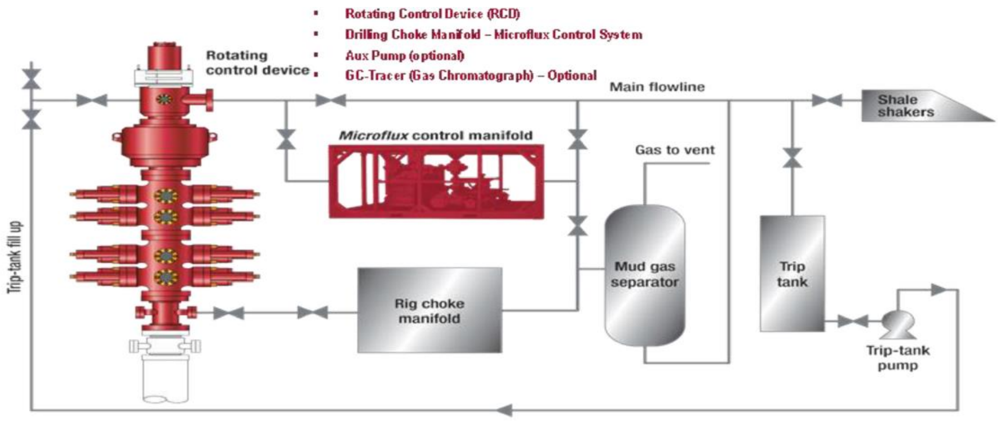

Fig. 5. MPD Equipment Layout [13]

b. MPD impact value

MPD is a basic explanation of the approaches for wellbore pressure management, which covers a variety of concepts describing procedures and equipment created to reduce well kicks, lost circulation, and differential sticking. A beneficial drilling method is one that addresses a real-world issue in a cost-effective way while having little influence on the other components of the drilling operation. Using of the MPD techniques in drilling has improved drilling performance, lessened drilling risks, and substantially decreased drilling cost [14].

3.3. Rotary steerable system (RSS)

One of the most important developments in drilling technology to come out of the petroleum industry in test years has been the introduction of rotary steerable systems, often known as RSS. These systems have been shown to be useful for both directional and horizontal drilling. These systems substitute specialized downhole technology for traditional deviated tools, such as drilling mud motor. RSS technological system offers well trajectory guidance despite the drill string's continuous rotation. This eliminates the need for an operator to control the well by sliding a mud motor. Frequently, these systems use automated drilling modes in which Automatic wellbore steering by a closed-loop system programmed into the downhole tool [15]. RSS tools are categorized broadly in three types point-the-bit, push-the-bit and Hybrid system. Fig. 6 and Fig. 7 describe main components of the point the bit RSS and push the bit RSS respectively. The system's potential to improve penetration is a major benefit (ROP). Continuous drill string rotation enhances ROP by effectively transmitting weight to the bit. Rotation enhances wellbore cleaning by stirring cuttings, enabling them to circulate out of the hole and onto the surface. These features lead to improved hydraulic, weight transfer during drilling, and drilling torque. Poor drilling efficiency may cause borehole instabilities in shale zones, resulting in lost time, equipment, and fluids [15]. Excessive torque and drag can be critical limitation during drilling horizontal oil wells. Using appropriate technique is regarded as an invaluable process to assist in well planning and to predict and prevent drilling problems [16]. As RSS enhances drilling performance, an engineer may drill a more complicated well route with less borehole tortuosity. RSS hole geometry is less harsh and calibrated compared to motor-drilled wells. Eliminating ledges and complicated well pathways makes running the well's casing or production string simpler [17].

Fig. 6. Point the Bit RSS Tool [18]

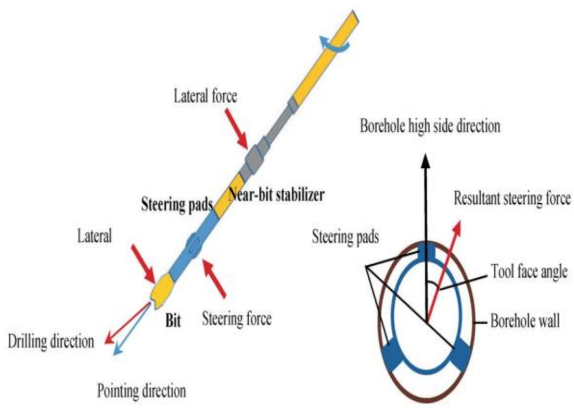

Fig. 7. Push the Bit RSS Tool [19]

3.4. Expandable liner hanger

Installations of cemented liners and liner hangers have long been regarded as crucial processes requiring the utmost care and attention to ensure operational success. The set cement sheath is the primary annular barrier for preserving wellbore integrity and withstanding stresses throughout the well's lifetime. Expandable liner hanger systems (ELH) are intended to improve the quality of liner cementing and provide a hydraulically activated liner-top seal during setting. this technology has superseded conventional cementing methods [7].

a. Comparison of Conventional and Reciprocating Liner Hangers

Conventional liner systems: There are a variety of methods used to connect the liner to the previous casing. Liner hanger design consumes a considerable portion of the available surface area to fit the slip-and-cone process and then provide the needed strength to support the liner in place. This offers a severe design challenge when seeking to reduce the OD of the assembly. Traditional liner hangers with integrated liner top packers separate the formation from the well surface in addition to the main cement. Packer components may be fastened mechanically to the hanger's body [20]. Fig. 8 shows the conventional liner seal components.

The reciprocating expandable liner-hanger (versa flex) system: using expandable liner, trustworthy cementing materials, and servicing facilities. To connect the assembly to the liner, the system employs an expanded liner-hanger structure with an integrated packer, a tieback refined receptacles, a setting-sleeve component, and a cross over component. The hanger's body is bonded using elastomeric components. The elastomer parts inside the annular area are squeezed as the hanger expands. Eliminating the hanger/casing annular space increases liner top pressure consistency and tension and compression loadings to remarkable levels [20]. Fig. 9 shows the expanding schematic.

b. Reciprocating liner features and benefits

The packer element's design permits large circulation rates. The mechanism rotates over troublesome sections of the hole without releasing the hanger or setting tool. The liner provides Enhancing fluid flow due to the lack of external components such as cage, hydraulic cylinder, and slip and others with a more straight-lined flow path directly next to the hangar which decreases surge and ECD. For a given liner length, less stress generation and more uniform stress distribution are created in the supporting casing. The hanger permits cleaning and reaming operations without requiring the hanger to be adjusted. The design features noticed that there is no significant damage to the supporting casing or slips "wickers" that Eliminating potential leakage routes. Since the hanger is secured after cementing, pipe movement improves zonal isolation across the cemented region and maintains tension and compression for the life of the well that leads to Reducing the amount of stages in a process [20].

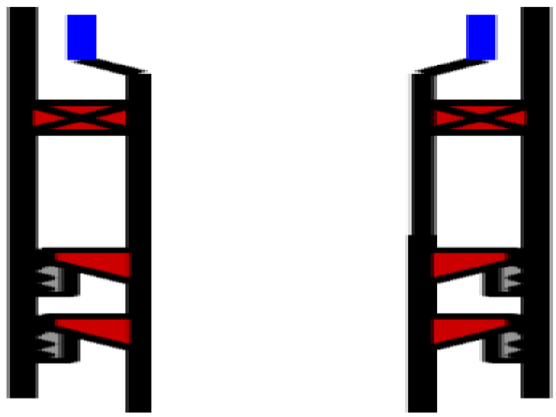

Fig. 8. Conventional Liner [20]

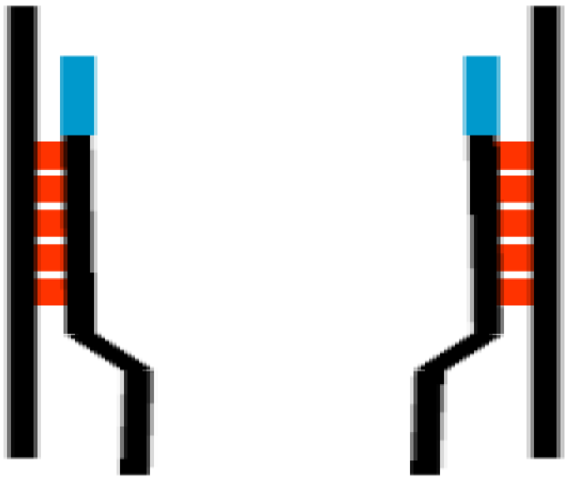

Fig. 9. Expandable Liner Hanger [20]

4- Result and discussion

4.1. Mud motor performance in 17.5” or 16” hole section

Mud motor performances incomparable with rotary conventional BHA performance in 17.5” hole section is illustrated in Fig. 10. The performance plot shows that the motor drilling ROP is significantly higher than conventional Rotary BHA due Substantial motor power generation to bit and providing excellent range of continual torque to the bit moreover isolating the bit from the most damaging consequences of fluctuating torque and speed due to drilling string vibrations. Drilling Mud motor increase drill string life by reducing drill string rotation and then reduces the drill string twist off.

As known, the 17.5” hole section has clay formation tendency that causes drilling NPT to maintain wellbore verticality. Drilling NPT is caused by control parameters with lower WOB and high RPM that reduce ROP. The significant advantage noticed of using drilling mud motor in 17 ½” hole section is to reduce hole deviation so that inclination angle that measured with electro multshot (EMS) or totco survey showed it is less than 1 degree.

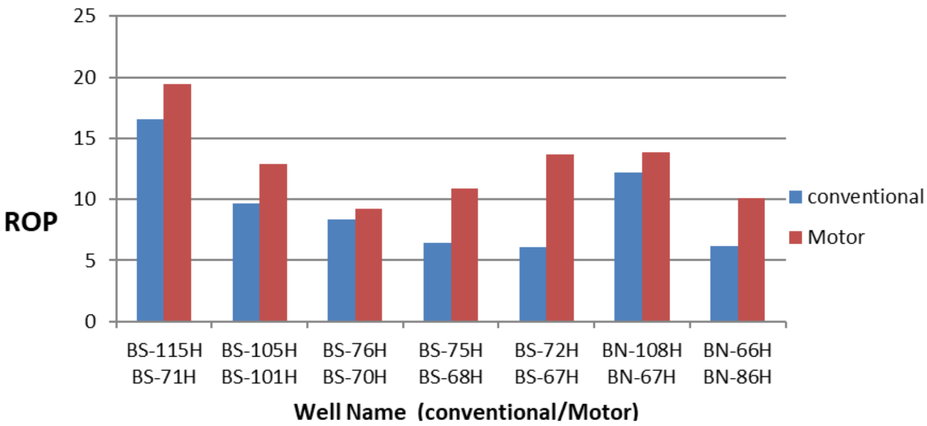

Fig. 10. Mud Motor and Conventional BHA Drilling Performance Comparison

4.2 Managed pressure drill (MPD)

a. Case study description in 12.25" hole section

MPD technology was conducted in north Buzurgan oil field. It was run in 12.25" hole section to mitigate the influx in abnormal zone. The constant bottom hole pressure variation is used to optimize the effect of annular pressure loss or ECD density to be within the fracture and pore pressure limits by applying back pressure to maintain Bottom hole pressure constant within the limits. Case study information is shown in in Table 1 below [21].

Table 1. MPD Case Study Run Information [21]

Well name	Hole size (inch)	Mw (g/cc)	ECD (g/cc)	Flow rate L/min	ROP (m/hr)	Section TD time (Day)	FIT (EMW) g/cc	Pore pressure psi
BUCN-59	12.25	2.2 -2.22	2.24- 2.3	2000-2230	5.45	16.145	2.37	2.2

MPD conducted in 12 ¼" hole in BUCN-59H. As a result of investigations and analyses of the summary daily reports and comparison this technique with conventional drilling of the offset well, it was found that MPD Enhanced well control safety so that Overflow was not detected during drilling 12 ¼" with MPD system. The Overflow flow occurred many times in other wells of this section specially BUCN-57H offset well, also it was occurred severely in BUCS-47 so that triple killing methods were made to stop gas overflow and formation fluid inrush that causing costly mud volume to control the well by using MPD system, the gas flow and kick accidents can be early detected if they occurred and mitigating by adjusting higher back pressure to stop influx. Finally, MPD system Enhance well control safety through early influx detection and treatment resulting of mitigating drilling hazards and associated invisible loss time.

Second Drilling performance shows that The average ROP during MPD run is 5.45 m/hr. while average ROP the offset well of BUCN-55H drilled with conventional drilling is 2.26 m/hr. The double increase of ROP belongs to reducing mud weight by using MPD from 2.28 to 2.2 g/cc replacing mud reduction by back pressure. Reducing mud weight leads to decrease chip hold down effect that is caused by difference between hydrostatic pressure and formation pressure. Drilling 12 ¼" hole section with 2.2 g/cc instead of 2.28 can significantly reduce mud material cost.

MPD effectiveness in wellbore stability treatment can be signified to treat stuck pipe accident caused by salt creeping. While drilling 12 ¼" hole section by MPD system to depth 2484.9 m, the drill string was stalled. Attempted to pick up drill string at 20 tons, no success. Back to neutral and apply torque. String released. According to lithology description at this depth, the formation is salt with 80% interbeded with calystone and anhydrite. Then the back pressure increase from 120 psi to 186 psi at ECD 2.3 g/cc. The next operation was running smoothly.

Finally, no mud losses occurred in this well, the mud loss most likely occurs when drilling 1m into MB1 formation loss layer to set 9-5/8" casing shoe. The mud loss risk can be avoided by MPD system through reducing ECD. The other reason for mud loss accident is to increase mud weight to kill mud because of formation influx. The higher density of killing mud causes mud loss as occurred in BUCS-47. This can be mitigated by MPD system through adjusting appropriate back pressure without formation break risk.

b. Proposed Managed Pressure Drill (MPD) in 8.5" hole section

There are expected risks in drilling 8.5" hole section that can be mitigated and solved by MPD if they are occurred.in this section, gas cut mud and mud loss complex situation problem case study description is presented and discussed how the MPD technique can be used to solve the complex situation in addition, MPD technique can be used to mitigate other expected risks in 8.5" hole.

Gas cut mud treatment gas cut was treated by increasing mud weight to stop gas influx, meanwhile mud loss was treated by loss circulation materials (LCM) and four cementing plugs [22]. The Table 2 below shows gas cut mud treatment. The table illustrates that the mud weight out is different from mud weight in because of gas cut that dilutes mud column. It is also shown that mud weight is increased gradually to stop gas influx at same time avoiding formation break, but gas is still overflowing resulting mud weight reduction. When the mud weight increased from 1.24 to 1.3 g/cc, the loss occurred causing complex situation. The operator tried obtaining optimum and balanced mud weight to reduce gas overflow and mud loss. After mud weight increasing and mud loss treated with LCM and cementing plugs, it is noticed that 1.34 g/cc -1.36 g/cc mud weight is used to drill this section safely with less gas overflow and without mud loss.

The Case study impact loss to treat this accident include four cementing plug with 1.9 g/cc cement slurry weight and pump Seal mud (LCM) twice with 18.4 m3 volume. the mud loss volume 248.88 m3 in addition Mud weighting and conditioning material cost. NPT time that is about 24days with 21.4 % percent of whole well time. The complex situation is the wellbore bottom hole pressure management that is difficult to control because the gas cut mud weight density as noticed in Table 2 below since mud weight in is different from mud weight out.in addition, mud loss reduces the mud column in wellbore that all make the bottom hole pressure very difficult to control. Managed pressure drill (MPD) provides wellbore bottom hole pressure management through controlling surface back pressure to overcome the complex situation.

Table 2. Gas Cut Mud Treatment

Depth	MW. before change		Mud weight after change	
	Mud in g/cc	Mud out g/cc	Mud in g/cc	Mud out g/cc
@ 3362m (Top of ALLIJI)	1.25	1.24	1.3	1.29 ~1.26
@ 3465 m (top of SADI.)	1.34	1.3	1.38	1.34
@ 3475 m (Cont. drilling)	1.38	1.38~1.36	1.34 – 1.36	1.36~1.34

Suggested MPD technique steps to mitigate the complex situation can be applied through Determining actual mud window to provide better understanding for drilling hole condition. When the top of ALIJI is identified, pore pressure is determined by unbalancing hydrostatic pressure. But additional SBP is applied to make BHP greater than formation pressure. Then, BHP is decreased by reducing surface back pressure (SBP) in increments, (i.e. 25 or 50 psi), and Monitor flow out. As soon as micro influx is observed, increase BHP quickly by increasing SBP until the gain is circulated out. Perform FIT to determine equivalent mud weigh by Increasing SBP in increments and Monitor flow out. As soon as bottom hole equivalent mud is reached, automated MPD Choke Manifold system will automatically calculate bottom hole pressure and provide information on FIT. Then, Put the hydrostatic pressure in balance or slightly higher than pore pressure then, increase FR to reach optimum flow rate from offset wells for good hole cleaning. after that, control surface back pressure so that BHP is appropriate to drill this section. If Gas cut occurred, increase SBP gradually and monitor gas flow out percent to get optimum SBP without gas flow out maintaining ECD less than FIT equivalent mud.

The important expected risk is in this section is Mud loss. The main reason of loss is loss formations that are cavernous or vugular in many formations of this section such us JADAL, ALIJI and HRATHA formations which formed from limestone lithology, also this section contains depleted reservoir that makes loss risk very high to occur. Mud loss costs too much because of mud volume lost, treatment material cost and NPT. Mud loss risk can be avoided by using MPD technique through controlling optimum ECD by balancing pore pressure with hydrostatic pressure and apply SBP with minimum differential pressure taking in consideration the equivalent mud weight that is taken from FIT.

Differential stuck occurred in many wells drilled in buzurgan oil field because of availability stuck conditions. Differential stuck can be mitigated by MPD technique by making the hydrostatic pressure balance with pore pressure and adding SBP with minimal differential pressure, moreover using optimum mud condition.

Wellbore instability is often demonstrated by sloughing shale, tight hole and caving that cause problems when running casing, Mechanical stuck and inefficient hole cleaning , by MPD technique ,the constant bottom hole pressure reduce pressure variations and minimizing wellbore instability and mechanical stuck ,moreover reducing ECD ovoids wellbore erosion, also drilling with lowest overbalance reduce mud filtration and formation damage specially in this section because of reducing oil pay zone damage in mishrif and asmari reservoir.

When Running drill string to fast can cause surge effect that lead to break weak formation such as jadala formation resulting mud loss problem, in same time pulling the string out too fast can cause swab effect that reduce bottom hole pressure resulting gas influx from ALIJI, the MPD system allows holding additional pressure to cancel out the swab/surge pressures by maintaining CBHP resulting wiper and short trip time reduction.

4.3. Rotary steerable system (RSS)

RSS system was first run in BUCN-138H well, recently it was run in BUCN-118H and BUCN-119H. The main advantages of ROP is enhancing ROP and reducing operation time. Moreover, reducing wellbore tortuosity that lead to smoothen borehole and reducing torque and drag drilling problems.

a. Drilling performance

The Rate of penetration of wells drilled with RSS shows that ROP of BUCS-138 is lower ROP than others with 3.64 m/hr. while the ROP in BUCS-118H and BUCS-

119H is high ROP than other wells as illustrated in Fig. 11 below. The lower ROP in BUCS-138 may be caused by inappropriate drilling parameter since it is the first well drilled with RSS in addition the bit description after drilling shows better bit condition without damage. On other hand, the high ROP of the BUCS-118H and BUCS-119H belongs to eliminating sliding mode time and appropriate drilling and mud parameters.

The operation time is defined as the time of make up and run in hole the RSS BHA in the well to the time of pulling out the RSS tool to the surface.as noticed from Fig. 12 below, the operation time of the wells drilled with RSS are lowest because of higher ROP in addition continuous rotation without sliding enhances wellbore cleaning and stability that leads to reducing wiper trip time. The average time saving of the wells drilled with RSS compare with wells drilled with mud motor is 29%.

It is important to be mentioned, the RSS system was run in 6” hole section in BUCS-118H.the results showed higher ROP and lower operation time than BUCS-117H offset well drilled with PDM although the offset well is less footage than BUCS-118H as illustrated in Table 3 below.

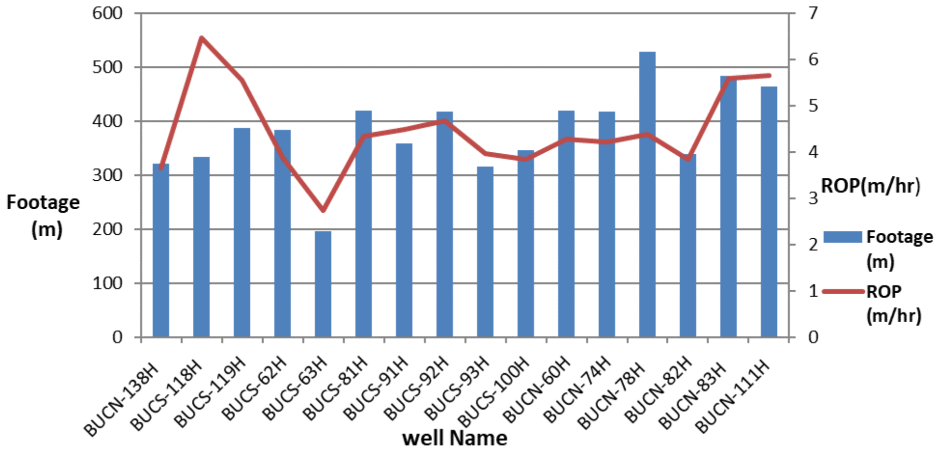

Fig. 11. ROP with RSS and Mud Motor

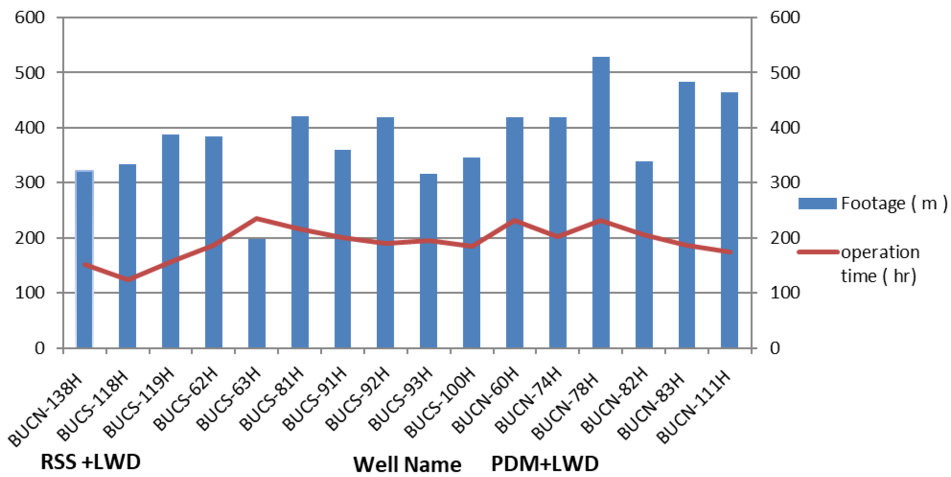

Fig. 12. Operation Time with RSS and Mud Motor

Table 3. ROP and Operation Time between RSS and PDM

Well name	Depth in(m)	Depth out(m)	Footage	WOB time(hr.)	ROP (m/hr.)	Operation time(hr.)	BHA
BUCS-118H	4118	4718	600	46	13.04	145.5	RSS+LWD
BUCS-117H	4077	4527	450	85.02	5.3	164.5	Motor+LWD

b. Wellbore tortuosity

As shown in Fig. 13 below, the wells drilled with RSS showing less tortuosity than wells drilled with mud motor. The reason that makes more tortuous well with motor belongs to drilling directional well with mud motor is made by sliding mode to build angle with desired dogleg and rotation mode to hold the angle. A Correction with high dogleg may be needed to maintain designed well path Because of BHA gravity and formation tendency during rotation. Then, adjusting to lower dogleg to follow the planned trajectory. These adjustments lead to more tortuous wellbore than made by RSS wish eliminates this process by only continuous rotation. Lower wellbore tortuosity enhances optimum well placement and running casing. Not only that, but also reduces torque and drag drilling problems.

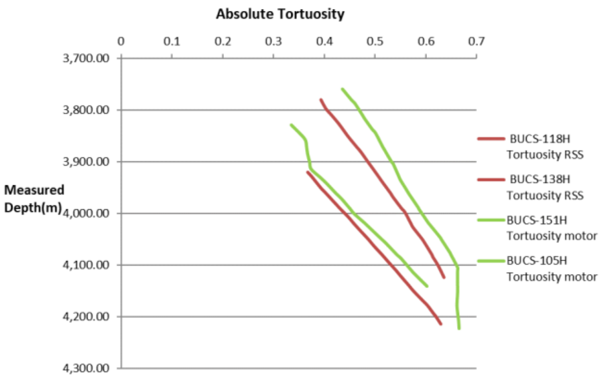

Fig. 13. RSS and PDM Absolute Tortuosity

4.4. Expandable liner hanger (ELH)

a. First case Study

7” x 9 5/8” Expandable liner hanger is first run in BUCS-117H well at 4075m Set depth. Casing specifications are VAM 95/VAM 21 /weight: 129 b/ft.M/U and RIH 7” liner casing to 1418m then, then M/U and RIH liner hanger to shoe depth. Circulate hole with 48 SPM and keep work string up and down. Later, preform cementing job and setting packer. The packer was set at 3300psi and Slack Off weight 30ton to release string tool, pick up string tool, and come free and the weight drop off to 46 tons (liner weight). Then, reverse circulation was made leading to successful string tool release and liner expansion [23].

b. Second case Study

7” x 9 5/8” Expandable liner hanger is second run in BUCN-120 well at 4085.5m Set depth. Casing specifications are VAM 95/VAM 21 /weight: 129 b/ft. M/U and RIH 7” liner casing to 1447m then, M/U liner hanger and RIH liner to shoe Circulation and mud condition there is no reciprocating and rotation during mud conditioning and cementing. Preform successful cementing job. The thickening time was 348 mins for lead slurry while The thickening time was 231 min. Setting hanger procedure was performed by Pumping pressure to 600 psi and 1000 at the F/R of 0.159 m3/min by cement pump, there was returns in well head, then stopped pumping immediately, total 4bbls was pumped, Design expansion pressure:2800-3500psi.The expansion of hanger cannot be confirmed, then started the emergency expansion operation by dropping the setting ball to verify the setting. Dropped the 2.5 setting ball on rig floor, make sure the ball leaves the cement head, and waited for 30min.then Pumped the pressure to 1080psi at the F/R of 0.159 m3/min by cement pump, the pressure dropped to 600 psi, and there was returns in well head, 1.1bbls volume was pumped. There was still 500psi left after stop the pumping. Finally, running tool was released by applying pick up weight with 200t and slack off weight with 110t, not released, Connect TDS, limited torque of 10 KN·m, S/to 60T, P/U to 215T, continue S/O to 55T, P/U the WHO dropped to 130T, successful release. Reverse circulation, hold pressure 913 psi. Lay down cement head. Pulled out drilling pipes. Found out that they cannot be moved, drill pipe stuck. Treat with accident [24].

c. Expandable liner hanger Postanalyses case studies

The major of reciprocating liner advantages that should be applied to say successful reciprocating liner are reciprocating liner through conditioning mud and displacing cement, liner top seal and good cement evaluation. Liner in first case (BUCN-117H) was reciprocated during mud conditioning with 48 SPM by keep work string up and down. But reciprocating and rotation were not made during cement displacement because of operator request.in contrast with second case(BUSC-120) there was no reciprocating through mud conditioning and cement displacement.

The first case showed that the liner hanger was expanded and running tool was released normally within 20 minutes so that liner expansion and top seal was tested successfully by weight and Hydraulic. While in second case, liner expansion conformity issue and difficult running tool release results stuck pipe. The root cause of stuck pipe accident that Halliburton liner hanger (versaflex) failed to work normally according to the design in the process of expansion and releasing the Running tool. It took too long to operate repeatedly and finally take emergency measures. Cement pump and displacement took 160min from the time @22:25 when the cement slurry was pumped to the time when cement displacement finished at bump pressure 2900 psi @01:05 as shown in Fig. 14 below. Expansion conformity issue and releasing running tool treatments took 150 minute from time 01:10 at which setting hanger procedure was started to 03:00 at which reverse circulation was made as shown in Fig. 15 below. hows that the pressure was held at 6.4 Mpa and the circulation is blocked that gives indication that thickening time starts to begin.in addition, the total time consumed from cement pumping to reverse circulation is 310 min. which is very close to the time when the slurry thickening time （T. T 348 Min for cementing slurry). so that the drilling pipe could not be pulled out of hole.

Evaluation of first case (BUCN-117H) showed that cement bond 33.12% poor, 40.8 medium and 26.08 good.it is important to mention the 175 m above shoe was not covered by CBMT. While the second case showed that the overlap cementing bond is poor, therefore, 7” casing tie-back was run. The Table 4 below showed that versaflex application in offset field. Table 4 shows that liner rotation applied with 10/15 rpm with successful top seal and installation in addition good cement bonding in comparison with conventional liner hanger.

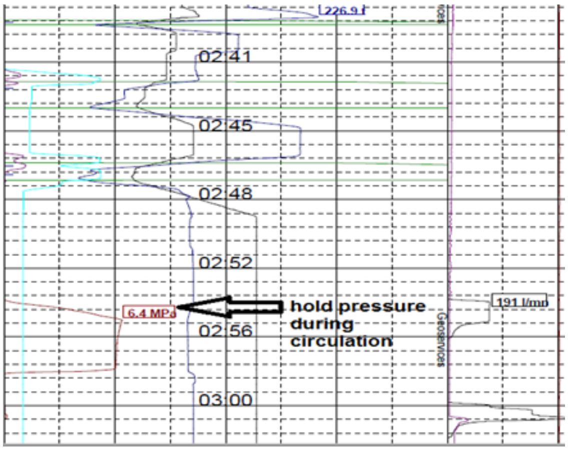

Fig. 14. End Time of Liner Cementing Job

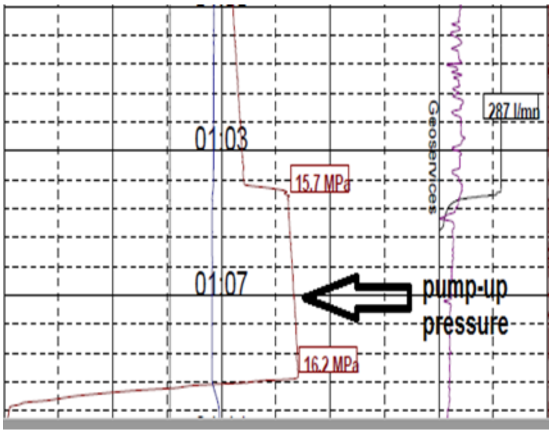

Fig. 15. Reverse Circulation End Time

Table 4. Reciprocating Liner Job Parameter

Well name	Rotation (RPM) & Reciprocating(m)		Torque(Klb.ft)		Top liner Test (psi)	Remedial squeeze required
	While mud condition	While cement displacement	While mud condition	While cement displacement		
X-1	15rpm rotate 3m recipro.	10rpm rotate 3m recipro.	18	20	3000*15min OK.	No
X-2	10rpm rotate 5m recipro.	10rpm rotate 5m recipro.	18	18	3000*15min OK.	NO
X-3	10rpm rotate 5m recipro.	10rpm rotate 5m recipro.	9	9	3000*15min OK.	No
X-4	15rpm rotate 3m recipro.	10rmp rotate 3m recipro.	4	3	3000*15min OK.	NO

5- Conclusion

According to the obtained results from this study, the conclusions have been reached that mud motor provides higher drilling performance (ROP) and wellbore verticality in comparison with conventional bottom hole assembly(BHA) in vertical drilling section. Because of higher ROP and reduced NPT caused by wellbore deviation, the total well cost will be decreased in spite of the higher mud motor cost. Although it is more expensive, MPD system shows several advantages through drilling 12.25” hole section through increasing drilling performance, wellbore stability and well control safety, but it is more effective to treat with drilling risks in 8.5” hole section specially gas cut mud complex situation treatment and other risks expected in this section. Because of eliminating sliding mode in rotary steerable system, the ROP in RSS is higher in 8.5” hole and 6 “hole than PDM, also RSS enhances wellbore quality through reducing wellbore tortuosity in comparison with PDM. Higher cementing quality can be obtained if expandable liner hanger is rotated and reciprocated in first case study. Second case job contingency plan was delayed that lead to stuck pipe accident. although expandable liner hanger is more expensive than conventional liner, but it is still magnificent technology for cementing improvement, top seal consistency and remedial job reduction as shown in offset field jobs.

Nomenclature

BUCN North Buzurgan Well
BUCS South Buzurgan well
CBHP Constant Bottom Hole Pressure
CBL Cement Bond Log
DDR Daily Drilling Report
ECD Equivalent circulating density
ELH expandable liner hanger system
FIT Formation Integrity Test
NPT Non-Productive-Time
MASP Maximum Allowable Surface Pressure
MD Measure Depth
MPD Managed Pressure Drilling
Mw Mud weight
PDM Positive Displacement Motor
PTB Point The Bit
PTB Push The Bit
RCD Rotating Control Device
ROP Rate of Penetration
RSS Rotary Steerable System
SBP Surface Back pressure

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أمثلية الحفر بواسطة استخدام تقنيات الحفر المتقدمة في حقل البزركان النفطي

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الخلاصة

يتطلب حفر البئر الاتجاهي الفعال والاقتصادي أفضل الممارسات لعمليات الحفر اضافة الى تقنيات الحفر المتقدمة لتحسين عمليات الحفر. إذا لم تؤخذ مخاطر الحفر بنظر الاعتبار، فإنها سوف تؤدي إلى عمليات حفر غير فعالة ووقت حفر غير منتج. يمكن اعتبار تقنيات الحفر المتقدمة أفضل الحلول التقنية للتعامل مع مخاطر الحفر على الرغم من أنها ذات كلفة عالية. الهدف من هذا البحث هو معرفة فاعلية تقنيات الحفر المتقدمة من أن تقلل من مخاطر الحفر وتعزز عملية الحفر مقارنتاً بتقنيات الحفر التقليدية. تشمل تقنيات الحفر المتقدمة المستخدمة في حقل نفط البزركان الحفر العمودي بالموتور، والحفر ثابت الضغط (MPD) ، ونظام الحفر الموجه بالتدوير (RSS) والبطانة المعلقة بواسطة التوسيع (ELH) بحيث هذه التقنيات يتم فحصها وتقييمها بناءً على تحليلات دراسة الحالات المستخدمة مقارنتاً بتقنيات الحفر التقليدية. اثبت الحفر العمودي بالموتور أداء حفر أعلى وانحراف قليل جدا من الحفر الدوراني التقليدي لحفر مقطع ١٧,٥ بوصة. أثبت نظام الحفر ثابت الضغط (MPD) في حفر مقطع ١٢,٢٥ بوصة عملية حفر آمنة وأدائية حفر أعلى من الحفر التقليدي. وكذلك اثبت نظام الحفر الموجه بالتدوير أقل تعرجيه وأعلى أدائية للحفر من الموتور في حفر المقطع ٥.٨ بوصة و ٦ بوصة. أخيرًا، كشفت نتائج دراسة حالات البطانة المعلقة بواسطة التوسيع عن ضعف جودة الإسمنت في الحالة الأولى وعملية استصلاح للفشل في البطانة في الحالة الثانية مقارنتاً بالعمليات الناجحة في الحقول المجاورة.

الكلمات الدالة: امثلية الحفر، والحفر ثابت الضغط، نظام الحفر الموجه بالتدوير، البطانة المعلقة بواسطة التوسيع.