A REVIEW ON CASING WHILE DRILLING (CWD) TECHNOLOGY FOR OIL AND GAS PRODUCTION

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ABSTRACT

The extraction of petroleum fluids from sub-surface accumulations mandates the drilling of a well into the formation containing the accumulation. The drilling techniques have evolved over time to overcome several challenges while some of the issues still prevail with the currently used drilling practices like loss circulation, large tripping time to change bottom hole assembly, stuck pipe problems and low well bore stability, to name a few. These decrease the drilling efficiency and increase the Non-Productive Time (NPT) of this highly capitalintensive industry encouraging the Petroleum Industry to look for new technology. Casing while Drilling (CwD) is a technique of drilling which has been proven to alleviate many of the problems faced while drilling. It has proven to be beneficial in controlling loss circulation and improving wellbore stability by 'Plastering' effect, high quality cement job and increased rig floor safety. It uses smaller rig and less fuel thereby reducing carbon footprint in the environment. This paper reviews casing while drilling (CwD) technology for oil and gas production. Categories, components, accessories and challenges of CwD are discussed in this paper.

Keywords: *Casing while Drilling, Categories, Components, Accessories, Challenges*

I. INTRODUCTION

Earth is a huge storehouse of oil and gas. A hole is drilled in earth to bring hydrocarbons to the surface. Technology for drilling oil and gas has undergone a great transformation from the ancient spring pole to percussion cable-tools to rotary drilling that it can drill several miles into the earth [1] and this transformation is continuously going on. Generally, drilling process is accomplished using tubulars called 'drill pipe' and drill bit. However, since a decade ago, drilling companies started experimenting with another type of tubulars called 'casing' to drill wells [2].

The innovation of this state-of-the-art technology began in 1890 when engineers drilled a well with a new approach which is rotary drilling process with casing and retrieving hydraulically expandable bit [3]. Russian oil companies reported the use of retractable bits in drilling operation with casing in 1920. Later in the 1930s, USA's operators made use of production tubing to drill open hole or barefoot completion wherein flat blade type bit was used for drilling and it remained in the well after the production began [4]. In Brown Oil Tools, Baker Hughes, first recognized these advantages in the 1960s and they developed an advanced system for drilling with casing that included retrievable pilot bit that drills pilot hole, under reamers to enlarge pilot hole size and downhole motors. However, its low penetration compared to conventional drilling limits the further development of this technology [5]. Around 1990, operators began the use of liners to drill potentially troublesome formations or sections like pressure-depleted intervals, which has a high possibility of loss circulation [4]. Till date, the experience of using casing drilling shows that the chances for stuck up problem in casing string is less, due to continuous rotation, when compared to conventional casing running operation [6].

The commercial acceptance of CwD technology by the oil and gas industry began in the 1990s after which concrete developments have taken place in this technology [7]. Here, standard casing string is used to transmit rotary power to bit and to circulate drilling fluid - mud into well bore whereby simultaneous drilling and casing activities in the well bore are carried out. The casing for drilling can be a liner or a full length casing string up to the surface. The use of CwD overcomes the drawbacks of conventional drilling practices, like well bore instability and loss circulation, with the help of plastering effect [8]. It leads to the formation of thin layer of mud cake that is strong enough to prevent fluid loss[9]. Experiments indicates that low radial clearance (casing to hole diameter ratio less than 0.7) and lower tangential contacts angles can increase plastering benefits [10]. Same annular space across well bore allows CwD optimization of hydraulics that results in good hole size and efficient transportation of cuttings [11,12]. The application of CwD with Managed pressure drilling gives a good control of Bottom Hole Pressure (BHP) thereby allowing drilling between the pore pressure and the fracture pressure to be carried out without damaging the formation [13]. Reduction in drilling time using CwD was observed in the tight gas fields of Fahud salt basin wherein about 5 days per well was saved [14]. In the last decade this technology has evolved rapidly and is currently being utilized for drilling both directional and horizontal wells.

II. CATEGORIES OF CWD

At present CwD is categorized into following types:

CwD with retrievable system:

CwD with retrievable system is very advanced having the ability of directional trajectory control and logging with retrievable BHA while keeping the casing string at the bottom. The retrievable system consists of special downhole locking arrangements to connect the directional BHA having drill bit, under-reamer, Positive Displacement Motor (PDM) or steerable motor, Measurement while Drilling (MwD)/Logging while Drilling (LwD) and stabilizer to the bottom most casing joint. To retrieve BHA, either a drill pipe or a wireline operation can be used while independently continuing the reciprocation of only casing string to avoid the potential problem of getting stuck. The drill pipe retrieval system is simple but requires static casing string while running the drill pipe in well bore. The wireline operations are more advanced but need permanent wireline unit adjacent to draw-works [12]. Thus, the selection between drill pipe and wireline operation depends upon the well bore condition and drilling economics.

Liner drilling with non-retrievable system:

Liner drilling has similarities to CwD in which a complete casing string from the surface is replaced by shorter length casing joints extended up to the last casing shoe and the liner string is lowered by a running and setting tool on a drill pipe. On the completion of the drilling, the non-retrievable system is able to set liner hanger till the Total Depth (TD) after which cementing is done.

Liner drilling with retrievable system:

In this, the BHA needs to be retrieved once the liner hanger has been set and then it is cemented. Liner drilling has been successfully practiced in the Gulf of Mexico to mitigate hole instability problem [16].

III. COMPONENTS OF CWD

CwD rig:

Casing Drilling is performed by a specially developed drilling rig or a conventional rig modified for casing drilling [18]. Rig equipped with a top drive has Casing Drive System (CDS) below it that provides connection, rotation and circulation of casing string. An automated hydraulic catwalk called ‘V-door’ is provided on drilling rig to move each casing joint from casing rack to rig floor after which it is picked up by a hydraulically activated single joint elevators attached to CDS.

The extra time related to trip out of drill pipe and running permanent casing inherent to conventional drilling is successfully eliminated in CwD as the casing is already set after reaching TD. It, thus, reduces NPT and in addition, less tubulars-handling requirement improves well site safety and allows drillers to use smaller size rigs. Also, new smaller rig for DwC requires less horsepower and fuel as effective hole cleaning can be done with less pumping pressure due to lesser annular space. Furthermore, it produces less emission, operates in small location and can be transported more easily and quickly than larger conventional rig [19].

Casing drive system (CDS):

The CDS, powered by top drive hydraulic control system, holds the full weight of casing string and applies torque for drilling and make up connections. The casing string is attached to the top drive via a casing drive system without screwing it into the top casing connection [20].The use of CDS and power slips makes casing connections faster and minimizes rig floor activity while making connections and assuring floor safety [21].

The CDS are of two types namely, internal for greater casing radius and external for smaller casing radius. The CDS has an internal spear assembly that provides a leakage seal for drilling fluid when it is connected to the pipe and a slip assembly to grip the interior of casing with larger diameter or exterior of casing with smaller diameter. A quarter turn to the right engages the spear to hold the casing string and apply rotational torque and a quarter turn to the left without axial load to release the tool [18]. A mud saver valve is incorporated to avoid spillage at the time of connections.

Casing string:

In CwD the drill string consists of pipes called 'casings'. Casings are of similar grade, class and sizes that are normally used in conventional drilling. They act as hydraulic conduit for drilling fluid and transmitting mechanical energy to bit. In addition, a wireline retrievable BHA consisting of at least a bit and under reamer that are present at the bottom of casing string to drill a hole of adequate size to allow the casing to pass freely.

In Casing String, BHA is attached to Drill-Lock Assembly (DLA) located above the casing shoe joint and plays a vital role during insertion and retrieval of tools from the bottom. The DLA locks into casing profile nipple and allows torque and weight to be applied on casing during drilling [20]. DLA provides two types of locking mechanism viz. axial lock and torsional lock. The force applied from the surface sets the axial lock, releases the running tool and the rotation engages torsional lock. DLA acts as a seal between the casing and the BHA thereby allowing the fluid to flow through the casing until it is directed through BHA [22]. Retrieval of tools is accomplished using pressure to engage DLA, open bypass and release axial locks. Torsional lock can be released by applying reverse torque to casing string.

The components of BHA are made to pass though the casing string used for drilling having an under reamer or a hole enlarger and mud motor. This results in less power than the optimum to steer the under reamer and bit [4].

A stabilizer is located opposite to the casing shoe that reduces lateral motion of the assembly inside the casing. The casing shoe is manufactured from very hard material to ensure that a full-bore hole is drilled ahead of casing string. Excess torque indicates under gauge hole drilled by under reamer. Conventional directional tools such as bent housing (bent sub), positive displacement motor or Rotary Steerable System (RSS), MwD and LwD tools can be suspended below casing shoe for directional drilling. A conventional core barrel can be run below DLA for coring operation.

The designing aspects of casing string in CwD are similar to those of conventional casing string except that special attention is given to buckling, fatigue and hydraulic forces that are experienced by casing during drilling operation [23].

IV. CWD ACCESSORIES

Major CwD accessories used for handling the casing and CwD operations are explained as follows:

Pump Down Displacement Plug (PDDP):

PDDP is an accessory used for preventing U-tube effect in cementing operation of CwD. Lesser chances of improper landing at downhole provide more advantages over normal float equipment used in conventional drilling.

Multi-lobe torque ring:

Multi-lobe torque ring ring provides positive make up shoulder to increase torque capacity when installed in standard API - Buttress Threaded Connections (BTC). This increased torque capacity keeps pins and coupling used in API casing and tubing connections from being overstressed in drilling thereby reducing tubular connection damage.

Wear resistant couplings:

Wear resistant couplings are mainly used to protect casing from excessive abrasion during drilling. They are installed at well site with a portable hydraulic crimping tool.

Centralizers:

In CwD, centralizers provide positive centering of casing string for cementing operation in vertical and deviated wells.

Warthog:

The warthog, a casing running and reaming tool, helps in setting up casing to TD despite the presence of potential hole problems such as bridges, doglegs, sloughing formations and deviated holes. It uses mechanical and hydraulic energy to break obstructions. Three spiral helix blades help to condition hole and provide centralization for cementing.

Torque monitoring device:

Torque monitoring device located at rig floor is used to monitor connection assembly torques.

V. CHALLENGES IN CWD

Major challenges associated with CwD are as follows:

- Cost: Though CwD showed reduction in daily drilling cost in almost every area, capital investment for CwD rig is still higher. Thus, it requires cost efficient manufacturing of major CwD rig equipment like CDS and hydraulic catwalk.
- Fatigue failure: It is most likely to occur in casing string with high doglegs that cause high levels of reversing stresses on casing connections. To prevent fatigue failure, a safe number of total revolutions must be calculated in pre-job analysis.
- Gas influx (well control): Due to less annular clearance in CwD, gas influx will expand more in terms of height of hydrostatic column. Thus, it will cause sudden decrease in BHP and this situation invites more influx from formation.
- High torque and drag: As casing is larger in diameter and heavier when compared to drill pipe, the torque required to rotate the casing string to TD is often high.
- Hydraulics: As the annular clearance in CwD is very small compared to conventional drilling practices, it requires a redesigning of hydraulic. As higher ECDs are hard to manage at greater depth, it is difficult to plan the hydraulics for CwD in deeper intervals even with optimal mud rheology and reduced flow.
- Managing stick out: In retrievable BHA, the benefits of CwD are not seen until the bottom most casing reaches the formations concerned. Thus, if the directional/logging BHA extends 90 ft past the casing shoe and the RoP is 30 ft hr-1, three hours of drilling is required before any benefit of plastering effect (reduction in losses) is seen.
- Tripping Casing: Saving tripping time is prolific advantage, Bit for CwD needs to be designed in a way that it completes drilling up to a minimum casing depth in one run. Otherwise, the whole casing string must be pulled out to change the bit. Thus, proper bit selection is a prerequisite to reduce tripping time.

VI. CONCLUSION

The oil and gas industry has a long history of innovating and developing best practices for drilling in which CwD is one-step in that direction. CwD provides numerous benefits right from its commencement to oil and gas industry. The main benefits of CwD technology are the reduction of non-productive times and enhanced well control for complicated areas. This is used in several types of projects like shale oil, tight gas and mature field. The case study of CwD application in Malay basin showed that CwD can be used in drilling top and intermediate sections with trouble giving formation. When CwD becomes a wide spread practice all over the world, the present cost will lower down considerably allowing drilling to be carried out at lower prices in the future. However, improvements like, use of lighter and more durable bit, proper casing centralization and minimizing mechanical tool failure in the present system should be made to improve the performance of CwD.

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