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OVERVIEW OF THE ADVANCES IN CASING DRILLING TECHNOLOGY

A. Kerunwa[1], C. I. C. Anyadiegwu[2]

[1,2]Department of Petroleum Engineering, Federal University of Technology, Owerri.
[1]anthonykerunwa@rocketmail.com,[2]drcicanyadiegw@yahoo.com

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Abstract

An alternative option to conventional drilling is casing drilling. This technology is among the greatest developments in drilling operations. Great operational and financial challenges has confronted the conventional drilling methods, which include the cost of purchasing, inspecting, handling, transporting the drill string and also during tripping operation (that is tripping in-and-out of the drill string). The tripping in-and-out of the drill string leads to Non Productive Time (NPT) and as well contributes to well control difficulties. Casing Drilling, also known as Casing while Drilling (CwD) or Drilling with Casing (DwC) makes use of standard oilfield casing instead of drillstring. It involves drilling and casing a well simultaneously. Drilling while casing the wellbore, handles issues such as stability, lost circulation, fluids control and the need to bridge troublesome zones. In casing drilling technique, downhole tools can be retrieved, through the casing on wire-line, which implies tool recovery or replacement can take minutes against hours through conventional approach. This technique employs wireline-retrievable tools and a drill-lock assembly, thus allowing the changing of bit and BHA, electrical logging, coring and even directional or horizontal drilling. This paper focuses on advances in casing drilling and their applications. The study also discusses the constant development of Displaceable DrillShoe, DS 3, in conjunction with field trials and applications, which will further boost its capabilities, thereby pushing the frontier of casing drilling applications as well as to further improve on the casing drilling technology by the application retrievable liner drilling.

Key words: Casing drilling; NPT; DWC; BHA; Drillshoe; DLA; CDS; RLD.

1. Introduction

The conventional method of drilling a well has been affected by several challenges such as of purchasing cost, inspecting and handling cost as well as the transportation of drill string [1]. Whenever need arises for the replacement of the Bottom Hole Assembly (BHA) or when total depth is reached, a common problem is tripping in-and-out of the drill string [2]. The tripping of the drill string contributes to both non productive time (NPT) and well control difficulties such as lost circulation and wellbore instability. The Trouble Time of wells constitute the NPT of such wells and comprises stuck pipe, lost circulation, well control, mud, cement, directional, mechanical and laydown of the casing [3]. An alternative drilling technique known as Casing Drilling however, addresses these problems [4]. Casing drilling has been employed as an effective technique for minimizing the total drilling costs by reducing drilling time and drillstring problems encountered during conventional drilling process in many countries. In addition to loss of productive drilling time during tripping, unscheduled events encountered in the cause of tripping can make the drilling process even more inefficient and can lead to loss of well. While the potential savings from reducing drillstring tripping and handling times are primarily important, the savings from reducing wellbore problems may be more significant.

There are many situations where problems such as lost circulation, well control incidents, and borehole stability problems are directly attributed to tripping the drill-string and other situations where these problems prevent the drill-string from being tripped [5]. One of the key factors leading operators to this technology is the removal of time from the drilling curve [6-8]. An industry term, "non-productive time", currently is used to describe problem time, and time associated with tool failures and inefficiencies. When drilling with casing, non-productive time can be referred to as any time spent not making hole or securing the well for further drilling or production [9]. A huge challenge faced by the Oil and Gas industry is the difficulty in reducing well cost and at the same time increasing production to maximize the return on investment in well reserves. This has been achieved to an extent by applying the technology of casing drilling. Casing drilling eliminates use of drill pipes, thus reducing tripping times as well as time lost due to unscheduled events such as 'reaming' and 'fishing' [10].

In Casing Drilling, the casing transmits hydraulic and mechanical energy to the drill bit through the Drill Lock Assembly (DLA) rather than the traditional drill string. A specific drilling shoe, connected to the end of a casing string, could be used in place of the normal rotary drill bit to drill ver-tical wells [11]. Casing drilling, otherwise known as drilling with casing (DwC), is not limited to retrievable systems. It even has a simpler and less expensive application in non-retrievable systems [12]. The non-retrievable system involves a simple rotate casing system at the surface [5] and a fixed drilling bit down hole [13]. The bit is attached to the end of he casing and is usually drillable enabling it to be drilled out when the casing point is reached or left in the well at Total Depth (TD) [14]. Casing drilling system has been designed primarily for multi-well offshore platforms, multi-well operations on land, deep-water operations, and for situations requiring operators to drill through and place casing across problem formations quickly. This technology was applied successfully to drill through depleted reservoir (problems: wellbore instability, mud losses into the depleted zones) as an alternative to the underbalanced drilling, which requires special equipment [5]. In certain subsea well control situations which require pipe shearing during drilling and also in situations where the wellhead can only accommodate a few casing strings, casing drilling may not however be practicable. To further increase drilling economics, there is therefore need for a more practical technique for improving the casing drilling technology [3].

2. Casing drilling

There are two major reasons for drilling oil and gas wells: (i) to produce hydrocarbons from formations that contains the hydrocarbon and (ii) for hydrocarbon production enhancement by the injection of fluids into the formations [3]. Obtaining hydrocarbons from reservoirs were found to be complex, thus, a need for the development of adequate drilling techniques to overcome these challenges. The rotary drilling process substituted percussion (cable) drilling in the 1930s and it involves attaching drill bit to the end of a length of hollow pipe and the bit is replaced whenever it is worn out [15]. The necessity to cut down on the trip time and reduce operating cost led to the introduction of casing drilling technique.

Casing drilling did not find a wide application due to the technological difficulties experienced in the late 19th century and a major part of the 20th century [16]. The first patent of casing drilling dates back to 1890, which involved a rotary drilling process for drilling the well with the casing and afterwards retrieving the hydraulically expandable bit [17]. Another patent was introduced in 1926, which included a retrievable and re-runnable casing bit. The advantages of this patent were the elimination of drill pipe, reductions in overall drilling time, stuck pipe, crew and drilling costs. Other benefits included application of few casing string, decrease in accident occurrence on the rig and the ability to drill every foot in the well [18]. However, the first extensive work on casing drilling was accomplished by Brown Oil Tools Company in the 1960s. This patent developed a casing drive system which comprised down hole and surface tools which were used to drill with the casing and retrievable bits [17].These components included casing centralisers, wire line retrievable drilling assembly, under reamer, casing drive tool and top drive. This patent, like the works that preceded it, was not successful due to the unavailability of the required technology [18]. Interestingly, the patent encouraged the development and commercialization of the top drive [4]. Tesco Corporation Ltd. eventually developed a casing drive system in the late 1990s, which was approved by the drilling industry. This system has been successful in reducing well costs and eliminating NPT [17]. Cost savings result through the elimination of purchasing, handling, inspecting, transporting, and tripping the drillstring while reducing hole problems that are associated with tripping. In addition, signifycant savings can be gained through a reduction of rig equipment needs and operating costs. Although modest savings may be achieved by reducing drillstring tripping and handling times in trouble-free wells, savings incurred through a reduction of hole problems can become far more substantial. The casing drilling system can reduce these incidents by eliminating tripping operations and providing a drillstring that is less prone to vibrations [40].Casing drilling involves the simultaneous drilling and casing of well with a casing string [17].The casing string replaces the drill pipe and other drill string components used in conventional well drilling. The casing is usually put into rotary motion and cemented in the well at the total depth (TD) [18]. It is imperative to note that the grade, size and weight of the casing string used in this process is not different from the casing set in place after drilling a ell traditionally [17].

2.1 Casing drilling systems

The casing drilling process eliminates the conventional drillstring by using the casing itself as the hydraulic conduit and means of transmitting mechanical energy to the bit [5]. Casing drilling can be employed in a number of ways but can be categorized into two main groups namely, retrievable and non retrievable systems [3]. Figure1 shows the BHAs for the two systems as well as the conventional drilling method.

2.1.1 Retrievable drilling with casing system

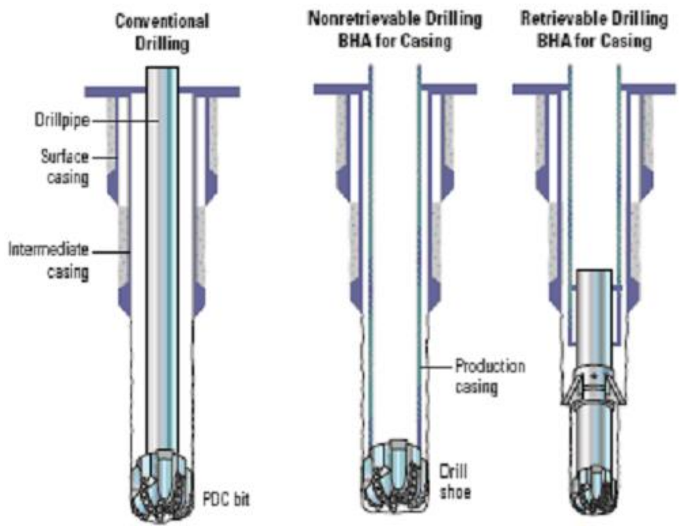

Figure1 Conventional drilling and casing drilling BHAs [3]

The retrievable system is made up of a BHA connected to the base of the casing string and stretching beneath with a pilot bit and an under reamer [17]. It also consists of a wire line winch, which is used to retrieve the drilling assembly. This enables the pilot bit to be replaced or kept outside the hole before cementing operation is done. This retrievable system, which could be used in vertical drilling, is the only practicable option for directional wells [13]. The size of casing used while drilling directionally determines the achievable build up rates. Table 1 shows the higher limits of the normal build rates attained with varying sizes of casing strings based on their fatigue limitations [17].

Table 1 Curvature for drilling with casing [17]

Casing Size (in)	Casing Weight (ppf)	Casing Grade	Max. Curvature
5.5	17	P110	13
7	23	L80	8
9.625	36	J55	4.5
13.375	54.5	J55	3

Tools used in retrievable casing drilling

Casing drilling is carried out with the aid of surface and downhole tools in which the standard oilfield casing is simultaneously used in drilling and casing of the well [19]. The descriptions of the tools are found below as written:

Casing drive systems

The requirements for turning the casing are identical to those for conventional drilling. The hoisting equipment must hold the weight, apply rotational torque and contain pressure [7]. Rotary drilling with casing requires a method of connecting the top drive to the casing, to drive the casing string [9]. The casing drive system (CDS) connects the casing string to a top drive without screwing into the top coupling. The use of casing drive system accelerates the casing handling process and also removes one make/break cycle, thus avoiding damage to the casing threads. Tesco Corporation Limited casing drive system (CDS), also known as casing quick-connect is a casing running and drilling system illustrated in Figure 2. It contains an internal spear assembly, which acts as a fluid seal to the casing, and a slip assembly to grasp either the external part of the small casing or the internal part of the large casing [2].

Figure 2 Casing drive System [20]

Casing connections

The casing connections used in casing drilling are different from that used in conventional drilling process. Casing drilling connections are subjected to severe well conditions [21]. A suitable casing drilling connection is primarily required to withstand the torsional, axial, and bending loads experienced while drilling and at the same time allow uninterrupted passage of wire line running tools. In addition, satisfactory operational characteristics including ease of rig handling, repeat make up, and the maintenance of adequate pressure integrity after drilling need to be exhibited by the connection [15]. Casing drilling connections are provided by Grant Prideco, Hydril, Hunting Energy Services, Vam, and GB Tubulars [3]. A casing connection is shown in Figure 3.

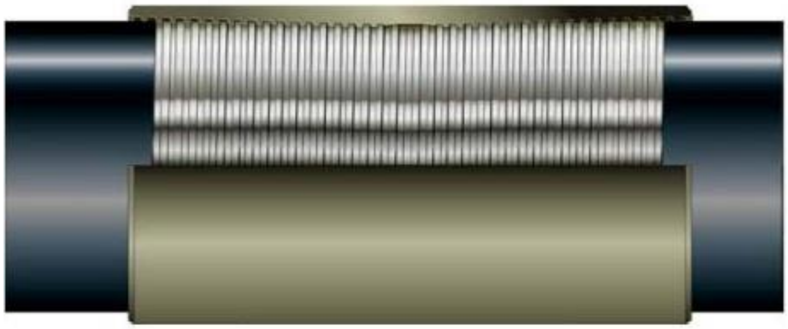

Figure 3 Grant Prideco DwC connection [22]

Top drive

The top drive connects the casing to the overdrive system and to the casing drive system in non- retrievable casing drilling and retrievable casing drilling respectively. It is located at the surface. The torque necssary to make-up the casing connections is made available by the top drive which also puts the casing in rotary motion [3]. In tight holes, the top drive is screwed in, by touching a nob which causes simultaneous rotation, reciprocation, and circulation of the drill-string, all at the same time through the full working height of the derrick. This surface tool makes-up the casing in a single smooth motion through its high horsepower [20].

Retrievable BHA

The retrievable bottom hole assembly (BHA) generally consists of a pilot bit and underreamer, but may include other tools needed to perform almost any operation that can be conducted with a conventional drill string. The pilot bit and underreamer pass through the drill-casing and drill a hole that provides adequate clearance for the drill-casing and subsequent cementing. Conventional directional tools (bent housing positive displacement motors, MWD tool, and isolation monels) and LWD tools can be suspended below the drill casing shoe for directional drilling. A conventional core barrel can be run for coring. The BHA is attached to a drill lock that fits into a full bore landing sub on the bottom of the casing in such a way that it can be retrieved with a wireline unit without needing to trip pipe out of the well. The wireline retrievable drill lock assembly is the heart of the casing drilling system. It lands in a lower section of casing consisting of a casing shoe, torque lock profi le and axial no-go and lock profile located in a specially machined collar section (Figure 4), [5].

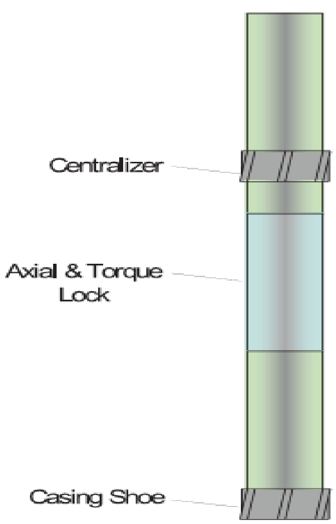

Fig.4 Exterior Casing compo-nents [5]

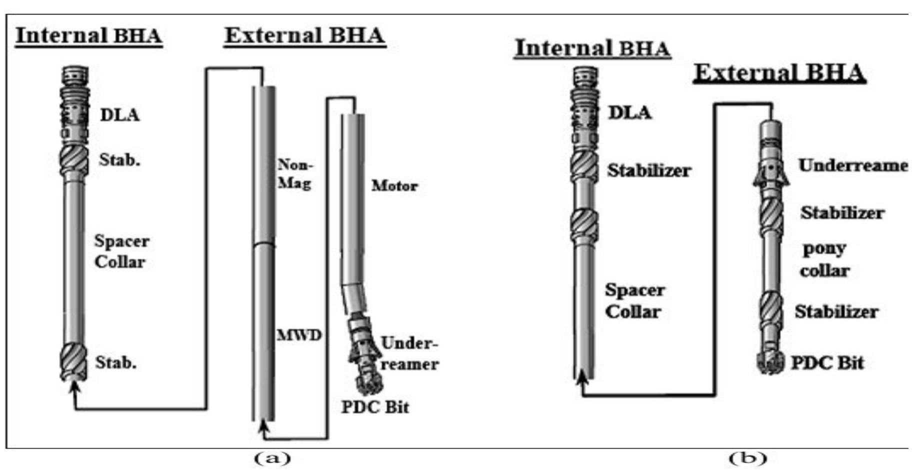

Figure 5 Retrievable BHA for (a) directional drilling and (b) vertical drilling [11]

In vertical drilling, stabilizers are added to the BHA to provide vertical control while directional drilling includes a nonmagnetic collar, steerable motor and a measurement while drilling (MWD) tool [13]. Figure 5 shows the BHA used in drilling directional and vertical well.

2.1.2 Non-Retrievable drilling with casing system

Non-retrievable drilling-with-casing (DwC) system (non-retrievable casing drilling system) milling, and cleanout based on recent developments in drillable bit technology. The enhanced performance is achieved with a new bit series that uses PDC cutting elements mounted on aluminum nose and blade supports. The design provides a premium cutting structure comparable with conventional PDC bits while reducing steel in the drill path by 80%. This steel reduction allows the DwC bit to be drilled out of the set casing without significant damage to the conventional PDC bit. The result is a long-sought balance between durability and drillability. In drilling operations from Asia/Pacific to the US Gulf of Mexico, the technology is enhancing performance in harder formations and over longer runs while reducing costs typically incurred when drilling out DwC bits [37]. When using non-retrievable casing while drilling (CwD) or simply drilling-with-casing (DwC) technology, the casing is drilled in using a drillable or sacrificial non-drillable bit that is left in hole, through which cement is pumped [12]. The non-retrievable casing drilling is a non-steerable system with a simpler and less expensive system than the retrievable casing drilling system [44]. It involves drilling vertical wells with a drill shoe connected to the end of the casing string which could be left in the ground or drilled out once the depth for setting the casing is reached [14].

Tools used in Non-Retrievable casing drilling

The tools peculiar to the non-retrievable system are overdrive system, casing drill shoe and float collar. The non-retrievable drilling-with-casing system uses the same casing connections and top drive as the retrievable drilling with casing system. The first three are briefly described below:

2.2 Casing drill shoe

The world´s first convertible casing drill shoe job is performed onshore Brunei in September 2003 during a 0.2445 m (9 5/8”) surface casing job on S-816 well in the Seria field [23]. Conventional drill bits are capable of drilling long intervals but are composed of non-drillable materials. The convertible drill shoe has a novel feature that allows the cutting structure and blades to be extruded outwards once section true depth (TD) is reached. By this process, the drill shoe converts to a cementing shoe, allowing the casing to be cemented in place. The cementing shoe and next hole section can then be drilled without interference from the casing drill shoe cutting structure and blades. Application of the extrusion process allows a more aggresive and durable cutting structure on the casing drill shoe and hence allows deeper, more resistant formations to be drilled [5]. The casing drill shoe, used in drilling formation, is a drillable casing drill bit attached to the end of the casing string [16]. Three kinds drill shoe are employed by Weatherford, namely- drill shoe I, drill shoe II (5 blade, 4 blade and 3 blade models) and drill shoe III [3]. The standard DrillShoe™I and DrillShoe™II are composed of drillable materials [23]. The major improvement in DS2 over DS1 is the use of Thermally Stabled Diamond (TSD) pellets impregnated in the aluminum blades to enhance bit durability. In addition, beyond the drift diameter of the casing and on the gage of the DS2, non-drillable PDC cutters are used instead of tungsten carbide to maximize gage protection and durability [24]. The drill shoe III was developed from the drill shoes I and II [3]. DrillShoe™III (DS III) has attributes of a conventional PDC bit [23]. The three drill shoes are shown in Figure 6. A common feature with all the drill shoes is their ability to optimize hydraulic performance with the aid of their interchangeable nozzles [25]. The table 2 below illustrates the various performances in different formations drilled by these drill shoes, their sizes, compressive strengths, cutting structures, number of blades and the casing strings attached to them.

Figure 6 Drill shoes I, II and III. The size of each is 9⅝″ x 12¼″ [25]

Table 2 Features of the different types of drill shoe [25]

	Drill Shoe I	Drill Shoe II (3 Blade)	Drill shoe II (4 Blade)	Drill shoe II (5 Blade)	Drill Shoe III
Formation	Very soft and soft unconsolidated formations	Soft to medium soft formations	Soft to medium soft formations	Soft to medium soft formations	Medium to medium- hard formations
Compressive strength (psi)	Cutting Structure (On Casing Body)	2000	7000	7000	15000
Cutting Structure (On Casing Body)	Carbide	Thermally stable Polycrystalline (TSP) diamond	TSP diamond	TSP diamond	Carbide
Cutting structure (drillable core)	Dense, thin layer of tungsten carbide	Polycrystalline Diamond Compact (PDC)	PDC	PDC	PDC on steel blades
No. of Blades	3	3	4	5	5 through $9^5/_8$ x $2^1/_4$ could also have 6
Sizes (Inc)	$9^5/_8$ to 20	$4^1/_2$ to 30	$4^1/_2$ to 30	$13^3/_8$x 17, 18⅝ x 21	7x$8^1/_2$,$9^5/_8$x$12^1/_4$
Casing String Attached	Conductor and surface	Surface or intermediate	Surface or intermediate	Surface or intermediate	Surface or intermediate

2.3 Overdrive system

A major boost to the safety, efficiency and performance of well drilling operations is represented by the OverDrive system. Integrated with any top drive, the technology combines conventional power tongs, bails, elevators, weight compensator, torque-turn/monitoring, and fill-up and circulating tools into one system. Safety is improved by remote-control capabilities and reduced personnel and equipment requirements. The OverDrive technology extends the functionality of the rig's topdrive from drillpipe to casing, enabling simultaneous rotation; reciprocation/push-down; and circulation of the casing string. This capability provides a significant advantage in reaching total depth in high-angle, extended-reach and problematic wellbores [26]. The heart of the overdrive system is the TorkDrive tool. With the aid of the rotational power provided by the top drive, the TorkDrive tool makes up or breaks out the casing thereby performing the duties, which would have required equipment, scaffolding and personnel on the rig floor. The TorkDrive tool is capable of circulating, reciprocating and rotating the casing, thereby decreasing any potential of Differential sticking and other issues resulting to NPT [25]. Figure 7 shows the overdrive system.

2.4 Float collar

A component installed near the bottom of the casing string on which cement plugs land during the primary cementing operation[27]. The float collar (Figure 8) and the drill shoe are usually made up to a casing joint before transporting to the drilling location. After drilling to the total depth (TD), the cementing operation can commence at once since the float collar is already installed within the drill string throughout the drilling operation [9]. This approach attains a single-trip procedure, which significantly reduces operational costs and time [7].

Figure 7 Overdrive system [25]

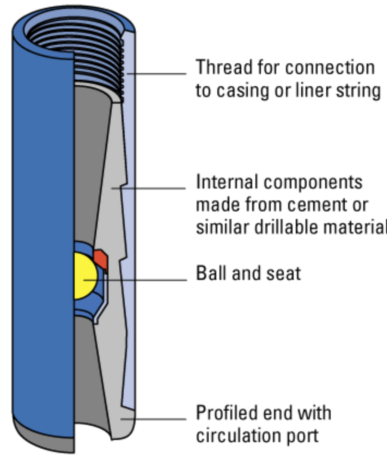

Figure 8 Float collar [27]

2.5 Casing drilling rig

Casing drilling can be implemented either with a specially developed drilling rig or by a conventional rig modified for casing drilling. To date, the system has been used only with a rig designed specifically to improve the entire system and to maximize the efficiencies of casing drilling [15]. One of the key components of a rig is the casing drive system (CDS) which provides safe, non-threaded connection between top-drive and casing string [38]. Compatibility between the rig and the casing-driving tool is of great importance to ensure the casing is firmly held and can be picked up, rotated, slacked off and packed off to maintain circulation [28]. The conventional rig is principally modified to incorporate an additional mud pump and enhancement on the gas-handling and well- control equipment. These improvements are necessary for safe handling of large influx of gas by the rig in natural fractures when high-pressure gases are encountered. A casing clamp is also incorporated in the rig for its capability enhancement to effectively and efficiently drill with casing [3].

Figure 9 Casing drilling rig [3]

On the conventional rig, the top drive is screwed to each casing joint with a casing thread crossover. It needs the making up and subsequent breaking out of the casing thread before the final make up. The thread is thus exposed to increased risk of damage [29]. Figure 9 below shows a rig designed by Tesco Corporation Ltd. The rig has topdrive and wireline incorporated in it for running and retrieving the downhole tools as well as a drive system for constant rotation of the casing [3].

2.6 Designing a well for casing drilling

In many ways designing a well for casing drilling is similar to designing a conventional well. One significant difference is that the casing is subjected to additional stresses while casing drilling [5]. The integrity of a casing is affected by a number of factors which can be addressed by the conventional drilling technique. Fatigue, hydraulics, buckling, torque and drag demand a lot of attention [3]. Figure 10 shows some of interactions that affect the integrity of casing used for casing drilling [5].

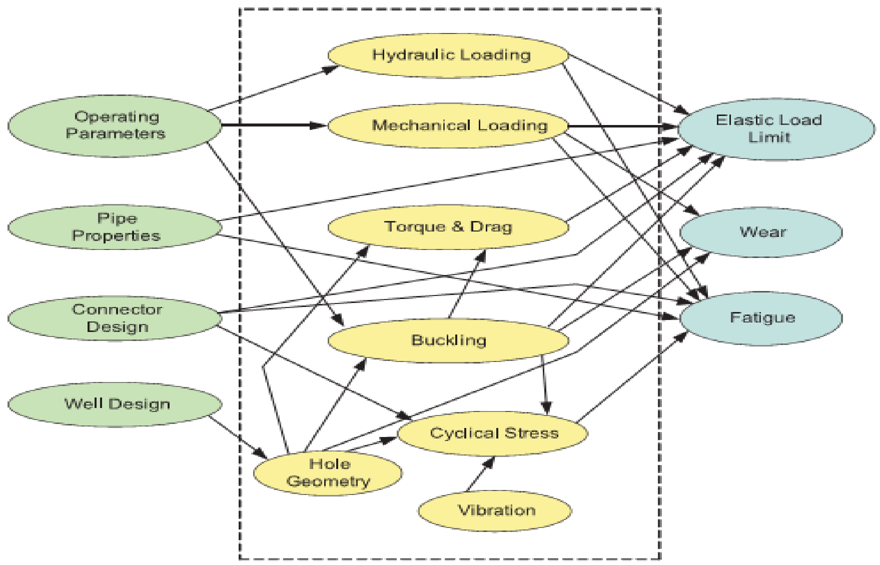

Figure 10 Interactions affecting casing integrity for casing drilling applications [5]

2.7 Fatigue

Cyclical loading at stress levels is the main cause of Fatigue failures. They are much lower than the elastic limit. Whenever, there is uninterrupted loading, a little crack starts to show at the zone of localized high stress and it spreads all over the whole body until the left cross sectional area is no more adequate to carry the static load. Fatigue failures are usually susceptible to local conditions and are normally statistical. Drill string failures arise from oscillatory bending loads. They are mainly located at the bottom of the drill string and not at the upper segment where the static tensile stresses are greatest. Sometimes, a fatigue crack is preceded by the final rapture. Generally, these failures are situated either in the slip region of the drill pipe or within the threaded portion of the connection [3].

2.8 Buckling

A significant difference between drilling with a conventional drill-string and casing drilling is that drill collars are not used to provide weight-on-bit [5]. The bottom of the casing is capable of accommodating restricted compressive load prior to buckling [30]. Buckling occurs when the compressive load and casing/hole geometry create a sufficient bending moment so that the casing becomes unstable. After it buckles (becomes unstable), it is incapable of supporting the compressive load without lateral support, but this does not mean that there is a structural failure. The borehole wall surrounding the casing provides lateral support to limit the lateral deflection for any given set of parameters. There is nothing inherently destructive in the fact that the casing buckles, but the buckling causes two effects that may be detrimental. First, the lateral contact forces between the drill-casing and borehole wall can cause wear on the casing and will increase the torque that is required to rotate the casing. Secondly, the buckling causes the casing to assume a curved geometry within the borehole that increases the stress in the pipe and may increase the tendency toward lateral vibrations. For casing drilling applications it is important to determine whether or not the casing is buckled and if so whether or not the buckling is sufficient to cause a problem (wear, high torque, or high stress) [5].

2.9 Hydraulics

Another noteworthy difference between the conventional drilling and casing drilling lies in the geometry provided by the fluid flow path. This path down the internal diameter of the casing is excessive and unrestricted resulting in a very small pressure loss within the internal diameter of the casing. The casing while drilling annulus usually provides a bigger restricted flow path causing increased pressure losses [11]. The large diameter of the casing allows for a smaller annular path for fluid to travel up the annulus. This causes an increased pressure loss and a higher ECD (Equivalent Circulating Density) at an equivalent flow rate. Casing drilling hydraulics are designed to use a reduced flow rate to produce an ECD that is only slightly higher than seen in a conventionally drilled interval. Historically, this higher ECD is considered as a negative aspect of hydraulic design due to higher susceptibility of fracturing the formation and lost circulation. However, the process of casing drilling utilizes the higher ECD to act against borehole collapse and improves wellbore stability [39].

2.10 Torque and drag

Torque and drag problems are very common during the drilling of highly-deviated wellbores [31]. The friction between drill string and the wellbore which is known as torque and drag is one of the critical limitations which do not allow the drilling industry to go beyond a certain measured depth. In deviated well construction, it is vital to monitor torque and drag to make sure they are in normal “acceptable” range. For this reason, the torque and drag modelling is regarded as an invaluable process to mitigate drilling problems in different stages of directional drilling [32]. When running casing strings, the torque created is as a result of the frictional forces acting between the casing and the wellbore. In casing drilling, the torque and drag is always higher than that of conventional drilling since the casing encounters some wellbore issues such as sloughing shale, differential sticking, tight-hole conditions and sliding during drilling operation. The drill pipe size and weight is less than that of the casing. To determining the suitability of a well (mostly directional well) for casing drilling, consideration for torque and drag is very important [3].

2.11 Cementing operation during casing drilling

Casing while rrilling (CWD) cementing differs from conventional cementing practices in several ways. It involves the use of casing attachments, such as centralizers, to provide good pipe standoff. During CWD operations, centralizers are required to be robust enough to drill the entire openhole section while withstanding the pipe rotation when drilling for extended periods of time. This casing hardware must keep its standoff capability while staying in place and in one piece. The float equipment is different from that used in conventional cementing operations. Where the possibility exists for more than one bit to reach the next casing point, CWD must allow full-bore casing access. To pull and run BHAs with wireline instead of pulling out the complete casing string by single joints, this full-bore access is required. In such cases, the float equipment is installed once the casing reaches the casing setting depth. When installing the floating equipment with casing on bottom, the float equipment will be exposed to high circulation rates for considerable time while drilling the entire hole section. In the retrievable system, where the bit has to be replaced before drilling to the next casing point, the CWD process requires full-bore access to enable the retrieving and running of the BHA through the ID of the casing. This makes it unsuitable to use floating equipment [33]. The initial solution to this challenge was to pump a wiper plug ahead of the cement and then a latch down cement plug behind the cement, which lands in the DLA locking profile. The problem with this procedure was the risk of the cement plug landing improperly [30]. With advance in technology, a pump down float valve was launched and landed in the same profile nipple used by the DLA. The valve serves as a conventional float collar to retain the back pressure from the cement job after bumping the cement plugs [34]. However with the non-retrievable system, the drill shoe is drillable and a float collar is already run on the casing string. This enables the cementing operation to commence immediately the total depth of the well is reached [7].

2.12 Limitations of casing drilling

In fields where casing drilling has been applied, the technology has proved effective and efficient as a drilling technique. However, the method is plagued with some difficulties. These challenges are addressed below.

2.12.1 Casing connection

Hegler *et al.* [35] pointed out that there three key requirements for casing drilling connections namely, the connection must economical, be fatigue resistant and be able to withstand high torques. Lu [21].wrote casing connections proved ineffective in withstanding high torque, fatigue and combined loads during bucking in casing drilling. Tessari and Madell [15] averred that a possible solution to this problem is to reduce the buckling to as low as practicable with decreased hole sizes while drilling the well with a torque reasonably low as well as low bit weight. Finite Element Analysis (FEA) can be used to evaluate the performance of connection before casing drilling [22]. Hegler *et al.* [35] again posited that Finite Element Analysis (FEA) by means of numerical techniques to determine stress profiles in connection designs is a shared resource between both drill pipe and casing connection designers. Stress distributions in connections can be determined by applying simulated loads in FEA. Well plan torque and drag module using landmark software can be employed to analyze torque and drag [3].

2.12.2 Formation evaluation

In casing drilling, a section is drilled before the actual casing of the wellbore [30]. This enables the open hole not to be logged with the traditional logging tools except the casing string is winch up above the logging zone of interest. This problem can be solved by having constant logging while drilling in place i.e. logging while drilling (LWD). The nature of zone to be logged is of paramount importance and would determine if open logs are to be run outside the casing bottom or the zones of interest are logged with cased hole logs inside the casing. Core barrels and testing equipment can be used after being secured on the casing. They are also suitable for the wireline retrieving tools [3].

2.12.3 Changing the bit and BHA

BHA retrieval as been somewhat challenging with an overall success rate of about 70%. The casing bore was confined in some cases, making it difficult for the tool to get to the top of the drill lock. This problem can be solved changing the operation or through tool modifycation [30].

3. Improvements on the technology

McKay *et al.* [36] wrote the design and development work of Displaceable DrillShoe Tool, DS 3, carried out to date has yielded enormous success in producing a casing drilling tool with a "hard" cutting structure similar to that applied to standard drill bits, this allows non-drillable material to be "displaced" into the annulus to achieve drill out and continuation of well drilling and construction. As the tool is at an early stage of development it is planned that constant improvement of the tool, in conjunction with field trials and applications, will further increase its capabilities and push the frontiers of casing drilling applications. Mohammed *et al.* [3] explained that future improvement should be focused on retrievable casing drilling with emphasis on liner systems, which could be called "Retrievable Liner Drilling" (RLD). The RLD can be seen as a development in the liner drilling technology. It is like the retrievable casing drilling, which uses BHA, and can be retrieved through the casing. The retrievable liner can be applied in directional wells since it has the capability of providing directional control.

3.1 Discussion

The Displaceable DrillShoe Tool, DS 3 development, enhances the existing DS 1 & DS 2 product line by providing a more capable cutting structure offering a solution to casing drilling applications where the existing solutions do not fit. There are no limitations on the size of tool that can be produced with the design, although certain features such as the number of blades may be altered to suit diverse anticipated conditions. Several wellbore instability issues are arrested by drilling-with-liner, including minimizing lost circulation. These challenges often lead to costly non-productive time (NPT) and increased operational risk. To reach the desired objectives, operators must make decisions "outside the box" to mitigate these risks. The RLD can as well drill and case the wellbore simultaneously. This technology has its origin from the casing drilling method. Surface tools similar to those employed in retrievable casing drilling are used in RLD. Generally, the downhole tools comprise a BHA, which could be retrieved with the aid of a drill pipe after disconnecting the liner or with a wireline. The BHA is made up a rotary steerable system to give directional control for directional wells applications, positive displacement motor(PDM), assembly locking mechanism, measurement while drilling (MWD) tool, extendible bit, pilot bit and stabilizer. The BHA possess also the capability to run core while liner drilling and core bit with barrels. Figure 11 shows a well schematic for the retrievable liner drilling (RLD).

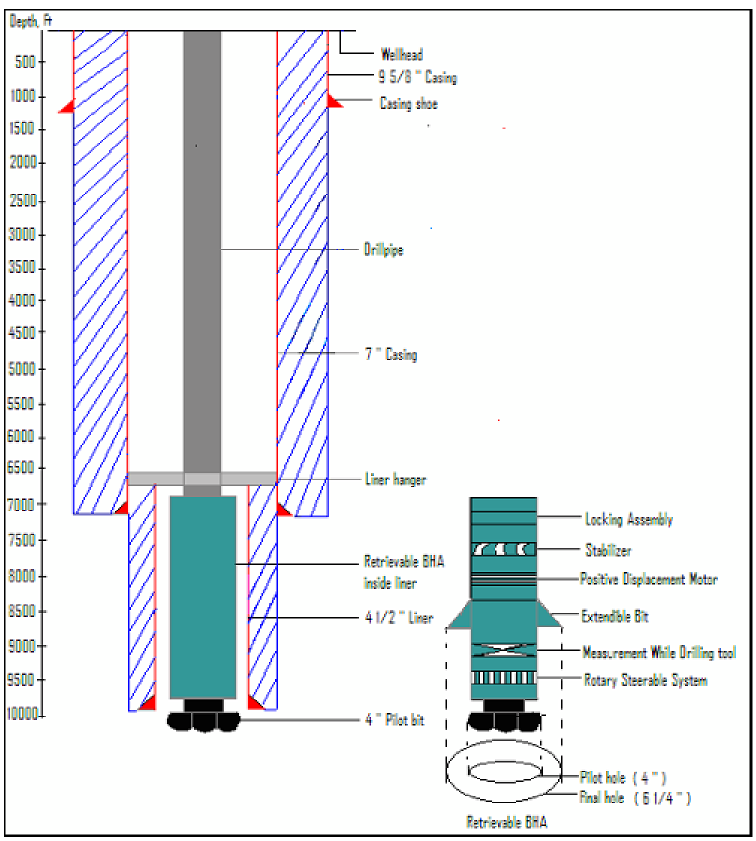

Fig. 11 Well schematic for a Retrievable Liner Drilling System [3]

4. Conclusion

From the study, the application of casing drilling technology has been discussed with its key benefits highlighted. Areas where casing drilling application has been plagued with challenge, Displaceable DrillShoe, DS 3, which provides a step change in the drilling capabilities of "cement in place" casing drilling tools was suggested for continued development, in conjunction with field trials and applications, to further increase its competence and push the frontier of casing drilling applications. The retrievable liner drilling has been identified as an alternative to the casing drilling technique. The application of this technology will result in enormous cost reduction by the well operator as well as improvement in drilling performances.

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