Nafta-Gaz 2023, no. 7, pp. 473–477, DOI: 10.18668/NG.2023.07.04

Improving well casing technology by drilling with expandable casing string

Usprawnienie technologii rurowania odwiertu poprzez wiercenie z rozszerzalną kolumną rur okładzinowych

Vugar N. Samedov, Vadim O. Bogopolsky, Magomed M. Shirinov

Azerbaijan State Oil and Industry University

ABSTRACT: This article discusses new (innovative) well completion technologies that reduce economic costs and construction time, including casing drilling, expandable casing and monodiameter technology. The advantages and disadvantages of these technologies are considered. Casing drilling is one of the most advanced well construction methods, which prevents complications in the wellbore, due to simultaneous drilling and casing of the wellbore with casing pipes directly in the process of work. Due to the dimensions of the casing, there is constant contact with the well wall, which leads to mechanical clogging. When drilling deep, ultra-deep wells and wells with a large quantity of waste, there is a need for a large number of casing strings of different diameters, and there is not always enough varieties of pipe to provide them. One of the technological solutions for maintaining the diameter of casing strings when designing a well is the use of expandable casing pipes. Of all the advantages of using expandable tubular products, only one of them has the greatest potential – a well with a single bore diameter (Monodiameter). Monodiameter technology reduces the telescopic effect inherent in traditional designs. The possibility of combining two technologies into one, namely drilling with expandable casing pipes will lead to obtaining a well of one bore diameter (monodiameter). It is shown that the use of an expandable casing instead of a drill string is subject to greater risks than drilling with an expandable liner. Based on this, expandable liner drilling is the best option for using expandable casing.

Key words: well completion, casing drilling, expandable casing string, monodiameter technology, liner.

STRESZCZENIE: W artykule omówione zostały nowe innowacyjne technologie udostępniania odwiertu, zmniejszające koszty ekonomiczne i czas montażu, w tym wiercenie rurami okładzinowymi, rozszerzalne rury okładzinowe oraz technologię monośrednicową. Omówiono także zalety i wady tych technologii. Wiercenie rurami okładzinowymi jest obecnie jedną z najbardziej zaawansowanych metod konstrukcji odwiertów, zapewniającą zapobieganie komplikacjom w odwiercie z powodu jednoczesnego wiercenia i rurowania przy pomocy rur okładzinowych w trakcie pracy. Ze względu na wymiary rur okładzinowych następuje stały kontakt ze ścianą odwiertu, co prowadzi do mechanicznego zapychania się. Przy wierceniu odwiertów głębokich, ultragłębokich oraz odwiertów z dużą ilością odpadów potrzebna jest większa ilość kolumn rur okładzinowych o różnych średnicach, a nie zawsze dostępna jest wystarczająca liczba asortymentu rur. Wykorzystanie rozszerzalnych rur okładzinowych jest jednym z rozwiązań technologicznych dla utrzymywania odpowiedniej średnicy orurowania przy projektowaniu konstrukcji odwiertu. Ze wszystkich zalet stosowania rozszerzalnych produktów rurowych tylko jeden z nich ma największy potencjał - odwiert o pojedynczej średnicy (monośrednicowy). Technologia monośrednicowa zmniejsza efekt teleskopowy właściwy konstrukcjom tradycyjnym. Możliwość połączenia dwóch technologii w jedną, a mianowicie wiercenie z rozszerzalnymi rurami okładzinowymi doprowadzi do uzyskania odwiertu o jednej średnicy (monośrednicowego). Wykazano, że użycie rozszerzalnego orurowania zamiast przewodu wiertniczego jest związane z większym ryzykiem niż wiercenie z rozszerzalnym lajnerem. W związku z tym wiercenie z rozszerzalnym lajnerem jest najlepszym wariantem w przypadku stosowania rozszerzalnych rur okładzinowych.

Słowa kluczowe: udostępnianie odwiertu, wiercenie rurami okładzinowymi, rozszerzalna kolumna rur okładzinowych, technologia monośrednicowa, lajner.

Corresponding author: V.O. Bogopolsky, e-mail: *vadim46.46@mail.ru*

Article contributed to the Editor: 21.04.2023. Approved for publication: 30.06.2023.

Introduction

At present, the state of the world oil and gas industry is characterized by hard-to-reach deepwater fields. There is a tendency to increase drilling depths, the length of wells and the complication of the geological conditions of the section.

To develop the reserves of offshore oil and gas fields, the most modern technologies for drilling and operating wells are needed.

Therefore, on the one hand, those areas of scientific and technological progress that will contribute to a significant reduction in capital costs in the implementation of design solutions are of paramount importance. On the other hand, the development of new progressive directions in the development of drilling equipment and technology that can solve the emerging difficulties associated with increasing the depth of wells, involving new areas in the development, and the increasing complexity of the geological conditions of drilling (Kane, 2014) is of particular importance and urgency.

Intensive development of the latest technologies makes it possible to reduce economic costs and time for well construction, including casing drilling, expandable casing technology and monodiameter.

Overview of available technologies

Casing drilling is one of the most advanced well construction methods, which provides prevention of complications in the wellbore due to simultaneous drilling and casing of the wellbore with casing pipes directly in the process of work. The casing pipe has a larger diameter compared to drill pipes. Due to the dimensions of the casing string, there is constant contact with the well wall. Because of this interaction, the effect of mechanical clogging is noted – the cuttings are pressed by the casing pipe into the well walls, pores and cracks are clogged, and in the case of absorption, they decrease or are completely eliminated (Figure 1).

Since the casing pipes are constantly in the well, the casing of problem intervals occurs immediately during the drilling process. Due to mechanical clogging, there is a reduction in non-productive time, which occurs due to the following downhole problems:

- shedding swelling of clays;
- narrowing of the wellbore;
- plugs in the wellbore;
- loss of circulation;
- large diameter of the conductor interval, which makes it difficult to remove cuttings from the annulus;
- formation damage in pay zones;

Figure 1. The effect of mechanical clogging during drilling on casing (comparison: conventional pipes on the left/casing pipes on the right) (Courtesy of Schlumberger Comp.)

Rysunek 1. Efekt mechanicznego zapychania się rur okładzinowych w czasie wiercenia (porównanie: rury konwencjonalne po lewej/rury okładzinowe po prawej) (dzięki uprzejmości firmy Schlumberger)

- stuck pipes (Drilling on casing string, Technology Allegro XCD-Pro).

The advantages of drilling wells on the casing string and liner are associated with the absence of the need for the process of lowering and retrieving the drill strings, as well as running the casing strings.

The benefits are as follows:

1. Reduced time costs. With this method of drilling, the time spent on tripping operations with drill strings and on running casing pipes and flushing them is eliminated. It also reduces the time spent on expanding the wellbore and drilling in this direction. On average, drilling time savings are about 18% to 50%.
2. Reducing the degree of deterioration in the quality of the wellbore. This is also achieved due to the absence of the need for tripping operations since the casing string is always at the bottom of the well.
3. Absence of complications of the drilling process, which are associated with pulsation or the effect of swabbing (absorption of drilling fluid) the formation of grooves in the walls of the well.
4. Reduction of depreciation costs, which is achieved due to the absence of components of the standard layout of the bottom of the drill pipes.
5. Improved hydraulic parameters. When drilling with casing and liner, the cross-sectional area of the annular channel between the outer diameter of the casing and the inner diameter of the well is significantly reduced. This advantage contributes to an almost 2-fold increase in velocity

in the annulus (Drilling of the wells on the casing string and liner).

The main disadvantages of casing drilling are:

1. It is necessary to limit the speed of drilling to minimize the risks of hydraulic fracturing.
2. Due to the small annular space between the casing string and the borehole wall, with a large number of cuttings, the ECD increases, which can lead to hydraulic fracturing and losses.
3. It requires the purchase of casing pipes with a special threaded connection that can withstand high torsional loads, with a high degree of metal strength.

When drilling deep, ultra-deep wells and wells with a large quantity of waste, there is a need for a large number of casing strings of different diameters, and there is not always enough pipe assortment to provide them.

In addition, complicated conditions encountered in the drilling of exploratory wells (instability of the well walls, incompatibility of drilling conditions along formation and hydraulic fracture pressure gradients, saline formations or subsalt formations) require additional running of casing strings, which leads to a decrease in the diameter of the wellbore, since the casing string for liquidation complications should be set above the planned level. Thus, the solution of these problems, using traditional technologies with multi-column structures, is becoming more difficult and more capital-intensive, especially in the presence of complex geological conditions in the section, as well as in deep and deep water drilling. One of the technological solutions for maintaining the diameter of casing strings in the design of well is the use of expandable casing pipes (Shvakov, 2007).

Currently, developments in the field of expandable tubular products are conducted by foreign companies: Halliburton, Schlumberger, Enventure, Weatherford, Baker Oil Tools, READ Well Services.

The principle of expanding casing pipes is based on the technology of hydraulic expansion of the profile part of the pipes and mechanical expansion, which is based on cold working (i.e., at a temperature not higher than the bottom hole) of steel pipes in the wellbore to the required diameter using expanders.

For expanding products, pipes with contact welding are used, which ensures the continuity of the wall thickness and leads to better expansion (Shvakov, 2007). Expandable pipe systems currently in use function as liners and patches (Figure 2).

However, of all the listed types of application of expandable tubular products, only one of them has the greatest potential – a well of one bore diameter (monodiameter) (Fischer, 2006; Aksenova et al., 2016). The idea is to install expandable liners one after the other in the well.

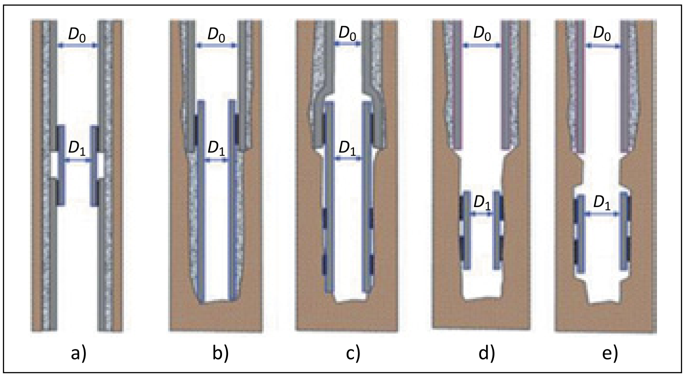


Figure 2. Types of expandable systems; a) casing patch, b) open hole liner, c) liner for an open wellbore without loss of diameter, d) open hole patch (reduced inner diameter), e) patch for an open wellbore without reducing the internal diameter

Rysunek 2. Typy systemów rozszerzalnych: a) łata orurowania, b) lajner w otworze niezarurowanym, c) lajner w otwartym odwiercie bez utraty średnicy, d) łata w otworze niezarurowanym (zmniejszona średnica wewnętrzna), e) łata w otworze niezarurowanym bez zmniejszenia średnicy wewnętrznej

The monodiameter technology reduces the telescopic effect inherent in traditional designs, which makes it possible to reduce the diameters of the upper sections of the casing strings, eliminate cases when the strings are not brought to the design depth, quickly close zones with abnormal pressure and various complications, which makes it possible to conduct further trouble-free drilling without reducing the internal volume of the well.

All this contributes to improving the quality of well construction, increasing productivity and reservoir recovery, as well as reducing capital costs (Jabs and Tools, 2004; Abusal, 2021).

In addition to direct economic benefits compared to traditional multi-string wells, the technology will allow drilling wells to great depths, wells with a large bottomhole deviation from the vertical in difficult mining and geological conditions, building wells in nature protection zones, etc.

The economic effect of the large-scale introduction of monodiameter technology is estimated at about 30–50% of the cost and time of drilling at the present time and is based on a reduction in the required amount of materials (cement, metal, drilling fluid), cuttings removal and a reduction in drilling time (Campo et al., 2003; Waddell, 2005).

The advantages of the technology include the following:

- transition to a new well design, which will reduce the diameter and number of running strings;
- reduction of drilling waste, especially cuttings, reduction of the required number of materials (cement, drilling mud, metal);
- the possibility of using smaller equipment in terms of geometric parameters and power (submarine equipment, riser, drilling rig, etc.);

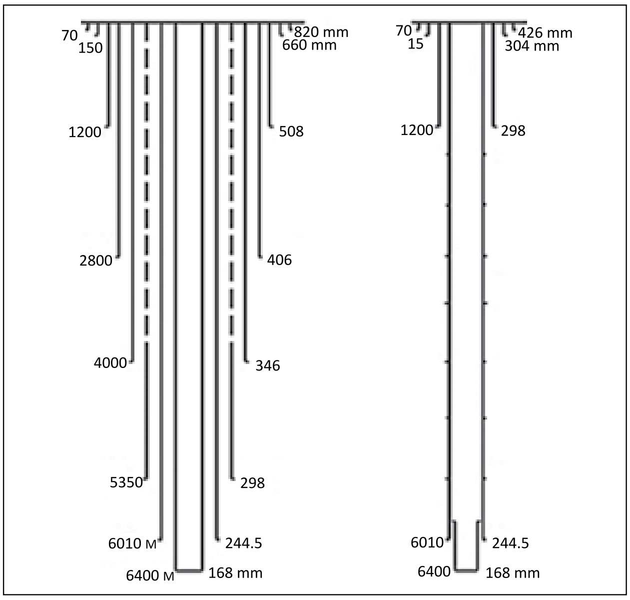


Figure 3. Standard well design on the Bulla-more block and its design of monodiameter tools

Rysunek 3. Standardowa konstrukcja odwiertu na bloku Bulla-more i jego konstrukcja monośrednicowa

- reduction of energy costs and emissions into the atmosphere;
- possibility of construction of wells with ultra-long reach from the vertical.

Thus, Mammadtagizade et al. (2012) presented the results of computer simulation for the Bulla-more oil and gas field according to the traditional design and according to the monodiameter design (Figure 3). Calculations showed that the cost reduction occurs as a result of a decrease in the volume of drilled cuttings by 55.6%, the mass of casing strings by 74%, and the required volume of cement slurry by 87.8%.

When using the monodiameter technology, there will be a decrease in the load on the rig from the weight of the heaviest string of 76%, which will make it possible to increase the length of the wellbore along the tool.

However, it should consider all the risks that may arise in the process of drilling and expansion of the casing string.

Shen and Aadnoy (2008) addresses some questions that need to be answered at the right time:

- How can this combined method work?
- Are expandable casing connections strong enough to drill with casing?
- How does expandable casing behave after drilling?
- What properties of expandable casing should be considered?
- Is the solution cost competitive?
- Are there any restrictions in this process?
- What are the risks of the combined method?

There are two technologies for casing drilling, the first one, when the casing string is used instead of the drill string, and the second one, drilling with a liner.

In the first case, the casing is rotated along with the fixed or retrievable bit, similar to rotary drilling on a drill string.

In the second case, when drilling with a liner, the casing string is suspended, moved, and rotated by the drill pipe.

During drilling on an expandable casing string, the following loads act on it:

1. tension from the own weight of the pipe string;
2. compression during partial unloading or installation of the column at the bottom of the well;
3. external crushing pressure created by the hydrostatic pressure of the liquid column in the annulus or rock pressure;
4. internal excess pressure acting in the pipe string during cementing or flowing wells;
5. torque during rotation of the column.

Considering these loads, it can be concluded that the use of expandable casing instead of a drill string is riskier than liner drilling.

Conclusions

Given these stresses, it can be concluded that using expandable casing instead of drill string is riskier than drilling with a liner.

Thus, liner drilling is the latest innovation in the use of expandable casing.

The liner drilling operation can be carried out in two or one pass.

The expandable liner is suspended on the drill string and, rotating with it, performs the function of mechanical sealing of the borehole walls, reducing the risk of caving and drilling fluid intake. Once the drill string reaches the target depth, it is disconnected from the liner and lifted to the day surface. The assembly, which includes an expanding device, is lowered, the cement slurry is injected, and the liner is expanded.

In the second variant, the expanding tool is mounted on a drill string and lowered together with the liner, which allows executing wellbore anchorage during one tripping procedure.

It should be noted, that, to get a wellbore of the same diameter (monodiameter), the reaming device must have a double reaming mechanism. This is necessary so that the lower part of the liner has an inner diameter larger than the inner diameter of the whole liner by twice the thickness of its wall after reaming.

References

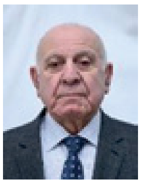
Abusal Y.A.Y., 2021. Prospects for the development of technology for the use of expandable pipes for casing wells with mono-diameter casing. *Ufa State Petroleum Technological University*.

Aksenova N.A., Tagirov Ya.A., Lubyagina N.V., 2016. Analysis of the possibility of using expandable systems to create well structures with casing pipes of the same diameter. Experience, current

problems and prospects for the development of the oil and gas complex. *Materials of the All-Russian scientific and practical conference of students, postgraduates and scientists dedicated to the 35th anniversary of the TIU branch in Nizhnevartovsk Tyumen TIU*.
Campo D., Williams Ch., Filippov A., Cook L., Brisco D.P., Dean B., Ring L., 2003. Monodiameter Drilling Liner – From Concept to Reality. *SPE/IADC Drilling Conference,Amsterdam, Netherlands, February 2003*. DOI: 10.2118/79790-MS.
Drilling of the wells on the casing string and liner. <https://spravochnick.ru/neftegazovoe_delo/burenie_skvazhin_na_obsadnoy_kolonne_i_hvostovike/> (access: March 2023).
Drilling on casing string, Technology Allegro XCD-Pro. <https://www.slb.ru/services/drilling/tools_services/allegro-xcd-pro/> (access: March 2023).
Fischer P.A., 2006. A well of one through diameter expands the possibilities. *Oil and Gas Technologies*, 11.
Jabs M., Tools B.O., 2004. Using expandable metal technology to create a monobore well. *OTC*, 16670: 3–6.
Kane S.A., 2014. Modern technical means of controlling the trajectory of directional wells. Textbook, allowance. *Ukhta State Technical University*.
Mammadtagizade A.M., Shmoncheva E.E., Babaev E.F., 2012. Research of modern technology and techniques of well fastening based on monodiameter technology. *Bulletin of the Azerbaijan Engineering Academy*, 4(2): 43–49.
Shen H., Aadnoy B., 2008. Feasibility Study of Combining Drilling with Casing and Expandable Casing. *SPE Russian Oil and Gas Technical Conference and Exhibition, Moscow, Russia*, DOI: 10.2118/116838-MS.
Shvakov A., Volkov R., 2007. The latest promising developments: monodiameter technology. <http://www.oilcapital.ru/edition/technik/archives/technik/technik_05_2007/115714/public/115728.shtml/> (access: March 2023).
Waddell K., 2005. Advances in Single-Diameter Well Technology: The Next Step to Cost-Effective Optimization. *SPE Annual Technical Conference and Exhibition, Houston, Texas*. DOI: 10.2118/90818-MS.

Vadim Oskarovic BOGOPOLSKY, Ph.D.
Assistant professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and İndustry University
16/21 Azadliq Ave, Baku, Azerbaijan
E-mail: *vadim46.46@mail.ru*

Vugar Nurakhmed SAMEDOV, Ph.D.
Assistant professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and İndustry University
16/21 Azadliq Ave, Baku, Azerbaijan
E-mail: *samedovvugar@mail.ru*



Magomed Makhmud SHIRINOV, Ph.D.
Assistant professor at the Department of Oil and Gas Engineering
Azerbaijan State Oil and İndustry University
16/21 Azadliq Ave, Baku, Azerbaijan
E-mail: *shirinov46@mail.ru*