Analysis and choice of construction of the detachable core assembly for casing while drilling

V G Gorelikov\(^1\), Yu V Lykov\(^1\), E N Rabota\(^1\), A M Uspekhov\(^2\)

\(^1\)Saint-Petersburg Mining University, 21 Line, No.2, 199106, Saint-Petersburg, Russia
\(^2\)FKU UPRDOR «Moskva-Nizhny Novgorod», Square Lenin, No.9a, 142403, Noginsk, Russia

E-mail: kaf_mech11@mail.ru

Abstract. The distinguishing features of drilling the upper strata of sedimentary rocks are considered. Based on the methods and technical means for drilling wells while casing, the main directions for the development of a removable core drill that can be used for drilling with a casing string are established. The results of field testing of the detachable core for drilling while casing are shown.

1. Introduction

Drilling of geological exploratory wells from the earth’s surface is strongly related to the dismembering/dismantling of the upper strata with different unstable sedimentary rocks. Usually these strata contain clay(mud), sand of I-IV drillability grades, gravel deposits with boulders and debris of rock formations of IX-XI drillability grades. Often the rocks are heavily bound and possess the ability to slip and collapse as well as become incredibly frozen. As a result, upon installation of the casing pipes (casing) the repeated dismembering and widening of the narrowed well hole should be taken into serious consideration.

In choosing the technical means and the well drilling technology in the upper strata of the unstable sedimentary rocks, it is essential to take into account the fracture, hardness and rock resistance which determines the degree of their connection [1,2,3,4]. Based on these factors, the drilling methods in the upper strata of the unstable sedimentary rocks can be highlighted in three ways:

1) casing after drilling;
2) casing while drilling;
3) combined drilling method.

Casing after drilling requires the dismembering of the upper strata of the unstable rocks and the casing of the wellbore is carried out afterwards. Drilling in this instance is carried out with the use of drill pipes and a simple core barrel. The drilling fluid (washing liquid) used here is the mud solutions [2,5,6].

Casing while Drilling can be performed with rotary drilling and rotary percussive drilling. In rotary percussive drilling, elements and components such as ODEX, Symmetrix, Superbit, Elemex, TUBEX, DTH-ROX, OBS [10, 11, 12, 13, 14, 15] are used. The general functionality principle of this method is
based on the destruction of rock/rock particles using a down-the-hole hammer with detachable boring head (drill bit). The drilling process is carried out with an outer barrel made up of drill and casing pipes. The drill pipes rotate the detachable boring head and the down-the-hole hammer is meant to transfer impact load to the casing that will lead to a downward motion. The working position of the drill bit leads to the creation of the bottomhole, with a diameter equal to the diameter of the casing pipes. Upon completion of drilling the detachable bits alongside the drilling pipes are turned in the opposite direction and transported through the casing and extracted to the surface (rig floor). Movement of the casing pipes occurs as a result of the impact load of the down-the-hole hammer. The casing during this process doesn’t rotate, allowing the reduction in the loss of energy due to friction that occurs between the casing pipes and wellbore walls. The difference between these evaluated accessories are nonexistent and lies in the construction of the detachable boring heads (drill bits).

In casing while drilling only the use of casing columns can be considered [7,8,9,13]. Here its rotation is transferred to the drill bit. In this process one can highlight the NKS-93 complex and special projectile called Advancer, a product of Borat Longir Firm. The distinctive feature of this drilling assembly is the presence of casing pipe on the float shoe 1 (specially design rock cutting tool). Rotation from the casing through the latches of the coring assembly is transferred to the roller bit 2 (or the coring bit). Overshot and drawworks are used for lowering and raising detachable instruments. The casing depth of the well will be determined by the durability of the fixed float shoe. The NKS-93 complex does not use a float shoe. The detachable diamond instrument (drill bit) ensures the simultaneous drilling and extension of the casing pipes (Figure 1).

The main elements of the core assembly are: 1 - valve head (for lowering and retrieving of core assembly); 3 – casing pipe; 9 - outer barrel. From the casing string through the outer core tube and the gripping unit 8, the rotation is transmitted to the removable three-sectional expander 5 and the core tube 6 with the pilot bit 7.

![Figure 1. Diagram of the NKS-93 core assembly in the working (A) and transport position (B)](image)

1- valve head; 2 - collar; 3 - casing pipe; 4 - ring; 5 - three-sectional expander; 6 - core tube; 7 - pilot bit; 8 – gripping unit; 9 - outer barrel; 10 - buttress assembly; 11 - stopper

The combined method involves two series of operations. Initially, the rotary drilling is carried out with the usual scheme (use of normal drill pipes). Upon arrival in the zones with the unstable rocks, the drill
pipes are extracted and the rest of the drilling operations is carried out with the inserted down-the-hole hammer and detachable drill bit. In essence, the locally adapted complex ODEX can be used without significant changes in the machine operation and drilling crew.

2. Results and Discussion

The positive feature of casing after drilling is the simplicity of construction of the drilling stings and the rock-destruction tool. Here, rotary drilling or rotary percussive drilling can be carried out with or without the use of mud solutions. This type of drilling does not necessarily require the use of powerful rotation units. The presence of a cased wellbore section with an initial diameter of 112-132 mm and a final drilling diameter of 93-76 mm can be a downside of this drilling method. Also, the installation of casing pipes can be time consuming with this type of drilling (about 50% of the entire time of well construction) which can result to the large consumption/expenditure of casing pipes and can subsequently lead to the limitation of the drill bit rotation speed when drilling the primary rocks.

Casing while drilling requires special complexes. The major downside of this type of drilling complex is highly noticeable in rotary percussive drilling where casing pipes are required to possess increased strength which can be achieved by increasing the thickness of the casing. In addition, the presence of the retractable bit might not guarantee core sampling along the entire drilling interval. Also, the use of a down-the-hole hammer in the drilling process makes the design really sophisticated. A distinguishing drawback is the simultaneous use of drilling pipes and casing to transfer the rotation to the bit. In addition, the design features of the complexes can lead to the deviation of the wellbore during the drilling process.

When the casing string is used to transfer the rotation to the rock-destruction tool, there is a significant drawback - the restriction on the depth of drilling due to the low torsional strength of the casing. The positive side of this drilling method is the simple design of the drill string, which is made of casing pipes. In this case, the most promising is the use of the NKS-93 core assembly. A bottomhole float shoe is not used here, and a detachable diamond tool provides drilling with a simultaneous expansion under the casing. This method is simple in execution and does not require an outer barrel, but there is a significant drawback - the restriction on the depth of drilling due to the low torsional strength of casing. Also, a significant drawback is the lack of fixation of detachable boring head on the expansion node. This leads to the fact that during the descent of the core assembly into the casing, the expanders come out of contact with the gripping unit and may not get into the casing. This will break the ring (see fig. 1).

The combined method of drilling has the same drawbacks inherent in the method of casing after drilling and for the method of casing while drilling.

3. Conclusion

1. In the practice of domestic drilling, there are no effective commercially available technical means for casing wells while drilling. Abroad, for these purposes, a number of complexes have been developed and used, the main structural elements of which are drill and casing, down-hole hammer and detachable drill bits.

2. The most effective way of drilling unstable sedimentary rock strata is by using the casing in the drilling method. At the same time, while adopting the percussive rotary drilling method it’s necessary to use casings with increased strength, and for the transfer of rotation to the detachable drill bit it is necessary to use drilling pipes. Here, the presence of the detachable drill bit does not ensure core sampling during the entire drilling period. For drilling operations, it is necessary to use the down-the-hole hammer that requires the use of special instruments.
3. The most economical and viable form of drilling in the upper unstable strata of the sedimentary rocks is the use of drilling strings, casings and detachable core assembly. The use of outer barrel likewise the use of high-power rotation units, and special extra equipment (compressors, down-the-hole hammer) are not necessary in this case. However, the downside of this method is the limitation on drilling depth due to the low torsional strength and some construction flaws of the casing.

4. The design of the NKS-93 detachable core assembly has been revised by the authors (Figure 2). Magnetic inserts are used to ensure a tight contact of detachable expanders with the gripping unit. The magnetic inserts hold detachable extenders during tripping in a fixed position. The proposed detachable core assembly provides core sampling over the entire drilling interval, expansion of the wellbore under the casing, and can freely reach the bottom of the well and be removed at the end of drilling.

![Figure 2. Column set NKS-93](image)

1 - magnetic insert; 2 - detachable extender

The core set was tested under the following geological and technical conditions: SKB-4 drilling rig; casing diameter - 89mm; drilling diameter - 93mm; rotational speed - 155-280 min⁻¹; axial load - 200-250 daN. During drilling there were sharp fluctuations in the mechanical speed (from 6 to 27m / h). This is explained by the fact that drilling was conducted on rocks of I-II drillability grades with a large number of boulder-pebble inclusions. As a result of tests, the operability of the NKS-93 column set was established. At the same time, the torque transmission unit (gripping unit) requires revision.

References

[1] Lomtadze V D 1990 Physicomechanical properties of rocks Methods of laboratory researches (Leningrad: Subsoil) 328

[2] I S Afanasyev, Blinov G A and Bukharev N N et al 2000 Reference book on drilling of prospecting wells (St. Petersburg: Subsoil) 712
[3] Nguyen K L, Gabov V V and Zadkov D A Le T B 2018 Justification of process of loading coal onto face conveyors by auger heads of shearer-loader machines IOP Conference Series: Materials Science and Engineering 327 042132 doi:10.1088/1757-899X/327/4/042132

[4] N L Andreev 2010 The technology of casing drilling of permafrost intervals Science and Technology in The Gas Industry 46 - 11

[5] Nguyen Khac Linh, Gabov V V and Zadkov D A 2018 Improvement of drum shearer coal loading performance EURASIAN MINING No. 2 22-25

[6] Brusco G, Lewis P and Williams M 2004 Drilling Straight Down Oilfield Review 16-3 14–17.

[7] Simultaneous casing drilling system Tubex. Retrieved from: http://www.rocktechnology.sandvik.ru/, access mode: free. - Title from the screen.

[8] Specificity of well drilling with simultaneous casing. Retrieved from: http://blog-potolok.ru/specifika-bureniya-skvazhin-s-odnovremennoj-obsadkoj/, access mode: free. - Title from the screen.

[9] 1995 Simultaneous drilling and casing of wells with the Tubex method. Mining 46

[10] Symmetric simultaneous casing system. Retrieved from: http://drillmarket.ru - Title from the screen.

[11] Patel D A, Thakar V, Pandian S, Shah M, Sircar A 2018 Review of oil and gas production Petroleum (Elsevier)

[12] Blinov G A and Gorelikov V G 1993 Methods of trunk casing pipes Technical and Technological Reconnaissance Review 2-33

[13] Williams M 2004 Better Turns for Rotary Steerable Drilling Oilfield Review 16(1) 4–9

[14] Gorelikov V G 2012 Design features of diamond crowns for drilling fractured rocks Journal of Mining Institute 197 26-29.

[15] Gabov V V, Zadkov D A, Nguyen Khac Linh 2019 Features of elementary burst formation during cutting coals and isotropic materials with reference cutting tool of mining machines Journal of Mining Institute 236 153

[16] Martyushev N V 2014 Alignment of the microstructure of castings from the heterophase lead bronzes. Advanced Materials Research 880 163-167

[17] Zykova A, Martyushev N, Skeeba V, Zadkov D, Kuzkin A 2019 Influence of W addition on microstructure and mechanical properties of Al-12%Si alloys. Materials 12(6) 981