

Development of engineering solutions for air drilling at Dulisminsk oilfield, Irkutsk oblast

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Abstract. The article presents the analysis of disastrous mud loss achieved during casing at Dulisminsk oil and gas condensate field (DOGCF) and comparative evaluation of geological structure of DOGCF and Naryksko-Ostashkinsk area of Kemerovo oblast, where the same problem was solved successfully. On the basis of the analysis, an engineering solution is proposed to prevent mud loss in the conditions of DOGCF.

1. Introduction

In recent years, oil and gas sector of the Eastern Siberia has been significantly developed in Russian industry, due to large hydrocarbon resources accumulation. Recoverable oil reserves at Verkhnechonsk field are estimated in 196 million tons, at Tolokansk and Yurubchen-Tokhomsk fields – in more than 170 million tons; at Dulisminsk oil and gas condensate field (DOGCF) – in 81.5 million tons of oil and condensate, and in 80 million m³ of gas [1]. However, all hydrocarbon reserves in East Siberia are under difficult drilling conditions due to the complex subsurface geological structure of the region.

2. Material and Methods

The paper describes the experience of drilling of the intervals for casing (“advance” drilling) with the application of air drilling and downhole hammer on the example of Dulisminsk oil and gas condensate field of Irkutsk oblast as a possible solution of a mud loss problem. The practice of drilling has shown that drilling of the intervals for casing (0-300 m) at Dulisminsk field of Irkutsk oblast is systematically performed under incompatible drilling conditions, which result from exogenic rock fracturing in the interval of Litventsevsk and Verkholsk suites [2].

The drilled rocks of Verkholsk suite consist of interbedded fractured siltstone of IV category (according to drillability), the 7th abrasiveness category with the density of 2650 kg/m³; as well as claystone and highly fractured dolomites of III, V category (according to drillability). Also there are marls of V category (according to drillability), the 4th abrasiveness category and the density of 2670 kg/m³. The density of the above mentioned rocks varies from 20 to 142 kgs/mm² according to L.A. Shreyner’s method.



The rocks of Litventsevsk suite consist of fractured limestones, dolomites and gypsum. The mineral density of these rocks of the suite is 2200 – 2850 kg/m³; hardness varies from 25 to 571 kgs/mm². The average abrasiveness of the rocks of this suite is 3.5.

Due to the specific geological structure and, in particular, the interbedded rocks with different permeability and mechanical properties, the drilling in the interval of 0–300 meters for casing is performed with incredible losses of drilling mud at an intensity of 30 cubic meters per hour, which inevitably results in enormous additional economic costs. For example, in well № 1106 incredible losses of drilling mud at an intensity of 20 cubic meters per hour started at the depth of 50 meters, in well № 713 from the depth of 110 meters up to the depth of 300 meters drilling was performed without drilling mud circulation, in well № 202 during the air drilling in the interval of 125 to 282 meters incredible losses of drilling mud at various intensity took place, and as a result, the total mud loss per the interval equal 580 m³. It is practically impossible to prevent mud loss at such a depth by mud lightening. Clogging material pumping into fractured formations also failed. As a result, the time of section installation for casing of Dulisminsk field is up to 20 days.

The important factor in solution of mud losses problem at Dulisminsk field is considered to be lack of real operational situation in the drilling design. For example, according to pressure scheme, mud loss in the interval of 0–300 meters must occur in case of exceeding pressure gradient of $1,34 \cdot 10^{-2}$ MPa/m, however, mud loss of various intensity occurs even when technical water is used to sweep well. Real pressure gradient in this case is much lower than the indicator in pressure scheme. Thus, the information given in the design does not find its practical application in drilling, and in this situation it is necessary to use other sources of data.

3. Results and discussion

To solve the given problem, the analysis of special technical and geological information has been performed. [3–7]. In particular, it has been established that the drilling practice and the results of air drilling with blowdown in Naryksko-Ostashkinsk area of Kemerovo oblast is very important [5]. The drilling in this area was performed to produce gas from coal formations.

The interval in the air drilling technique was made in the following rocks: clay, touchstone, sandstone, siltstone, mudstone and coal. The density of rocks in this interval ranges from 1300 kg/m³ to 2730 kg/m³. Maximum compression breaking strength of the rocks in this interval ranges from 60 kgs/cm² to 620 kgs/cm². Average abrasiveness of the rocks is 1.5. According to drillability, the rocks belong to the following categories; clays – III, touchstones – IX, sandstones – V, siltstones, mudstones and coal – IV. The elastic modulus of the rocks of Litventsevsk suite ranges from 400 kgs/mm² to 3200 kgs/mm².

Figure 1 shows the pressure scheme of formation and fracture pressures for wells of Naryksko-Ostashkinsk area and well design in compliance with formation pressure and fracture pressure data.

Based on systematic mud loss indicators, as well as the rock structure in Naryksko-Ostashkinsk area the technical specialists suggested using air drilling and blowdown in the interval from 0 to 150 meters, justifying this choice in terms of accidents-free well drilling [2].

In the process of drilling, BHA with downhole percussive drills was used in mud loss interval of 0-150 m. BHA for rotary-percussive drilling is given in table 1.

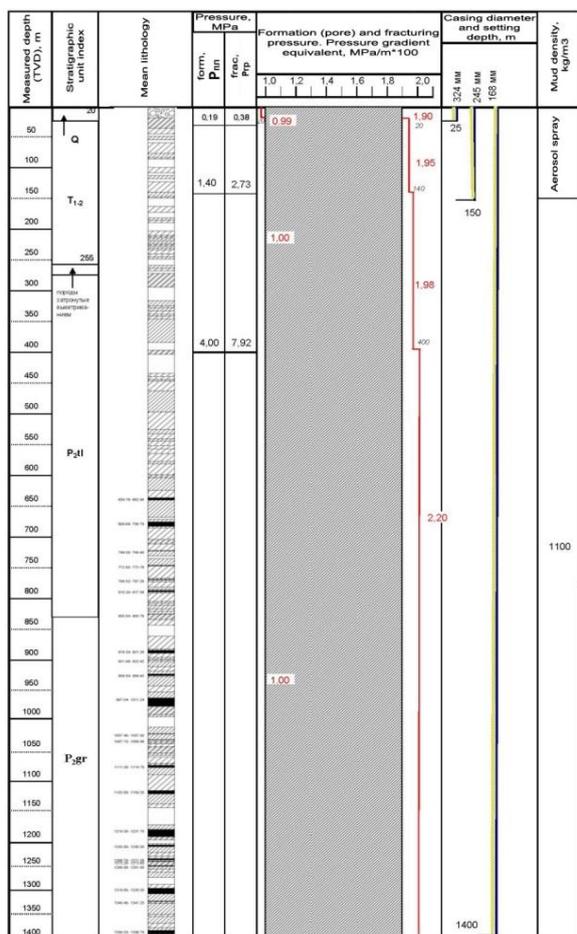


Figure 1. The pressure scheme of formation and fracture pressures for wells of Naryksko-Ostashkinsk area.

Table 1. BHA, used for rotary-percussive drilling in Naryksko-Ostashkinsk area.

Series №	BHA components	External diameter, mm	Length (height), m	Mass, kg	Function
1	DTH Drill Bit 311 mm	311	0.33	105.3	Bit
	Downhole percussive drill DTH HAMMER TD 90	196.8	1.6	238.6	Percussive drill
2	Stabilizer sub	139.7	0.38	31	Sub
3	Stabilizer	301.6	3.66	885	Stabilizer
4	HWDP sub	196.8-139.7	0.45	72	Sub
5	HWDP 139.7	139.7	9.1	893	HWDP
6	Sub	196.8-139.7	0.45	72	Sub
7	Stabilizer	301.6	3.66	885	Stabilizer
8	HWDP sub	196.8-139.7	0.45	72	Sub
9	HWDP 139.7	139.7	9.1	893	HWDP
10	Sub	196.8-139.7	0.45	72	Sub
11	Stabilizer	301.6	3.66	885	Stabilizer
12	HWDP sub	196.8-139.7	0.45	72	Sub
13	HWDP 139.7	139.7	rest	11500	HWDP

Downhole percussive drill DTH HAMMER TD 90 shown in figure 2 is used for drilling interval of 0-150 m. in Naryksko-Ostashkinsk area according to its possibility to destroy any rocks. Depending on downhole percussive drill features, it can be used for water supply well drilling, blast holes, open-pit mining, and oil-field exploration, as well as for construction operations in which a great number of rocks need to be removed. The features of downhole percussive drill are the following: diameter is 196.8 mm, length equals 1.6 m; a bottom valve pipe offset, which determines its important characteristics, is 52.3 mm.

The main feature of the downhole percussive drill DTH HAMMER TD 90 by Atlas Copco is controllable supply of compressed air in the pressure vessels. This advantage is achieved due to the presence of a poppet valve in the design of this percussive drill. The control over the position of air channels enables the supply of pressure to the rotochamber when the piston is in its top of stroke, and cut-off of pressure supply, when the piston is near the hit point, thus ensuring maximum efficiency factor [6].

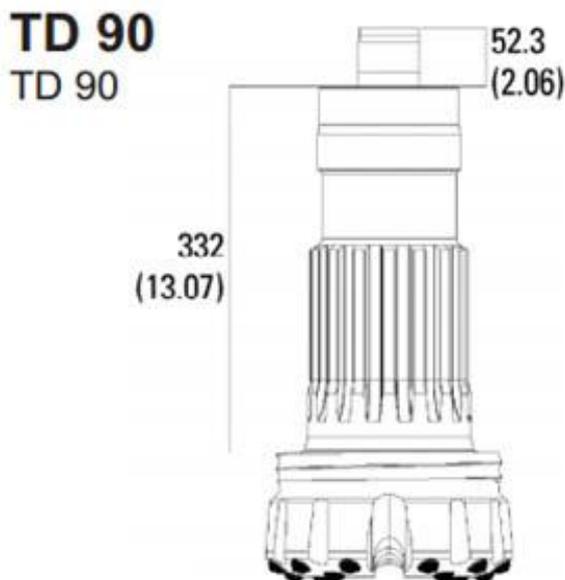


Figure 2. Downhole percussive drill DTH HAMMER TD 90.

In this case a universal flat-shaped drilling bit having a high-capacity gage side with large spherical bit inserts was used. This design of the bore provides the highest efficiency in drilling through hard and abrasive rocks, present in the cross-section of Naryksko-Ostashkinsk area.

According to the operational data, air generation and pumping into wells were done with the following compressors:

- Ingersoll Rand deck-based compressor with an output of 35.4 m³/min and the operating pressure of 2.5 MPa;
- XRVS606 compressor with the capacity of 36 m³/min and the operating pressure of 2.5 MPa;
- XRVS336 compressor with the capacity of 19.8 m³/min and the operating pressure of 2.5 MPa.

It was proved that while drilling, in order to provide a good quality clearing of the wellbore, speed of air-water mixture flow rising should be 15 – 30 m/s. Based on these indicators; air supply rate from compressors was calculated. Maximum output of the three compressors is 91 m³/min. The speed of flow rising with such an output, taking into account possible water inflow (100 m³/day) is 19 m/s. In case of minimum water inflow, the speed increases to 23 m/s.

It was also proved by field tests, while the air drilling with a blowdown, the following three types of pressure loss are taken into account [5]:

- the fluid column pressure – 1 MPa,

- the bit pressure – 0.4 MPa,
- In the annulus and feeding lines pressure – 0.4 MPa.

The total pressure loss in air circulation drilling is 1.8 MPa.

Special drilling parameters were designed for the interval: Bit load – not more 20 kN, bit rotating speed – 1 rotation per 0.1 meters of depth, maximum supply of compressed air – 91 m³/min. Surface casing drilling in Naryksko-Ostashkinsk area with these parameters allows achieving accident-free drilling, and mechanical drilling speed up to 18 m/hour.

Finally, the time for air drilling for wells № 13, № 15, № 17, № 19, № 25, № 27 and № 29 was on average 27 hours.

This result indicates the efficiency of fractured rocks destruction, including high drillability category rocks, with air drilling and blowdown.

The mentioned above facts show the possibility of using this technique at Dulisminsk oil field with mobile drilling rigs by Sramm. We suggest using mobile drilling rig and then the standard drilling equipment. This method was informally called “advance” or “keep ahead drilling”.

The novelty and practical effect of the proposed solution is not only in the justification of the use of downhole percussive drill and air for drilling of the intervals for casing at Dulisminsk field, but also in the development of technique, as well as optimal drilling modes, and also in the practical implementation of the “keep ahead” drilling.

As any other engineering solution, the implementation of blowdown requires a detailed analysis and research. An important component of the research is the results evaluation and the experience analysis of air drilling and blowdown. All these are planned to solve mud loss problems at Dulisminsk field in the nearest future.

To show other aspects of air drilling at Dulisminsk field, it should be noted that there is a disadvantage of actual G&G data for drilling wells. Thus, for example, due to various reasons, there are no data on the geophysical survey of Verkholsk and Litventsevsk suites. It prevents to identify the reasons for mud loss in the interval of 0–300 m for casing and make the development of drilling technique involving downhole percussive drill difficult.

Nevertheless, it can be assumed that the analysis of rock, their genesis, and sedimentation conditions will allow identifying the possibilities for advance drilling.

4. Conclusion

The mentioned analytical data of the tectonic framework in the region, lithological rocks characteristics in the well cross-section, as well as rock composition, the process of geological area formation, and the similarity of geological conditions at Dulisminske and Naryksko-Ostashkinsk fields in terms of rock fracturing, fossilization, and the successful experience of blowdown in Naryksko-Ostashkinsk area are considered as positive aspect for advance drilling at Dulisminsk field.

References

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