Analysis and Application of Torsion Impact Tool in Igneous Rock

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Abstract. The previous drilling practice showed that there were many drilling difficulties in igneous rock, such as less footage of one bit, lower roundtrip ROP, more tripping times, etc., which severely influenced the exploration and development process of carboniferous formation. After analysis, the reasons are mainly as follows: (1) Igneous rock has high hardness and poor drillability, which generally led to the few footage for tricone bits. (2) Igneous rock has complex lithological characters and poor homogeneity, which resulted in the limited use of PDC bits. (3) The formation dip angle of piedmont tectonic belt in BH block is big, which made well deviation grow fast.

Through analyzing its adaptability when drilling in igneous rock, the torsional impact tool can convert part of drilling fluid energy into the impacting downhole mechanical rock-breaking energy with a certain frequency and circumferential torsion and directly transmitted to the drill bit, so the stick-slip phenomenon of PDC bits can be eliminated effectively, the problem of limited use about PDC bits in igneous rock was solved, and the ROP in igneous rock can be enhanced.

Through firstly used in igneous rock of Well BH1, the torsional impact tool continuously worked 649h with 457.5m of drilling footage on one trip. Compared with the drilling situation of adjacent upper igneous rock, the roundtrip ROP that was 0.7m/h was increased by 45.8 percent and at least 11 trip time and bit cost were saved. So the compound drilling technique with high efficiency PDC bit and torsion impact tool was an effective way to realize optimal and fast drilling in igneous rock formation.

Introduction

Torsional impact tool is a new-type fast drilling tool adopted the interaction of three rock-breaking methods, including mechanical shear, hydraulic power and torsion impact[1, 2]. It can effectively eliminate the stick-slip phenomenon and greatly improve the service life of PDC bits when drilling in the more than medium hard formation or high abrasive formation. Through firstly used in igneous rock of Well BH1, it had achieved successful application and realized optimal and fast drilling in igneous rock formation.

Analysis of drilling difficulties in igneous rock

In the Φ311.2mm hole of Well BH1, carboniferous strata was drilled. It was mainly igneous rock, which had tuff, andesite, conglomerate, tuffaceous breccia, and so on. When drilling in the igneous rock of 2011~2788m, some conventional technology for improving ROP, like high efficiency tricone bit or PDC bit with hydraulic pressure tools, the compound drilling with high efficiency tricone bit and screw drill, etc., were successively applied. The application effects of these high efficiency bits are shown in Fig.1. However, all of them had not good effects, and there were many drilling difficulties in igneous rock, such as less footage for single bit, lower roundtrip ROP, more tripping times, etc.. The main reason were as follows:

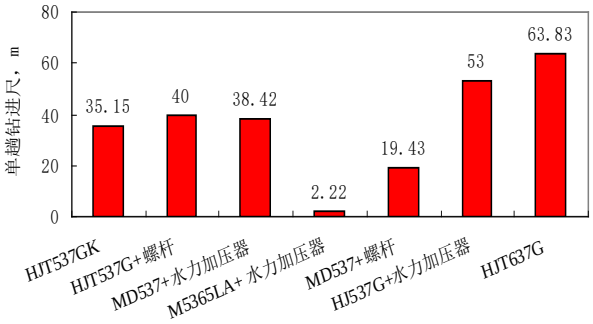

Fig. 1 Application effects of high efficiency bits in Well BH1

(1) Igneous rock has high hardness and poor drillability, which generally led to the few footage for tricone bits[3, 4]. According to the experimental results of igneous rock mechanics, the cone drillability of igneous rock in BH block was 7.82~8.38, and its highest hardness was up to 2780MPa. So during drilling with tricone bits, it was easy to cause the teeth, gauge and cone to be seriously worn, and then with the development of drilling, the ROP would rapidly decrease.

(2) Igneous rock has complex lithological characters and poor homogeneity, which resulted in the limited use of PDC bits. According to the results of cuttings recognition during logging, igneous rock in Well BH1 had many rock types, in which there were volcano breccia, conglomerate, etc. So during the use of PDC bits, the phenomenon of stick-slip and bit jumping was easily taken place, which caused PDC bits to be rapidly damaged.

(3) The formation dip angle of piedmont tectonic belt in BH block is big, which made well deviation grow fast. Well BH1 was arranged in the piedmont tectonic belt of BH block, and the formation dip angle was not less than 25°, which often caused well deviation growing up since the well depth of 2300m. the growing trend of well deviation in igneous rock of Well BH1 is shown in Fig.2.

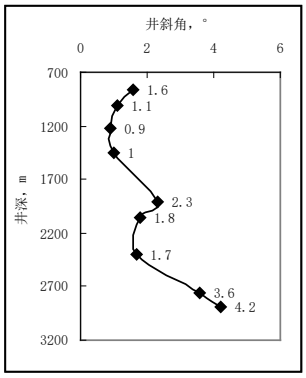

Fig. 2 Growing trend of well deviation in Well BH1

Adaptability analysis of torsion impact tool

When drilling in igneous rock, because it has complex lithological characters, many types of rocks and poor homogeneity, under some WOB and rotational speed, the downhole working environment of PDC bits was usually extremely bad. It was often subjected to axial, transverse and torsional vibration and the coaction by these kinds of vibrations, which could lead to the phenomenon of stick-slip, bit jumping, and gyration. So cutting teeth of PDC bits would be made abnormal wear, and then PDC bits would be damaged rapidly, their service life sharply shorten, and ROP significantly decreased[5-7].

Torsional impact tool is a new-type fast drilling auxiliary tool, and designed to solve the stick-slip problem of PDC bits and improve ROP of the strata hard to drill as well. In the premise of not affecting normal drilling, based on the principle of fluid dynamics and energy conversion, with the help of some drilling fluid energy, torsional impact tool can impose an additional homogeneous steady circumferential high-frequency impact on PDC bits, which changes the motion mode of PDC

bits. It is equivalent to cut rocks by the high frequency of more than 1000 times per minute, which can help PDC bits cut rocks without accumulating enough energy. So it can not noly eliminate the stick-slip, bit jumping, and gyration, extend the service life of PDC bits, and alleviate the fatigue failure of drill pipe and bottom hole assembly, but also it is feasible to make the PDC bit drill the hard stratum (like igneous rock) because it enhances the energy efficiency delivered to PDC bits.

Field application

During October 27 to November 23, 2014, torsional impact tool and PDC bit were run into Well BH1. The drilling section was 2788~3245.5m. It continuously worked 649h with 457.5m of drilling footage on one trip. The average ROP was 1.0m/h, and the roundtrip ROP was 0.7m/h.

During the field application，the bottom hole assembly adopted was: Φ311.2mm PDC bit+Φ254mm torsional impact tool +Φ229mm double-way shock absorber +Φ228.6mm drill collar×2+Cross-over Sub (731×630) + Φ203.2mm drill collar×6+ Cross-over Sub (631×410) + Φ177.8mm drill collar×3+Φ127mm heavy weight drill pipe×15+Φ127mm drill pipe. The drilling parameter were as follows: WOB was 60-80kN; pump pressure was 13~15MPa; rotational speed was 70~95r/min; displacement of pump was 37~39L/s; density of drilling fluid was 1.19-1.24g/cm^3, and its viscosity was 55-90s.

Bit life was greatly extended

Throughout the compound drilling with torsional impact tool and PDC bit, 5 kinds of igneous rock which were respectively andesite 32m, tuffaceous breccia 15m, tuff 67m, tuffaceous shale 123m and basalt 220.5m were successively drilled. The picture of PDC bit tripped out is shown in Fig.3. In spite that igneous rock had complex lithology and high hardness, there were not necking down about this PDC bit. Its new degree was still 80%. The other part kept well except that only 7 gauge tooth were damaged serious. All of the above said that the working envinonment of PDC bits was significantly improved with the help of torsional impact tool, so its life was greatly extended.

Fig. 3 Picture of PDC bit tripped out

Drilling cycle was sharply shortened

Compared with the adjacent upper igneous section of 2011~2788m, due to the use of torsional impact tool, the roundtrip ROP was increased by 45.8 percent and the average single bit footage was increased by 11.35 times. So at least 11 trip time and bit cost were saved. The contrast of application effect between the compound drilling with torsional impact tool and several adjacent conventional techniques is shown in Table 1. As can be seen from the table, the influence of torsional impact tool on PDC bit was very great. For example, although the same type of PDC bit was run in the fifth trip, its footage was only 39.5m and the ROP was only 0.64m/h under the condition of no using torsional impact tool. In addition, during the compound drilling with torsional impact tool, through strengthening the monitoring of well deviation and adjusting drilling parameter in time, well deviation was reduced from 5.2°/2782m to 1.3°/3210m, which indicated that the compound drilling with torsional impact tool and PDC bit had a good effect on controlling well deviation.

Table 1 Contrast of application effect between several drilling techniques

Bit type	Bit footage (m)	ROP (m/h)	WOB (kN)	Rock name	other
HJT637G	89	0.77	160~180	andesite	
HJT637G	33	0.66	160~180	andesite	
PK6245MJD	457.5	1	60-80	andesite、basalt, etc.	torsional impact tool
VM-44CDX0	18	0.35	100-120	basalt	
PK6245MJD	39.5	0.64	60-80	basalt	

Conclusion and suggestion

(1) The main drilling problems when drilling in igneous rock is few footage of tricone bits and limited use of PDC bits because of its poor drillability, big formation dip angle, etc.

(2) The compound drilling with torsional impact tool and PDC bit can effectively solve the difficulties drilling in igneous rock, such as serious well deviation, low ROP and few bit footage existed, etc, so it provides an effective way to realize optimal and fast drilling in igneous rock.

(3) It is suggested that field application of torsional impact tools should be further strengthened, so as to the tool's performance like working life and reliability were enhanced greatly.

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