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Research on Rock Breaking Mechanism with PDC Impact Composite Drill

Zhihao Shi, Yingxin Yang

Southwest Petroleum University, Chengdu Sichuan 610500, China

ABSTRACT. *With the gradual development of economy, the demand for petroleum resources is also increasing, and the exploration of petroleum gradually develops into ultra-deep wells. The deeper the area is, the harder the formation rock is, and the worse the abrasiveness and drillability is. When drilling in hard formations, it is obvious that the drill fails quickly, the speed of mechanical drilling is difficult, and the cost is high. The composite drill can not only suppress or even eliminate stick-slip that occurs during drilling, but also reduce the situation of skipping, which has higher value in rock formations. The author briefly introduces PDC impact composite drill, and analyzes the rock breaking mechanism of PDC impact composite drill.*

KEYWORDS: *PDC impact composite drill, Rock breaking mechanism, Speed of mechanical drilling, Application research*

1. Introduction

Around 1980, China introduced PDC drills from abroad. After more than 30 years, China has been able to independently develop PDC drills and obtained independent intellectual property rights. As an upgrade of PDC drill, PDC impact composite drill is equipped with cutting teeth on carcass to improve the rock breaking efficiency, and a higher speed of mechanical drilling can be obtained in combination with downhole power drilling tools. PDC impact composite drill is relatively reliable and has a long drill life. There is few research on rock breaking mechanism of this composite drill. Therefore, the author studies rock breaking mechanism in this paper.

2. PDC Impact Composite Drill

The full name of PDC is polycrystalline diamond compact, which is characterized by strong hardness and wear resistance that have high practicability to realize low drilling. PDC impact composite drill is mainly used to cut the formation with cutting teeth to realize the function of drilling. There will be composite chips on the cutting teeth. This kind of polycrystalline diamond material has high hardness, ideal impact resistance and high wear resistance. From mechanical properties of rock, it is known that shear rock breaking is of great help to improve the efficiency of rock breaking. PDC impact composite drill completes rock breaking with the use of shear stress. The early scraper drill is also a shear stress rock breaker, but its wear resistance is reduced because the cutting edge needs to bear a large area. PDC impact composite bit has excellent properties of polycrystalline diamond material. When the bit torque is given during drilling, the composite slice can be cut into the formation, and the drilling can be completed under the pressure, so that the rock breaking can be completed.

PDC impact composite drill has the following four characteristics after carrying out in-depth analysis. (1) High hardness and high wear resistance. Due to characteristics of the composite material, PDC impact composite drill has better hardness and wear resistance. (2) High strength. In PDC impact composite drill, the diamond material is brittle, but the composite has substrate. This tungsten carbide material can help the drill to have better pressure bearing capacity and impact resistance, and the strength of drill is high. (3) Good self-sharpness. It has a great relationship with good self-sharpness and the ability of the drill to maintain high-speed drilling. The material of cutting teeth is tungsten carbide, and the composite material is diamond. The wear speed of the former is much faster than that of the latter. The former wears out when the drill continues to advance, but the latter still has a small amount of cutting edge, and the cutting teeth are always sharp. (4) Poor thermal stability and impact resistance. The temperature of friction heat generation is more than 350℃, and the drilling temperature continues to rise. Therefore, in the drilling stage, enough water is needed to cool the drill, which can not only maintain the high drilling speed, but also extend the service life of the drill. The poor impact resistance is that the cutting edge is under too much pressure and the impact load may break.

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3. Rock Breaking Mechanism with PDC Impact Composite Drill

In the traditional drilling process, the core tooth formation line speed of the drill is lower, the cutting volume is smaller, the cutting power is lower, and the increase in power causes wear. At this time, the core teeth of the drill are not easy to fail. The use of PDC impact composite drill can improve drilling efficiency, but the drills fail faster, and heartbreaking occurs. Rock breaking with composite drill is a combination of axial and torsional impact provided by the drill. PDC-impact composite drill bit can achieve rock breaking by relying on shear stress and impact stress. When drilling with PDC impact composite bit, the speed of mechanical drilling has been greatly improved, because the rock breaking mode with PDC impact composite drill is quite different from the ideal rock breaking mode, as well as the increase of drilling rate.

The differences between rock breaking with PDC-impact composite drill and ideal drilling rock breaking are mainly reflected in the following three aspects:

(1) The cutting teeth of PDC impact composite drill used in compound drilling can have a good effect on the formation rock. The depth of infiltration continuously changes but it is greater than the range of infiltration depth on the whole. The cutting tooth wing of PDC impact composite drill exceeds the in-depth range, the in-depth of middle and core cutting teeth on the drill increases, and the outer shoulder cutting teeth are detached from the well wall, so the speed of drilling has been significantly improved. However, as the penetration depth of the cutting teeth gradually increases, the cutting area gradually increases, the load on the cutting teeth gradually increases, the load on the cutting teeth and the wear of the cutting teeth increase, and the service life of composite drill will be greatly affected. When PDC impact composite drill has a small penetration depth, the tangential speed is relatively large, the speed of cutting teeth on outer shoulder of the drill is high, and the wear will increase. This is the main reason for the wear of outer shoulder cutting teeth of PDC impact composite drill.

(2) The cutting teeth of PDC impact composite drill and the formation rock will have serious contact unevenness. Part of the cutting teeth will contact the rock for a time, and the total pressure area of the cutting teeth of PDC impact composite drill is large, but it is smaller than the ideal drilling condition. Therefore, under the same weight-on-bit condition, the cutting teeth of PDC impact composite drill can easily penetrate the formation rock, and the speed of mechanical drilling has been significantly improved.

(3) PDC impact composite drill is not an ideal motion state in composite drilling, and the cutting teeth will have a cutting path, which will cross cut through the bottom rock ridge after crossing. There will be a series of convex rock ridges in cross scraping, and the contact surface between cutting teeth composite and rock ridge is relatively small at the beginning. The cutting teeth have shear stress and tensile stress on the rock ridge, so the effect of rock breaking is relatively ideal. The rock ridge is in the shape of slope peak. The relative distance between cutting teeth and rock ridge is relatively short, and the cohesion of rock is smaller. Therefore, the drill has less effect on rock breaking, but PDC impact composite drill has significantly improved the efficiency of rock breaking.

4. Conclusion

With the deepening research on global geology, the development of rock breaking by drill is imperative. When PDC impact composite drill is used to break rock, the cutting depth is deepened from the axial impact, the torsional vibration is increased from the reciprocating torsional impact, which can protect the drill well while the high-speed bit is moving forward. In addition, with the axial impact movement and torsional impact, the cutting torque of drill increases, the shear force is greatly improved, and shear resistance is reduced. The formation of cutting torque peak makes the cutting efficiency improved.

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