Study on rock breaking mechanism of single tooth PDC cutting

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With continuous exploitation of shallow geological resources, the drilling field begins to take the direction and breakthrough of deep crust, deep sea and deep space. Polycrystalline Diamond Cutter (PDC) drills have the advantages of wide applicability in drilling soft-medium hard formations, low manufacturing costs, fast drilling speeds, and can be used for small diameter drilling, so many researchers turn their attention to how to improve the use of PDC bits in deep geological drilling[1]. However, in the process of deep geological drilling, the drilling pressure is often difficult to transfer to the drill bit portion, so the drilling efficiency is very low.

In order to solve the problem of low drilling efficiency, many people have conducted research, in which drilling parameters have a great impact. As early as 1920s, Salomon[2] found that when the cutting speed reached a certain value, the cutting force and cutting temperature of some workpiece material no longer rise, but decreased. In 1979, P.G. Wemer used high-speed cutting technology in the machining of various parts, and the material removal rate Q+ reached 50-1000 $m^3/(mm \cdot s)$. In 2002, TerraTek began a low-drilling, high-speed drilling experiment for diamond drill bits. Research shows that by applying high rotational speeds (greater than 10,000 rpm), efficient Rate of Penetration (ROP) rock cutting can be achieved under deep and hard rock conditions. The occurrence of energy and weight-on-bit is significantly reduced compared to conventional drilling engineering. This proves the feasibility of high-speed cutting rock breaking, but at present there is no research on the rock breaking mechanism of PDC cutters for high-speed cutting.

In order to study the rock breaking mechanism of PDC cutters in high-speed cutting, combined with most of the cutting experiments at conventional speeds, this research was carried out by experiments or simulations in single-tooth cutting. In this paper, the process of cutting rocks by a PDC cutter under high speed conditions will be analyzed by the ABAQUS software. The PDC cutting speed will be changed to study the rock breaking mode, surface temperature, stress concentration, and Mechanical Specific Energy (MSE). It is found that compared with high-speed cutting conditions, the plastic rock breaking mode dominated by crushing at a conventional cutting speed will be transformed into a brittle failure mode mainly based on cutting action; the front end surface of the tool will also accumulate more heat. These results show that PDC teeth have a higher cutting efficiency under high speed conditions and this will provide a theoretical basis and reference for further research and practice of high speed cutting and drilling.

References

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