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Analysis of Rock Cutting Progress with a New Axe-Shaped PDC Cutter to Improve PDC Bit Performance in Elastoplastic Formation

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Abstract : Polycrystalline diamond compact (PDC) bits have occupied a large market of unconventional oil and gas drilling. The application of PDC bits benefits from the efficient rock breaking of PDC cutters. In response to increasingly complex formations, many shaped cutters have been invited, but many of them have not been solved by the mechanism of rock breaking. In this paper, two kinds of PDC cutters: a new axe-shaped (NAS) cutter and cylindrical cutter (benchmark) were studied by laboratory experiments. NAS cutter is obtained by optimizing two sides of axe-shaped cutter with curved surfaces. All the cutters were put on a vertical turret lathe (VTL) in the laboratory for cutting tests. According to the cutting distance, the VTL tests can be divided into two modes: single-turn rotary cutting and continuous cutting. The cutting depth of cutting (DOC) was set at 1.0 mm and 2.0 mm in the former mode. The later mode includes a dry VTL test for thermal stability and a wet VTL test for wear resistance. Load cell and 3D optical profiler were used to obtain the value of cutting forces and wear area, respectively. Based on the findings of the single-turn rotary cutting VTL tests, the performance of A NAS cutter was better than the benchmark cutter on elastoplastic material cutting. The cutting forces (normal forces, tangential force, and radial force) and special mechanical energy (MSE) of a NAS cutter were lower than that of the benchmark cutter under the same condition. It meant that a NAS cutter was more efficient on elastoplastic material breaking. However, the wear resistance of a new axe-shaped cutter was higher than that of a benchmark cutter. The results of the dry VTL test showed that the thermal stability of a NAS cutter was higher than that of a benchmark cutter. The cutting efficiency can be improved by optimizing the geometric structure of the PDC cutter. The change of thermal stability may be caused by the decrease of the contact area between cutter and rock at given DOC. The conclusions of this paper can be used as an important reference for PDC cutters designers.

Keywords : axe-shaped cutter, PDC cutter, rotary cutting test, vertical turret lathe
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