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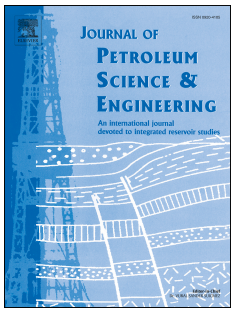

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Research on Rock-breaking Mechanism of Cross-cutting PDC Bit

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Abstract

Cross-cutting PDC (Polycrystalline Diamond Compact) bit is an efficient drilling technology that increases the rock-breaking efficiency and prolongs the service life of the bit through forming mesh-like pattern in the bottom-hole. This paper studies the rock-breaking mechanism of the cross-cutting PDC bit with the combination of both experiment and numerical simulation. With the nonlinear dynamical model being established, the stress status within rock units, sliding fracture characteristic, plastic energy consumption and stress distribution along the cutter edge are analyzed in the cross-cutting process. Compared with unidirectional cutting, cross-cutting generates larger tensile stress within the rock unit and achieves lower plastic energy consumption. Moreover average stress on the cutter edge in cross-cutting is much smaller than that in unidirectional cutting. When cutters break the rock protrusions formed during cross-cutting process, cracks inside of the rock will rapidly run through the protrusion, generating brittle fractures within the rock and consequently producing sizable volumetric fractures. During cross-cutting, the rock is damaged not only because the shear failure, but also brittle fracture, which is conductive to improving the rock-breaking efficiency. Through unit experiment under cross-cutting condition, this paper studies the influencing regularity of experimental parameters (including the cutter diameter, back rake angle, cross-cutting angle, cutters spacing and rock hardness etc.) on the cutting load, the research achievements are conductive to the deeper understanding of rock-breaking mechanism of the new bit and provides theoretical basis for the application of the technology.

Keywords

Cross-scraping, Rock-breaking, Track, Load, Experiment

1. Introduction

With the advantages of high ROP (Rate of Penetration), good stability and high design flexibility, the PDC bit is widely used in the exploration and exploitation process of oil and gas[1-2]. As oil and gas exploration being gradually propelled toward deeper formation, low penetration rate and high energy consumption become the main factors affecting drilling efficiency[3-5]. Besides formation adaptability and drilling parameters, the structure of PDC bit is also an important factor directly affecting the ROP in deep formation[6-7]. For the past few years, material performance of PDC cutters has gained a great improvement, which, to a certain extent, has made up for the deficiency of conventional PDC bit structure[8-10]. However, since the cutting tracks of PDC cutters are still concentric circles, rock-breaking efficiency in the PDC bit drilling process cannot be further improved.

To address this problem, Yang Yingxin et al. from Southwest Petroleum University put forward a cross-cutting PDC bit technology, which makes it possible that cutters on the PDC bit successively cut rock and form mesh-like bottom-hole pattern[11]. Experiment results show that the new-type PDC bit (i.e. the