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EXPERIMENTAL STUDY OF ROCK BREAKING EFFECT OF STEEL PARTICLES*

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Abstract: Particle impact drilling is an efficient drilling technology for deep-well hard formation, With this technology, the rock is cut mainly by high-speed spherical particle impact under hydraulic action. In this article, the influence of jet flow factors, hydraulic factors and abrasive factors on rock breaking is studied through indoor experiments of impact by steel particles. The results indicate that the particle water jet has an optimal standoff distance and particle concentration; the rock breaking effect declines with the increase of the confining pressure and the decrease of the pump pressure and particle diameter. This study will provide some food of thought for the development of particle impact drilling technology.

Key words: hard formation, particle impact drilling, water jet, rock breaking effect, experimental research

Introduction

Hard formation is often encountered in deep wells of oilfields in China and shallow wells in West China. Some problems still exist for drilling hard formation, such as slow Rate Of Penetration (ROP), short service life of drilling pipes, long drilling cycle, and high drilling cost, which directly affect the overall profit of hard formation oil exploration and development[1]. The technologies of electron beam, laser, plasma, rock hot melting, high pressure thin water jet and particle impact rock breaking were among the others developed to cut hard rock[2]. Indoor tests and field tests indicate that the particle impact rock breaking is an effective method. Based on the experience of shot impact for rock breaking, Curlett et al.[3] suggested the practice of particle impact drilling, followed by many indoor experiments and on-site tests and related equipments were developed. Compared with the conventional drilling, the particle impact drilling could greatly improve the ROP, shorten the drilling period and reduce the drilling cost. The particle impact rock breaking mechanism is similar to the general rock breaking mechanism by abrasive water jet, butwith the following differences: the general abrasive water jet will wear drilling pipelines and drilling strings severely and make the drilling fluid density difficult to be controlled, the spherical steel particle could prevent the abrasive to fall to pieces and can be used repeatedly[4].

In addition, although the particle impact rock breaking mechanism is studied in China, the economical benefit should be explored before its meaningful field applications in deep oil fields. Wu et al.[5] studied fundamentals of single particle and double particle rock breaking by numerical simulations but with no experimental verification. Xu et al.[4] studied particle impact drilling by numerical simulations, showing that the best effect of breaking rock would be obtained when the particle diameter is 10 mm - 30 mm, impact velocity is 100 m/s - 250 m/s

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