

Evaluation of Rock-Coring Capacity of Different Specifications of Core Drilling Tools

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ABSTRACT

In order to solve the problem of low rock carrying efficiency of coring drilling tools in the process of coring operation under extreme ultra-high temperature and high-pressure environment, and considering the key rock carrying parameters such as coring bit type, cuttings particle size, drilling speed and drilling fluid viscosity in different formations, the three-dimensional model and flow field coupling model of coring tools with different specifications are established. The finite element method is used to evaluate the rock carrying capacity of the annulus of the coring outer cylinder. The results show that for the same type of coring tools, reducing the particle size of cuttings, increasing the viscosity of drilling fluid and reducing the drilling speed can reduce the volume fraction of residual cuttings and improve the rock carrying capacity of coring tools. For the 121,140,172 type coring tools, when the two drilling speeds are 0.8 m/h and 2.1 m/h respectively, the rock carrying capacity gap decreases with the increase of cuttings particle size. When the two drilling speeds of 203 type coring tools are 0.8m/h and 2.1m/h respectively, the difference of rock carrying capacity increases with the increase of cuttings size.

KEYWORDS

Coring Tool; Rock-carrying Transport; Cuttings Size; Drilling Speed; Drilling Fluid Viscosity.

1. INTRODUCTION

With the increasing demand for oil and gas resources, the drilling and production efforts are also "From shallow to deep", "From point to cover surface", the structure and properties of underground rocks are more and more different and complex. The coring tool is a tool that carries the underground rocks to the surface in blocks during drilling. It can obtain the important formation parameters directly from the underground rocks, the tool structure is mainly composed of core bit, outer core barrel, inner core barrel and core claw, as well as suspension bearing, water diversion head, back pressure valve, centralizer and so on. At present, with the development of materials science, manufacturing technology and intelligent technology, the core drilling tool has made remarkable progress in cutting ability, wear resistance, corrosion resistance and intelligent level, however, it is always a difficult problem for coring tools to carry rocks in deep and complicated wells.

Lu CH et al. [1] designed a new type of two-tube forced fidelity coring tool to improve the coring quality, structure and working efficiency of weak and broken ore bed, at the same time, the coring motion and the coring force are analyzed and calculated. At last, the indoor test shows that only 15 ~ 20KN vertical pressure is needed to make the core claw close. Deng Z Q et al. [2] developed a new coring bit structure to solve the problem of low coring rate, the interaction model of coring bit tool with planetary weathered layer is established, and the influence of tool structure parameters on cutting force and coring rate is analyzed. The test shows that the block ring structure can effectively improve

the core rate, but the horizontal cutting force and axial force are obviously larger. Xigui Wang et al. [3] designed a coring tool for deep and ultra-deep wells with the functions of pressure preservation, heat insulation and sealing, under the condition of variable pressure, the temperature simulation test and closed coring of coal samples with different particle size were carried out by using equipment and technology research. Da Guo et al. [4] put forward a new design of IPP coring tool (IPP-coring) with 70 mpa pressure holding capacity for accurate evaluation of onshore deep oil and gas resources, the performance of pressure retaining is described in detail. The tool can use the hydraulic lifting force of drilling fluid to complete the pressure-keeping operation. The pressure-keeping mechanism is attributed to the combined effect of the fixed seal structure, the split seal structure and the pressure controller seal structure. Jiale Peng et al. [5] attempted to solve the problem that the sidewall coring tool (SCT) can not withstand the extreme temperature and can not ensure the long-term operation and reliability in the distribution of exploration oil and gas resources, a durable and reliable SCT system (TMS) for sidewall coring tool with good temperature uniformity is proposed. Bin Liu et al. [6] established a three-dimensional finite element model of the threaded joint of coring drill tool with a diameter of 172 mm, the stress distribution of the common threaded joint is mainly concentrated near the shoulder, while the special threaded joint is mainly concentrated near the main shoulder and the auxiliary shoulder, the stress distribution of special thread joint is more uniform than that of traditional thread joint. Liu, He et al. [7] for the current core cutting system of pressure-keeping coring tools, the response of the pitch differential module is slow, and the position error of the cutting core is large, so the self-locking core claw can not effectively clamp the falling core, this paper puts forward a design idea of intelligent cutting core for pressure-keeping coring device system. Nair, V. V. et al. [8] based on the tri-continuum method, a colloid migration model is established to analyze the colloid migration in fractured formation. In addition to the fracture and rock matrix, the fracture skin is merged into a third continuum. Based on the finite difference method, a fully implicit numerical model is used in part of the coupled system to solve the transport differential equation formula in the fracture medium, the migration of colloid in Fractured Formation is studied. Yashar Tavakkoli Osgouei et al. [9] have carried out experimental and numerical studies on matrix-fissure heat transport in fractured rocks. In order to study the heat transfer of matrix fracture by injecting cold water, a membrane heat flow sensor was used to measure the fracture temperature and heat flow density at the fracture interface by using a single fracture core plugging agent under different flow rates. Qiuping Lu et al. [10] designed a new type of ball valve sealing rope pressure coring system, and it was first applied to the Guangzhou Marine Geological Survey Bureau (GMGS) in the South China Sea during the China hydrate survey voyage. Jialiang Wang et al. [11] based on Bernoulli's mathematical equations, the internal model of the drill tool for the variation of drilling fluid pressure is established, the influence of drilling fluid pressure and drilling tool parameters on drilling tool performance is expounded, and the flow characteristics of drilling fluid during drilling are analyzed. Yang, Liwen et al. [12] designed and developed the GW-CP194-80A take-off and pressure-keeping coring tool. The application results are as follows: the core diameter of the new tool is increased from 70mm to 80mm, the rated pressure-keeping capacity is increased from 20mpa to 60mpa, the ball valve sealing device is rotatable and controllable, and the high-strength pressure-keeping inner cylinder. The internal differential assembly and up-down synchronous seal mechanism of the new tool effectively solve the closure problem and improve the success rate of coring and pressure-keeping in highly deviated wells. In the field application of horizontal wells, 27 barrels were used in 5 wells with an average core recovery of 87.5% and a success rate of 92.6%.

The effects of drill tool type, cuttings particle size, drilling speed and drilling fluid viscosity are not considered in the above-mentioned researches on core drilling tools, different cuttings size, drilling speed and drilling fluid viscosity are set to evaluate the carrying efficiency of core drilling tools.

2. NUMERICAL SIMULATION MODEL ESTABLISHMENT

Considering the key rock-carrying parameters such as cuttings size, drilling speed and drilling fluid viscosity, the flow field geometric models of different coring tools are established, carrying capacity evaluation of core outer cylinder annulus was carried out. Firstly, the geometric structure of coring tool is meshed by ANSYS, and the meshes are introduced into Edem for coupling, in the Edem, some parameters such as the particle size, the total mass of the cuttings and the interaction between the cuttings particles are set up, and a specified number of cuttings particle models are generated, the parameters of viscosity and feed speed of drilling fluid are set in Fluent. The key carrying parameters of core drilling tools are shown in Table 1.

Table 1. Key rock carrying parameters of core drilling tool

Research content	Study parameters
Model of drill tool	121, 140, 172, 203
Particle size of cuttings	2mm, 2.5mm, 3mm
Drilling speed	0.8m/h, 2.1m/h
Viscosity of drilling fluid	0.02kg/m·s, 0.075kg/m·s, 0.1kg/m·s

As shown in Figure 1, the 3D model and mesh model of 172 coring drill are simplified and mainly composed of annulus inlet and outlet, flow hole, middle flow passage and bit flow passage.

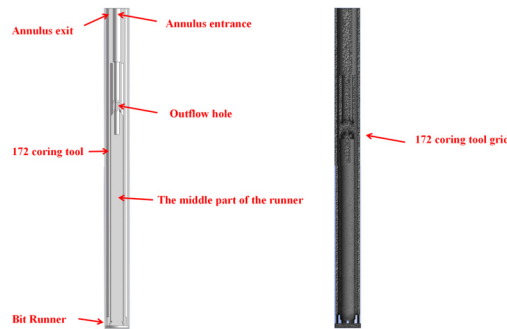


Fig 1. 172 coring tool model

3. RESULTS AND DISCUSSION

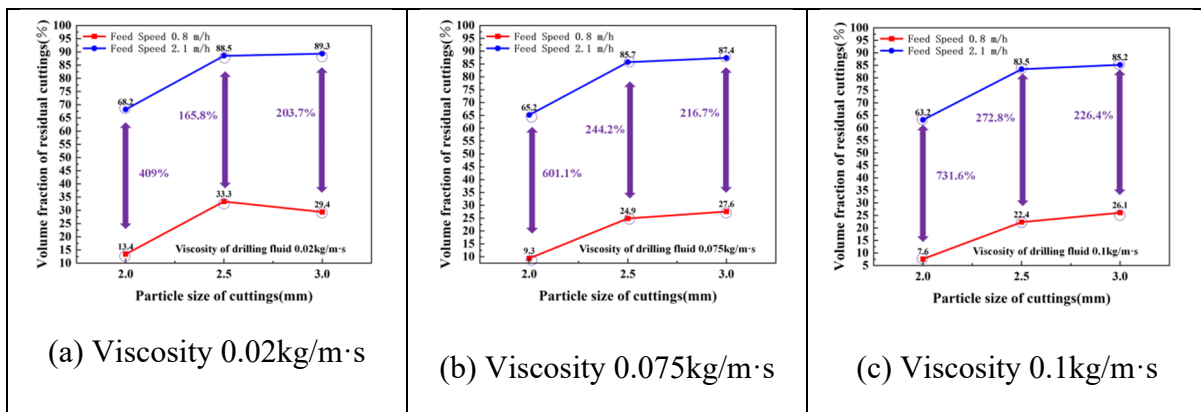


Fig 2. Rock carrying capacity map of 121 coring tool

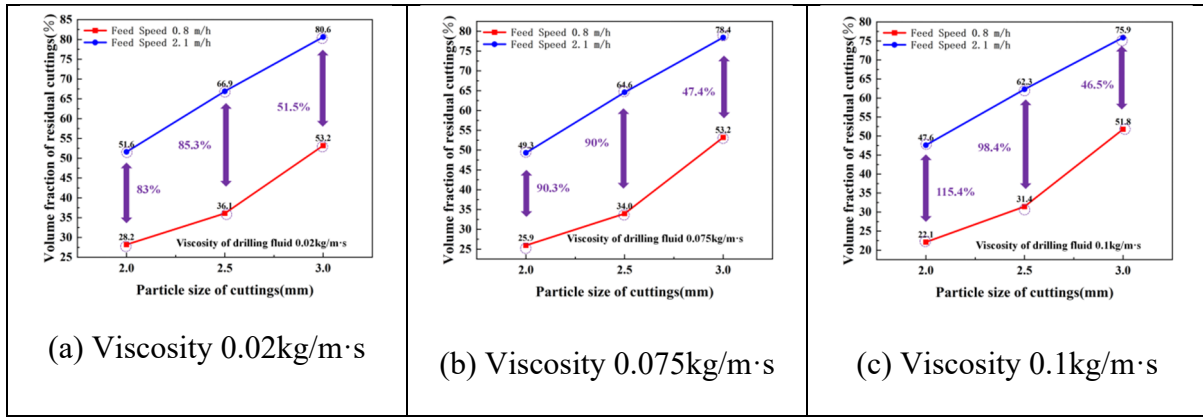


Fig 3. Rock carrying capacity map of 140 coring tool

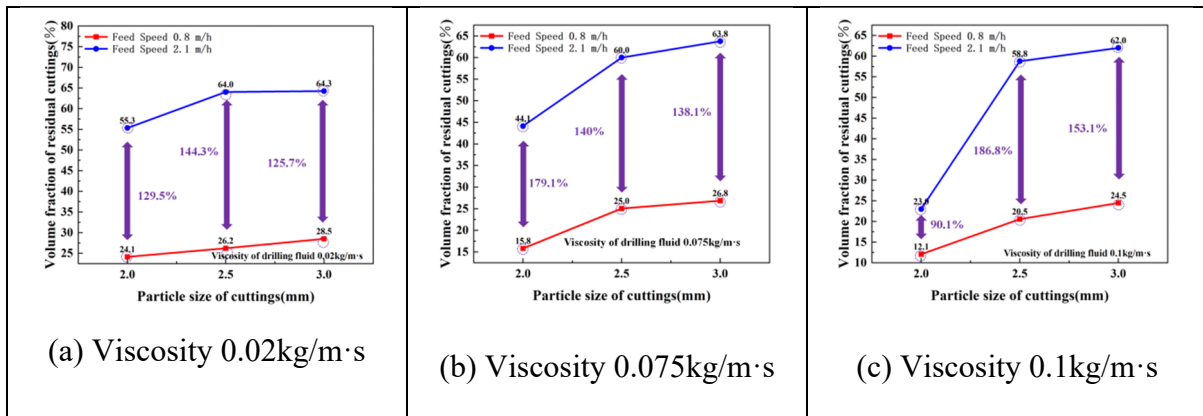


Fig 4. Rock carrying capacity map of 172 coring tool

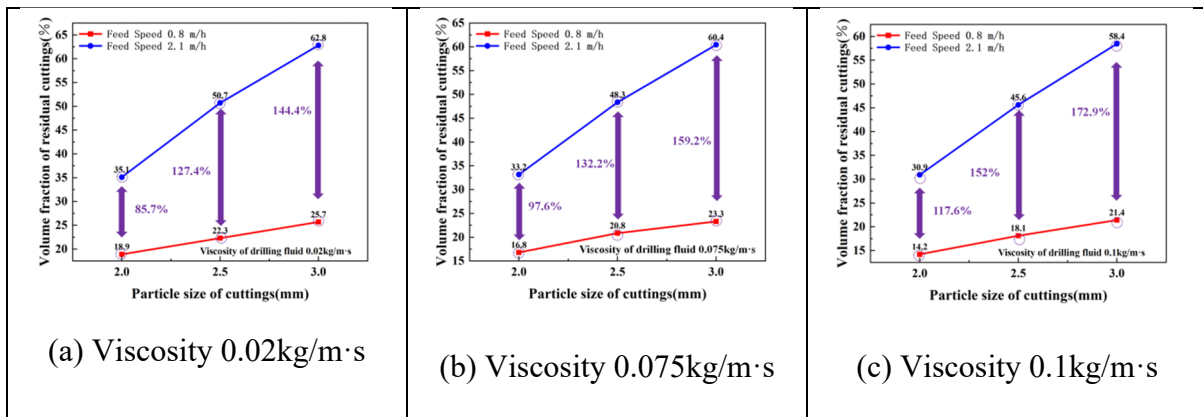


Fig 5. Rock carrying capacity map of 203 coring tool

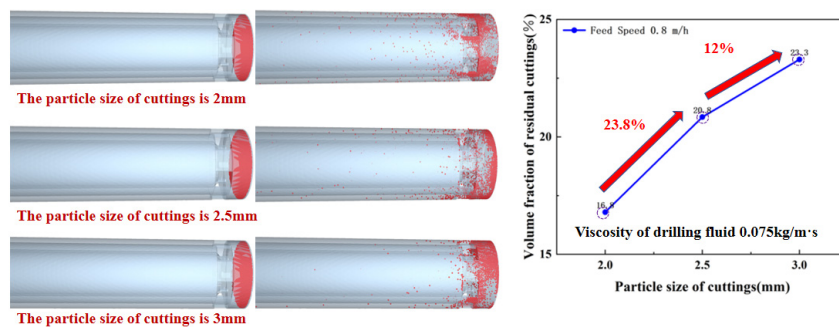


Fig 6. 203 coring drill tool with feed speed of 0.8 m/h

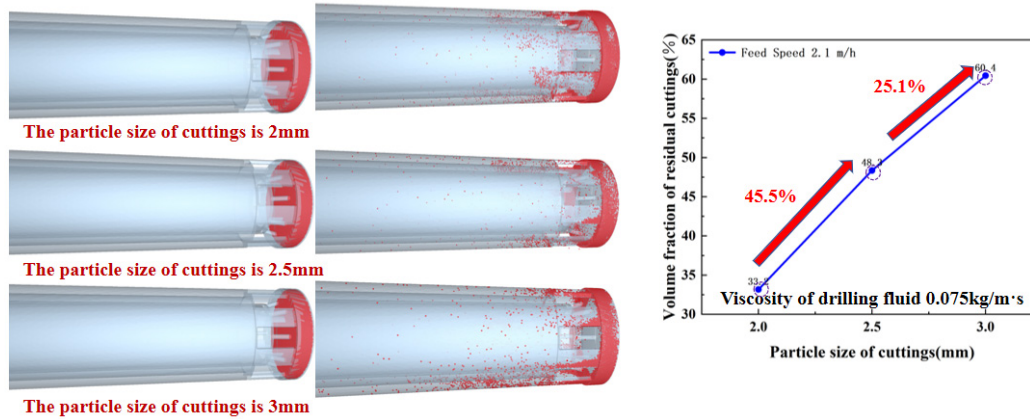


Fig 7. 203 coring drill tool with feed speed of 2.1 m/h

As shown in figure 2, the simulation result curve of 121 coring drilling tool shows that with the increase of cuttings particle size from 2mm to 2.5mm and finally to 3mm, the volume fraction of remaining cuttings shows an increasing trend, and the rock carrying capacity of coring drilling tool decreases. When the viscosity of drilling fluid is 0.02 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 4 times, 1.7 times and 2 times more than the remaining cuttings volume fraction of 0.8 m/h. When the viscosity of drilling fluid is 0.075 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 6, 2.4 and 2.2 times more than the remaining cuttings volume fraction of 0.8 m/h. When the viscosity of drilling fluid is 0.1 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 7.3, 2.7, 2.3 times more than the drilling speed of 0.8 m/h. It can be seen that under the same drilling fluid viscosity and cuttings particle size, the volume fraction of remaining cuttings at a drilling speed of 2.1 m/h is much larger than that at a drilling speed of 0.8 m/h, and the rock carrying capacity is also reduced. However, with the increase of the particle size of the cuttings, the difference between the two drilling speeds is decreasing, and the larger the viscosity of the drilling fluid is, the larger the volume fraction of the remaining cuttings is, and the rock carrying capacity is improved.

As shown in Figure 3, the simulation result curve of 140 coring drilling tool shows that with the increase of cuttings particle size, the volume fraction of remaining cuttings also shows an increasing trend, and the rock carrying capacity of coring drilling tool decreases. When the viscosity of drilling fluid is 0.02 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 0.83, 0.85 and 0.52 times more than the remaining cuttings volume fraction of 0.8 m/h. When the viscosity of drilling fluid is 0.075 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 0.9, 0.9 and 0.47 times more than the remaining cuttings volume fraction of 0.8 m/h. When the viscosity of drilling fluid is 0.1 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 1.15, 0.98 and 0.47 times more than the remaining cuttings volume fraction of 0.8 m/h. The removal value is different from the simulation results of 121 coring drilling tool, and the other laws are consistent.

As shown in Figure 4, the simulation result curve of 172 coring drilling tool shows that with the increase of cuttings particle size, the volume fraction of remaining cuttings also shows an increasing trend, and the rock carrying capacity of coring drilling tool decreases. When the viscosity of drilling fluid is 0.02 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 1.3, 1.4 and 1.3 times more than the remaining cuttings volume fraction of 0.8 m/h. When the viscosity of drilling fluid is 0.075 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 1.8, 1.4 and 1.4 times more than the remaining cuttings volume fraction of 0.8 m/h. When the viscosity of drilling fluid is 0.1 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 0.9, 1.9 and 1.5 times more than the remaining cuttings volume fraction of 0.8 m/h.

As shown in figure 5, the simulation result curve of 203 coring drilling tool shows that with the increase of cuttings particle size, the volume fraction of remaining cuttings also shows an increasing trend, and the rock carrying capacity of coring drilling tool decreases. When the viscosity of drilling fluid is 0.02 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 0.86, 1.27 and 1.44 times higher than that of the drilling speed of 0.8 m/h. When the viscosity of drilling fluid is 0.075 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 0.98, 1.32 and 1.6 times more than the remaining cuttings volume fraction of 0.8 m/h. When the viscosity of drilling fluid is 0.1 kg/m·s, with the increase of cuttings particle size, the drilling speed of 2.1 m/h is 1.2, 1.5 and 1.7 times more than the remaining cuttings volume fraction of 0.8 m/h. It can be seen that different from the first three types of coring drilling tools, the difference of rock carrying capacity between the two drilling speeds of 203 coring drilling tools increases with the increase of cuttings particle size.

Fig.7 and Fig.8 are the rock-carrying working diagram of 203 coring drilling tool. The viscosity of drilling fluid is 0.075 kg/m·s. When the feed rate is 0.8 m/h, the cuttings particle size increases from 2 mm to 2.5 mm, and the rock-carrying efficiency decreases by 23.8 %. When the particle size of cuttings increases from 2.5mm to 3mm, the rock carrying efficiency decreases by 12 %. When the feed rate is 2.1 m/h, the cuttings particle size increases from 2 mm to 2.5 mm, and the rock carrying efficiency decreases by 45.5 %. When the particle size of cuttings increases from 2.5mm to 3mm, the rock carrying efficiency decreases by 25.1 %.

4. CONCLUSION

- (1) For the same type of coring tools, reducing the particle size of cuttings, increasing the viscosity of drilling fluid and reducing the drilling speed can reduce the volume fraction of residual cuttings, so as to improve the rock carrying capacity of coring tools.
- (2) For the 121,140,172 type coring tools, when the two drilling speeds are 0.8 m/h and 2.1 m/h respectively, the rock carrying capacity gap decreases with the increase of cuttings particle size. For the 203 type coring drilling tool, when the two drilling speeds are 0.8 m/h and 2.1 m/h respectively, the difference of rock carrying capacity increases with the increase of cuttings particle size.

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