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Design and Analysis of Powder Vertical Spiral Feeding Based on EDEM

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Abstract: In order to solve the problems of low automation degree of micro-high-precision powder addition in the laboratory, large influence of human factors and high labor cost, a set of screw feeding and weighing integration device is designed to realize the automatic addition of powder agent, the mechanical structure and speed of screw feeding are closely related to the accuracy of powder addition, and the discrete element method (EDMEM) is used to simulate spiral powder feeding at different speeds, and the simulation analysis shows that the spiral speed is positively correlated with the motion speed of particles. The spiral velocity is inversely correlated with the density of the particles.

Keywords: Screw add, EDEM, Rotate speed.

1. Introduction

Drilling fluid plays an important role in removing cuttings, balancing formation pressure, cooling and lubricating drill bit, and providing power for downhole power tools. In order to give full play to the function of drilling fluid in oil and gas exploitation, it is necessary to prepare drilling fluid with different properties according to different geological conditions. At present, the preparation of drilling fluid in the laboratory is mainly through the staff to first weigh various agents, then pour into the mixing cup and use the mixer to stir to form drilling fluid. In order to solve the problems of low efficiency of manual weighing and adding powder agents in laboratory, and the adding accuracy depends on the operation standard of personnel, a set of components is designed to realize the automatic adding of powder agents.

Hong Haijin applied disc feeding technology and multi-dimensional adaptive intelligent control technology to carry out relevant research on the measurement of micro-powder feeding, and verified the accuracy and qualified rate of quantitative feeding [1]. Ningtingzhou used EDEM software to conduct orthogonal simulation experiment analysis on key parts of horizontal screw conveyor such as blade shape, pitch and axle diameter [2]. Zhu Hongxiang studied the factors affecting the detailed working performance of the inclined screw conveyor through discrete element software [3]. By using the computer fluid dynamics technology of Ansys Fluent and the orthogonal test design, Zhou Dan analyzed the geometric parameters of the screw that affect the quality of the horizontal conveying screw, and determined the geometric parameters for obtaining the maximum filling rate [4]. Based on the discrete element model, Liu Weili et al. analyzed the relationship between the mass flow rate, particle velocity, energy consumption, energy dissipation rate and the dip Angle and speed of the screw conveyor in the conveying process [5].

In some structural designs, because of spatial layout and other reasons, it is necessary to realize vertical spiral feeding, so it is an important research direction to study vertical feeding spiral transportation, especially for the addition of high precision and trace powder agents. Simulation analysis of powder operation by discrete element method, It provides theoretical basis for the optimization design and control design of key parts of screw conveyor.

2. Screw Feeding Model and Main Parameters

2.1. Establishment of simulation model

In order to accelerate the simulation speed and quickly obtain the simulation results, the model was simplified and only the mechanical parts directly in contact with powder feeding were retained. The specific simulation model is shown in Figure 1.

Figure 1. Simplified model of screw conveyor

2.2. Material parameter Settings

Bentonite powder, an agent of drilling fluid used in the experiment, is the experimental object, and the shape of bentonite powder is. The storage cylinder and screw rod are made of SUS304 material. The contact parameters of SUS304 stainless steel with bentonite powder and storage cylinder and screw rod are set in Table 1 below.

Table 1. Material properties of conveying medium and spiral conveying parts

Material	Poisson's ratio	Modulus of shear/Pa	Density/m (kg.m-3)
Bentonite soil	0.25	1.0x107	1580
Stainless steel	0.3	1.94x1011	7930

Table 2. Contact properties between bentonite and bentonite and between bentonite and spiral conveyor parts

Object of action	Coefficient of recovery	Coefficient of static friction	Coefficient of dynamic friction
Bentonite and bentonite	0.02	0.9	0.75
Bentonite and snails Rotary conveying parts	0.05	0.8	0.6

2.3. Particle parameter analysis and setting

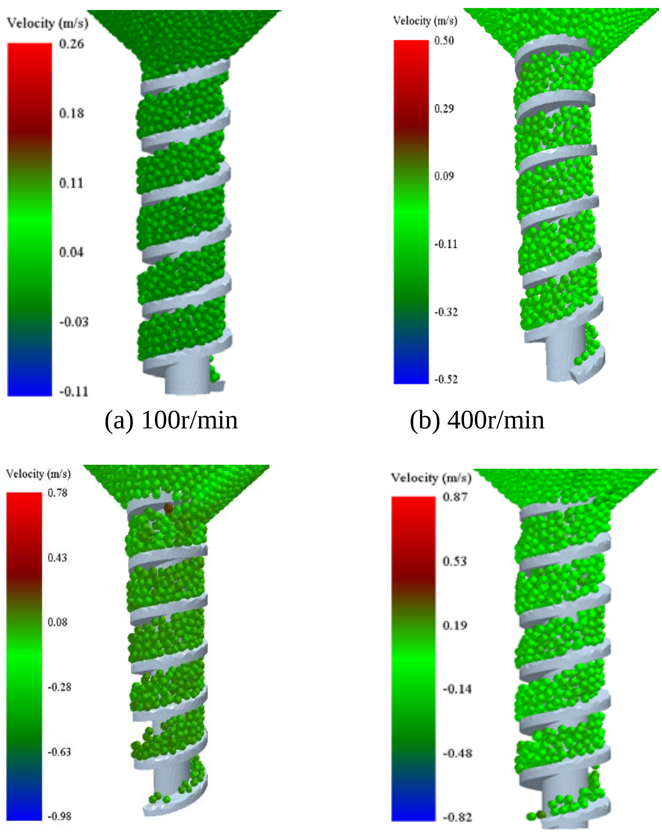
The bentonite powder is composed of irregular non-spherical particles with an aspect to length ratio concentrated in 0.7 ~ 0.9, and more than 95% of the particles are less than 0.075mm in diameter. Using the similarity theory of the discrete element method to scale the particle size artificially is to use the similarity theory and dimensional analysis, replace the actual small particles with the simulated particles with large particle size, and determine the relationship between the simulated physical quantity and the actual physical quantity through the physical quantity scaling factor [6]. The particle diameter of the simulation amplified by the similarity theory is 0.75mm. This method ensures the effectiveness of the simulation for the real working condition, and can effectively save the simulation time and reduce the requirements of the simulation on the computer performance.

There are many specific contact models in EDEM software. The Hertz-Mindlin with JKR Cohesion model, also known as JKR Cohesion model, was selected in this simulation [7]. It is suitable for powder particles and wet materials such as crops, ores and soil. The particles are obviously bonded and aggregated due to electrostatic force and wet moisture. This kind of contact model can truly express the stress of bentonite.

3. Simulation Results and Analysis

3.1. Simulation analysis of conveying process at different speeds

Screw feeder vertical layout, analysis of 4 different speed (100 r/min, 400 r/min, 800 r/min, 1200 r/min) under the condition of the movement law, the feeding machine particle speed distribution is shown in Figure 2, the size of the speed using color to distinguish. Increasing the rotational speed of the spiral rod will increase the velocity of the particles, especially the particles sticking to the upper surface of the spiral blade. When the rotational speed increases, the density of particles in the screw rod decreases, mainly because the centrifugal force of particles increases with the rotational speed increasing. Therefore, with the increase of the rotational speed of the spiral shaft, the trend of increasing the particle velocity is correct.



(c) 800r/min (d) 1200r/min

Figure 2. Motion velocity of particles at different rotational speeds

3.2. Motion distribution diagram of particles with different diameters

Bentonite powder has particles of different diameters. FIG. 3 shows the distribution diagram of particles under the condition of movement. It can be found from this diagram that the particles are evenly distributed in the movement without obvious segregation and surge [8], which is conducive to the quantitative and high-precision addition of agents.

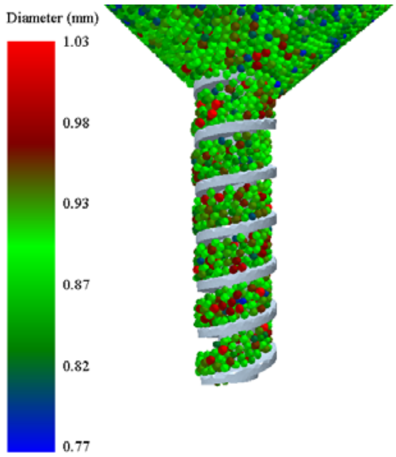


Figure 3. Motion distribution of particles with different diameters

3.3. Velocity vector diagram

As can be seen from the motion vector diagram in Figure 4, the velocity and motion of particles are mainly divided into two categories. One is mainly that particles with small particle size rotate with the blade, and the motion direction is basically perpendicular to the blade surface. The other type is mainly the larger particle size along with the spiral rod to do axial movement. Each particle rotates with the spiral blade under the push of the spiral blade, the spiral shaft and the comprehensive action of other particles.

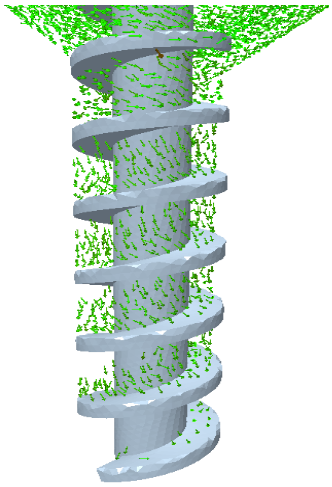


Figure 4. Motion vector diagram

4. Conclusion

Helical powder addition has dual functions of quantification and transmission, especially for ultrafine powder addition has high efficiency. Through the simulation analysis of discrete element software EDEM, the motion velocity and motion law of powder particles were analyzed. The main conclusions are as follows:

(1) The discrete element software EDEM was used to visually observe the velocity distribution of particles in the spiral feeder. The velocity of particles close to the cylinder wall was small, while the velocity of particles close to the surface of the spiral blade was large.

(2) The higher the spiral speed, the higher the particle velocity, and the lower the density of particles.

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