Numerical simulation of flow field characteristics of three heavy medium classifier

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Abstract

In order to clearly understand the distribution of internal flow field in a new type of hydraulic classifier, the relationship between different top water velocities, different feeding velocities and internal flow field was simulated by using computational fluid dynamics software ANSYS FLUENT 14.5. Through the simulation, it can be concluded that the top water velocity and the feeding speed are too large, which lead to the uneven distribution of the flow field in the body, increase the turbulence of the internal flow field, and have a negative impact on the separation. However, there is a certain range of top water velocity and feeding speed to stabilize the air flow field in the classification area, so as to improve the classification efficiency of the classifier. Finally, through material experiments, the simulation results are in good agreement with the experimental results.

Keywords

Classifier; internal flow field; flow field distribution; classification efficiency.

1. Introduction

With the rapid development of science and technology, high-precision powder is becoming more and more important in all walks of life. It plays an important role in the mining, building materials, food, chemical, energy and pharmaceutical industries. [1-2] Classifier is a kind of separating equipment. The fine separating performance of classifier directly affects the separating precision of powder. The key to the separating precision is the setting of the structure parameters and operation parameters of the classifier. Therefore, it is particularly important to analyze the internal flow field of the new hydraulic separator. The ANSYS FLUENT 14.5 software is used to study the flow field characteristics of the new hydraulic classifier, which provides a theoretical basis for the experiment and actual production.

2. Classification Principle of New Hydraulic Classifier

The new hydraulic classifier divides the wide-grade particles into two or more narrow-grade particles according to the different settling velocity of the particles in the medium. The medium used for classification can move vertically, horizontally or rotationally. In vertical motion, the flow upwards takes the particles with low settling velocity to the top and expels them. The resulting fine particles are called overflows. The particles with large settling velocity are discharged from the bottom, and the coarse product obtained is called sand grit. The separation process is determined by the following formula according to the direction of the absolute velocity V of particles in the rising medium flow. The absolute velocity and direction of a particle depend on its size. When > V is negative and the particle is pushed upward by the medium; when < V is positive, the particle can still move downward; and when =, the particle will be suspended in space and the absolute velocity is zero. The schematic diagram of particle settling of the new hydraulic classifier and the classification area is shown in Figure 1. If more than one grain size product is to be obtained, the overflow (or sediment) can be further classified in ascending flow with successive decreases (or increases).

3. Calculation Model and Solution Method

3.1 Physical Model

According to the actual structure of the new hydraulic classifier and the main components needed for simulation, the classifier is modeled. The main parameters of the classifier are shown in Table 1. The new hydraulic classifier mainly includes feeding pipe, overflow trough and overflow outlet, classification chamber, reflector, water supply network, underflow outlet. The traditional hydraulic classifier mainly relies on vertical feeding. The new hydraulic classifier improved in this paper relies on spiral feeding, so that the materials entering the classifier are dispersed at a certain spiral angle, thus avoiding the water flow disorder caused by the traditional hydraulic classifier relying on vertical feeding to the classifier chamber. A reflecting plate is designed at the lower part of the feeding pipe, so that the spiral feed slurry has an upward reversion effect. According to the size of Table 1, the corresponding model is set up in CAD, as shown in Fig. 1.

Table 1 setting of model parameters

Structural	Parameters	Structural	Parameters
Feeding pipe diameter /mm	40	Cylinder diameter/mm	20
Insert depth /mm	150	Bottom flow cone height /mm	20
Over flow column diameter/mm	60	Bottom flow cone /mm	R1=50,R2=8
Overflow column height /mm	80	Bottom outlet diameter/mm	5
Overflow outlet diameter/mm	30	Water supplynetwork diameter/m	8

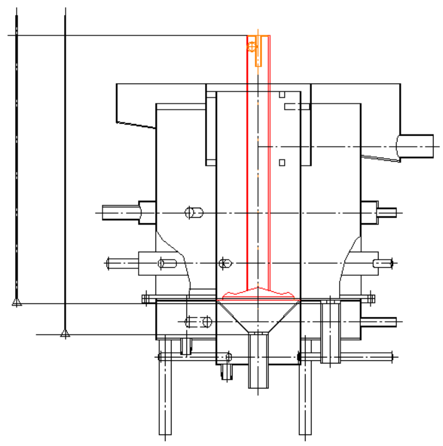


Fig. 1 2-D diagram of three heavy medium classifier

3.2 Mesh Generation and Boundary Conditions

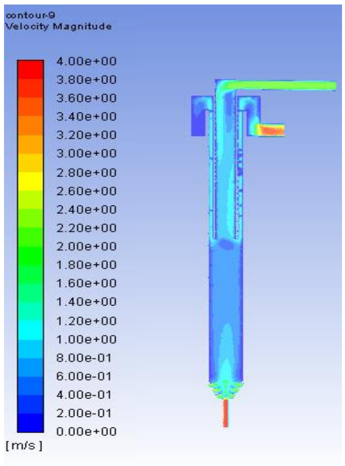
Dividing computational grids is an indispensable part of CFD in solving discrete control equations. And should be CFD The mesh quality should be as high as possible in order to meet the high demand of computing accuracy, efficiency and stability. There are two main categories of Grid: structural grid and unstructured grid. In this paper, Gambit preprocessing software is used to generate grid with higher accuracy of structural mesh types. In view of the irregular body and complex structure of the new type slime hydraulic separator studied in this paper, in order to improve the grid quality, the whole model is divided into several pieces to divide the grid, and finally assembled. And use the Grid/Check command in FLUENT to conduct grid checking to avoid mesh errors. The basic boundary parameters set in this paper include three basic boundary conditions: velocity inlet, pressure outlet and fixed wall.

Flow velocity inlet boundary: In this paper, the feed inlet and the top water inlet are both set as velocity inlet.

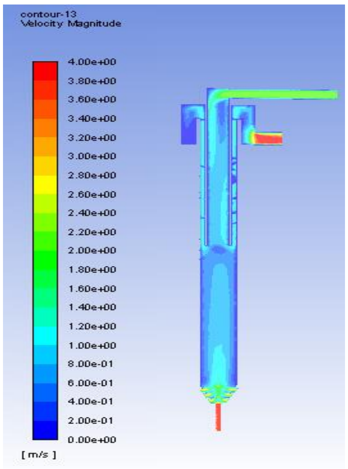
Velocity inlet. The inlet velocity is calculated according to the formula V = flow / inlet area. The feed is fully filled with liquid water, no air, that is, 100% liquid water, 0% air. This simulation mainly inspects the influence of different feeding speed and top water speed on the flow field distribution in the separator.

Flow pressure outlet boundary: Since the product outlets of the sorter are connected with the atmosphere, it is assumed that the outlets are Pressure outlets and the outlet pressure is 0 Mpa.

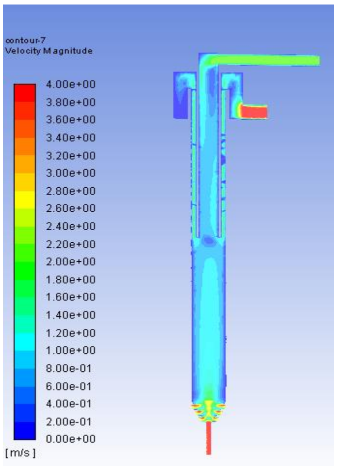
Fixed wall boundary: the separator wall is impermeable, no energy exchange, and no movement slip, set to the standard wall.



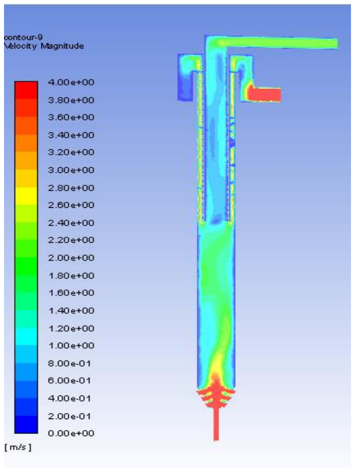
Inlet1.58m/s velocity value



Inlet1.9m/s velocity value



Inlet2.5m/s velocity value



Inlet3m/svelocity value

Fig. 2 velocity of X-Z plane flow

4. Calculation Results and Analysis

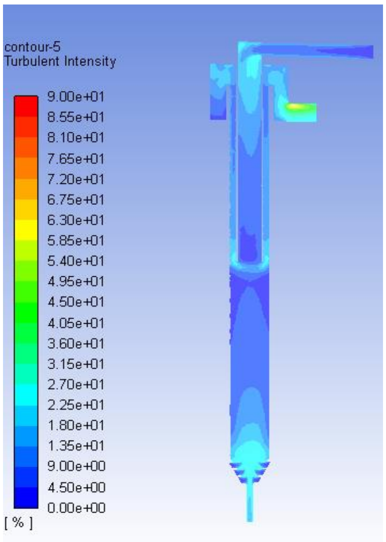
The classification particle size of iron powder by the new hydraulic classifier is determined by the final sedimentation velocity of iron powder in water and the flow velocity of ascending water. There are many factors affecting the classification of particles by classifier, among which water inlet speed and feed speed are the main factors. [3-4] They affect the turbulence intensity of the internal flow field, and the turbulence intensity also affects the separation stability of particles. Therefore, in order to obtain the ideal separation particle size range, it is necessary to understand the influence of the inlet velocity and the feed velocity on the internal flow field. This paper mainly studies the influence of the above two factors on the internal flow field, and studies the advantages of the traditional hydraulic classifier and the new hydraulic classifier under the same variable.

4.1 Simulation Results of Influent Speed

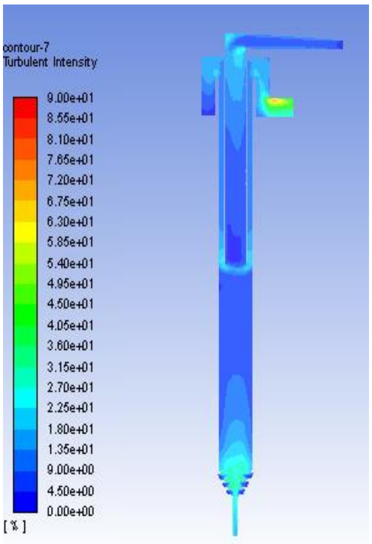
The influence of inlet speed on the flow field of classifier is simulated. Under the condition of a certain feed rate, the water inlet velocity is set as follows. The flow field distribution under different inlet velocities analyzed by the simulation results is shown in Fig. 2.

As can be seen from Fig. 2, the velocity of water flow in the inlet is high, and the velocity gradually weakens in the upward process. When the feed speed is constant, with the increase of the inlet speed, more and more particles enter the overflow. By adjusting the inlet speed, particles with different particle sizes can be obtained. However, when the inlet speed is 4.5m/s, it is found that the rate of water rising at the end of the feeding pipe is equal to or exceeds the feed speed, so that the feeding water is directly carried out into the overflow without the separation of water rising, which cannot achieve the separation and classification effect.

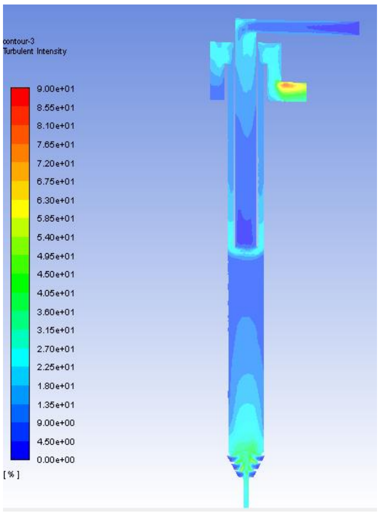
When the water inlet velocity is small, the flow field distribution in the container chamber is symmetrical. Only when the water inlet velocity is large enough, the flow field in the container chamber is obviously disordered, so the large water inlet is not suitable for sorting and classification. The turbulence intensity at different inlet velocities is simulated and analyzed as shown in Fig. 3.



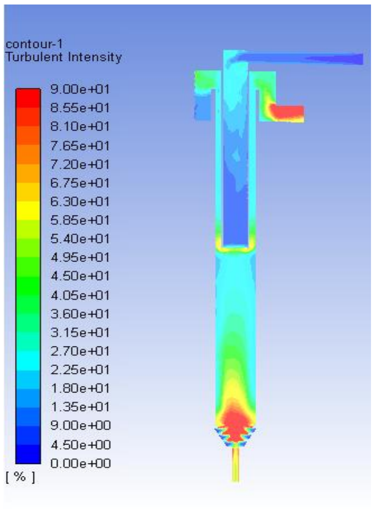
Influent1.58m/turbulence



Influent1.9m/sturbulence



Influent2.5m/sturbulence

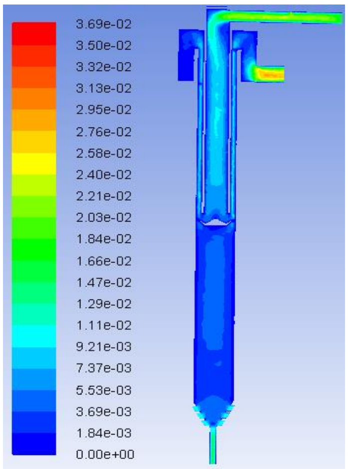


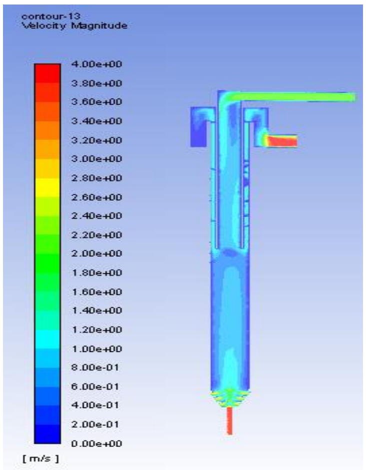
Influent4.58m/sturbulence

Fig. 3 turbulence intensity x-z plan

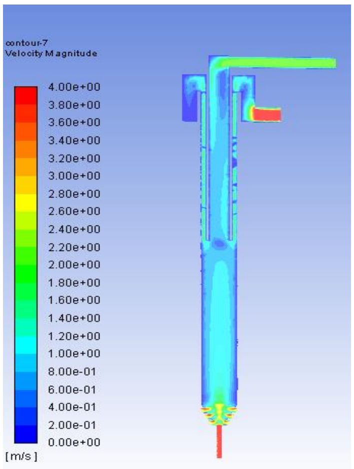
4.2 Feed rate Simulation Results

The influence of feed rate on the flow field of classifier is simulated. Under the condition of a certain inlet velocity, the feed velocity is set as follows. The simulation results show that the flow field distribution under different feed velocity is shown in Figure 4.

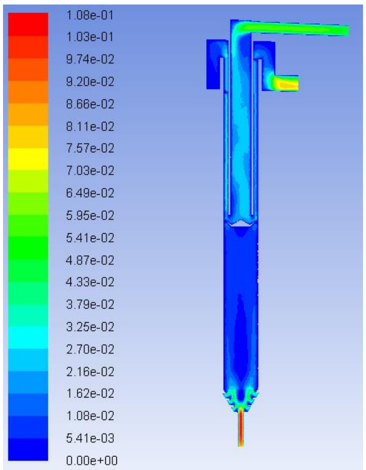




Feed 0.0158m/s speed value



Feed 0.025m/s speed value



Feed 0.045m/s speed value

Fig. 4 distribution of flow field at different feed speeds

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