Computer based Numerical Simulation and Experimental Study on Coarse Slime Separation in Water Medium Fluidized Bed

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Abstract. At present, there is still a lot of room to improve the separation effect of coal blocks, which is mainly due to the lack of effective support for the screening of coal blocks within a certain size and diameter range, which seriously affects and restricts the overall operation efficiency of coal preparation plant and the improvement of economic benefits of operation. Based on this, this paper first studies the current situation and problems of coarse slime separation process, then analyzes the numerical simulation technology and process of coarse coal slime particle number process in water medium fluidized bed, and finally gives the numerical simulation and experimental verification of coarse coal slime separation in water medium fluidized bed.

Keywords: Numerical Simulation, Coarse Slime Separation, Water Medium Fluidized Bed

1. Introduction
At present, with the continuous progress of social economy, the demand for various kinds of energy has increased significantly. As a country with more coal, China's coal consumption has a significant growth every year. However, the washability of China's coal is not high, mainly due to the high proportion of fine coal in domestic coal. In order to further improve the washability of coal, coal preparation plants usually use jigging or heavy medium separation method for coal screening and separation[1]. The two methods used in the past still have a lot of room to improve the separation effect of coal blocks, mainly due to the lack of effective support for the screening of coal blocks within a certain size range, which seriously affects and restricts the overall operation efficiency of coal preparation plant and the improvement of economic benefits of operation. On the other hand, with the continuous rapid iteration of modern technology represented by computer, the coal separation technology based on liquid-solid fluidized bed has made a significant breakthrough and development. This separation technology and method has the typical advantages and characteristics as shown in Figure 1 below, so it has been applied rapidly and widely in recent years.
Advantages and characteristics of coal separation in liquid-solid fluidized bed.

As a new type of coarse slime separation technology, water medium fluidized bed separation technology has been developed and applied rapidly with the application and popularization of computer information technology in recent years. Compared with the traditional coal screening technology, the technology has many advantages and typical applicability, which are shown in the following aspects. First of all, this technology has the advantages of short experimental period, high efficiency and good screening effect. Secondly, the application of this technology can significantly reduce the workload of coal screening, and help to get the characteristics and laws of coal fluidization in water medium from the coal separation process, which lays the foundation for the numerical simulation of coarse slime separation in water medium fluidized bed. In addition, based on the study of the trajectory of coarse slime particles with different density and particle size, it can further lay a theoretical basis for the separation performance analysis of water medium fluidized bed.

The separation methods used in coal preparation industry can be divided into two types: the separation method based on the mass force field and the separation method in the mass force field. The former includes several methods as shown in Figure 2; while the latter's separation accuracy deteriorates with the decrease of particle size\(^2\). With the large-scale of dense medium cyclone, the lower limit of effective separation is increased, and the slime with some diameter particles cannot be effectively separated. Both mass force separations based on density difference and flotation based on surface physicochemical properties have defects in separation of coarse slime. Therefore, it is very urgent to find effective separation technology, equipment and separation mode of coarse slime, which is an important problem to be solved in coal preparation field. Therefore, it is of great practical value to study the computer-based numerical simulation and experiment of coarse slime separation in water medium fluidized bed.

![Figure 1. Advantages and characteristics of coal separation in liquid solid fluidized bed.](image1)

![Figure 2. Types of sorting methods based on mass force field.](image2)

2. Current status and problems of separation technology for coarse slime treatment
2.1. Necessity of coarse coal slime washing and processing
With the continuous improvement of coal mining technology, its modern technical means and equipment are constantly applied to its mining process, which not only improves the mining efficiency, but also leads to the continuous increase of the proportion of fine coal and pulverized coal in the raw coal mined by the coal mine\(^3\). At present, its proportion has been nearly half. In this case, the separation of coarse slime has a practical role and value, which is embodied in the following aspects. First of all, with the continuous improvement of environmental protection requirements, the requirements of coal desulphurization technology are constantly stringent, and the separation upper limit of coal ash desulphurization requirements is constantly reduced, which requires that the content and proportion of each kind of coarse slime in the original need to be greatly increased, so as to achieve economic and effective desulphurization. Secondly, some raw coal desulphurization processes can only remove the coarse-grained inorganic sulfur, which leads to higher requirements for the washing process of coarse coal slime.

2.2. Status quo of coarse slime separation technology
First of all, at the level of coarse slime separation process in power coal preparation plant, there are mainly two kinds of treatment currently implemented, one is not to separate fine coal and slime, the other is to use spiral separator to separate fine coal and slime. Secondly, at the separation level of coarse slime in coking coal preparation plant, there are mainly the following separation processes: desliming and non desliming process, feeding pressurized and non-pressure process, demixing screen is linear screen and banana screen, and medium purification is concentrated magnetic separation or direct magnetic separation process. Among them, the non desliming separation process has the advantages of omitting part of the process and simple system, but its disadvantages are also prominent, such as lower separation accuracy, lower processing capacity, ineffective separation of coarse coal slime, unstable medium, large flow rate of medium separation and higher operation cost of equipment.

In addition, although the desliming process increases the desliming process, it has many advantages, such as improving the separation accuracy and processing capacity, the medium mixing is very stable, the medium separation flow is small, and even no diversion, and the medium recovery efficiency\(^4\). Therefore, compared with the non desliming process, the desliming process has significant application advantages. Figure 3 below shows a typical high frequency screen coarse slime recovery process.

![Figure 3. Typical high frequency screen coarse slime recovery process.](image)

2.3. Problems in current coarse slime separation process
First of all, in the application level of the spiral separator for coarse slime separation, although it has a series of advantages such as low cost and simple operation, the process also has obvious defects, such as low separation accuracy, limited separation density and low single machine processing capacity. Secondly, in the application level of water medium cyclone separation of fine coal and coarse slime, although it has a series of advantages such as low medium requirements, low production cost and relatively simple links, there are still some shortcomings, such as low processing capacity, and the processing capacity of the process for medium washable and difficult to prepare coal still needs to be further improved.

3. Numerical simulation technology of coal slime number process in water medium fluidized bed

3.1. Characteristics of medium fluidized bed coarse separation technology
Compared with other separation methods, the medium fluidized bed coarse separation technology has more typical characteristics, such as its strong economic, scientific, intuitive and application advantages[5]. In the economic level, it can provide data support for the real coarse peat separation, so as to reduce the waste of resources and save the cost. Secondly, at the scientific level, the numerical simulation technology can explore the relationship between coarse peat particles and environment. In addition, it can show the process of simulation experiment more realistically and reduce the error of simulation.

3.2. Numerical simulation process of coarse separation in water medium fluidized bed
To carry out the numerical simulation of coal slime number process in water medium fluidized bed based on computer, it is necessary to build its mathematical model, and set the parameters of the mathematical model by giving the size and boundary conditions of the fluidized bed equipment. Secondly, based on the discretization of spatial region, the control process is replaced by the set of finite discrete points[6]. In addition, the discrete control equation should be established to realize the parameter solution and approximate value calculation under certain initial and boundary conditions. It should be pointed out that the numerical simulation of coarse separation in water medium fluidized bed needs to be compared with the actual experimental research, so as to modify and improve the numerical simulation model, so that the model is constantly optimized and iterated to an acceptable range of differences.

3.3. Numerical simulation method of coarse separation in water medium fluidized bed
Numerical simulation of coarse separation in water medium fluidized bed mainly includes discrete element method, group equilibrium model and computational fluid dynamics method, as shown in Table 1. Firstly, the models are classified into hard sphere model and soft sphere model. The hard ball model is suitable for the case of less collision, while the soft ball model is suitable for the case of multi-point contact instantaneous collision. Secondly, the particle to particle and the contact force between particle and wall are used to model the dispersion, separation and accumulation of coarse peat particles.

| Methods | Features | Disadvantages |
|---------|----------|---------------|
| DEM | Particle contact and interaction model | High computational cost, combine with other simulation algorithms |
| PBM | Describe changes in particle distribution | Cannot be used in scale-up of fluidized bed granulation process |
| CFD | Determination of fluid flow drag | High computational complexity, and costs |

4. Numerical simulation and experimental study on coarse slime separation in water medium fluidized bed
4.1. Numerical simulation of coarse slime separation in water medium fluidized bed
Firstly, the mathematical model and numerical method of water medium fluidized bed coarse coal slime separation numerical simulation are established and simulated. In the simulation of boundary conditions and initial conditions, the velocity inlet is the inlet pipe and the material pipe, and the outflow boundary is the overflow pipe and underflow pipe. Secondly, based on the simulation results of clean coal separation, it can be judged that the movement of coarse slime particles is a kind of disordered movement, and the particles are interfered and collided in the process of fluidized bed movement, which affects the movement speed of particles and prolongs the time required for completing the separation process. In addition, at the tailings separation level, the tailings particles all move downward, and all the particles are discharged from the underflow outlet.

4.2. Experimental study on separation of coarse slime in water medium fluidized bed
The coarse slime separation test system based on computer is composed of water supply, fluidized bed and control system, and has two control modes: automatic and manual. The particles whose settling velocity is equal to the water flow velocity form a fluidized bed with a certain density, and the particles whose falling velocity is less than or greater than the water flow velocity become clean coal. In addition, the operational parameters of water medium fluidized bed include feed concentration, rising water velocity and feeding direction. When the particle size, i.e. the operating parameters, is suitable, good separation effect can be achieved. Based on the experiment of coarse slime separation in water medium fluidized bed, in order to ensure the effect of removing mismatching, enlarge the size of coarse slime separation and ensure the efficient and stable operation of liquid-solid fluidized bed, it is necessary to further optimize the structure and process parameters of liquid-solid fluidized bed.

5. Conclusion
In summary, compared with the traditional coal screening technology, the water medium fluidized bed separation technology has many advantages and typical applicability. This technology has shorter experimental period, higher efficiency and better screening effect. Secondly, the application of this technology can significantly reduce the workload of coal block screening, and help to get the characteristics and laws of coal fluidization movement in water medium from the coal separation process. In this paper, through the research on the current status and problems of coarse slime separation technology, the status quo and problems of the existing coarse slime separation process are analyzed. Through the analysis of the numerical simulation technology of the coarse coal slime particle number process in the water medium fluidized bed, the method and process flow are studied. Finally, the conclusion is verified by numerical simulation and experiment based on water medium fluidized bed.

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