Semi-industrial experimental research on the influence of moisture on air dense medium fluidized bed separation

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Abstract. This paper conducted a semi-industrial experimental study on the influence of moisture on air heavy medium fluidized bed separation. The research results show that with the increase of coal moisture, the separation accuracy of the separator decreases. When the coal external water is 6.83%, it is difficult to effectively sort the coal; with the increase of the sorting time, the medium moisture will increase slightly; the medium consumption of clean coal and gangue products increases with the increase of the coal external water; when the water exceeds 3%, the media consumption has an almost linear relationship with the external water content; the media with agglomeration or excessive water content is not suitable for direct use as a sorting media and needs to be dried.

1. Introduction
With the increasing awareness of environmental protection and comprehensive utilization of coal resources in countries around the world, fluidized coal preparation technology has attracted the attention of more countries. At present, many scholars are studying the separation of air in a dense medium fluidized bed [1-5]. The water transfer behavior in the gas-solid fluidized bed and its influence on the fluidized bed coal preparation process are extremely critical[6].

2. Industrial test system
The air-dense-medium vibrating fluidized bed semi-industrial test system is a comprehensive sorting system.

![Schematic diagram of air-dense medium semi-industrial test system](image-url)

1-roots blower 2-control valve 3-air bag 4-speed regulating valve 5-rotameter 6-feeding device 7-air dense medium separation section 8-density detection device 9-bed height monitoring device 10-vibration discharge section 11-gangue de-medium screening 12-clean coal de-medium screening 13-electromechanical control box

Fig.1 Schematic diagram of air-dense medium semi-industrial test system
It takes the sorting machine, the density and bed height online monitoring system and the electromechanical control device as the main body, and is equipped with a feeding system and an air supply system, Media recovery and product delivery systems, etc. Each single system and link must be matched and coordinated with each other to ensure the overall relevance of the entire sorting system. During the test, the feeding device continuously feeds coal and medium. After the coal enters the fluidized bed, it is separated according to density, and the light and heavy products are discharged through the clean coal and gangue deintermediation sieve respectively, and finally clean coal and gangue are obtained. The physical map of the system is shown in Figure 1 and Figure 2.

2.1 Feeding system
The feeding system is mainly composed of a coal feeding silo, a medium feeding silo and a silo gate. During the operation of the system, materials and media enter the bed from the warehouse through the gate control. The feed ratio of materials and media will have an important impact on the sorting, so the reliability and stability of the feeding system play a key role in the sorting effect of the equipment.

2.2 Air supply system
The air supply system is mainly composed of air compressors, wind drums, rotameters, pipelines, and electromechanical control devices. Each air chamber in the sorting machine corresponds to a rotameter and a pipeline, and the range of the rotameter is 1000m³/h. The air compressor provides compressed air. When the compressed air flows through the filter, the impurities and moisture in the gas are filtered out. The purified air enters the air chamber of the sorting machine after being stabilized by the air bag; meanwhile, the air volume entering the air chamber must be adjusted by the control valve, and the air volume can be measured by a rotameter.

2.3 Sorting system
The sorting machine is mainly composed of a machine body, an air distributor, a reclaimer, an on-line monitoring device for density and bed height, and a vibration exciter. The equipment is connected to the base through four rubber springs and fixed on the ground of the work site; the vibration frequency of the sorting machine is adjusted by a digital frequency modulator; the angle between the exciter and the sieve plate is 45°, and the angle between the sieve plate and the ground is 6°. For the first time, the TQ-883 intelligent density meter was applied to the density detection of fluidized bed, which opened up a new way for the density detection of air dense medium fluidized bed.
2.4 Sorting system
The media recovery and product conveying system is mainly composed of a clean coal removal screen, a gangue removal screen, a clean coal belt, a gangue belt, a media transfer belt, a media belt, and an electromechanical control device. After selection, the products are separated into the gangue bin and the clean coal bin after being separated by the gangue and clean coal. The media under the sieve is recovered and recycled.

3. Experiment
The coal sample used in the experiment is non-stick coal with a particle size of 80-6mm. The results of the float-sink experiment are shown in Table 1, and the selectivity curves are shown in Figure 3. The dominant particle size of the selected magnetite powder is 0.300-0.074 mm, and the true density is 4166kg/m³.

From the results of the float-sink test, we can see that the content of each density level of coal is not uniform, and the ash content of each density level gradually increases with the increase in density. The density level of <1.3 g/cm³, 1.3~1.4 g/cm³, 1.4~1.5 g/cm³, 1.7~1.8 g/cm³, 1.8~2.0 g/cm³, >2.0 g/cm³ has a larger content, and the other density levels have a larger content less; By analyzing the content of adjacent density levels, it can be seen that when the sorting density is 1.3 g/cm³, 1.4 g/cm³, coal is extremely difficult to be selected, and when the sorting density is 1.5 g/cm³, 1.8 g/cm³, coal is more difficult to select coal; When the sorting density is 1.7 g/cm³ and 1.9 g/cm³, the coal is medium-selectable coal, and when the sorting density is 1.6 g/cm³, the coal is easy to be cleaned. Through the analysis of the selectivity curve: when the ash content of clean coal is 16%, the yield of tailings is 46%, the yield of clean coal is 54%, the sorting density is 1.62 g/cm³, and the content of δ±0.1 is 7%. For easy coal preparation.

| Density level (g/cm³) | This level yield (%) | Ash (%) | Float accumulation | Accumulation of sinking | Sorting density +0.1 content |
|-----------------------|----------------------|---------|--------------------|------------------------|----------------------------|
|                       | Yield (%)            | Ash (%) | Yield (%)          | Ash (%)                | Density (g/cm³)            | Yield (%) |
| <1.30                 | 16.46                | 8.32    | 16.46              | 8.32                   | 100.00                    | 38.42      |
| 1.30 – 1.40           | 18.63                | 15.75   | 35.09              | 12.26                  | 83.54                     | 52.35      |
| 1.40 – 1.50           | 17.21                | 21.56   | 52.30              | 15.32                  | 64.91                     | 63.75      |
| 1.50 – 1.60           | 1.65                 | 33.11   | 53.95              | 15.87                  | 47.70                     | 63.75      |
| 1.60 – 1.70           | 3.23                 | 38.97   | 57.18              | 17.17                  | 46.05                     | 64.84      |
| 1.70 – 1.80           | 12.40                | 47.74   | 69.58              | 22.62                  | 42.82                     | 66.79      |
| 1.80 – 2.0            | 15.33                | 69.18   | 84.91              | 31.03                  | 30.42                     | 74.56      |
| >2.0                  | 15.09                | 80.03   | 100.00             | 38.42                  | 15.09                     | 80.03      |
| total                 | 100.00               | 38.42   |                     |                        |                           |            |
4. The influence of the external moisture content of coal on the sorting effect

This article defines the external moisture as the percentage of the moisture mass removed from the coal after being dried for a long time at 50°C in the drying oven to the original mass of the coal. Non-stick coal with different external water content is used as the selected material. Figure 4 shows the distribution curve when the external water content of coal is 2.03%, 2.85%, 3.60%, 5.53%, and 6.83%, respectively. It can be seen from Figure 4 that when the coal external water increases from 2.03% to 5.53%, the EP value changes from 0.045 to 0.115; when the coal external water reaches 6.83%, the EP value is 0.16; this shows that with the increase of coal moisture, the sorting accuracy of the sorter decreases. When the coal water is 6.83%, it is difficult to effectively sort the coal.

This is because after the wet coal enters the fluidized bed, it contacts, collides and rubs with the aggravated material, and a certain amount of medium adheres to the surface of the wet material. As the medium wraps the material, the average density of the material increases, so that the material in the bed cannot be layered according to the original density. At the same time, water transfer behavior occurs between the material and the fluidized bed, which increases the moisture content of the aggravated material, and the fluidized bed is viscous and has poor fluidity, which deteriorates the fluidization effect.
and affects the normal sorting of materials. As the moisture content of the medium increases, the bubbles in the bed will also become larger, which increases the instability of the bed and the unevenness of the density, and the sorting effect becomes worse. Tests have proved that the external moisture of coal should be controlled below 6%.

5. The changing law of the moisture content of the heavier in the bed
When coal with a certain amount of external water is continuously selected and the medium is recycled, the change in the moisture content of the heavier mass in the bed is shown in Figure 5. It can be seen from Figure 5 that as the sorting time increases, the water content of the medium will increase slightly. After the material enters the fluidized bed, it will come into contact with the aggravated material, and the medium will adhere and wrap on the surface of the material. At this time, the transfer and transfer of moisture will occur between the material and the fluidized bed, which greatly increases the moisture content of the coal surface medium; Most of the wet medium will adhere to the surface of the material and be discharged with the material, but due to the constant collision and friction between the material and between the material and the medium, a small part of the wet medium will fall off the bed.

![Fig.5 The change regulation of medium moisture content in the bed](image)

Because the material is continuously fed and the circulating medium is not dried, the amount of newly added moist medium in the sorting area is higher than the discharge amount of the wet medium, so the moisture content of the bed in the sorting area will gradually increase. However, the blast effect is beneficial to the volatilization of water in the bed, which will slow down the increase in water in the bed.

6. The influence of different external water coal on media consumption
Through the sorting experiment of non-stick coal with different external water content, the influence of different external water coal on media consumption was investigated. When the coal water content is 2.03%, 2.85%, 3.60%, 5.53%, respectively, the amount of adhesion medium of the clean coal and gangue products is shown in Figure 6.
It can be seen from Figure 6 that the medium consumption of clean coal and gangue products increases with the increase of coal water; when the water exceeds 3%, the medium consumption has an almost linear relationship with the water content. Due to the different surface properties of clean coal and gangue, the media consumption of clean coal is significantly higher than that of gangue. When the external water content is 4%, the medium consumption per ton of coal is about 2.7kg; therefore, from the perspective of reducing medium consumption, the external water content of coal should be controlled below 4%.

7. The influence of the moisture content of the heavier mass on the sorting effect
The media with agglomeration or high moisture content is not suitable for direct use as a sorting medium and needs to be dried. Because when the aggravated matter moisture is too high, the resistance of the gas through the bed increases and the bubbles become larger, the initial fluidization velocity $U_{mf}$ increases, which makes the gas-solid two-phase rheology of the air-heavy medium fluidized bed worse. The fluidization effect of the bed layer will deteriorate with the increase of the aggravating moisture, and phenomena such as leaping and "dead zone" will appear; from the appearance of the fluidized bed layer, the higher the medium moisture, the more unstable the bed surface. According to the test, when the aggravated moisture reaches 0.5%, the medium can hardly fluidize normally.

8. Conclusion
(1) With the increase of coal moisture, the sorting accuracy of the sorting machine decreases. When the coal water is 6.83%, it is difficult to effectively sort the coal.
(2) As the sorting time increases, the water content of the medium will increase slightly.
(3) The medium consumption of clean coal and gangue products increases with the increase of coal external water; when the external water exceeds 3%, the medium consumption has an almost linear relationship with the external water content.
(4) The medium with agglomeration or high moisture content is not suitable for direct use as a sorting medium and needs to be dried.

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