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Fine coal dry classification and separation

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ABSTRACT

The quantities of coal being separated and the levels of separation required are increasing with the demand of environmental protection. Although coal is currently cleaned with the minimum of size reduction, fine particle processing, recovery, and tailings disposal are major problems. Furthermore, adequate water resources are not always available. For example, two thirds of China's coal are located in arid areas. Hence, dry separation provides an alternative approach. Of the dry coal separation methods available, air dense-medium fluidized beds have been used to separate 50-6mm coal efficiently. However, excessive bubbling and back mixing of the separated solids in the air-dense media fluidized bed causes the high lower size limit of 6mm for the feed material, this affecting the preparation efficiency. Based on prior study on air-fluidized dense media for 6-50mm coal preparation, this paper presents methods and test results on the fine coal dry classification, static electricity beneficiation of 0-0.5mm coal, and magnetically stabilized fluidized beds for separating 0.5-6mm coal.

Keywords: Fine coal; Classification; Separation; Magnetically stabilized fluidized beds; Static electricity beneficiation

1. INTRODUCTION

Fine coal dry classification and separation becomes more and more important in China. The commercially available classification technologies are far from meeting the industrial needs, especially for dry classification of moist raw coal at separation size smaller than 6mm. A new classification technology of raw coal, referred to as vibrated fluidized bed air classification technology, has been invented and patented by the authors. The vibrated fluidized bed air classifier completely eliminates the aperture-blinding problem, resulting in an effective classification of raw coal at separation size smaller than 6mm, even down to 0.125mm. After classification, the fine coals 0-0.5mm and 0.5-6mm are beneficiated with dry static electricity separator and magnetically stabilized fluidized bed respectively.

2. DRY CLASSIFICATION OF 0-6MM COAL

The 50-0mm coal can be screened into 50-6mm and 6-0mm coal by QGS2020 type piano-wire probability screen (Yaomin et al., 1998). Then, the 0-6mm coal is first classified into two fractions: the coal fines with the size below 0.5mm and the fine coal with the size between 0.5mm and 6mm. In this process, a pneumatic classification technology is adopted (Guohua et al., 1999). The working principle of the pneumatic classification in a vibrated bed is shown in Figure 1. The 0-6mm coal is fed at one end of a rectangular chamber, which has a vibrated porous plate in its lower part and flows along the vibrated porous plate to the other end under the effect of the vibration. Under the actions of ascending air and vibration, particles are so mobile as to behave as a fluid, forming a vibrated fluidized bed. The particles move in all directions, jostling, rubbing, readily breaking up the agglomerates of fines and abrading off fines stuck on the surface of coarse particles into individuals. The fine and light particles with settling velocities

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less than the air velocity are entrained by the ascending air. Eventually the retained coarse particles are removed from the discharge. As a result, the efficient extraction of fines from the coarse is achieved. In this process, the vibration action is very important and necessary for separation of moist feed of wide size distribution. Otherwise, the load will not be able to spread out in a uniform layer over the full width of the bed, get loosened, or move from the feed end to the discharge end.

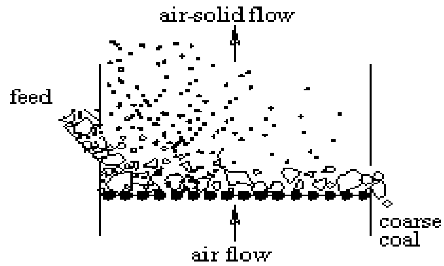
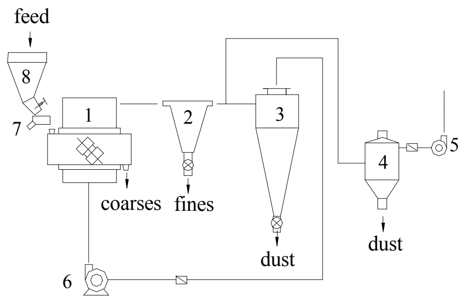


Figure 1. Pneumatic classification in a vibrated bed

A pneumatic classification system is shown in Figure 2, consisting of a feeder, a vibrated fluidized bed classification chamber, a fines collector, a dust cyclone, a bag filter, an exhaust fan, and a circulating fan There may be three air flow patterns: closed circuit, open circuit, and partly open circuit. A closed circuit is suitable if the feed contains very fine dust that cannot be removed by a cyclone. However, the finest dust in closed circuits tend to accumulate in the air if de-dusting is incomplete, which reduces the dust-entraining capacity of the air or accelerates its saturation. Humidity may also build up in the air, reducing its de-dust capacity and wetting both the machine and products. In a fully open circuit, high-grade air purification or de-dusting is required, which is rather costly.



1. VFB separator 2. fines collector 3. cyclone 4. bag filter
5. exausting fan 6. circulating fan 7. feeder 8. hopper

Figure 2. A pneumatic classification system

A great number of test results show that the classifying efficiencies can reach 78.62%-85.57% for 0.5 mm classification when the surface moistures of the 0-6mm coal are below 6.0%. These classification efficiencies and the minimum classifying sizes of coal usually can't be obtained by conventional dry screening. One group of 0-6mm Chongqing coal pneumatic classification test results is shown in Table 1.

Table 1
Pneumatic classification test results of 0-6mm Chongqing coal

Surface moisture of feed, %	Ash content of 0-6mm coal, %	Classification Efficiency, %	Ash content of coarse coal, %	Ash content of fine coal, %	Ash content of 0-0.5mm coal in feed, %	Ash content of 0-0.5mm coal in fine product, %
2.24	14.60	85.57	17.96	10.39	12.94	10.55
4.50	14.60	83.44	17.84	10.56	12.94	10.63
6.35	14.60	81.89	17.67	10.85	12.94	10.96
8.82	14.60	78.62	17.63	10.89	12.94	10.98

Table 1 shows that the pneumatic classification efficiency decreases from 85.57% to 78.62% as the surface moisture of feed increases from 2.24% to 8.82%. It also shows that there is a noticeable separation process in the pneumatic classification. The ash content of 0-0.5mm coal in fine product is lower than the ash content of 0-0.5mm coal in feed. The ash content of fine coal is lower than 11.00%, which can meet the ash content requirement of clean coal. If necessary, the pneumatic classification fine product with the size range of approximately 0-0.5mm can be further separated with static electricity technology.

3. DRY SEPARATION OF 0-0.5MM COAL

Using coal dry static electricity beneficiation technology, the ash content of the fine product (0-0.5mm coal) of the above pneumatic classification in a vibrated bed can be further reduced down to 6.54%, while the ash content of the refusal coal can be up to 58.69% (Qingru et al., 1997).

4. DRY SEPARATION OF 0.5-6MM COAL

The authors studied magnetically stabilized fluidized beds (MSFB) for fine, 0.5-6mm, coal dry preparation (Maoming et al., 2000, 2001, 2002). The MSFB has good fluidization characteristics (Tuthill, 1969; Siegell and Carl Pirkle, 1984-1985; Lochmuller and Wigman, 1987; Rosensweig et al., 1987; Harel et al., 1991; Cohen and Tien, 1991; Saxena and Shrivastava, 1991; Sergeev and Muromsky, 1994; Hristov, 1996; Brandani and Astarita, 1996; Wu et al., 1997; Maoming et al., 2000), and is especially suitable for 1-6mm coal separation.

4.1. Characteristics of the fluidization media

We studied many fluidization media, from which we chose the magnetic beads recovered from coal-fired power plant cinder. The magnetic beads are mainly composed of Fe_3O_2 and Fe_3O_4, and are mostly hollow spheres as shown in Figure 3. The size distributions of three kinds of magnetic beads range from +300μm to -25μm.

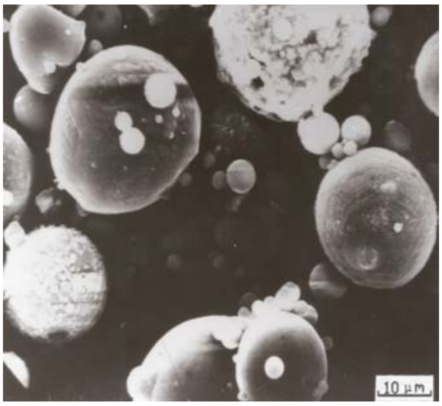


Figure 3. Micrographic of magnetic beads

The real density and bulk density of magnetic beads are shown in Table 2. The real density mainly depends on the mineral composition, while the bulk density depends on both the real density and the porosity of the magnetic beads.

Table 2
Real density and bulk density of magnetic beads from three sources

	Zouxian	Shiliquan	Fushun
Real density (kg/m^3)	3650	3680	3720
Bulk density (kg/m^3)	1780	1800	1840

The specific magnetization susceptibility (X) of the magnetic beads has been found on a type-9500 magnetometer to exceed 6.30×10^{-6}m^3/kg.

4.2. Experimental system

The experimental system, shown in Figure 4, is composed of two flow regulating valves (1), an flowmeter (2), a manometer (3), a DC power supply (4), a fluidized bed (5) electromagnet coils (6).

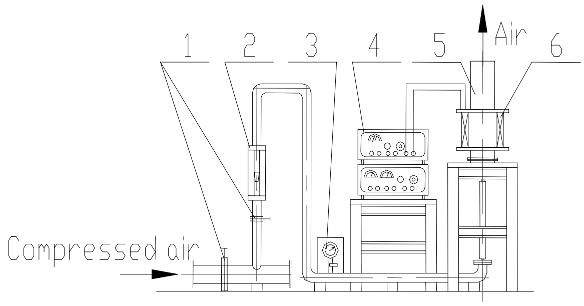


Figure 4. Experimental system

Fluidization was carried out in a vessel made of non-magnetic materials, including the interconnecting pipes, screws and nuts. The fluidization vessel had an inner diameter of 100mm, an effective height of 300mm, and was fitted with a stainless steel sintered distributor plate. The electromagnet coils were wound with 1.5mm diameter insulated wire, each 100mm in height, 180mm i.d., and 210mm o.d. The magnetic field intensity could be adjusted by regulating both the quantities of the electromagnet coils in operation and the electric current.

4.3. Separation results

Run of mine coal was separated into three particle size groups: 0-0.5mm, 0.5-6mm and 6-50mm. The 0.5-6mm coal was used in the present MSFB study, since the 6-50mm coal can be separated in air-fluidized dense media, and the 0-0.5mm coal can be separated by static electricity technology.

We chose Zouxian magnetic beads (size distribution shown in Table 2) as the fluidization media. The magnetic field intensity used was 30 oersted and the gas velocity was 12.3mm/s. Under this condition, the fluidized bed density of the magnetic beads MSFB could be maintained at 1520kg/m^3. The 0.5-6mm coal to be separated was introduced into the MSFB by dropping it from a height of 30mm above the bed surface. The coal particles floated to the surface of the MSFB, while the gangue particles sank to the bottom of the MSFB.

After forty seconds of separation, both the fluidizing gas flow and the magnetic field were shut off. Then two samples of the float product in the top bed stratum and the sink product in the bottom bed stratum were taken. The float-and-sink results and the partition coefficients are shown in Table 4. The corresponding partition curve, which relates the partition coefficient (i.e., the percentage of the feed material of a particular density that reports to the sink product) to density, is shown in Figure 3.

Table 3
Float-and-sink results for 0.5-6mm coal in Zouxian MSFB

Density kg/m^3	Mean density kg/m^3	Feed wt. %	Floats % of feed	Sinks % of feed	Reconstituted feed wt. %	Partition coefficient
-1350	—	11.92	11.67	0.31	11.98	2.60
1350-1400	1375	24.19	23.37	0.74	24.11	3.18
1400-1500	1450	21.87	20.19	1.82	22.01	8.25
1500-1600	1550	8.64	3.23	5.22	8.45	61.75
1600-1700	1650	7.73	1.47	6.19	7.66	80.81
1700-1800	1750	6.05	0.59	5.60	6.19	90.50
1800-1900	1850	6.26	0.34	5.81	6.15	94.38
1900-2000	1950	6.71	0.25	6.34	6.59	96.07
+2000	—	6.63	0.19	6.67	6.86	97.23
Total		100.00	61.30	38.70	100.00	

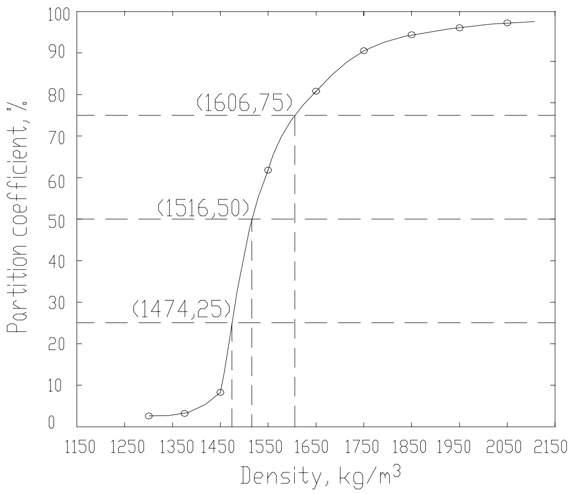


Figure 3. Partition curve

The partition curve between 25% and 75% gives a reasonable straight-line relationship, which shows the efficiency of the separation process. The probable error of separation, or the Ecart probability (E) shown in Figure 3, is defined as half the difference between the densities at which 75% reports to sinks and 25% reports to sinks:

$$E = \frac{1606 - 1474}{2} kg/m^3 = 66 kg/m^3 \quad (1)$$

The E value of 66kg/m^3 shows good separation efficiency. By comparison, the E value for the 0.5-6mm coal separation in ordinary air-fluidized dense media is only 247kg/m^3.

The density at which 50% of the particles report to sinks is known as the effective density of separation, which is 1516kg/m^3, according to Figure 3. This is close to the fluidized bed bulk density of the MSFB, 1520kg/m^3.

4 CONCLUSIONS

The pneumatic classification efficiency is between 85.57% and 78.62%. There is a noticeable separation process in the pneumatic classification. The ash content of 0-0.5mm coal in fine product is lower than the ash content of 0-0.5mm coal in feed. Usually that can meet the ash content requirement of clean coal. If necessary, the pneumatic classification fine product with the size range of approximately 0-0.5mm can be further separated with static electricity technology.

Magnetic beads recovered from coal-fired power plant cinder produce the heavy media, which are suitable for magnetically stabilized fluidized bed (MSFB) to separate fine coal into light and heavy fractions. Experimental results show that the probable error of separation (E) is 66kg/m^3.

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