Vol. 5 No. 2
Nov. 1998

J. CENT. SOUTH UNIV. TECHNOL.

FINE COAL AND THREE PRODUCT DRY BENEFICIATION WITH VIBRATION AND DOUBLE-DENSITY FLUIDIZED BEDS *

Wei Lubin

(Department of Mineral Engineering, Central South University of Technology, Changsha 410083, China)

Chen Qingru Luo Zhenfu

(China University of Mining &Technology)

Abstract The fluidizing performance and density uniform stability of vibration fluidized beds were analyzed. The experimental results in 2000 mm×80 mm×200 mm model apparatus show that the vibration fluidized bed can efficiently separate fine coal of size 6—0.5 mm, the beneficiation lower limit is 0.5 mm, the E_p value is 0.07. A double-density fluidized bed was formed by which the bed structure was specially designed with a pyramidal part. It can efficiently turn out three products according to densities in a fluidized cascade. The suitable range of gas flow rate is 4.4—4.6 m^3/h. In the lighter area, the separation density is around 1.49 g/cm^3, and E_p value is 0.06. In the denser area, the separation density is about 1.85 g/cm^3, and E_p value is 0.07.

Key words dry beneficiation; vibration fluidized bed; three-product separator

The dry beneficiation technology with air dense medium fluidized bed can efficiently beneficiate the coarse coal of size 50～6mm. However, this technology can not beneficiate efficiently the small coal of size < 6 mm for two reasons. First, air dense medium fluidized bed belongs to bubble fluidized bed that has a bigger viscosity and back mixing of medium solids, so, the feedstock that has layered according to bed density may be mixed again, and the beneficiation efficiency will be lower. In addition, the grain size of medium solid is not small enough compared with that of feedstock, and good fluidizing quality can not be maintained if the grain size of medium solid is reduced[1-5]. The current separator with air-dense medium fluidized bed can only turn out two products at the same time with single separating density. Two separators must be exploited in the way of serials connection to turn out three products, which leads to the complication of technical system and the increase of construction investment and operation cost. Moreover, it is difficult to operate continuously owing to the problems of preparation and recovery of dense media[6]. To improve further this technology, research on the extension of the beneficiation range of grain size and the three-product separator is carried out.

1 FINE COAL BENEFICIATION WITH VIBRATION FLUIDIZED BED

The vibration fluidized bed (VFB), which introduces the vibration energy into common fluidized bed, strengthens the contact between gas and solids, and improves the fluidizing performance of fluidized bed[7,8]. So, VFB can make the medium solids fluidized, and the size of medium solids is very small, This reduces the back mixing of medium solids. Those characteristics are very suitable for the beneficiation of small coal.

On the basis of the feasibility study of small coal beneficiation with VFB, we designed and manufactured the VFB apparatus of size 2000 mm ×80 mm×200 mm which can continuously beneficiate the small coal. The schematic diagram of system is shown in Fig. 1. This system mainly consists of air supply, beneficiation apparatus, and dust removal, etc.

First, we put the medium solids (such as magnetic powder with a specific size distribution) into chamber, and then let air enter the bed homogeneously via an air distributor at the bottom of the bed . During the period, we adjust the vibration parameters and air flow rate to make air and

* Project supported by the National Doctoral Fund of the State Education Committee of China

Synopsis of the first author Wei Lubin, born in July 1962, received Ph D degree in 1995, majoring in mineral dry beneficiation and dry deep screening of moist fine coal.

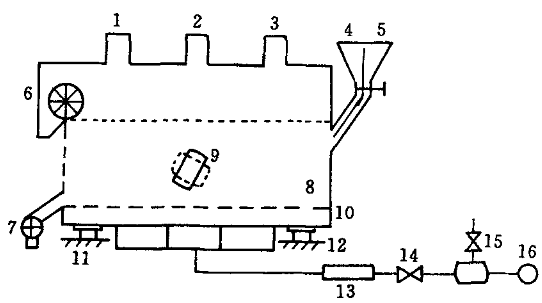
Manuscript received March 19, 1998

Table 1 Sink-float composition in products of Baijiazhuang coal mine

Density /g·cm^{-3}	Feedstock		Cleanings			Tailings			Partition coefficient/%
	I	Ash/%	I	II	Ash/%	I	II	Ash/%	
−1.3	12.51	1.81	15.01	12.42	1.81	0.51	0.09	1.87	0.72
1.3−1.4	56.22	5.65	66.98	55.43	5.65	4.56	0.79	5.83	1.41
1.4−1.5	7.41	15.71	8.72	7.22	15.70	1.12	0.19	16.12	2.56
1.5−1.6	3.07	25.30	3.43	2.84	25.24	1.34	0.23	26.08	7.49
1.6−1.8	7.36	36.52	5.34	4.42	36.14	16.97	2.93	37.09	39.86
1.8−2.0	3.18	51.80	0.46	0.38	50.88	16.25	2.80	51.93	88.05
+2.0	10.26	76.55	0.06	0.05	75.41	59.25	10.21	76.56	99.51
total	100.00	17.53	100.00	82.76	8.50	100.00	17.24	60.88	

I: Percent of tailings or cleanings(%).
II: Percent of feedstock(%).

solids contact enough. After the uniform and stable fluidized bed is formed, We feed the feedstock into fluidized bed. The feedstock will disperse gradually in the bed due to the effects of vibration and airflow parameters. In the meantime, the feedstock will continuously stratify by bed density and move to releasing end for the effect of horizontal vibration force and overflow. Finally, the clean coal and tailings coal will be released out of apparatus and the beneficiation process is fulfilled.



1,2,3—dust removal; 4—feedstock; 5—dense medium; 6—cleaning coal vane; 7—tailings vane; 8—bed; 9—vibration electrical machinery; 10—air distribution; 11,12—rubber spring; 13—floater flowmeter; 14—air valve; 15—air buffer; 16—inlet fan

Fig. 1 Schematic diagram of vibration fluidized bed apparatus

Experimental results show that VFB has characteristics of a good fluidizing performance and stable uniform density of bed under optimal vibration and fluidizing parameters with magnetic powder or magnetic pearl as medium solids. The beneficiation results for small coal of size 6—0.5mm show that VFB can beneficiate efficiently small coal, the lower limit of beneficiation is 0.5 mm.

We use the mixture of magnetic powder with a specific size distribution of coal powder as medium solids, and some operation parameters are the bed height of 75 mm, the vibration intensity of 1.23, the vibration direction inclination of 40°, and the gas velocity of 1.65 cm/s. The beneficition results show that when ash content of the small coal of size 6—1mm is 17.53%, and the beneficiation density is 1.72 g/cm^3, ash content of the clean coal is 8.50%, recovery yield of the clean coal is 82.76%, the E_p value is 0.07. The sink-float composition in products and distribution coefficient are shown in Table 1, the corresponding partition curve of tailings is shown in Fig. 2. When we use magnetic pearl as medium solids, VFB can efficiently beneficiate small coal within lower density range under the optimal vibration and gas velocity parameters. So, the fluidized bed density of VFB also can be adjusted between 1.3 g/cm^3 and 2.1 g/cm^3, which can meet the beneficiation demands for various coals.

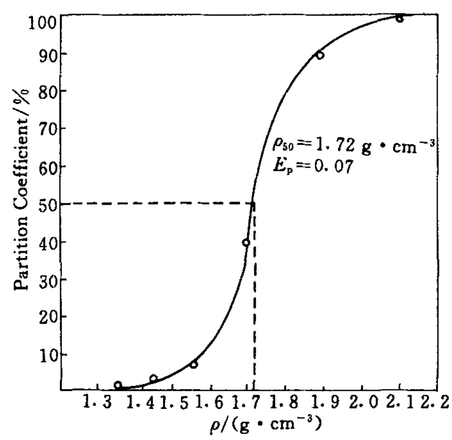


Fig. 2 Partition curve of tailings

2 THREE-PRODUCTS SEPARATOR WITH AIR-DENSE MEDIUM FLUIDIZED BED

The formation of double-density fluidized bed is the key to three-product separation. It means that two separating areas with different densities are formed in a fluidized cascade. In each separating area, the bed density is uniform and meets respectively the technical needs of coal preparation. Therefore, the settled materials can be separated as three products according to density.

Considering the preparation and recovery of dense media, we chose the magnetic powder and magnetic pearls as dense media to form double-density fluidized bed. The magnetic powder is larger and denser than magnetic pearl.

The exploratory study, carried out in conventional bed with rectangular cross-section structure, shows that it is impossible to turn out three products by conventional fluidized bed because the ordinary-structure bed can only form a multiple-density bed[9,10]. The multiple-density bed makes the settled materials easily accumulate in bed and the quality of products greatly affected by the cut points along the bed height.

The exploratory study indicates that the great difference of critical fluidization velocity between the magnetite powder and magnetic pearls requires the operation condition in range of gas velocity to fluidize uniformly the dense media particles which locate at the bottom of bed and are mainly composed of magnetite solids. At high velocity of gas, the mixture of magnetite powder with magnetic peals caused by bubbles will enhance, which results in the formation of axial density gradient along the total height of fluidized.

On the basis of exploratory study, a special structure of bed is exploited. The schematic diagram of model system for three-product separation is shown in Fig. 3. The model separator is composed of three parts. They are lower part with smaller cross-section area of rectangular prism, upper part with larger cross-section of rectangular prism and middle part with pyramidal shape. The middle part is connected with upper part and lower part. In this special-structure fluidized bed , the upper layer dense media mainly composed of magnetic peals can be fluidized at lower superficial velocity of gas, while the lower layer dense media mainly composed of magnetite powder can be fluidized at higher superficial velocity of gas. Besides, the gas velocity decreases along the height of pyramidal part, which strengthens the segregation between two media. Therefore, a double-density fluidized bed is formed.

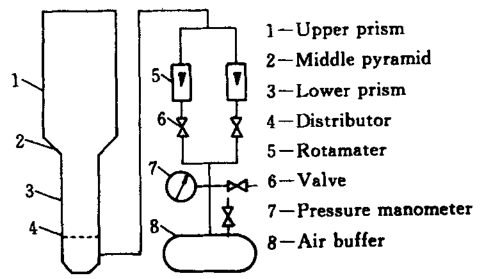


Fig. 3 The schematic diagram of model system for three-product separation

In a wide range of gas flow rates, the experiments of three-product separation are carried out in the double-density fluidized bed. The comprehensive evaluation of separation results is shown in Table 2.

The separation results show that with the increase of gas flow rate, the separation density ρ_{50} and probable error E_p value increase in lighter density area, but decrease in denser density area. At too low gas flow rates , the activity of dense media particles is small, so the separation efficiency is low

Table 2 Comprehensive evaluation of three-product separation

Density areas	Gas flow rate/($m^3 \cdot h^{-1}$)									
	4.0		4.2		4.4		4.6		4.8	
	ρ_{50}/($g \cdot cm^{-3}$)	E_p	ρ_{50}/($g \cdot cm^{-3}$)	E_p	ρ_{50}/($g \cdot cm^{-3}$)	E_p	ρ_{50}/($g \cdot cm^{-3}$)	E_p	ρ_{50}/($g \cdot cm^{-3}$)	E_p
Lighter	1.50	0.03	1.49	0.04	1.48	0.06	1.50	0.06	1.62	0.07
Denser	2.02	bad	2.01	bad	1.85	0.07	1.85	0.06	1.76	0.07

in the denser density area. At too high flow rates, the difference of separation density between two density areas is too small to meet the technical needs for coal preparation. The gas flow rate should be chosen in the range of 4. 4—4. 6 m^3/h.

3 CONCLUSIONS

1) Vibration fluidized bed has a good performance, uniform and stable bed density. It can efficiently separate fine coal of grain size 6—0. 5 mm. The lower limit of beneficiation is 0. 5 mm and the E_p value is 0. 07.

2) It is impossible for current air-dense fluidized bed to obtain three quality products at the same time. By means of specially designed bed structure with a pyramidal part, a double-density fluidized bed is formed. In the suitable range of gas flow rates, satisfactory three-product separation results are obtained.

References

1 Geldart D. Types of gas fluidization. Powder Technol, 1973, 7: 285—292

2 Granfield R R. Solids mixing in fluidized beds of large particles. A I Ch E Symp Ser, 1978, 74(176): 54—59

3 Geldart D, Harnby N, Wong A C. Fluidization of cohesive powders. Powder Technol, 1984, 37: 25—37

4 Geldart D, Wong A C. Fluidization of powder showing degrees of cohesiveness. Chem Eng Sci, 1985, 40: 653—661

5 Lin J S, Chen M M, Chao B T. A novel radioactive particle tracking facility for measurement of solids motion in gas fluidized beds. A I Ch E J, 1985, 31: 465—473

6 Chen Q R, Wei L B, Liang C C. Three-product separator with double-density-air-dense media fluidized beds. Chinese Patent ZL, 96231636. 9. April 10, 1996

7 Ryzhkov A F, Kipnis I E. Engineering methods of analysis of devices with a vibrationally fluidized bed. J Eng Physics, 1991, 60: 687—692

8 Hasatani M, Itaya Y, Miura K. Drying of granular materials in a inclined vibrated fluidized bed by combined radiative and convective heating. Drying Technol, 1991, 9: 349—366

9 Wei L B, Chen Q R, Zhao Y M. Study on the double-density fluidized bed. J Basic Sci & Eng (in Chinese), 1996, 4: 275—279

10 Wei L B. Segregation and mixing of two types of particles in air-dense media fluidized beds. The Chinese J Nonferrous Metals (in Chinese), 1997, 7(Suppl. 3): 7—9