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Separation performance of flotation column with inclined plates in the froth zone

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ABSTRACT

Cyclonic micro-bubble flotation column (FCMC) has been widely used in Chinese coal preparation plants. It shows a good separation performance of fine coal slimes. Joining inclined plates into Reflux Flotation Cell and Reflux Classifier shows better performance than conventional Reflux Flotation Cell and Reflux Classifier. In this investigation, the inclined plates were also joined into the froth zone of a cyclonic micro-bubble flotation column in order to reduce the concentrate ash. Both the dip angle and spacing of inclined plates were discussed, and the lowest concentrate ash could be obtained while the dip angle was 70° and the spacing was 15 mm. Throughout this paper, it was found that both the concentrate yield and ash were significantly affected by the inclined plates and their existence form.

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1. Introduction

Flotation column is a type of efficient equipment for the upgrading of fine coal particles. In general, flotation column contains froth zone and collection zone (pulp zone). Froth zone is usually considered as concentration zone while collection zone is grab picking zone. Fine coal particles are separated and concentrated by these two zones. It is necessary to indicate that cyclonic micro-bubble flotation column (FCMC) created by Professor Guangyuan Xie in China University of Mining and Technology contains an additional zone named cyclonic zone (Xie and Ou, 2002; Xie et al., 2004; Xie et al., 2014). This cyclonic zone is a scavenging zone produced by a circulating pump. FCMC usually shows better separation performance than conventional flotation cell in the beneficiation of fine Chinese coals (Wang et al., 2005; Sha et al., 2009; Zhang et al., 2010). Especially, FCMC can enhance the separation efficiency of <0.045 mm coal fines (Xie et al., 2014). FCMC can reduce the ash content of clean coal, which assures the quality of clean coal.

In FCMC, froth zone is also a key zone like other flotation columns, such as Jameson flotation column and Hydrochem flotation column (Jameson, 1988; Schneider and Van Weert, 1988). Flotation column usually has a thicker froth than flotation cell, and hence flotation column can obtain clean coal with lower ash content. Many fine high ash content coal particles can detach from the bubbles in froth zone. The detached high ash coal particles are pushed into the tailings. Therefore, it is necessary to enhance the detachment of high ash coal fines.

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Table 1
Size composition of coal samples.

Size fraction/mm	Weight/%	Ash/%	Cumulative	
			Weight/%	Ash/%
0.50–0.25	4.08	18.70	4.08	18.70
0.25–0.125	13.96	20.55	18.04	20.13
0.125–0.074	13.19	26.80	31.23	22.95
0.074–0.045	4.58	29.21	35.81	23.75
−0.045	64.19	49.23	100.00	40.11

Galvin and his research team inserted the inclined plates into Reflux Flotation Cell and Reflux Classifier in order to obtain good performance in classification and flotation separation (Galvin et al., 2009; Galvin et al., 2010; Galvin et al., 2012; Dickinson and Galvin, 2014; Galvin and Dickinson, 2014; Galvin et al., 2014). In this investigation, similar structure was introduced into a cyclonic micro-bubble flotation column (FCMC). Both the optimum dip angle and spacing of inclined plates for producing the lowest concentrate ash were discussed based on the flotation results.

2. Materials and experimental procedure

2.1. Materials

Coal samples were supplied by Coal Preparation Plant in Shandong province, China. Table 1 is the size composition of coal samples. The weight of size fraction −0.045 mm is the highest. The weight of −0.045 mm size fraction is 64.19% with 49.23% ash while the weight of 0.5–0.25 mm is only 4.08% with 18.70% ash. It can be obtained that the higher ash content and weight of −0.045 mm size fraction may produce higher ash content clean coal (Peng et al., 2013).

Fig. 1 is the X-ray diffraction patterns of coal sample. It indicates that the primary minerals in coal sample are kaolinite, quartz and calcite. The clay mineral, i.e. kaolinite, is an easy-to-mud mineral which may worsen flotation results and cause serious entrainment of ultra fine similes into the concentrate (Peng et al., 2013).

2.2. Experimental system

Fig. 2 illustrates the experimental system of FCMC with inclined plates in froth zone. The inclined plates were placed in froth zone of the upper of flotation column. It consists of a FCMC, an agitator cell, a feeding pump, a circulation middling pump and a tailings box. The

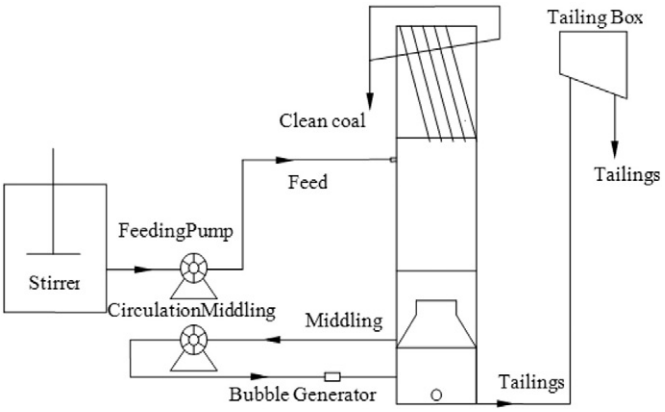

Fig. 2. Experimental system of FCMC with inclined plates in the froth zone.

pulp is conditioned in the agitator cell, and then fed into the column by the feed pump through the feed pipe. The tailings box connects to the bottom of the lower cylinder by the tailings pipe. The discharge of tailings is based on the principle of communicating vessels. The clean coal is discharged from the collection tank in an overflow way. The working principle of FCMC has been described in literatures (Xia et al., 2011).

In this investigation, the dip angles of inclined plates were 60, 70 and 80°. The spacing of inclined plates was 15, 20 and 25 mm. In the flotation tests, the pulp density was 60 g/L. The collector dosage was 2000 g/t and the frother dosage was 500 g/t. The feeding flow was 2.0 L/min. The total height of flotation column was 1500 mm. For FCMC, the pressure of circulation pump was one most important parameter determining the separation performance. Therefore, the pressure of circulation pump ranged from 0.12 to 0.18 MPa. The flotation results were obtained by dozens of experiments (in a period of 30 min) and representative and reproducible. The pulp taken from concentrate and tailings was collected, filtered, dried and analyzed for the ash content.

3. Results and discussion

3.1. Effect of spacing of inclined plate

Figs. 3, 4 and 5 are the flotation results at the dip angles of 60°, 70° and 80°, respectively. Both the concentrate yield and ash increase with

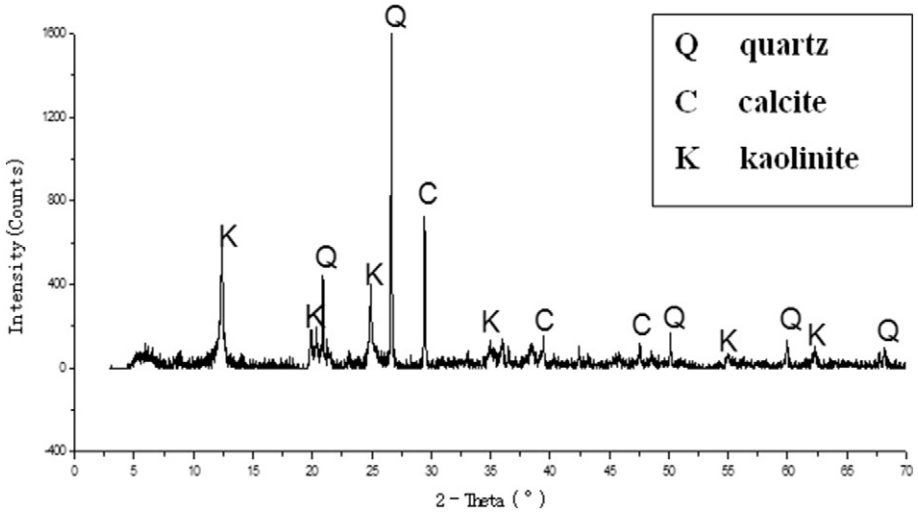

Fig. 1. X-ray diffraction patterns of coal sample.