International Journal of Mineral Processing 160 (2017) 76–80

Contents lists available at ScienceDirect

International Journal of Mineral Processing

journal homepage: www.elsevier.com/locate/ijminpro

Review

Preliminary study on foreign slime for the gravity separation of coarse coal particles in a teeter bed separator

Xiangning Bu [a,b], Chao Ni [a], Guangyuan Xie [a,*], Yaoli Peng [a,*], Linhan Ge [b], Jie Sha [a]

[a] School of Chemical Engineering and Technology, China University of Mining and Technology, Xuzhou 221116, PR China
[b] Department of Chemical Engineering, The University of Newcastle, University Drive, Callaghan, NSW 2308, Australia

ARTICLE INFO

Article history:
Received 5 July 2016
Received in revised form 6 December 2016
Accepted 21 January 2017
Available online 23 January 2017

Keywords:
Foreign slime
Coarse particles
Teetered bed separator
Gravity separation
Coal

ABSTRACT

The teetered bed separator (TBS) is a gravity concentration device based on the principle of hindered settling velocity, which has been widely applied for the density separation of coarse coal particles. The influences of the teeter water velocity on the density separation of coarse coal particles were investigated based on the slip velocity model and the experimental results. The ash content of clean coal increased as the teeter water velocity decreased initially and increased afterwards according to the relationship between teeter water and minimum fluidization velocity. It was observed that the foreign slime had an effect on the separation of coarse particles, while the effect of the foreign slime was not as significant as that of the teeter water velocity.

Contents

1. Introduction

Teeter bed separators are hydraulic classifiers that have been recognized as low-cost and high capacity devices for both classification and density separation. Presently over 200 such units have been installed worldwide, in mineral processing applications including silica sand for construction grade, foundry and glass making purpose, mineral sands and hematite processing along with coal (Littler, 1986; Kumar et al., 2013; Tripathy et al., 2013). The conventional teeter bed separator (TBS) is developed from the concept of hydrosizer and the initial designs have been manufactured since 1934. There are various commercial units based on the conventional TBS such as floatex density separator (FDS), reflux classifier (RC), cross flow separator (CFS), allflux classifier and hydro float separator, which work based on the principles of fluidization and hindered settling with different types of equipment configuration, feeder and discharge systems (Tripathy et al., 2015).

Drummond et al. (2002) demonstrated that the circuit efficiency could be improved by introducing the teeter bed separator between

* Corresponding authors at: School of Chemical Engineering and Technology, China University of Mining and Technology, 1 Daxue Road, Xuzhou 221116, Jiangsu, PR China.
E-mail addresses: xgywl@163.com (G. Xie), pengyaoli@sina.com (Y. Peng).

http://dx.doi.org/10.1016/j.minpro.2017.01.009
0301-7516/

dense medium cyclones and froth flotation. However, it has been shown that these devices can be effectively applied to gravity separations provided that the size distribution of the feed is within acceptable limits, depending on the application (Bethell, 1988; Heiskanen, 1993; Honaker and Mondal, 1999; Luttrell et al., 2006; Kumar et al., 2013). This is due to the fact that when treating wider size distributions, coarse, low density material will be misplaced to the underflow due to its net greater sizing effect. In the same way, extremely fine, high density material will report to the overflow irrespective of its overall density. Several investigations carried out by using the conventional TBS are summarized in Table 1.

Most of the published literature on TBS has focused on the prominence if operational variables on the gravity separation of coarse particles. Li et al. (2013) investigate the separation of coal particles inside the TBS by collecting the samples at different heights of the separation column. It was concluded that size based classification is predominant across the length of the column and the separation efficiency of −0.25 mm particle is poor compared to the coarser fraction (+0.25 mm). It has been demonstrated that the performance of TBS units can be predicted reasonably well using a slip velocity model and steady-state mass balance equations, where the narrowly coarse particle fraction is considered to be mono-size for the theoretical calculation and its size distribution is not considered (Sarkar et al., 2008; Das et al., 2009). The computed data from four different slip velocity models have been compared and contrasted with the experimental observations by Sarkar and Das (2010). It has been shown that a slip velocity model based on the modified Richardson and Zaki equation, in which the dissipative pressure gradient is considered to be the primary driving force for separation, predicts the performance more accurately than the other three. In this study, the effect of the foreign slime of −0.25 mm on the gravity separation of coarse particles was investigated based on the experimental and computational results.

2. Materials and experimental procedure

2.1. Coal samples

Two types of coal samples with different size distributions were prepared for the study. The narrowly sized, F1, of −1 + 0.25 mm nominal size and an ash content of 22.20% was designated as coarse fractions. Meanwhile, the widely sized, F2, having −1 mm nominal size with an ash content of 27.26% was selected as the coarse fractions with fine fractions. The size fraction of −0.25 mm was considered as the foreign slime compared the coarse fraction. In fact, F1 was from F2 by removing coal smile of −0.25 mm.

Sieve analysis of the feed F2 and ash content according to size distributions are shown in Table 2. It was observed that the ash content witnessed an increase trend with decreasing size. The ash content of −1 + 0.25 mm size fractions was obviously lower than that of −0.25 mm. For all practical purposes, narrowly sized fractions showed in Table 2 were considered as a mono-size fraction in this study.

Table 2
Size and ash distribution of the feed F2.

Size range (mm)	Median size d_{med} (mm)	Wt (%)	Ash (%)
1–0.25	0.625	59.18	22.20
−0.25	0.125	40.82	27.86
Total		100.00	24.51

2.2. Experimental procedure

The schematic of the TBS used in this work is shown in Fig. 1. The column was fabricated using 2400 mm diameter and 3200 mm long steel pipe. The experimental apparatus contained an actuator, PID controller, pressure probe, teeter plates and spigot valve. The feed slurry enters tangentially through a feed well and a fluidised or teetered bed is created based on the fluidization of the heavier particles in the suspension using an upward current of water. When a steady state is reached, the particles which are lighter than the density of the teetered bed will float and report to the overflow stream, while the higher density particles will subside and report to the downflow current. The column was allowed to attain the steady state and the steady state was confirmed by constant the effective density of the teetered bed. Steady state was also confirmed by mass balance of top and bottom solids flow rates with the feed rate of solids(Drummond et al., 2002). A simple PID controller and a capacitance pressure probe (4–20 mA) are utilized to keep the effective density of the teetered bed constant. The effective density is compared to the operating set point. If the effective density is too high, the spigot valve will be activated by the actuator and excessive solids are discharged as the underflow. Conversely, the control system acts to restrict the solids discharge if the effective density is too low (Drummond et al., 2002; Tao et al., 2012).

Tests of F1 anf F2 were executed at dfferent teetered water velocities of 16.46, 22.05, 28.94 and 34.59 mm/s. Feed solid content and effective density of the teetered bed were constant at 45% and 1.18 g/cm^3 respectively. These overflow and underflow products of F1 and F2 were screened into two size fractions (1–0.25 mm and −0.25 mm), filtered, dried, stored in sealed bottles. For simplicity, coarse fractions of 1–0.25 mm of the feed F1 and F2 were named as C1 and C2, respectively. Those coarse coal fractions (1–0.25 mm) obtained from the overflow and underflow products were used as the feed in the float-sink analysis.

3. Results and discussion

3.1. Effect of teeter water flow velocity

In order to investigate the influence of the foreign slime on the separation performance of coarse particles thoroughly, separation tests were carried out in a TBS with different teeter water velocities. The yield and ash content of clean coal (without slime) are summarized in

Table 1
Summary of the study on conventional TBS.

Investigator	Material	Equipment type	Particle size (mm)	Variables
Bethell, 1988	Coal	Plant	>0.074	NA
Drummond et al., 1998	Coal	Plant	1.2–0.15	NA
Newling et al., 1998	Coal	Plant	1.2–0.35	NA
Galvin et al., 1999	Coal	Pilot	2.0–0.375	Suspension density and teeter water velocity
Cho and Kim, 2004	Coal	Pilot	1.7–0.15	Set point and teeter water velocity
Maharaj et al., 2007	Coal	Pilot	2.0–0.038	Distributor configuration and teeter water velocity
Sha et al., 2012	Coal	Pilot	1.0–0.25	Column height
Tao et al., 2012	Coal	Plant	1–0.25	NA
Ni et al., 2015	Coal	Pilot	1.0–0.25	Teeter water velocity
Ergun et al., 2016	Coal	pilot	0.5–0.038	Teeter water velocity and set point