Advanced Powder Technology xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Advanced Powder Technology

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

Original Research Paper

Cleaning of high pyritic sulfur fine coal via flotation

Ercan Sahinoglu

Karadeniz Technical University, Department of Mining Engineering, 61080 Trabzon, Turkey

ARTICLE INFO

Article history:
Received 6 October 2017
Received in revised form 26 March 2018
Accepted 5 April 2018
Available online xxxx

Keywords:
Coal
Flotation
Ash rejection
Sulfur rejection
Particle size

ABSTRACT

Large quantities of fine coal have been produced during mining and processing activities of coals. Use of these fine coals after cleaning is important in terms of recovering of economically valuable energy source and prevention of environmental pollution. In the present study, amenability of a high ash-sulfur coal sample to flotation process was investigated. Coal particle size and collector dosage were selected as variables. Increasing coal particle size affected sulfur and ash rejections adversely. On the other hand, more combustible matter was recovered at coarser particle sizes. Maximum combustible recovery, ash rejection, pyritic sulfur rejection and sulfate sulfur rejection were achieved to be 82.56%, 82.84%, 90.04% and 81.45%, respectively. Polished section examinations and scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) analysis confirmed the rejection of significant level of ash and sulfur from the coal.

1. Introduction

Coal is an important resource for humanity due to its huge reserves and role as fuel. However it is also a candidate for environmental pollution because of its ash and sulfur content [1]. Sulfur restricts coal usage due to its negative effect on environmental pollution [2]. Environmental awareness on sulfur emissions have been increased in all over the world. Therefore, all coal producers will have to be able to meet coal standards in the near future [3].

Sulfur levels in coals are highly variable in the world. It ranges from 0.5% to 11% [3]. Coal with sulfur percentage of over 3% is defined as high sulfur coal [4]. Sulfur in coal can be present in organic and inorganic forms [1,5,6]. Organic sulfur is chemically bonded with the carbon in coal [6]. The inorganic sulfur is mostly found in disulfides and sulfates [5]. Pyrite is major sulfur containing inorganic matter in coal [7].

Combustion of low quality coal causes several environment problems such as acid rains, air pollution [6,8,9], food pollution [6], loss in energy recovery, waste accumulation [8]. Coal cleaning before combustion is required to increase the quality of coal and to prevent its negative effects on environment. The methods applied for coal cleaning may be physical, physico-chemical, chemical. In addition, several methods assisted by microwave, ultrasonic and bacteria have been improved recently [10].

Among cleaning methods, froth flotation, oil agglomeration, flocculation, and enhanced gravity separation methods have been used for cleaning of fine coal [11]. However, flotation is the most common method among them [12] for removal of ash sources [13] and inorganic sulfur [6,14,15] from fine coal. Effective sulfur reduction by physical coal cleaning processes cannot be achieved unless sulfur is reasonably well liberated from coal. Hence, it is important to emphasize that the sulfur removal potential of a coal depends on both the quantity and degree of liberation of pyrite [16]. Separation by flotation is based on differences in hydrophobicity of organic coal and mineral matters. Mineral matters are generally hydrophilic unlike hydrophobic coal matter [17]. In flotation, hydrophilic mineral matter remained in the pulp while coal is taken into the froth [2].

Many parameters, such as feed rate, mineralogy, particle size, pulp density, agitation, pH, types-dosages of collectors and frothers influence the combustible recovery, ash rejection, sulfur rejection in coal flotation [3]. Particle size is one of the most important parameters among them [18]. The effect of size fractions on coal flotation has been previously investigated.

Li et al. [19] investigated the effect of particle size on selectivity of the flotation process. The best selectivity was obtained for the middle size fraction of 0.25–0.075 mm, while the flotation selectivity of larger (0.5–0.25 mm) and smaller (−0.075 mm) particles was diminished. Jorjani et al. [20] examined the different size fractions of coal in term of their maceral composition and flotation response. Among the different size fractions of −500 + 150, −150 + 75, −75 + 40, −40 + 25, and −25 μm, −40 + 25, and −25 μm size fractions were found to have greater amount of liptinite. It was stated that liptinite rich samples had better flotation response and separation

E-mail address: ercansahinoglu@ktu.edu.tr

https://doi.org/10.1016/j.apt.2018.04.005
0921-8831/

the maceral groups by particle size is as important as other established factors in flotation. Wei et al. [21] examined the role of different parameters in float stability that is an important determinant of performance of the flotation and revealed that froth stability changed depending on coal particle size, process water quality, and chemical reagents dosage. The froth stability in flotation of fine coal particles (−106 μm) with process water was found to be very high due to the interaction between particle size and salts. Mixing of coarse and fine coals, dilution of process water with de-ionised water and reducing reagent dosages had adverse effects on froth stability. Liang et al. [22] reported that more stable frothes were created by finer hydrophilic particles having no considerable effect in maintaining the froth in the froth decay process. Fine and moderate hydrophobic particles enhanced the froth stability in the froth formation process. Fine particles with high hydrophobicity had the minimum effect in stabilizing the froth due to the lowest water solid ratio. Sahoo et al. [23] classified the coal into five discrete size fractions (−500 + 150 μm, −150 + 75 μm, −75 + 36 μm, −36 + 25 μm, and −25 μm) and determined the effect of size distribution on flotation kinetics. It was reported that combustible recovery was not be affected significantly by feed size. Maximum recovery was achieved at the greatest particle of −500 + 150 μm.

Most of the previous studies some of which was mentioned above evaluated the performance of flotation process in terms of only combustible recovery and ash rejection. However, current study focuses also on pyritic sulfur rejection. Pyritic sulfur rejection is comes first to determine the contribution of any coal cleaning process to environmentally friendly energy generation. In this study, a coal sample with considerably high pyritic and sulfate sulfur content was used. No previous study related to flotation of Muzret coal has not been met before. Extremely high pyritic and sulfate sulfur content of Muzret coal make its flotation worth researching. In the present study, flotation performance the coal sample of different particle sizes was investigated by using different dosage of kerosene as collector. Combustible recovery, ash rejection, pyritic sulfur rejection, and sulfate sulfur rejection of the process were determined. The findings obtained in the study were supported by advanced characterization techniques (i.e. polished section and SEM-EDS examinations), which provided an invaluable insight into the flotation process.

2. Materials and methods

Coal sample was obtained from a coal deposit in Muzret-Artvin region of Turkey. A fine coal sample of ≈150 kg was taken from coal deposit. Large portion of the sample was below a particle size of 0.5 mm. Remaining part whose size was over 0.5 mm was reduced to −0.5 by controlled dry grinding. In controlled grinding, time of the grinding was kept short to prevent overgrinding. After screening, oversize material was subjected to another short-time grinding. Representative part divided from main sample was subjected to size reduction process to obtain material with size fraction of −0.25 mm and −0.125 mm. Cone – quartering and chute rifflers was used as repeated cycles successively for dividing the sample into small quantities. Final samples of 100 g to be used in the tests were prepared by using the method of chessboard squares.

Table 1
Proximate, sulfur and calorific value analyses of the coal sample.

	Air dried	Dried
Proximate analysis		
Moisture (%)	2.25	–
Ash (%)	34.85	35.65
Volatile matter (%)	10.73	10.98
Fixed carbon (%)	52.17	53.37
Sulfur analysis		
Sulfate sulfur (%)	0.99	1.01
Pyritic sulfur (%)	5.44	5.57
Organic sulfur (%)	1.3	1.33
Total sulfur (%)	7.73	7.91
Calorific value analysis		
Calorific value (kcal/kg)	4970	5084

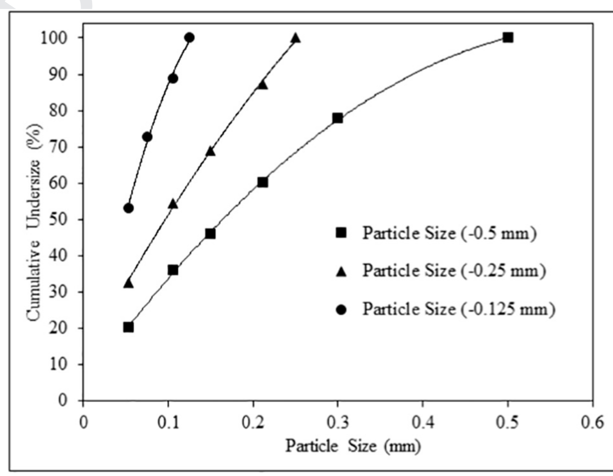

Fig. 2. Particle size distributions of coal samples.

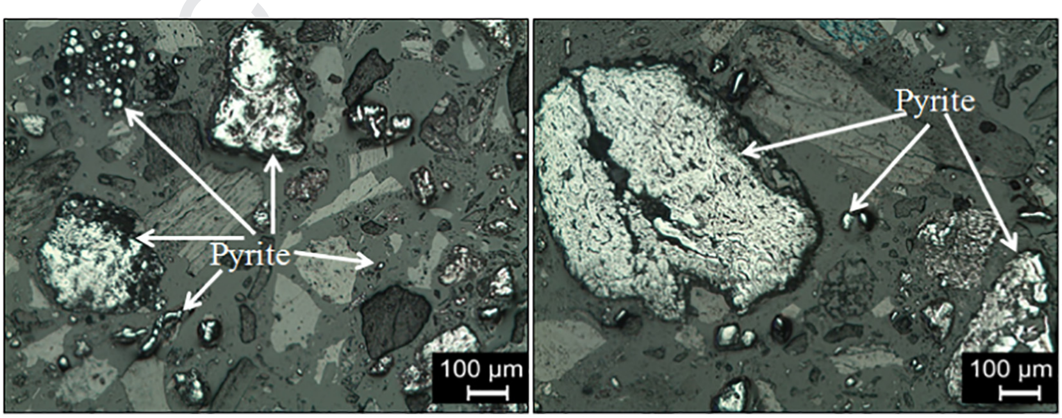

Fig. 1. Pyrite grains of different size and shapes in coal structure.