Effect of a Dispersant Agent in Fine Coal Recovery from Washery Tailings by Oil Agglomeration (Preliminary Study)

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Abstract. Among the fine coal cleaning methods, the oil agglomeration process has important advantages such as high process recovery, more clean product, simple dewatering stage. Several coal agglomeration studies have been undertaken recently and effects of different variables on the process performance have been investigated. However, unlike flotation studies, most of the previous agglomeration studies have not used dispersing agents to minimize slime coating effects of clays. In this study, agglomeration process was applied for recovery of fine coals from coal washery tailings containing remarkable amount of fine coal. Negative effect of fine clays during recovery was tried to be eliminated by using dispersing agent instead of de-sliming. Although ash reductions over 90 % were achieved, performance remained below expectations in terms of combustible matter recovery. However, this study is a preliminary one. It is considered that more satisfied results will be obtained in the next studies by changing the variables such as solid ratio, oil dosage, dispersant type and dosage.

1. Introduction

Fine coal cleaning is difficult as the small size of the particles limits the efficiency of traditional gravity separation techniques. Enhanced coal cleaning circuits, involving froth flotation machines and gravity concentrators, may be implemented to recover fine coal. However, difficulties may still be encountered in the handling, transportation and dewatering of the fine coal product. In addition, not all coal may be suitable for treatment using existing technologies especially if there is a high proportion of clays or a large amount of slimes present in the slurry. The problems associated with the processing of fine coal are directly related to the small size of the individual particles. This means that if the particles were enlarged, they could be classified using a screen [1].

Among fine coal cleaning methods, oil agglomeration has superiorities over others. It is more suitable for oxidized coal and coals including clay slimes. Higher recovery, cleaner product, easier and cheaper dewatering are its other advantages [2].

The process of agglomeration is based on the principle that coal particles are naturally hydrophobic or at least less hydrophilic than inorganic materials, and can therefore, be agglomerated and separated from the mineral matter by the addition of a suitable bridging liquid that wets the carbonaceous constituents. The oil agglomeration process is very promising for beneficiation of coal, especially for the extreme fines which cannot be treated by conventional processes, recovery and upgrading of coal slurries and effluents originating from the conventional coal preparation plants, and preparation of coal that has specifically low ash and inorganic sulphur contents [3].

In coal washeries of Turkey, gravity separation is generally used to beneficiate upper 500µm coal. Fine tailings of these washeries are sent to tailing ponds leading to significant economic loss due to coal-rich character of tailings. These tailings also cause environmental problems [4-6]. Total loss of recoverable amount of fine coal is estimated to be over 1 million tons/year [4,6]. Tailings area of GLI after several years contains over 6 million tons of tailings [7].

In the present study, fine coals in the tailings of Tunçbilek Coal Washery of GLI was tried to be recovered by oil agglomeration. In preliminary studies that are first to use oil agglomeration for fine coal recovery from the washeries of Turkey, it was reported that over 80% ash was removed from the deslimed tailings by combustible recovery of over 50% [8, 9]. By using different salts, combustible matter recovery and ash removals was risen to over 90% and over 60%, respectively [10]. However, agglomeration without desliming resulted in much lower organic matter recoveries as low as 20% [9]. In the present study, possibility of oil agglomeration of tailings of Tunçbilek Coal Washery without desliming by using a dispersing agent (Na_2SiO_3) was investigated.

Several coal flotation studies reported that clays in the slurry inhibit coal flotation by reducing the hydrophobicity of coal due to surface coatings [3, 11-13]. Although the performance of the oil agglomeration of coal depens on the hydrophobicity as in flotation, and clay slimes have adverse effect on hydrophobicity, most of the previous agglomeration studies have not touch the elimination of effects of fine clays on the process by using dispersing agents.

2. Materials and Methods

2.1 Materials

Sample of fine washery tailings was taken from Tunçbilek Coal Washery of G.L.I of TKI before entering thickener for dewatering. Proximate-calorific value analysis and particle size analysis of the tailings sample including also ash values, and proximate analysis of -0.5 mm fraction used in the tests are illustrated in Table 1-3, respectively. As bridging material, filtrated waste sunflower oil was used. Its viscosity and density are 35.81mm^2/s and 0.918 g/cm^3, respectively.

Table 1. Proximate-calorific value analysis of the sample

Proximate Analysis	Air Dried	Dried
Moisture (%)	4.83	-
Ash (%)	55.60	58.42
Volatile Matter (%)	21.92	23.03
Fixed Carbon (%)	17.65	18.55
Lower Cal.Value(kcal/kg)	2353	2472
Upper Cal. Value(kcal/kg)	2501	2628

Table 2. Particle size analysis of the sample

Particle size (mm)	Amount (%)	Ash (%)
+0.5	37.14	33.45
-0.5+0.25	12.07	53.49
-0.25+0.125	5.62	51.72
-0.125+0.075	2.55	43.51
-0.075+0.038	3.98	52.76
-0.038+ 0.025	2.31	60.95
-0.025	36.33	80.35

2.2 Methods

Agglomeration experiments were undertaken in cylindrical glass vessel whose diameter was 11.7 cm. Four portable baffles were inserted to vessel. The stirring process was achieved by means of RZR

2021 type overhead stirrer. Water was distilled before the experiments. Coal samples were mixed with water (solid ratio: 10%).

Table 3. Proximate analysis of fraction of -0.5 mm used in the tests

Proximate Analysis	Air Dried	Dried
Moisture (%)	3.37	-
Ash (%)	68.6	71.08
Volatile Matter (%)	19.7	20.42
Fixed Carbon (%)	8.22	8.50

Coal-water mixtures were stirred at 1000 rpm for 5 min. to provide perfect wetting of coal grains. The oil (10wt. % of coal) was then put as agglomerant and mixture of coal-oil-water was stirred at 1400 rpm for 10 min. Na_2SiO_3 (0.5 to 3 kg/ton) was used as dispersant. The experiments were performed at ambient pH of the mixture. After agglomeration, the suspension was transferred to a sieve with aperture of 0.5 mm to separate the agglomerates from water and tailings. Agglomerates were washed with 1.5 L water to remove the entrained mineral matter. Then, vacuum filtering and acetone washing for de-oiling were applied for agglomerates. After drying of oil-free agglomerates at 105±5 °C, weighing was carried out and cleaned coal products were stored for analyses. Finally, ash analyses were undertaken. The combustible recovery (CR), ash reduction (AR) and ash separation efficiency (ASE) were calculated by means of following equations:

$$CR\ (\%) = \left[\left(\frac{MP}{MF}\right) \times \left(\frac{(100-AP)}{(100-AF)}\right)\right] \times 100 \tag{1}$$

$$AR\ (\%) = \left[1 - \left(\frac{MP \times AP}{MF \times AF}\right)\right] \times 100 \tag{2}$$

$$ASE\ (\%) = CR + AR - 100 \tag{3}$$

, where MP: Mass of dry and oil-free product(g) MF: Mass of dry feed (g), AF: Ash in dry feed (wt.%), AP: Ash in dry and oil-free product (wt.%).

3. Results and discussions

As seen from Figure 1, combustible matter recoveries and ash reductions changed in the ranges of 14.4%-15.9% and 94.0%-95.2%, respectively. In other words, over 90% of ash was removed from the tailings while recovered combustible matter remained below 16%. Unsatisfactory recovery of combustible matter can be attributed to the presence of slimes in the vast amount. The large number of clay particles inhibited the contacts between coal particles and oil droplets. Likewise, small agglomerates could not be growth due to prevention of contacts with other agglomerates and coals. Na_2SiO_3 could not disperse the awful lot of clay particles despite its increasing dosage from 0.5 to 3 kg/ton.

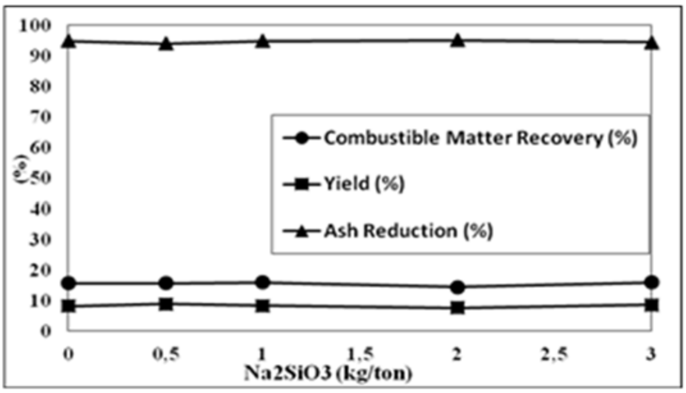

Figure 1. Effect of Na_2SiO_3 dosage on the performance of the process

Ash percent of clean coal and ash separation efficiencies changed between 44.3-48.4%, and 9.6-10.8%, respectively (Figure 2-3).

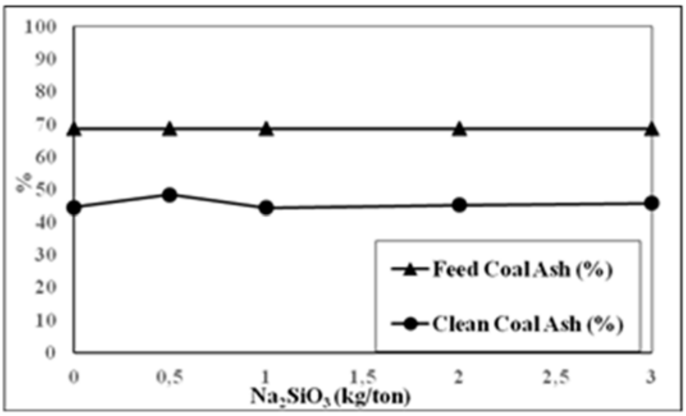

Figure 2. Effect of Na_2SiO_3 dosage on the ash contents of clean coal

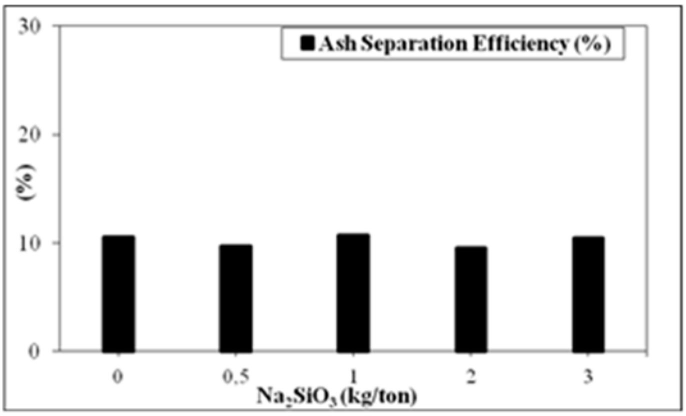

Figure 3. Effect of Na_2SiO_3 dosage on the ash separation efficiencies

4. Conclusions

Without a desliming stage, fine coal was tried to be recovered from washery tailings by oil agglomeration using a dispersant (Na_2SiO_3). Use of Na_2SiO_3 in the range of 0.5-3 kg/ton has not contributed to performance of the process. While ash reduction exceeded 90%, most of the organic matter of coal reported to refuse. However, this study is a preliminary one. It is expected that organic matter recovery will be increased to acceptable levels as a result of changing parameters such as dispersant dosage-type, solid ratio, and oil dosage.

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