Techno-Science

Scientific Journal of Mehmet Akif Ersoy University

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Original Research Article

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Concentration of Zonguldak Hardcoal by Flotation: Comparison of Classical (Kerosene) and Vegetable Oil (Sesame Oil)

Selma ŞİMŞEK [1*], Yakup CEBECİ[2]

[1]*Vocational High School, Cumhuriyet University, Turkey*
[2] *Department of Mining Engineering, Cumhuriyet University, Turkey*

ARTICLE INFO

Article History
Received : 29/11/2019
Revised : 30/12/2019
Accepted : 30/12/2019
Available online : 30/12/2019

Keywords
Flotation, kerosene, sesame oil, combustible recovery, ash reduction, efficiency index

ABSTRACT

Flotation is a widely used physicochemical separation method for the benefication of fine coals. In this study, the use of vegetable oil(sesame oil)an alternative to kerosene has been investigated for flotation of Zonguldak Hardcoal. The effects of collector concentration, pH, flotation time, pulp density, impeller speed and frother concentration on combustible recovery, ash reduction and efficiency index were studied and optimum conditions were determined for hardcoal. As can be seen from these results, vegetable oil (sesame oil) for Zonguldak Hardcoal showed high collecting ability as an alternative to the petrol such as kerosene. In other words, it was found out that vegetable oils could be used as collector in coal flotation.

1. INTRODUCTION

Flotation is one of the many methods for separation. The basis of flotation is the difference in wettabilities of different minerals. Particles range from those that are easily wettable by water (hydrophilic) to those that are water-repellent (hydrophobic). Coal is a good example of a material that is typically naturally hydrophobic, because it is mostly composed of hydrocarbons. Flotation is often very effective for coal cleaning since coal is naturally hydrophobic and minerals are hydrophilic [1]. Generally, flotation is the technique used for the beneficiation of coal particles below 0,5 mm in size [2]. In this technique, separation of fine coals relies upon the wetting ability differences between the coal-rich and mineral-rich particles in an aqueous solution [3-4]

In the coal flotation, classical oils such as kerosene,fuel oil and diesel oil have been used as collectors. These collectors are used to promote the rigid adhesion of air bubbles to the coal surface. Coal is floatability in wide range of pH. But the best floatability of coal is defined around natural pH [5]. In this study, the use of vegetable oil as an alternative to classical oil for flotation on Zonguldak Hardcoal has been investigated. Kerosene was used as classical oil and sesame oil was used as vegetable oil. The effects of collector concentration, pH, flotation time, pulp density, impeller speed frother concentration on combustible recovery, ash reduction and efficiency index were studied and optimum conditions were determined.

2. MATERIALS AND METHODS

The sample was obtained from Zonguldak Coal basin in Turkey. The total ash value was 14,08 %. The coal sample was dry-ground to -0,5 mm in a rod mill for flotation tests. The experiments were performed in a 1000 ml. flotation beaker. The pulp density and impeller speed were kept content at 10 wt % and 1050 r/min respectively. The reagents used were kerosene and sesame oil as collectors and pine oil as frother. In the evaluation of experimental results, combustible recovery, ash reduction and efficiency index of products were considered [6]. The combustible recovery, ash reduction and efficiency index were calculated from the equations below.

* Corresponding Author: selmasim@cumhuriyet.edu.tr

To cite this article: Şimşek, S., Cebeci, Y. (2019). Concentration of Zonguldak Hardcoal by Flotation: Comparison of Classical (Kerosene) and Vegetable Oil (Sesame Oil). *Techno-Science* vol. 2, no. 4-Special Issue p. 119-126.

e-ISSN 2651-3722

$$\text{Combustible recovery (\%)} = \frac{C(100-c)}{F(100-f)} * 100 \quad (1)$$

$$\text{Ash reduction (\%)} = 100 - \left[\left(\frac{C}{F} * \frac{c}{f}\right) * 100\right] \quad (2)$$

$$\text{Efficiency index (\%)} = \quad Combustible\ recovery + Ash\ reduction - 100 \quad (3)$$

C [g] the mass of the concentrate

F [g] the mass of the feed

c [wt%] the ash contents in concentrate

f [wt%] the ash contents in the feed

3. EXPERIMENTAL

3.1. The Effect of Collector Concentration

Fig. 1 and Fig. 2 show the effects of classical (kerosene) and vegetable oil (sesame oil) concentration on combustible recovery, ash reduction and efficiency index from the feed coal, respectively. Results show that combustible recovery increased with increasing collector. As the kerosene concentration increased from 0 to 10000 g/t, the combustible recovery increased from 84,78 % to 96,40 %. For the sesame oil, the combustible recovery increased from 84,78 % to 97,60 %. As well as for kerosene and sesame oil after 2000 g/t concentration of the combustible recovery, ash reduction and efficiency index is also no significant change. Therefore, the optimum values of them both oil were found to be 2000 g/t.

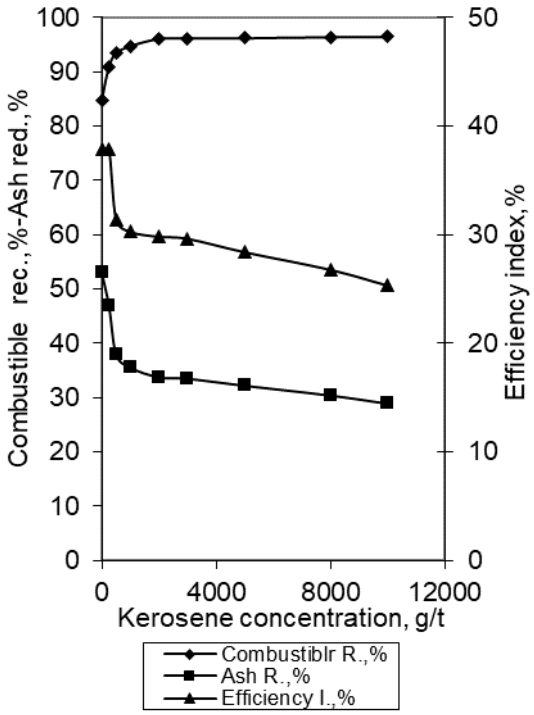

Fig. 1. The effect of kerosene concentration on the combustible recovery, ash reduction and efficiency index.

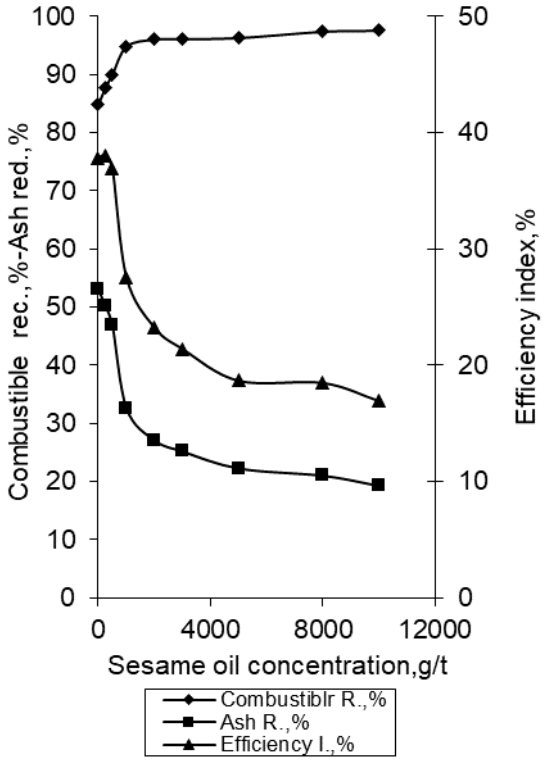

Fig 2. The effect of sesame oil concentration on the combustible recovery, ash reduction and efficiency index.

3.2. The Effect of pH

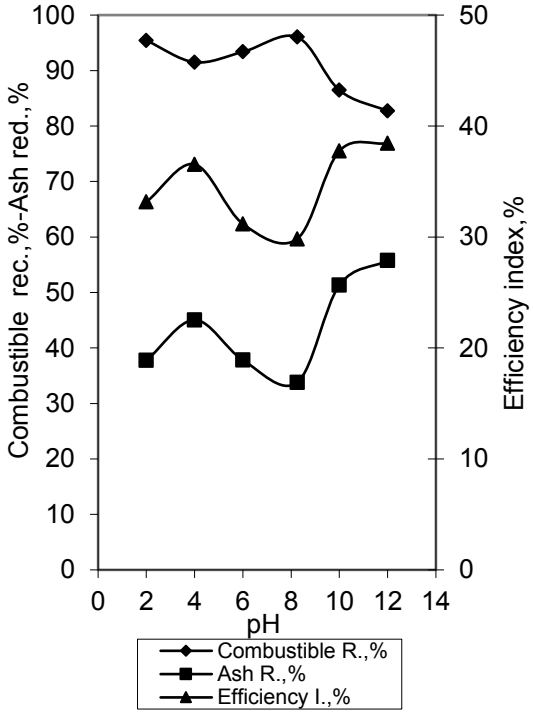

Fig. 3. The effect of pH on the combustible recovery, ash reduction and efficiency index (Kerosene concentration: 2000 g/t; pulp density: 10 %; impeller speed: 1050 r/min; pine oil concentration: 100 g/t)

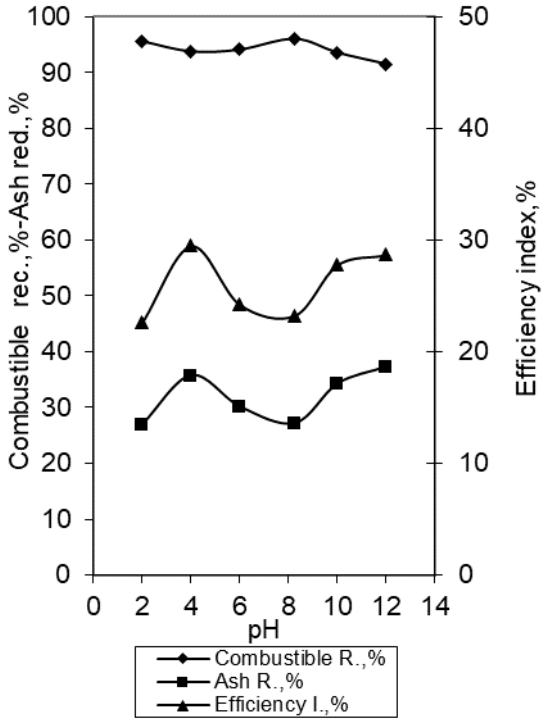

Fig. 4. The effect of pH on the combustible recovery, ash reduction and efficiency index (Sesame oil concentration: 2000 g/t; pulp density 10 %; impeller speed: 1050 r/min; pine oil concentration 100 g/t)

The combustible recovery initially increased with increasing pH reached to the optimum value pH 8,25 (natural) then decreased gradually. Both kerosene and sesame oil the natural pH has reached to high combustible recovery. Therefore the following flotation experiments were conducted at natural pH.

3.3. The Effect of Flotation Time

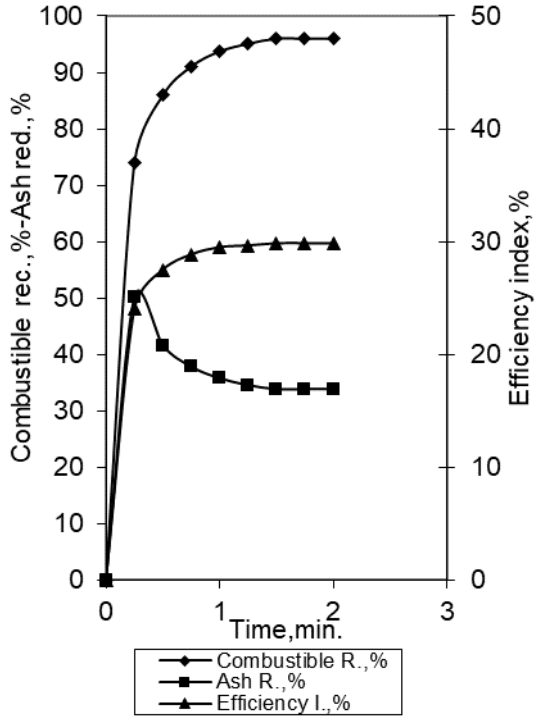

Fig. 5. The effect of flotation time on the combustible recovery, ash reduction and efficiency index (Kerosene concentration: 2000 g/t; pH: 8,25 (natural pH); pulp density: 10 %; impeller speed: 1050 r/min; pine oil concentration: 100 g/t)

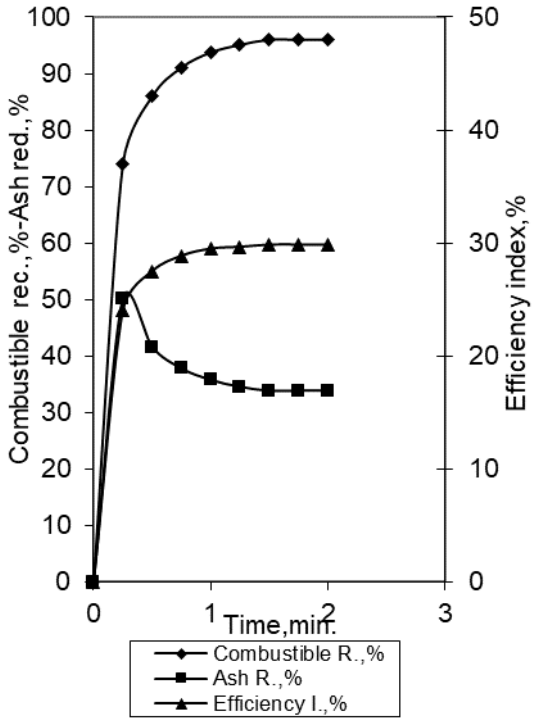

Fig. 6. The effect of flotation time on the combustible recovery, ash reduction and efficiency index (Sesame oil concentration: 2000 g/t; pH: 8,25 (natural pH); pulp density: 10 %; impeller speed: 1050 r/min; pine oil concentration: 100 g/t)

In the flotation experiments carried out with kerosene and sesame oil, when the combustible recovery, ash reduction and efficiency index values are examined, it was found the flotation time is 1 min.for kerosene and sesame oil.

3.4. The Effect of Pulp Density

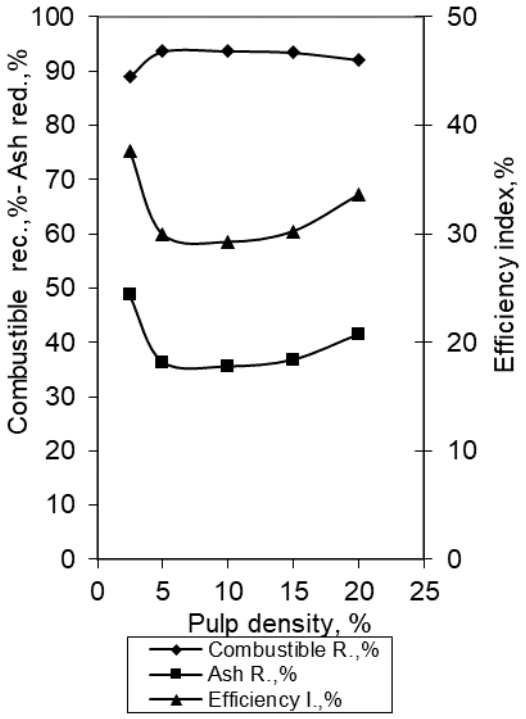

Fig. 7. The effect of pulp density on the combustible recovery, ash reduction and efficiency index (Kerosene concentration: 2000 g/t; pH: 8,25 (natural pH); flotation time: 1 min.; impeller speed: 1050 r/min.; pine oil concentration: 100 g/t)

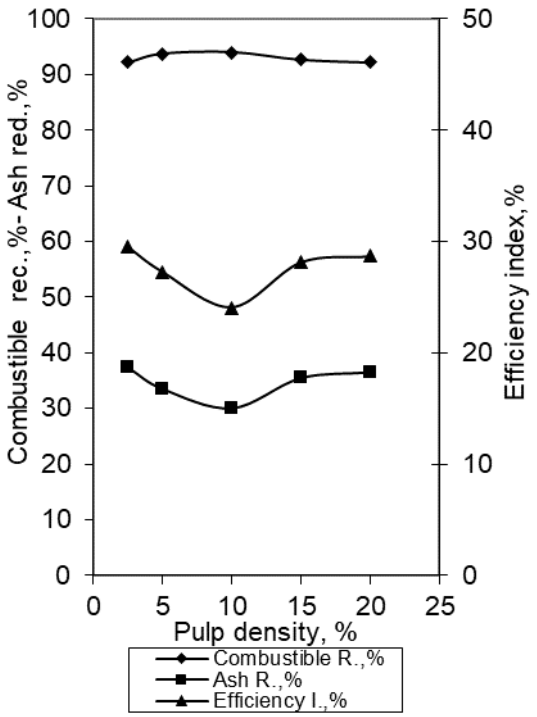

Fig. 8. The effect of pulp density on the combustible recovery, ash reduction and efficiency index (Sesame oil concentration: 2000 g/t; pH:8,25(natural pH); flotation time: 1 min impeller speed: 1050 r/min.; pine oil concentration : 100 g/)

Considering the combustible recovery and ash reduction values yield for kerosene and sesame oil; the best values were obtained by 10 % pulp density.

3.5. The Effect of İmpeller Speed

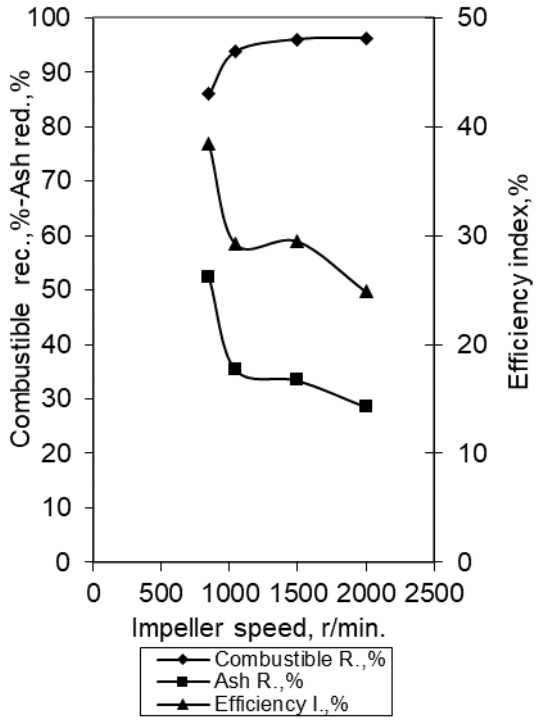

Fig. 9. The effect of impeller speed on the combustible recovery, ash reduction and efficiency index (Kerosene concentration: 2000 g/t; pH: 8,25 (natural pH); flotation time: 1 min.; pulp density: 10 %; pine oil concentration: 100 g/t)

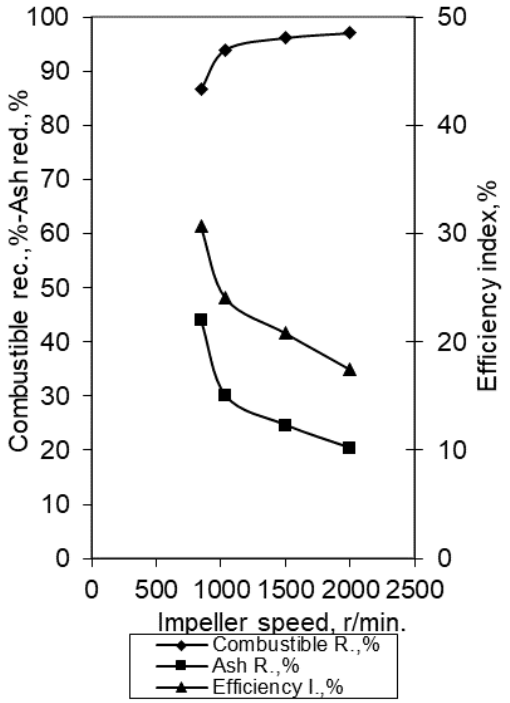

Fig. 10. The effect of impeller speed on the combustible recovery, ash reduction and efficiency index (Sesame oil concentration: 2000 g/t; pH:8,25 (natural pH); flotation time: 1 min.; pulp density: 10%; pine oil concentration : 100 g/t)

It is not increased too much after impeller speed of 1500 r/min for both kerosene and sesame oil. Therefore; this value was determined as 1500 r/min.

3.6. The Effect of Frother Concentration

Pine oil was used as frother Figs. 11 and 12 show that combustible recovery increased with increasing frother concentration for kerosene and sesame oil. Based on experimental results; for kerosene amount of frother 75 g/t. On the other side, for sesame oil high combustible recovery values were determined without frother. Therefore there is no need frother for sesame oil.

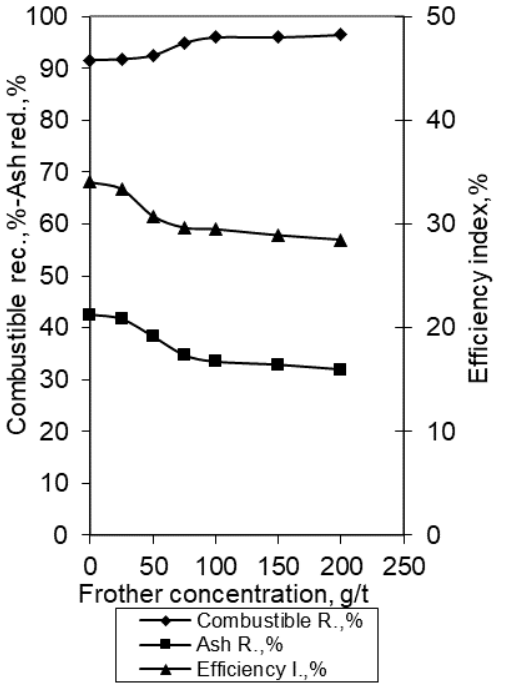

Fig. 11. The effect of frother concentration on the combustible recovery, ash reduction and efficiency index (Kerosene concentration: 2000 g/ton; pH: 8,25 (natural pH); flotation time: 1 min.; pulp density: 10 % ; impeller speed: 1500 r/min)

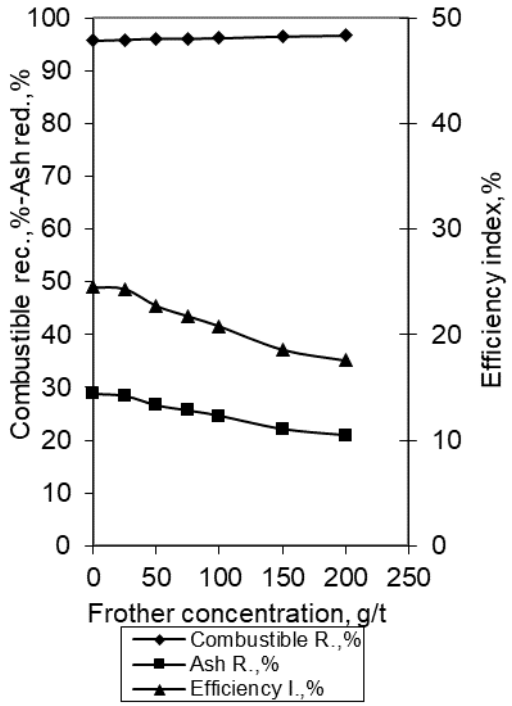

Fig. 12. The effect of frother concentration on the combustible recovery, ash reduction and efficiency index (Sesame oil concentration: 2000 g/t; pH: 8,25 (natural pH); flotation time: 1 min.; pulp density: 10 %; impeller speed: 1500 r/min)

4. RESULTS

Optimum conditions with usage of kerosene for flotation experiments by coal follow as; Kerosene concentration: 2000 g/t; pH: 8,25 (natural pH); pulp density: 10 % ; impeller speed: 1500 r/min; pine oil concentration : 75 g/t. It has been reached as 94.93 % combustible recovery value via using kerosene in experiment which performed at optimum condition. Experiments which performed by sesame oil follow as; Sesame oil concentration: 2000 g/t; pH: 8,25 (natural pH); pulp density: 10 %; impeller speed: 1500 r/min. It has been reached as 95.68 % combustible recovery value via using sesame oil in experiment which performed at optimum condition. Considering findings from these experiments, it has been determined that can also be taken high efficiency for sesame oil using without pine oil. Finally, the use of vegetable oils instead of oils derived from petrols such as kerosen in the concentration of hardcoal by using flotation method has been shown.

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