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The Performance of Coal-Based Activated Carbon on Sulfur Adsorption in Waste Engine Oil

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Abstract—*East Kalimantan is one of the provinces in Indonesia that produces the largest coal. Lignite coal has less economic value because it has a low calorific value. In addition, the use of engine oil increases often increasing the number of motor vehicles, engine oil that has been used has the potential to pollute the environment, especially because of the presence of sulfur content. Therefore, efforts are needed to reduce the sulfur content contained in the used oil, one of the alternatives is by adsorption techniques. In the adsorption process, an adsorbent is needed as an absorbent medium, so by utilizing low-rank coal into activated carbon which will act as an adsorbent, it will be able to increase the economic value of low-rank coal. The adsorption process is carried out by varying the activated carbon derived from low-rank coal, which is (5-25) % by weight to used oil which is carried out at room temperature within 30 minutes. The purpose of this study is to evaluate the adsorption capacity of low-rank coal in reducing sulfur and metal content contained in waste engine oil. The best results obtained in the adsorption process are at a carbon dose of about 10% for engine oil waste with an activated carbon absorption capacity of 14.8%, but the best percentage of removal conditions is obtained at a 15% activated carbon dose, in which the percentage of sulfur removal in engine oil waste reaches (38 - 50) %.*

Keywords— *Coal, adsorbent, waste engine oill, adsorption, sulphur.*

I. INTRODUCTION

As a country that has the 5th largest coal reserves in the world (39.9 billion tons), coal is still the main energy source. Indonesia's coal production is expected to continue to increase, especially to meet domestic needs (power generation and industry) and foreign demand (exports). There are several types of coal, there are anthracite, bituminous and lignite. Anthracite and bituminous have good calorific value so they are widely used as energy sources, in contrast to lignite which is not utilized optimally [1].

Lignite coal is usually soft and has a brownish colour and has a low calorific value so it is not used as an energy source because it is considered inefficient. However, there is a carbon composite in low-rank coal, so it can be used as an alternative as an absorbent medium commonly called activated carbon. As raw materials for making activated carbon, various basic materials that have hydrocarbon bonds can be used, in this study coal with the lowest rank is used. Activated carbon uses coal from East Kalimantan as raw material [3]. It requires more difficult activation compared to raw materials derived from wood, husk, coconut shell, etc. so carbonization techniques are needed first and a combination of chemical and physical activation. Chemical activation involves the impregnation of administered precursors with activating agents such as phosphoric acid (H_3PO_4), chloric acid (HCl), nitric acid (HNO_3), zinc chloride ($ZnCl_2$), and alkali metal compounds. Research with chemical activation of bituminous coal in East Kalimantan using a combination of H_3PO_4-NH_4HCO_3 activator solution as discussed in the previous discussion. however, in this study NH_4CO_3 will be substituted with $NaHCO_3$ [2].

Every year a large amount of waste engine oil (WEO) or used oil is generated from various sectors such as industry, vehicles, aviation and marine. There have been many studies reporting that engine oil waste is one of the types of waste that is harmful to the environment, it is said that there is a certain amount of metal produced and sulphur from the activity of engine oil as lubricant in motor vehicles, changing the basic composition of lubricant oil after use causes no longer quality good [4]. Because sulphur is one of the big problems in environmental, so it must to purified, there are many desulfurization methods that have been carried out such as extraction, precipitation, adsorption and changing boiling point by alkylation. However, in this study, the method to be carried out is the adsorption method. This method was chosen because adsorption does not require too high costs and its effectiveness is higher when compared to other methods. This method is based on the capacity of solid adsorbents to selectively adsorb organosulfur compounds, either by physical adsorption (desulfurization adsorption) or by chemical reactions between organosulfur compounds in the fuel and adsorbents, usually forming sulphides (reactive adsorption desulfurization) [5]. This research will focus on evaluating the adsorption capacity of low-rank coal in reducing the sulphur content contained in waste engine oil.

II. METHOD

There are two procedures carried out in this study, the first is the process of activating low-rank coal into activated carbon, then the activated carbon produced will be directly tested for its use in the absorption of sulphur content in used oil through the adsorption process.

A. Coal Activation Process

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Low rank coal is crushed to reduce its size which ranges from 100-200 mesh, then carbonized to increase its carbon value, carbonization is carried out through a pyrolysis process at a temperature of 600^0C for 3 hours. The carbonized coal is then soaked using a mixture of H_3PO_4-$NaHCO_3$ with a concentration of 2.5M for 6 hours. Next, it is filtered and neutralized to a constant pH using aquods, then as the last step of activation is a filter to remove the moisture content at a temperature of 105^0C in the oven to constant weight.

B. Adsorption process

After the coal activation process is complete, the used oil is then prepared by filtering the used oil which will be used as a raw material sample in the adsorption process. The adsorption process will be carried out at room temperature where the used lubricating oil raw material will be mixed with varying doses of activated carbon (5-25) %, the process will last for 1 hour with stirring at 150 rpm, the process is as follows.

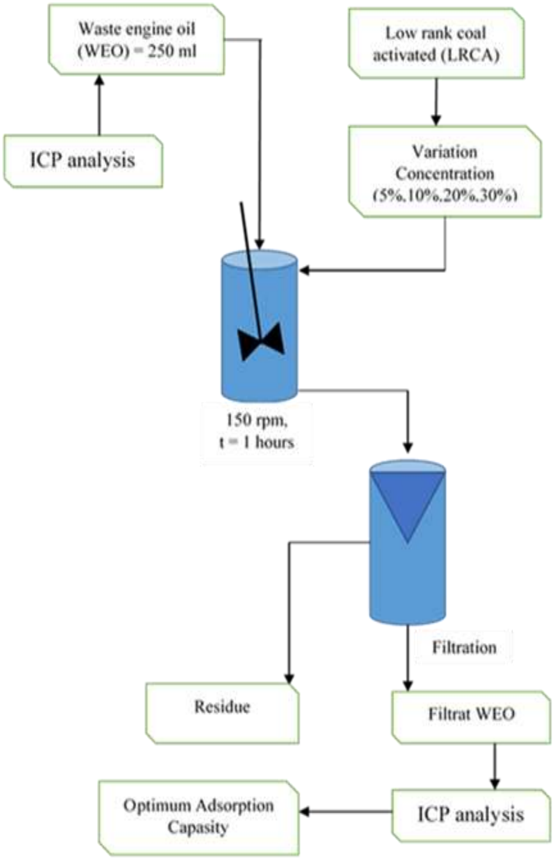

Fig. 1. Adsorption flow diagram.

III. Results and Discussion

The first is the testing of used engine oil raw materials 250 mL with density is 0.8582 g/L. The data to be taken is to focus on the initial sulfur contained in WEO, while the initial sulfur content results are 3244 ppm.

Table 1. Provide information on the effect of increasing the dose of adsorbent in the form of low-rank coal activated carbon on engine oil waste. Experimental data conducted at room temperature with a stirring time of 30 minutes showed that sulfur absorption occurred with increasing doses of adsorbents, but after passing the 10% dose there was a tendency to absorption. Sulfur absorption began to stagnate, this shows that although there is a decrease in sulfur content at each increase in adsorbent dose, at adsorbent doses greater than 10% there is a tendency for adsorbent adsorption ability to reach close to equilibrium state.

TABLE 1. Sulfur content in the adsorption process

	Unit	**Content of sulfur by various dosage, activated carbon (Ca)**					
W adsorbent		0%	5%	10%	15%	20%	25%
Sulfur	Ppm	3244	3024	2592	2280	1994	1987

This finding is supported by the calculation of % sulfur removal and adsorption capacity using the equation, namely:

% Removal = $(Ca_0 - Ca) / Ca_0 \times 100\%$………………..…… (1)

Capacity = $(Ca - Ca_0) \times V_{WEO}$ / (W adsorbent) ………… (2)

From the equation above, a graph is obtained as follows in Figures 2(a) and 2(b) below.

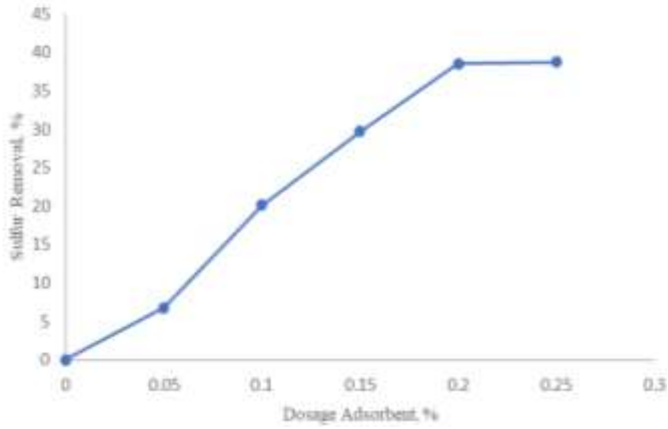

Fig. 2 (a). Percent sulfur removal

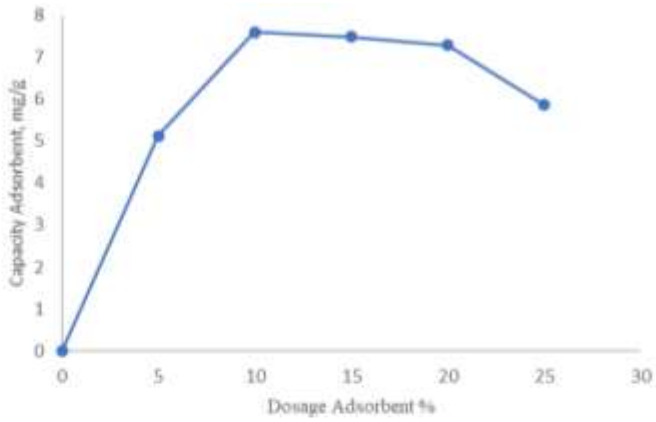

Fig. 2 (b). Capacity adsorbent

The adsorption process using an adsorbent consists of on four stages including: 1). Adsorbed gas or liquid molecules will undergo a process movement towards the adsorbent surface, 2). The molecules will then undergo a diffusion process through adsorbent surface, 3). The solute that is adsorbed will undergo a diffusion process again through the pores in the adsorbent, 4) Solutes undergo an adsorption process only on the surface just the adsorbent [6].

In graph 2 (a) is depicting the percent removal event. Sulphur removal is a value that states the amount of adsorbate that has been successfully Sulphur removed. The more adsorbate that is removed, the better the adsorption process takes place. In this research, the adsorbate in question is specifically for the sulfur element contained in waste engine oil, while in graph 2(b) Adsorption capacity describes the ability to absorb adsorbate per unit weight of adsorbent. In other words, this value is what states the amount of adsorbate can accumulate on the surface of the adsorbent in waste engine oil [7]. The dose of adsorbent added in the adsorption process will of course affect the adsorption capacity because the more mass of activated carbon added, the more activated carbon will react with the adsorbate from waste engine oil [8].

Based on Figures 2 (a) and 2 (b) above, the amount of sulfur content removed is expressed in percent, the sulfur content removed increases as the dose of adsorbent increases, it can be explained that the ratio of the amount of adsorbent increases while the concentration of sulfur in the waste fixed engine oil, will have a greater probability. A large quantity of adsorbent will certainly have a better ability to absorb sulfur so that the sulfur released from waste engine oil increases, as shown in graph 2(a). However, this does not mean that sulfur removal is effective if the amount of adsorbent is greater. This is confirmed by adsorption capacity data which shows that the greater the dose of adsorbent, the more the adsorption capacity decreases. The best adsorption capacity is 10%, and after adding more than 10%, the adsorbent will experience a decrease in its capacity to adsorb sulfur contained in used engine oil as seen in figure 2(b) above.

III. CONCLUSION

The performance resulting from activated carbon derived from coal in sulfur adsorption experiments on used oil, it was found that the active carbon produced had a significant influence. The best condition is obtained at a carbon dose of around 10% for waste engine oil with an adsorption capacity of 14.8% for sulfur, however the best removal condition percentage is obtained at an activated carbon dose of 15%, in which condition the percent removal of sulfur in used oil reaches (35 - 38)% allowance.

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