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SEPARATION OF METAL ELEMENTS FROM USED ENGINE OIL BY USING CERAMIC MEMBRANE TECHNOLOGY

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ABSTRACT

The engine oil use nowadays has been increasing due to high quantity of vehicle use. The more the engine oil was used, the more waste of used oil in environment. After periodic use, the characteristic of used-engine oil would be different in composition and colour. Used engine oil contained the metals namely aluminium (Al), iron (Fe), copper (Cu), zinc (Zn) and the other metals element. Ceramic membrane technology would be used in this research to separate the metal elements from used engine oil. This study would focus to analyze the metals element separation process from used engine oil and to investigate the used engine oil characteristic after refinement. In this study, membrane ceramic that used were compounds with clay, zeolite and iron. The result of this research were calculated by flux equation, coefficient of rejection, and flashpoint of waste of used oil. The result showed that ceramic membrane that compound with 30% zeolit, 5% iron powder and 65% clay at flowrate 3l/min were resulted in Al 0.12 ppm, 0.12 ppm Fe, Cu 0.003 ppm and Zn 0.07 ppm in flux analysis. The temperature flashpoint of used oil slightly the same with the temperature flash point of oil standard.

KEY WORDS : Used oil, Ceramic membrane, Filtration, Engine oil

INTRODUCTION

The engine oill nowadays has been increased due to high quantity of vehicle use. The more the engine oil is used, the more waste of used engine oil in environment. Engine oil was commonly used as lubricant, cover and cleaner in machine. After periodical use, this oil would contain metals and other elements that made the function of this oil to decrease (Hudoyo, 2011). This engine oil would change in composition and colour after periodically use in machine (Sani, 2010). This oil waste would contain acid, corosion material, and metals elements (Sukarmin, 2004). Aluminium (Al), iron (Fe), chopper (Cu) and zinc (Zn) were metals that commonly found in used oil. The waste from used oil might become the environmental and health issue. They were unwanted elements that should be removed to decrease the environmental problem.

The used oil could be refined by using ceramic membrane technology. This technology would separate the particle based on their molecul size. Ceramic was used in this study as media that has semipermiable pore size. Ceramic membrane would be use as media that contain bond element like zeolite, carbon, iron, and etc. In this study, ceramic membrane would be used to separate the metals element that has different size with oil in molecule. The asymetric pore size in ceramic membrane was commmonly used in ultrafiltration and microfiltration study. It could trap and bond the unwanted elements that hs different size of molecule. In this study, the used oil were refined by using ceramic membrane. It could separated the metals from used oil After refinement, the used oil were expexted could be reuse as engine oil as asphalt additive, lubricant in machine, and as fuel. This study would focus on the analysis of the metals element separation process from used engine oil and to investigate the used engine oil characteristic after refinement by using ceramic membrane.

EXPERIMENTAL DETAILS

Time and Place

The research was conducted in the Laboratory of Chemistry at Sriwijaya University and Politeknik Sriwijaya during October 2013 to January 2014.

Materials and Equipments

The used oil was obtained from service station at Musi Raya street, Palembang. The equipments that used in this study were ceramic membrane that compound with clay and zeolite and iron as bond element, the housing instalation, oil pump, flowmeter, PVC pipe, analytical balance, plastic container, and plastic pipe.

Methodology

This experiment would be divided into four procedure; the instalation of equipments, the preparation of used oil, the filtration process, and the used oil refinement analysis.

The Instalation of Equipments

The ceramic membrane equipments instalation were designed for filtration through any pressure type filter holder. The volume of instalation was set up for 5 litre. Before initial use and after each use of this ceramic membrane, the instalation were rinsed with laboratory-grade water. For a more thorough cleansing, the vessel were washed with a mild, nonabrasive detergent and a soft brush or sponge. The installation part were dried before assembly.

The Preparation of used oil

The used oil preparation was obtained by heating the used oil at 40 ^{0}C at 30 minutes. After heating, the used oil was directly used in the filtration process.

The Filtration Process

This experiment would use ceramic membrane with different combination of compound, namely:

1.zeolite ceramic membrane 20%, 2. Zeoilt ceramic membrane 30%, and 3. Ceramic mambrane that contain 30% zeolite and 5% steel powder.

The used oil would pass through three different kind of ceramic membranes that has different function and way to trap unwanted waste. This three different ceramics were used to investigate the correlation between flux and time process and to investigate the metals element that would be trapped by using three different ceramic membranes. In this study, The used oil was passed through the ceramic membrane instalation. The metals elements and unwanted waste in used oil was expected would be trapped in this different kind of ceramic membrane.

The analysis would be calculated by flux analysis procedure. the used oil that has been passed through the membrane, per unit area of membrane would be calculated as J:

$$J = \frac{Q_p}{A_m} \quad .. (1)$$

Where:

J = flux of used oil, L/hr/m^2 (gal/d/ft^2) or Lmh (gfd)

Q$_p$ = filtrate of used oil that flow rate through membrane, L/hr (gal/d)

A$_m$ = surface area of ceramic membrane, m^2 (ft^2)

The recovery of used oil (R),was defined as the percentage of oil fed to the membrane unit that actually would passed through the membrane:

$$R = \frac{Q_p}{Q_f} \quad .. (2)$$

Where:

R = recovery of used oil inthe membrane unit as a percentage

Q$_f$ = feed oil flow to the membrane unit, L/hr (gal/d)

Then, the general flow balance would be:

$$Q_f = Q_c + Q_p \quad .. (3)$$

Where:

Q$_c$ = feed oil that was not passed through the membrane L/hr (gal/d)

TMP was the pressure difference across the membrane:

$$TMP = P_f - P_p \quad .. (4)$$

Where:

TMP = transmembrane pressure, psi

P$_f$ = pressure on the fed oil side of the membrane, psi

P$_p$ = pressure on the filtrate side of the membrane, psi

TMP was the driver of the membrane flux, so the equation could related as:

$$J_T = \frac{TMP}{R_t \cdot \mu_T} \quad .. (5)$$

Where:

J$_t$ = flux at temperature T, Lmh (gfd)

R_t = total membrane resistance, psi/gfd-cp

μ_T = viscosity in centipoises at water temperature T,

Then the total membrane resistance, R_t, coul be calculated as:

$$R_t = R_m + R_f \quad \text{.. (6)}$$

Where:

R_m = intrinsic membrane resistance, psi/gfd-cp

R_f = resistance of the foulant layer, psi/gfd-cp

3. Flash point analysis could be investigated by observing the lowest temperature at which vapours of a volatile of used oil will ignite, when given an ignition source. In this study, flash point of used oil was analyzed to find whether the temperatur flash point of used oil near the temperature flash point of oil standard.

The Used Oil Refinement Analysis

The used oil was passed through filter with different flow rate treatment. Filtrate was collected in every 30 minute to 180 minutes in the filtration process.

RESULTS AND DISCUSSION

The Correlation between Flux and Time

The different composition of ceramic membrane would be correlated with flux and time. The correlation between flux could be seen in Figure 1 to 3. It showed that the metals element has been decreased in used engine oil after refinement by using ceramic membrane.

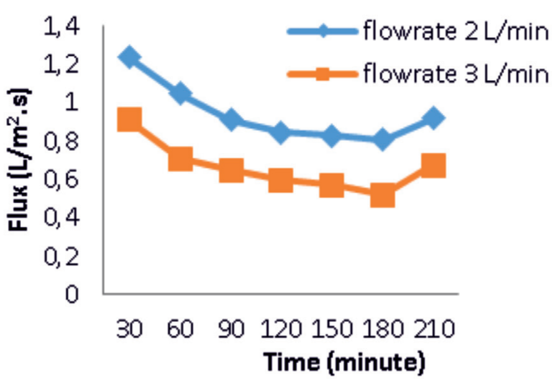

Fig. 1. The Correlation between Flux and Time <Zeolite 20%; Clay 80%>

The flux analysis showed that the ceramic membrane (Figure 1-3) with flowrate 2L/min was higher than the flux value of ceramic membrane with flowrate 3L/min. It could be seen from the Figure that the refinement process by using ceramic membrane was affected by different compound of materials in its ceramic. It was not dependent on the flowrate that has been used in the study. The variety of flowrate and the variety of zeolite composition of membrane were not significant. The composition material of membran zeolite were not support to flux increased. On the contrary, The decrease of flux value belongs to flowrate 2l/min (red line) should be more than the decreased for 3 l/min (blue line). On the Figure 1-3 also showed that flux value was high at 210 minutes. In 210 minutes, the backwash occured so flux value would be higher than other periodic time. The liquid waste that has been trapped on the ceramic would be accumulated during operation and made its performance decreased.

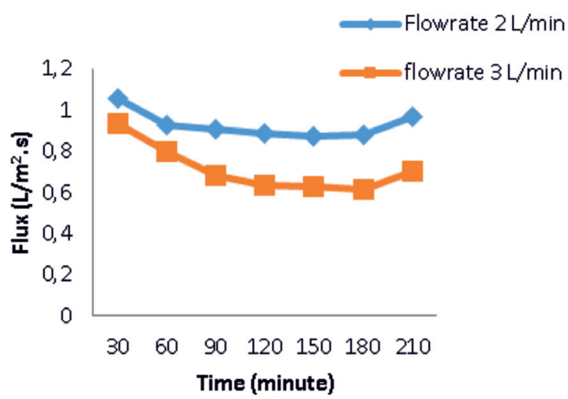

Fig. 2. The correlation between Flux and Time <Zeolite 30%; Clay 70%>

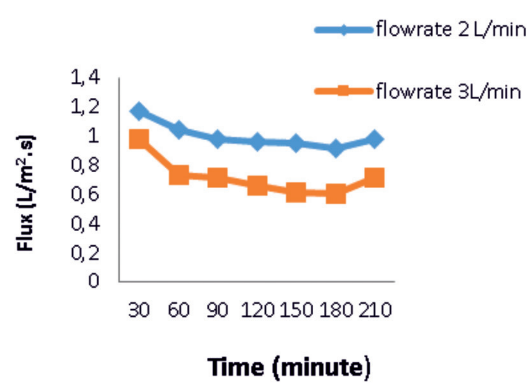

Fig. 3. The Correlation between Flux and Time <Zeolite 30%;steel powder 5%;Clay 65%>

Coeficient of rejection

The coeficient of rejection was used to calculated the membrane perform to filter the metals element in used engine oil. The metals element that trapped in membrane was Aluminium (Al). Figure 4 Showed that the coeficient of rejection value of Aluminium in ceramic membrane. It could be seen that the coeficient of rejection value was high in Alumunium, the membrane perform to separate metal in used oil was high.

It could be also seenn in Figure 4 that the maximum value of coeficient rejection (flowrate 2l/min) was 47,5% and 50 % (flowrate 3l/min) at 180 minute collected time. The coefficient rejection value for flowrate 2l/min and 3l/min showed that the value for the composition material of zeolite 20% and 30% were not significant (Figure 5).

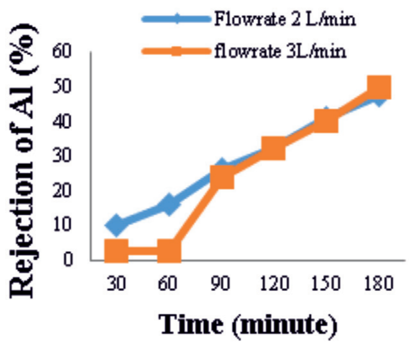

Fig. 4. The Correlation between Coeficient Rejection of Al and Time <*Zeolite 20%; Clay 80%*>

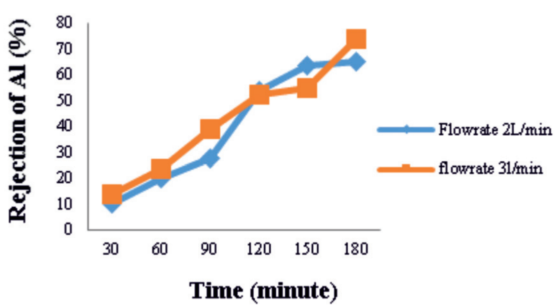

Fig. 5. The Correlation between Coeficient Rejection of Al and Time <Zeolite 30%; Clay 70%>

The coeficient of rejection value was correlated with the ceramic membrane perform to separate the metals element. It could be seen in Figure 5 that the highest coeficient value was 65% for flowrate 2L/min and 73.75 % for flowrate 3L/min.

The Decrease of Aluminium Value Removal During Operation Time

The decrease of Aluminium value was calculated by correlated it with operation time. Before treatment, the Aluminium value was 0.8 ppm. After treatment, At flowrate 2L/min (30 minutes), the aluminium value was 0.72 ppm and at minute-180, aluminium value was 0.42 ppm. In *Flowrate* 3 l/min, the aluminium value was decreased from 0.8 to 0.4 ppm.

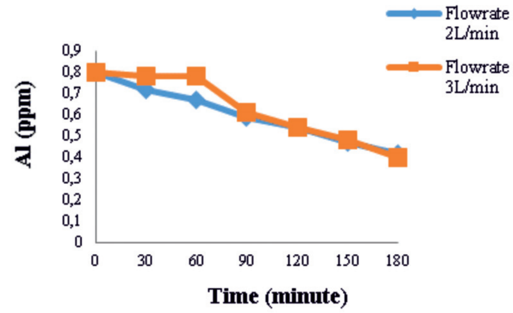

Fig. 6. The decrease of Aluminium value in used oil during operation time <membrane: zeolite 20% and clay 80%>

The Correlation Between Flash point and Operation Time

The flash point of used oil before treatment could be seen in Figure 7, it was 196 ^{0}C. After treatment (flowrate 2L/min) flash point was 199 ^{0}C to 207 ^{0}C. After treatment with *flowrate* 3l/min, the flash point value was ranged between 200 ^{0}C to 211 ^{0}C. The flash point value was increased during operation time.

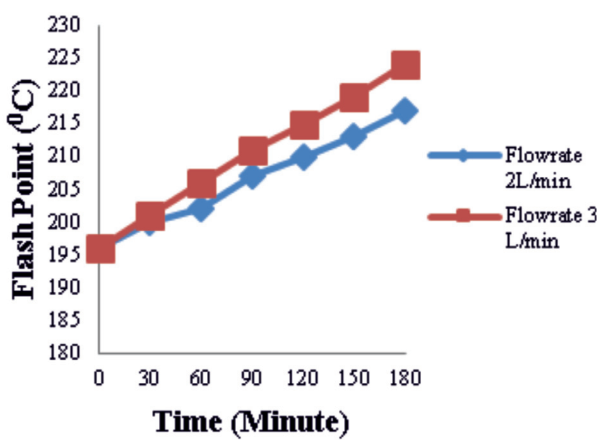

Fig. 7. The Correlation between flash point and operation time <membrane: Zeolit 20% and clay 80%>

Figure 8 showed that at *flowrate* 2l/min, the flash point were ranged between 200 ^{0}C to 217 ^{0}C, and at *flowrate* 3l/min was 201 ^{0}C to 224 ^{0}C. It means that the higher flow rate the flash point to increased. To caompared with the temperature flashpoint of oil standar the results in this reasearch is slighly the same that means the separation of used oil by using the membrane separation is good. The material zeolite with two composition of membrane 20% and 30% were founded significantly. Also the material of clay with two composition of membrane 80% and 70% were founded the samely. It should be

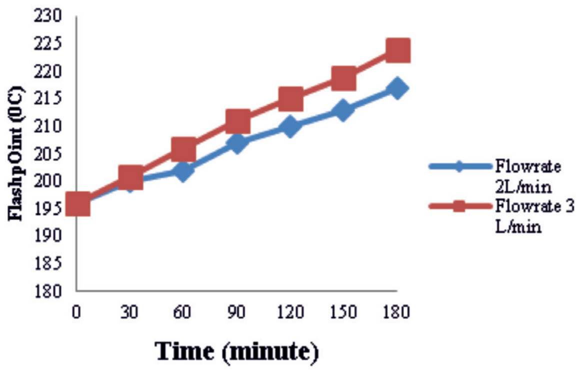

Fig. 8. The Correlation between flash point and operation time <membrane: zeolit 30% and clay 70%>

known that the flash point of used oil with the membrane treatment is not dependent on the material composition of membrane also, but depends on the material of used oil composition. On the other hand, the older time of used oil may cause reduction of flash point than the fresh time used oil.The composition of iron powder material of membrane also did not affect significantly with two component zeolite 70% and 80%. It should be known that the compostion of material membrane like iron powder as additive for composition of membrane to support increased the flashpoint but this reasearch were not fully supported.

CONCLUSION

It could be concluded in this research that the used oil refinement could be separated by using ceramic membrane technology. Ceramic membrane composition with zeolite, clay, iron could be used to separate the metals elements in used oil. The flowrate that has been used in this study were not significantly affected the performance of the membrane. The flash point value compared with the temperature engine oil standar showed that the used oil after refinement with ceramic membrane and the engine oil was not significantly different.

Nomenclature

J = flux, L/hr/m^2 (gal/d/ft^2) or Lmh (gfd)
Q_p = filtrate flow rate through membrane, L/hr (gal/d)
A_m = surface area of membrane , m^2 (ft^2)
R_m = intrinsic membrane resistance, psi/gfd-cp
R_f = resistance of the foulant layer, psi/gfd-cp
R = recovery of the membrane unit as a percentage
Q_f = feed water flow to the membrane unit, L/hr (gal/d)
J_t = flux at temperature T, Lmh (gfd)
R_t = total membrane resistance, psi/gfd-cp
μ_T = viscosity in centipoises at water temperature T, cp

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