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The Influence Of Pump Rotation Speed, Time, Amounts Of Nozzles Hole During The Spray Water Washing Process In Determining Characteristics Of Cpo In Biodiesel Production

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Abstract:- The analysis on Crude Palm Oil (CPO) resulted the amount of substance of Free Fatty Acid (FFA) is 0.13%, in which the analysis done through a transesterification reaction using Potassium Hydroxide (KOH) as the catalyst, therefore this relatively low amount allows the biodiesel-making to get processed without esterification reaction. High amounts of water and FFA might cause saponification reaction that produces soap and water that could result the low amount of methyl ester. The transesterification reaction is processed with 90 minutes of stirring time, 500 rpm speed of stirrer and 60º Celcius temperature. The CPO then washed using a designed equipment with the following specifications; 1) wash tank in a form of 20 cm diameter cylindric tube, 30 cm height, acrylic based with 5 mm thickness 2) 20 mm diameter pipe, 110 cm in length, 30 cm thickness 3) Centrifugal pump with 1400 rpm rotation speed, a motor with 0.37 horsepower and pulley ratio between the motor and the engine shaft is 1:6. The washing time for CPO are 5 minutes and 10 minutes. The amounts of nozzle hole ranging from 3, 4 and 5, each is distanced in 24 mm, and each of them has 0.7 mm diameter. The nozzles are 10 cm away from the biodiesel surface. The desired speed of pump rotation are 2000, 3000 and to 4000 rpm. The ratio between biodiesel and water is 1:3, with the washing process carried out twice. The result of the first washing with 5 minutes time, is the yield decreased 20% from the initial volume. The second washing that carried out using speed of stirrer 4000 rpm, resulted the first washing's yield decreased 6.25% and pH of wastewater of washing process decreased 0.7%. On the other hand, the washing process carried out in 10 minutes, using five nozzle hole, showed the pH decrease as well. The characteristics of the biodiesel from the first washing process had surpassed the SNI and ASTMD 6751 standards in terms of density, viscosity, cetane number and flash point.

Keywords:- Transesterification reaction, CPO, speed of stirrer, time, washing, nozzels, characteristics

I. INTRODUCTION

This document is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the publications committee as indicated on the website. Information about final paper submission is available from the website. Biodiesel is an alternative renewable energy sources; a solution that deemed right for depleting non-renewable energy sources like oil, particularly diesel fuel. In general, biodiesel is vegetable oil based fuel for diesel machine, specifically, it consists of alchyl esters that processed through alcoholysis (transesterification) between tryglicerida and methanol with Potassium Hydroxide (KOH) as the catalyst. The results of such reaction are alchyl ester and glicerol. During the biodiesel production, the washing process is one of the phases that determine the required quality of biodiesel's yield. Within the washing process there would be several problems that could affect biodiesel quality, the primary one and frequently exist is emulsification. Such problem possibly would appear when the transesterification is processed improperly, in which if there are substances like monoglyceride and diglyceride still exist that could emulsify water, hence it could decelerate the separation process between water and biodiesel and decreasing the amounts of biodiesel's yield. Emulsification could happen because of two factors; the poor quality of the biodiesel and the overly vigorous speed during the stirring process.

Several studies has been done by Pramudita, et al (2009), in which the studies were focused in terms of how the effect of washing method could determine the quality of biodiesel. In the study, the method used for biodiesel production was bubble washing spray and stirring, the aim of the study was to determine biodiesel with characteristics that meets ASTM 6751's required standards. Variables used in the study are; washing method, in which bubble washing spray was chosen as the method; stirring process and the required time; 0 hour, 0.5 hour, 1 hour, 2 hours and 4 hours. The biodiesel resulted from the process has met the ASTM 6751's required standards, in which the best biodiesel was carried out through using bubble washing method in 4 hours.

Other studies about biodiesel carried out by Berrios and Skelton (2008), Predojevic (2008) and Atadashi et al (2011), were comparing three purification methods to determine the most optimized one that could completely diminish all contaminants within. The biodiesel purification using water washing process done by Atadashi et al (2011) was assumed to be the most effective to diminish remnants of glycerol and methanol within biodiesel. But the problem occurred in such method was the stirring process could create emulsion. It goes the same for Berrod and Skelton study (2008), in which it was concluded that biodiesel washing method using water could significantly diminish methanol compared to other washing methods, but it couldn't diminish the glycerol significantly. On the other hand, the study by Predojevic (2008) stated that biodiesel washing method using water spray at 50º C temperature could determine 97.92% FAME substance and specifications that meet EN 14214's required standards that suggest minimum 96.5% of FAME substance. The previous studies showed biodiesel washing process must be carried out precisely and cautiously. Biodiesel washing could be carried out using an engine and spray water method, in which the washing is carried out by circulating water using a pump, and spraying it through different nozzles, each with particular different conditions within the biodiesel. It also used varied height of water spray within the oil, therefore the water get spread in the oil before eventually went down and getting through the biodiesel while washing it at the same time*[1]-[5]*.

II. METHODOLOGY

2.1 Material

Materials used for this study are; Crude Palm Oil (CPO), made of palm oil, as the main source for biodiesel production. Methanol (90 %) as reactant and KOH as catalyst during transesterification reaction. A reactor with following specifications; 5 liter capacity, 1000 watt heater, stirrer motor with 0.7395 horsepower capacity, temperature controller with measurement numbers up to 100 ^{O}C, washing equipment consist of stirrer motor armed with a 0.37 kW capacity pump, 1400 rpm rotation capacity, 1.905 cm diameter pump, 20 cm diameter washing tube with 30 cm height and acrylic based material, 20 mm diameter and 150 cm length tubing made of acrylic, flowmeter equipped with ballast that had been calibrated from 5.4 gr to 1.7 gr.

2.2 Transesterification reaction and washing equipment

This is an experimental study, in which the experiment equipments were made of several components such as; combustion furnace with two burners, each has 1000 to 1200 watt capacity, stirrer that equipped with electrical motor with 0.7395 horsepower capacity, in which the rotation could be adjusted using a rotation inverter, this stirrer also equipped with a panel control to adjust the temperature using thermocouple, temperature sensors and a temperature controller OMRON that works by halting the burner and rotation when the desired temperature had gained, but would carry out again afterwards. The stirrer consists of blades, each has particular angle degree. The oil material would get inserted into reactor and the controller would seal the reactor throughout the stirring process, so that it would prevent a saponification reaction. The washing process carried out by circulating the water using a pump and spraying it with nozzles. There are variables used in such process; rotation pump, spraying time and the specification of the nozzles.

2.3 Transesterification reaction

The transesterification reaction used methanol and oil as reactants with molar ratios 1:5. A 5.3 gram/liter oil potassium hydroxide (KOH) as catalyst. Afterward, a preheating process is carried out to diminish all remnants of water within the oil, because the presence of water in the oil could trigger hydrolysis that would produce soap substance. The soap might be in semi-massive or massive form, and it would be very difficult to cope with. To make the methoxide solution, 20 % methanol of the used oil is mixed with 5.3 gram/liter oil KOH. The mixing is carried out in secluded medium and would produce potassium methoxide later on. If the methoxide had formed and the amount of water is under 1 %, oil would be moved into the reactor to get processed through transesterification reaction, using the said methoxide with varied temperatures, time and speed of stirrer. The result of the transesterification then would be precipitated for less or more 24 hour, this aimed to solve glycerine from methyl ester (biodiesel) entirely.

2.4 Washing spray water unified

3 liter of water is put into a washing tube, then, the resulted biodiesel from transesterification process mixed with the water. The washing process used following equipment; pump, tube, tubing, pump motor, flowmeter and nozzles. The chosen speed of stirrer are 2000, 3000 and 4000 rpm. The chosen time are 5 and 10 minutes. The chosen amounts of nozzles are 3, 4 and 5. The washing is carried out twice; the first consists of solving the water from biodiesel manually. This is carried out after measuring the pH of water, yields and biodiesel. The second process consists of mixing the water and biodiesel in 1:3 ratio, then the biodiesel would get tested in laboratory in order to find particular characteristics; flash point, viscosity, density and cetane number.

2.5 Biodiesel analysis

Identifying the amounts of FAME in biodiesel could be done through gas chromatography (GC) method. The procedure consists of [4]; 1 gram biodiesel was taken as a sample, benzene-alcohol is added into the sample with mass ratios 1:1 between the biodiesel and the benzene-alcohol, mix them until they became a homogenous mixture. Afterwards, take a 0,5 μl from the mixture to get analyzed with GC equipment.

III. RESULT AND DISCUSSION

3.1 *Characteristics of CPO*

The chosen method for washing process is *washing spray water*, in which the water is sprayed into oil. The oil was CPO that resulted through transesterification reaction using a reactor, processed in 1.5 hours, using 500 rpm speed of stirrer and 60ºC temperature. The ratios between oil and water during washing process are 3:1. Water and biodiesel would get inserted into tube. Ǿ 0.7 mm nozzle was chosen, with amounts of holes ranging from 3, 4 and 5, each has 24 mm distance from each other. The time for the washing process 5 and 10 minutes. The chosen speed of stirrer are 2000, 3000 and 4000 rpm. The process was carried out twice. The identified results would be described in graphics. Figure 1 shows the amounts of CPO yield.

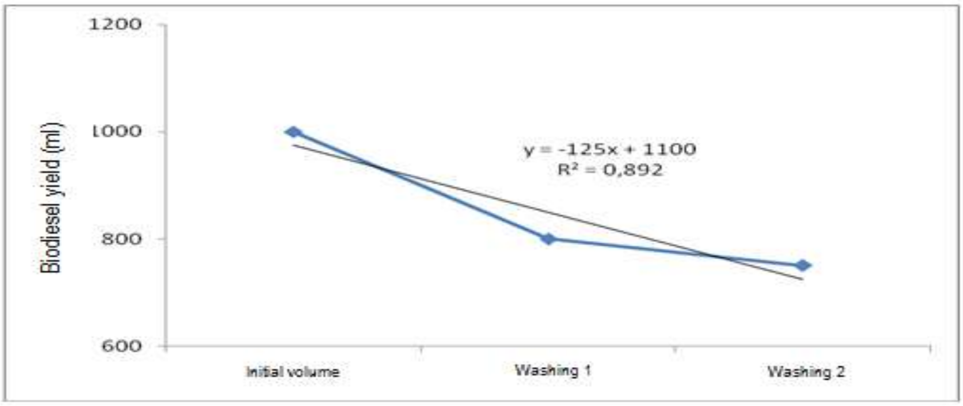

Fig 1. The results of biodiesel yield

PH in the wastewater of washing process could be used to determine efficiency of the washing process itself. It could be seen in the amounts of remnants of KOH catalyst and the contaminants that still remain in biodiesel. The washing process is carried out until the amounts of pH in the said wastewater nearing the neutral value (pH 7), which is a sign that all the catalyst remnants and contaminants had washed properly. The pH of wastewater of CPO washing process is showed in Figure 2.

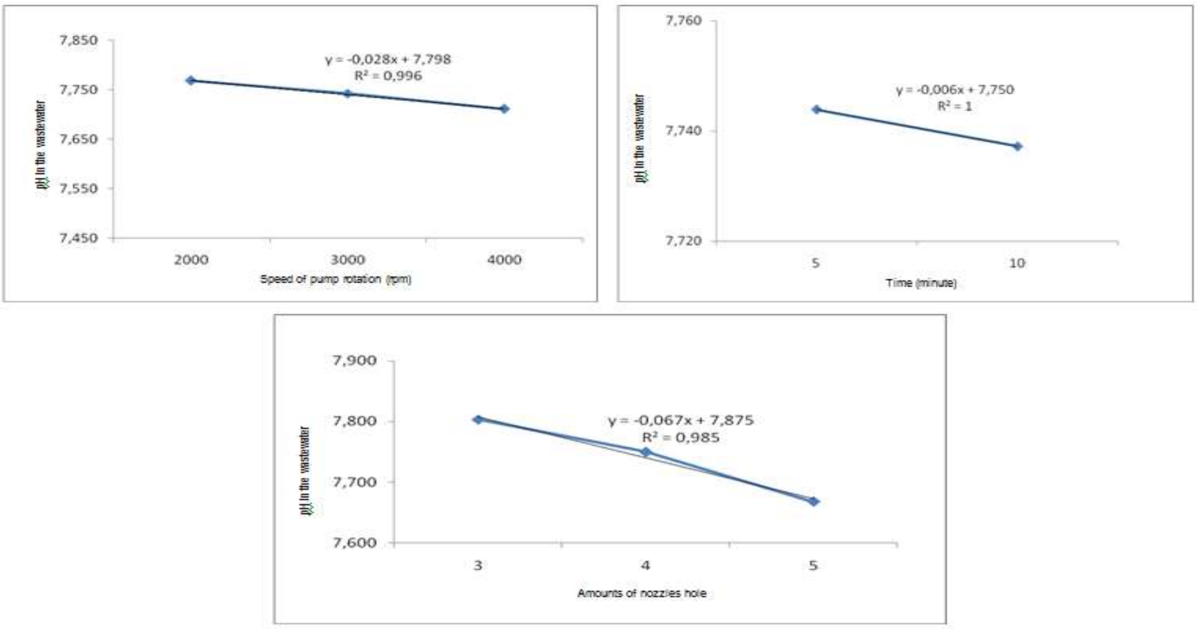

Fig 2. The influence of the variables (time, speed of pump rotation and amounts of nozzles hole) to the resulted pH of wastewater from biodiesel washing process

Main characteristics of oil fuel are density. In terms of substance, density is its mass per unit volume. The CPO mass per unit volume is showed in Figure 3.

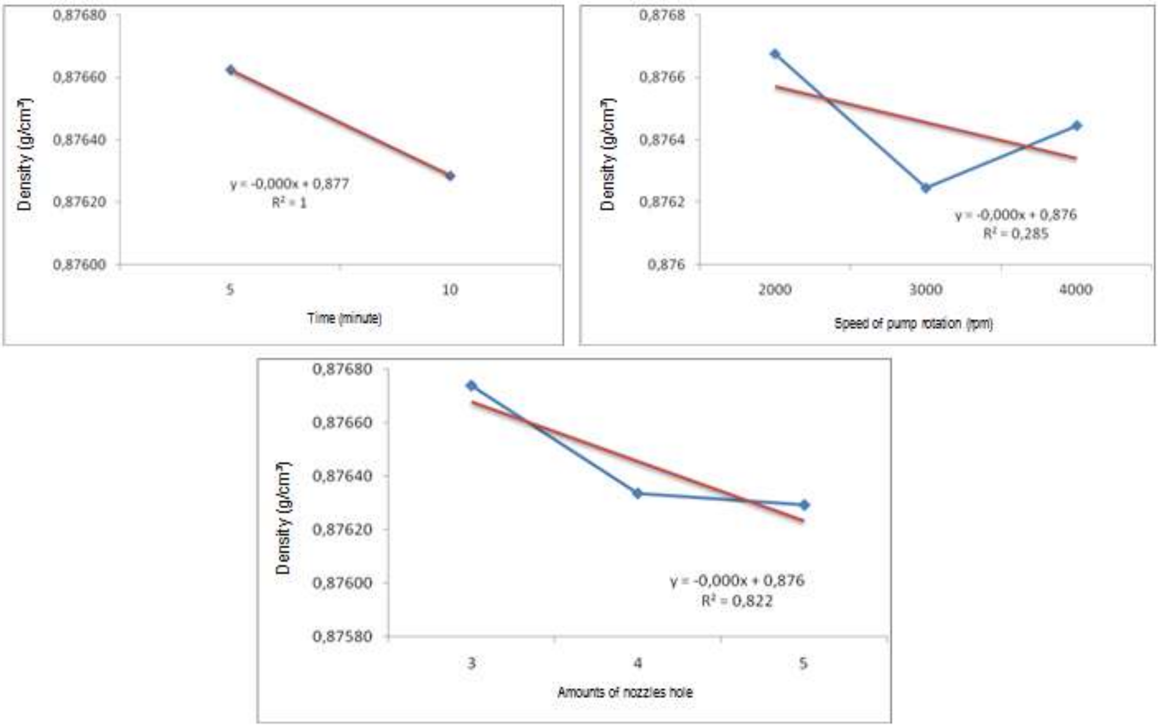

Fig 3. The influence of the variables (time, speed of pump rotation and amounts of nozzles hole) To the density of biodiesel

Viscosity is a physical properties that has strong influence to atomization patterns, heat conduction and performances of oil fuels. Viscosity is determined based on the required time (in second) for a fuel with particular volume, to pass a certain medium in particular condition (ASTM 2002), those characteristics on CPO is showed in figure 4.

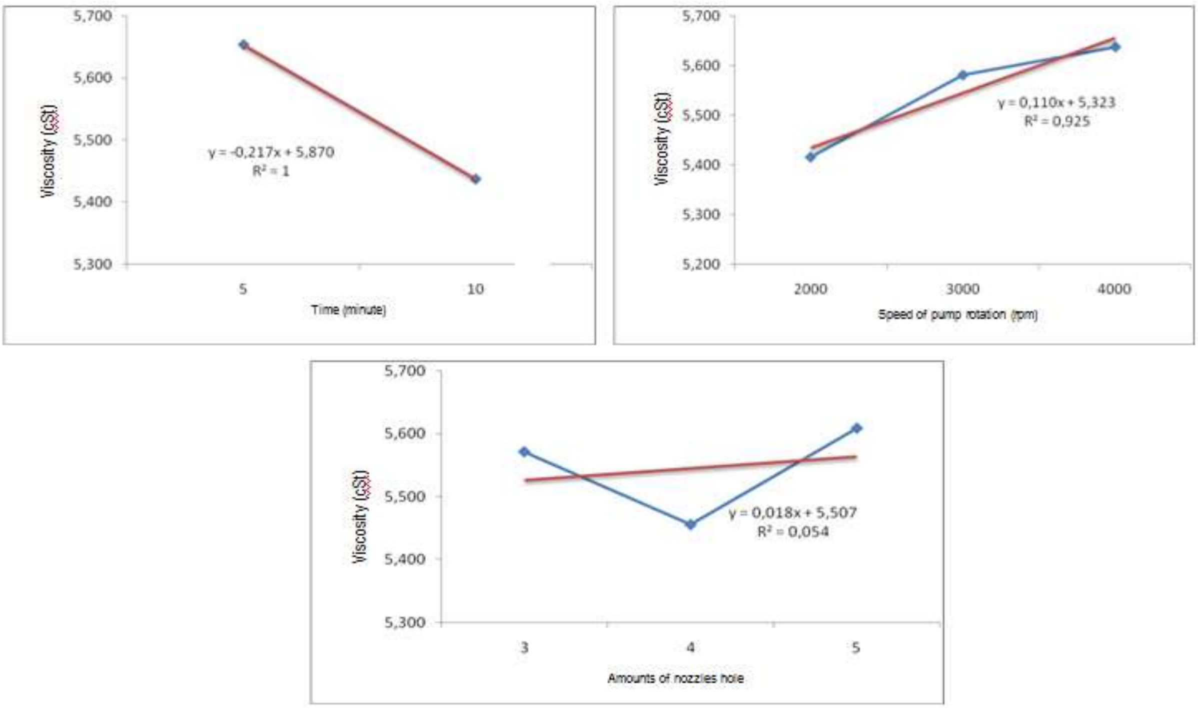

Fig 4. The influence of the variables (time, speed of pump rotation and amounts of nozzles) to the resulted viscosity from biodiesel washing process

Flash point is the lowest temperature in oil or fuel where it can vaporize to flash for a moment when ignited. Figure 5 shows the influence of the variables (time, speed of pump rotation and amounts of nozzles) to the resulted flash point from biodiesel washing process.

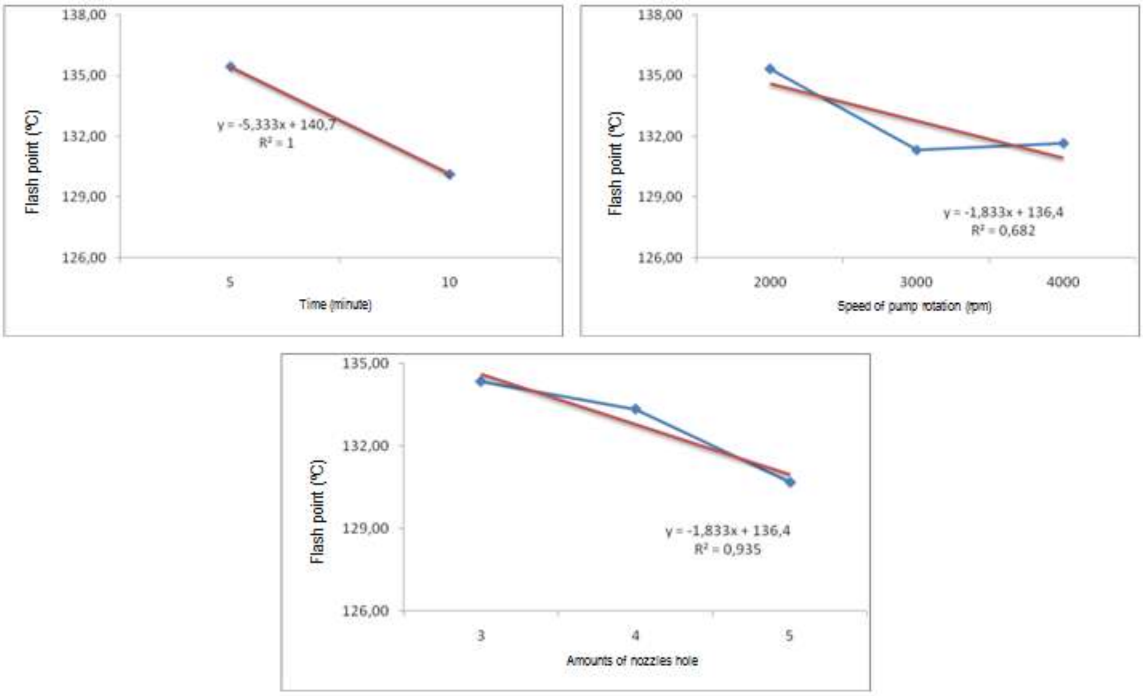

Fig 5. The influence of the variables (time, speed of pump rotation and amounts of nozzles) to the resulted flash point from biodiesel washing process

Cetane number is a measurement of the combustion quality of fuel during compression ignition. (Anonym, 1994). High cetane number shows that the fuel could ignite in relatively low temperature. The usage of fuel with high cetane number could prevent detonation or knocking, because when it's put into combustion chamber it would immediately combusted and not accumulated. The influence of the variables (time, speed of pump rotation and amounts of nozzles) to the resulted cetane number from biodiesel washing process would be explained in figure 6.

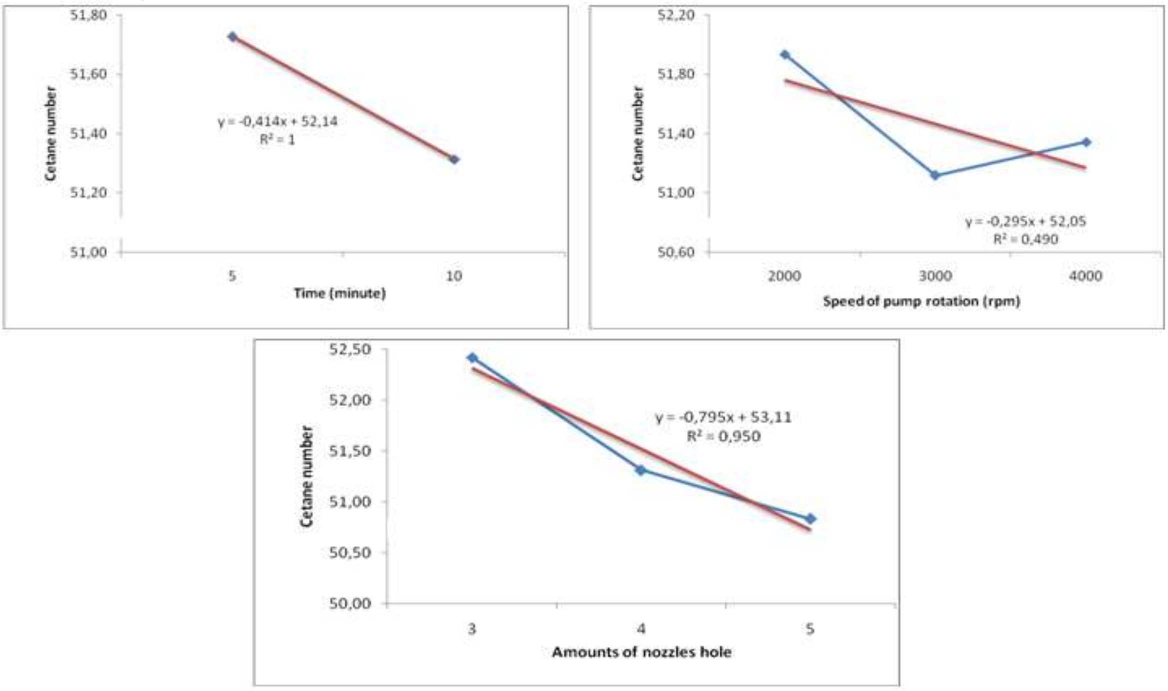

Fig 6. The influence of the variables (time, speed of pump rotation and amounts of nozzles) to the resulted cetane number from biodiesel washing process

3.2 Discussion

Figure 1, the initial volume of biodiesel yield is 20% decreased in first washing process and 25% decreased in second washing process. This showed there was a 6.25% amount of reduction between the first and second washing process, this means there was a very few reduction of the yield in the CPO from the second washing process, hence this oil's quality was still suitable for biodiesel.

Figure 2 shows that during the first washing process, pH of wastewater would increase nearing alkali (greater than 7), but on the second washing process the initial pH of wastewater equals the initial pH of water before the washing process. This means the remnants of KOH in biodiesel was strongly bounded with water during the washing process. Pelly (2005) stated, the faster pH increase in the wastewater means the more efficient the washing process itself *[6]*. A pH in wastewater of the washing process that nears initial pH of water indicated that biodiesel has no remnants of catalys (KOH), methanol and glycerin within. CPO has pH value nearing pH in water. With 2000 rpm until 3000 rpm speed of pump for the washing process, showed that in between, there was 0.3 % pH reduction in CPO. Meanwhile with 2000 rpm until 4000 rpm speed of pump showed that there was 0.7% pH reduction. With amounts of nozzles ranging from 3 to 4, there was 0.6% pH reduction and 1% reduction for amounts of nozzles hole from 4 to 5. For the washing process that carried out in 10 minutes, there was 0.09% pH reduction, which showed that the pH reduction was not significant in this variable.

Figure 3, a graphic of density in CPO is showed. With washing process that carried out in 10 minutes, there was a 0.04% density reduction from its initial value, 0.8766 gr/cm³. With 3000 rpm speed of pump, there was a 0.05% density reduction from its initial value 0.8767 gr/cm³ that would increase 0,0023% with 4000 rpm speed. With amounts of nozzles hole from 4 to 5, there was an insignificant density reduction, with each nozzle usage resulted 0,87634 gr/cm^3 and 0,87629 gr/cm^3. SNI standards for density are **0,850** to **0,890** gr/cm^3 and ASTM standards are **0,8566** to **0,8815** gr/cm^3.

Figure 4, a graphic of viscosity of CPO is showed. For the washing process that carried out in 5 minutes, there was a 5,65 cSt viscosity reduction. For the washing process that carried out in 10 minutes there was a 3,84 % viscosity reduction from its initial value, 5,437cSt. For the washing process that carried out on 2000 rpm speed of pump rotation, the resulted viscosity is 5,416 cSt, this number increased in 3% on 3000 rpm speed of pump rotation and on 4000 rpm, there was a 2.1% increase. With 4 nozzles hole, the resulted viscosity was the closest to the standard value, 5.4 cSt, if compared to the usage of amounts of nozzles hole. SNI standards for viscosity are **2,3** to **6,0** cSt and ASTM standards are **1,9** to **6,0** mm^2/s.

Figure 5, there is a graphic explaining the influence of the chosen variables to the resulted flash point for biodiesel washing process. With the process carried out in 10 minutes, the resulted flash point in CPO shows there was a 3,94 % reduction from the result of 5 minutes' process, from 135,44 ^{O}C to 130,11 ^{O}C. With the process carried out on 3000 rpm speed of pump rotation, there was a 2,96 % reduction of the resulted flash point, meanwhile on 4000 rpm speed of pump rotation, there was a 0,26 % reduction from 131,33 ^{O}C to 131,67 ^{O}C. With 3 nozzles hole, the highest flash point was 134,33 ^{O}C, mean while with 4 and 5 nozzles hole, there were 0,75% and 2,7% reduction from its initial flash point. SNI standard for flash point is minimum **100 ^{O}C** and ASTM standard is minimum **130 ^{O}C**.

Figure 6, there is a graphic explaining the influence of the chosen variables to the resulted cetane number for biodiesel washing process. With the process carried out in 5 minutes, the resulted cetane number was 51,73, mean while with the process carried out in 10 minutes the resulted cetane number was 0.81% decreased. With the process carried out on 2000 rpm speed of pump rotation, the resulted cetane number was 51,94, mean while there was a 1,58 % reduction on 3000 rpm speed of pump rotation and 0,43 % increase on 4000 rpm. With 3 nozzles hole the resulted cetane number was 52,42, while there was 2,12 % and 3.03 % reduction on usage of 4 and 5 nozzles hole. SNI standard for cetane number is minimum **48** and ASTM standard is minimum **47.**

IV. CONCLUSIONS

Analysis resulted the amounts of FFA in CPO was 0.13%. During biodiesel production process, a transesterification reaction with KOH as catalyst could be carried out right away without going through esterification first, it has to be stirred in 1.5 hours with 500 rpm speed of the pump rotation and 60º C temperature. The result of the washing process showed there was a 20% reduction of yield from its initial volume. During the second washing, there was a 6.25% reduction from the first washing's result. pH in the waste water lowered in 0.7% with the process carried out in 4000 rpm speed of pump rotation and in 10 minutes. With the process carried out using 5 nozzles hole, there was also a pH reduction. As a result of the washing process, the biodiesel has these following characteristics; 1) With the process carried out in 5 minutes, the resulted density is 0,8766 gr/cm^3 gr/cm^3; with 2000 rpm speed of pump rotation, the resulted density is 0,8767 gr/cm^3; with 3 nozzles hole, the resulted density is 0,8767 gr/cm^3, 2) With the process carried out in 10 minutes, the resulted viscosity is 5,45 cst; with 4000 rpm speed of pump rotation, the resulted viscosity is 5,65 cst ; with

4 nozzles hole, the resulted viscosity is 5,46 cst, 3) With the process carried out in 5 minutes, the resulted flash point is 135,44 ^{O}C; with 2000 rpm speed of pump rotation, the resulted flash point is 135,33 ^{O}C; with 3 nozzles hole, the resulted flash point is 134,33 ^{O}C, 4) With the process carried out in 5 minutes, the resulted cetane number is 51,73; with 2000 rpm speed of rotation pump, the resulted cetane number is 51,94; and with 3 nozzles hole, the resulted cetane number is 52,43

REFERENCES

[1]. Mahfud, Muharto, Pramudhita, danMarwoto. 2007. Pengaruh Metode Pencucian pada Pembuatan Biodiesel Jarak Pagar.ITS. Surabaya.

[2]. Berrios, M. and Skelton, R.L.. 2008. Comparison of Purification Methods for Biodiesel. Chemical Engineering Journal 144: 459 – 465

[3]. Predojevic, ZlaticaJ.. 2008. The Production of Biodiesel from Waste Frying Oils: A Comparison of Different Purification Steps. Fuel 87: 3522 – 3528

[4]. Atadashi, I.M., Aroua, M.K., and Abdul Aziz, A. 2011.Biodiesel Separation and Purification: A Review. Renewable Energy 36: 437 – 443

[5]. Atadashi, I.M., Aroua, M.K., Abdul Aziz, A., and Sulaiman, N.M.N.. 2011. Refining Technologies for The Purification of Crude Biodiesel. Applied Energy 88: 4239 – 4251

[6]. Ayu, Dyahdan Ali Zibbeni. 2011. Pengaruh Stir Washing, Bubble Washing, dan Dry Washingterhadap Kadar Metil Ester dalam Biodiesel dari Biji Nyamplung (Calophylluminophyllum). ITS. Surabaya