# PERFORMANCE TESTING ON MIXTURE OF KISAMIR PURE PLANT OIL (PPO) AND KEROSENE AS WICK STOVE FUEL

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***ABSTRACT***

*Pure Plant Oil (PPO) which is made from "kisamir" seed has smaller kinetic viscosity value than jatropha and coconut oil. So it has potential to be used as alternative fuel/ mixed kerosene.*

*The test result of some main physical/chemical characteristics of fuel made from kerosine and pure plant oil (5% to 20% volume) are still in the limit of kerosene specification as decided by the government. However, the maximum power test result of the mixture of PPO and kerosene that has been tested on 16 wicks stove shows that the higher content of PPO in kerosene will decrease the maximum stove performance as well as stove's efficiency value. But the blue color of fire gets clearer, because of less amount of sulfur by adding PPO in kerosene. The use of PPO up to 20% will reduce sulphur content up to 20%.*

***Key Word:*** *PPO, Kerosine Alternatif fuel, Spesification, Maksimum Power, Efficiency stove*

## I. INTRODUCTION

Kerosene is one of liquid fuels; produced by atmospheric distillation process of crude oil, it is one of fuels subsidized by government in Indonesia. The common utilization of kerosene is as household fuel, where it is used for stoves, whether wick stove or pressure stove.

The domestic supply of kerosene in

Indonesia is dicreasing. This situation is caused by goverment program of conversion of the use of kerosene to LPG as household fuel. However, the national demand of household fuel consumption in national energy policy of 2010 as stated is still considerable; where natural kerosene demand is predicted to be up to 10 million kilo liter. Usually, kerosene is used as household fuel on the stove, whether wick stove or pressure stove. Beside that, kerosene is also used as fuel for industry .

The purpose of this research is to study the use pure plant oil (PPO) as an alternative fuel that substitutes kerosene in line with Indonesian energy diversification and conservation acceleration policy and to understand how well is the performance of mixtures of PPO and kerosene on wick stove.

Test result evaluation is done by comparing main biokerosene characteristics test result with kerosene specification requirement. Performance test was done by comparing the performance of bio kerosene with that of kerosene.

## II. LITERATURE OBSERVATION

### A. *Kerosene*

Kerosene is colorless and clear distillated fuel, which is the product of petroleum refining (asmopheric distillation) with boiling point from $150^0$C to $310^0$C and other physical and chemical characteristics that fit the specification required by the government as declared in Directorate General of Oil and Gas Decree No. 17 K/72/DDJM/1999 of April 16, 1999.

### B. *Pure Plant Oil* (PPO)[2, 3]

Pure plant oil is the oil produced from plants and well known as renewable and environmentally friendly fuel. When used as fuel, this plant oil is also known

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as biofuel. Biofuel can be classified into three groups, which are biodiesel, biooil/PPO, and bioethanol. These groups commonly have higher flash point than fossil fuel, so those are safer when they are being kept and delivered. Biofuel generally does not contain sulfur and polycyclic aromatic hydrocarbon compounds (PAH). If it does, it is in a very small concentration. Nonetheless, sulfur dioxide PPO and PAH in small emission's reduced gas. PPO or biooil is vegetable oil which has been purified through the purifying process, such as degumminng, neutralizing, and deascidificating (Rama Prihandana 2007). PPO can be used as alternative fuel for direct consumption to the machine or through the chemical reaction process. Direct consumption PPO to the machine can be done for low and medium speed diesel engine, namely generator set and tractor (Unggul Priyanto, 2007). Consumption of 100% PPO has also been experimented on pressured kerosene stove, where some of its parts have been modified. PPO utilization as wick stove fuel can be experimented in mixure with kerosene. The advantage of plant fuel is that it is able to reduce carbon monoxide solid particle emission and to the air.

### C. *Wick Stove* [5]

Stoves for household needs that are availabe in the market generally can be divided into two large groups, kerosene stove and gas stove (use LPG or city gas as the fuel).

Kerosene stove can be classified into two, which are pressure stove and wicks stove (one-wick stove and many wicks stove). Basically, a stove is assembled from main elements, such as: (a) fuel storing facilities; (b) fuel transportation system; (c) burning room; (d) fire managing mechanism and (e) pans holding.

In kerosene wicks stove, the kerosene is stored in a tank. That kerosene is transported from the tank to the burning room to the wick whick fixed to holder (fixed wick), or it can be moved up or down (adjustable wick). On the fixed wick stove, fire managing mechanism is a value that can manage fuel flow to the wick. However, on the adjustable wick , fire managing mechanism is jacking up lever or racking or cranking system.

To light up the stove, the wicks are rollied up and then lighed. Through fire produced flow, ambient air is pulled through the small holes on muffler into the firing room. In this room, the air reacts with the flammable kerosene vapor. If the wicks are rolled up to reach proper height, upper part of fire will raise slowly. Finally, this fire will cover whole room and the open upper part will create blue stable ray. The effect of heat that is produced by the reaction from the air and fuel vapor, the muffler will light up to, red color. To prevent heat radiation, the stove is completed with a cover. Maximum blue ray gives maximum heat to the black smokeless condition.

On Figure 1, can been the main part of wicks stove can be moved up and down.

**Table 1**
**Kerosene Specification*)**

| *No.* | *Characteristics* | Units | Specification Limit | | ASTM Test Method / Other |
|---|---|---|---|---|---|
| | | | Min | Max | |
| 1 | Density at 15°C | $kg/m^3$ | | 0.835 | D 4052-96 or D 1298 |
| 2 | Distillation: | | | | D 86 – 99a |
| | Recovery at 200°C | % vol. | 18 | | |
| | End Point | °C | | 310 | |
| 3 | Flash Point Abel | °C | 38 | | IP-170 |
| 4 | Smoke Point | mm | 15 | | D-1322 |
| 5 | (Calorific Value) | Mg/Kg | | 40 | IP-10 |
| 6 | Sulfur Content | % wt | | 0,20 | D 3227 |
| 7 | Copper Strip Corrosion | ASTM | | 1 | D-130 |

*) Kerosene Specification according to General Directorate of Oil and Gas Decree No. 17 K/DDJM/1999, April 16,1999.

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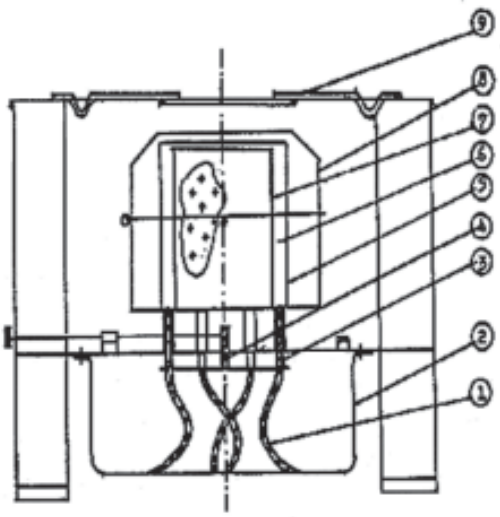

Explaination :
1. Wick
2. Kerosene tank
3. Wick pipe
4. Outside Nest Fire Managing Mechanism
5. Outside Nest
6. Firing Room
7. Inside Nest
8. Cover
9. Pan Holder

**Figure 1**
**The Wicks Stove**

## III. METHODOLOGY

Performance test of Kisamir Pure Plant Oil (PPO) and kerosene mixture as wick stove's fuel is done by making alternative fuel (biokerosene) with volume percentage, mixture variation such as 0%, 5%, 15%, and 20%. Each biokerosene sample is given a code (BK-0, BK-5, BK-10, BK-15, and BK-20). Then, main physical and chemical characteristics (such as kinematic viscosity, density, flash point, smoke point, sulfur content, and calorific value) area tested using kerosene fuel specification as reference. After that, parameters of wick stove's fuel performance are measured namely maximum power, fuel consumption, and stove efficiency. Next, evaluation of physical-chemical characteristics and stove performance test results are conducted by comparing the results for all samples.

## IV. RESULT AND EVALUATION

### A. *Physical and Chemical characteristics test result*

Comparison of kisamir seeds' PPO characteristics test result with coconut and jatropha oil are shown on Table 2. Composition of PPO mixure and kerosine as kerosine alternative fuel, are shown in Table 3.

Next, kerosene sample's physical/chemical characteristics analysis result are compared with kerosene's specification accordance to Oil and Gas General Directorate Decree No. 17K/DDJM/1999, of April 16, 1999, shown in Table 4.

Table 2 shows that Kisamir seeds' PPO physical/chemical characteristics are almost same as that of jatropha's PPO physical/chemical characteristics, or coconut. Kisamir seed's PPO is thinner then the others and it has lower kinematic viscosity value than of jatropha's PPO or coconuts. So kisamir seeds' PPO can be utilized for alternative fuel to substitute kerosene.

Table 4 shows that the result of physical/chemical characteristics test of mixed alternative fuel of PPO and kerosene, meet kerosene specification required on Decree of Oil and Gas General Directorate No. 17K/DDJM/1999 of April 16, 1999. The results of sulfur content test from each alternative fuel very from 0.028% wt to 0.0336% wt, and the reference of kerosene's sulfur content is 0.0351% wt. It shows that utilising 20% volume of PPO kisamir seed in mixture with kerosene can reduce 20% sulfur content. It has positive effect to the environment.

### B. *The Result of Performance Test*

Performance test was conducted on a wick stove and with 20 cm diameter pan in line with World Bank

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**Table 2**
**Chemical and Physical Characteristics Kisamir Seeds, Jatropha dan Coconut PPO**

| No. | Kind of Test | Analysis Result of Physical/Chemical Characteristics | | |
|---|---|---|---|---|
| | | Kisamir Seeds | Coconut | Jatropha |
| 1 | Density (gr/ml) | 0,91249 | 0,920 | 0,920 |
| 2 | Flash point at (°C) | 284 | 300 | 236 |
| 3 | Kinematic viscosity (mm2/s) | 30,91 | 40,7 | 44,0 |
| 4 | Acid number (%) | 4,03 | 6,9 | - |
| 5 | Water content (% vol.) | 0,051 | 0,05 | 0,075 |
| 6 | Ash content (% wt) | 0,1 | 0,01 | 0,01 |

recommendation for stove test. The tests include maximum power test, fuel consumption tests and stove efficiency test. The result of each PPO and kerosene alternative fuel mixture performance test are shown on Table 5.

### 1. The Result of Power Test [4]

Maximum power is measured on maximum blue ray of fire, this position is the highest wick position that gives the maximum heat in smokeless condition. At this position, if the wicks are lifted just a little will give yellow fire. Power at this level tells the Power of a stove to transfer kerosene from the container to the firing room through the wicks. Maximum and minimum Power will show maximum and minimum fuel consumption of a stove. Maximum Power can be measured using this formula bellow:

$$P = \frac{mf.E}{\Delta t} \quad \text{.....} \quad (4)$$

where:

P = Stove power, in kW

mf = Fuel consumption during measuring, in kg.

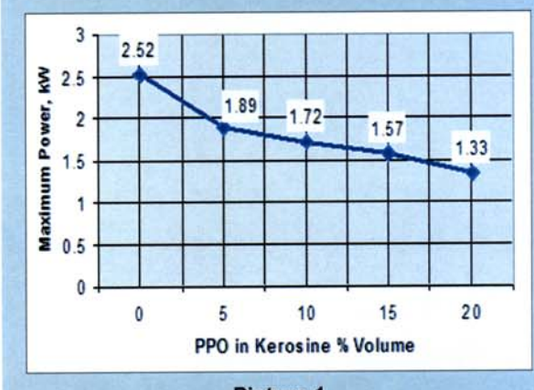
E = Fuel net calorie, in kJ/kg

$\Delta$ t = Measuring duration, in s.

The result of maximum Power measurement from each biokerosene is shown on Table 6. The comparison of maximum Power from each biokerosene sample is defined on Figure 1. The correlation amongs consumption and maximum Power produced from each biokerosene fuel is shown on Figure 2.

**Table 3**
**Composition of PPO mixture and Kerosene Alternative Fuel**

| No. | Fuel Code | Composition |
|---|---|---|
| 1 | BK-0 | 100 % Kerosene (Reference) |
| 2 | BK-05 | 95 % Kerosene + 5% PPO |
| 3 | BK-10 | 90% Kerosene + 10% PPO |
| 4 | BK-15 | 85 % Kerosene + 15% PPO |
| 5 | BK-20 | 80 % Kerosene + 20% PPO |




**Picture 1**
**The Result of Biokerosine Alternative Fuel Maximum Power on the Stove S-16**

**Table 4**
**Result of Physical/Chemical Characteristics of**

| No. | Kind of Test | Limit Specification*) | Kind of Kerosene Alternative Fuel | | | | |
|---|---|---|---|---|---|---|---|
| | | Min - Max | BK-0 | BK-05 | BK10 | BK-15 | BK-20 |
| 1 | Density (Kg/cm3) | 0,835 | 0.806 | 0.812 | 0.817 | 0.822 | 0.828 |
| 2 | Flash Point Abel ($^{o}$C) | 38 | 47 | 45 | 44 | 43 | 43 |
| 3 | Smoke Point (mm) | 15 | 21 | 23 | 25 | 28 | 30 |
| 4 | Calorific Value (Mj/kg) | 40 | 45.88 | 45.41 | 44.81 | 44.74 | 44.20 |
| 5 | Sulfur Content (% wt) | 0.20 | 0.035 | 0.034 | 0.030 | 0.029 | 0.028 |
| 6 | Copper Strip Corrosion | 1a | 1a | 1a | 1a | 1a | 1a |

Explaination:

*) Kerosene's specification fits with Oil & Gas General Directorat' Decree No. 17/K/DDJM/1999, April 16, 1999

**Table 5**
**The Result of Each PPO and Kerosene Alternative Fuel Mixture Performance Test**

| NO. | OBSERVATION | UNIT | BIOKEROSENE SAMPLE | | | | |
|---|---|---|---|---|---|---|---|
| | | | BK-00 | BK-05 | BK-10 | BK-15 | BK-20 |
| 1. | Fuel Calorie | Kj/kg | 45880 | 45410 | 44810 | 44740 | 44200 |
| 2. | Fuel Consumption | Kg/hour | 0,1976 | 0,1497 | 0,1377 | 0,1257 | 0,1138 |
| 3. | Water Mass | kg | 2,17 | 2,17 | 2,17 | 2,17 | 2,17 |
| 4. | Fuel Mass to Boil Water | kg | 0,03 | 0,042 | 0,044 | 0,047 | -- |
| 5. | Maximum Power | kw | 2,52 | 1,89 | 1,72 | 1,57 | 1,33 |
| 6. | Boiling Efficiency | % | 48,18 | 34,77 | 32,88 | 31,53 | -- |
| 7. | Water Boiling Duration | minute | 24 | 26 | 30 | 36 | At 32nd minute and temperature 50$^{O}$C fire decreases, comes below the nest at 42$^{nd}$ minute and at 65$^{0}$ C almost dead. |
| 8. | Fire Stability | | The ray of fire is reddish blue, stable dan maximum lighted with ½ wick | Ray of fire is blue, stable, getting lower, the fire is shorter,BK–00 with maximum wick | Ray of fire is blue, stable, getting lower, the fire is lower than BK–05. maximum wick position | Ray of fire is blue, stable, getting lower, the fire is lower than BK–10. maximum wick position | Ray of fire is blue, lower than BK–15 unstable, fire keeps getting lower, can't boil water. Maximum wick position |
| 9. | Wick Point Condition | | burned a little | burned a little | burned a little | burned a little | Burn more than BK-15 |
| 10. | Fuel Flow (capilarity) to the Point of Wick | | good | good | < BK-05 | < dari BK-10 | < BK-15 |
| 11. | Lighten up the Fire after Turning off | | easy | easy | A little hard | A little hard | hard |

The more PPO of kisamir seed used in the mixture, the smaller calorie value and maximum power.

## 2. The Result of Efficiency Test [4]

Stove efficiency is the comparison among useable heat, which is needed to cook some food in certain amount from beginning temperature to cook by the heat that is given from kerosene, which is being used during cooking. The simple way of the efficiency test of a stove is boiling water method. Normal boiling temperature depends on atmospheric pressure above

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sea level. Efficiency of a stove can be counted (measured) by the following formula.

$$\eta = m\frac{ma(Td - Ta) + mu.L}{mf.E} x100(\%) \qquad (4)$$

where :

ma = Boiled water mass, in kg.

Td = Boiling temperature, in °C.

Ta = Beginnig temperature of water, in °C.

cp = Water heat, 4,186 kJ/kgK.

mu = water evaporation mass, in kg.

L = Evaporated water latent heat, 2257 kJ/kg.

mf = Fuel consumption during Measuring, kg.

E = Fuel net calorie, in kJ/kg

The result of stove efficiency test that uses biokerosene, is shown on Table 7.

Table 7 shows that value of stove efficiency of on BK-20 could not be measured because the fire was very low biokerosene, if allowed to continues to fire more and smaller so that in the 30th minute to flame down into the bottom of the stove nest in this condition, water temperature was only 50° C. Next, at 42nd minute the fire is almost dead, at the time water temperature was 65° C. This condition did not last a long time, the fire is finally off.

The correlation measured of efficiency of stove and maximum Power of is depicted on Figure 3.

### 3. The Result of Consumption Test

Fuel consumption test on wicks stove with biokerosene fuel; each has been tested on 16 wicks stove by using 20 cm diameter pan, with its duration for 10 minutes. The result of fuel consumption test is provided on Table 8. Table 8 shows teral the higher percentage of PPO in kerosene the smaller of fuel consumption, and that the amount of PPO in kerosene in the stove maximum Power test will influence the used fuel consumption. It happens because the fuel flow from the tank to the firing room gets smaller with more PPO content in kerosene. This is shown from the produced fire from each biokerosene sample, whereas its height gets lower by adding PPO content in biokerosene.

The relationship between fuel consumption and maximum Power from each bio kerosene sample is drawn on picture 4.

**Table 6**
**Analysis Result of Calorific Value and Maximum Stove Power to PPO Mixture and Kerosene Alternative Fuel Test**

| No. | Kind of Fuel | Calorific Value (Mj/kg) | Maxsimum Power (kw) |
|---|---|---|---|
| 1. | BK - 00 | 45.88 | 2,52 |
| 2. | BK - 05 | 45.41 | 1.89 |
| 3. | BK – 10 | 44.81 | 1,72 |
| 4. | BK – 15 | 44.74 | 1,57 |
| 5. | BK – 20 | 44.20 | 1,33 |

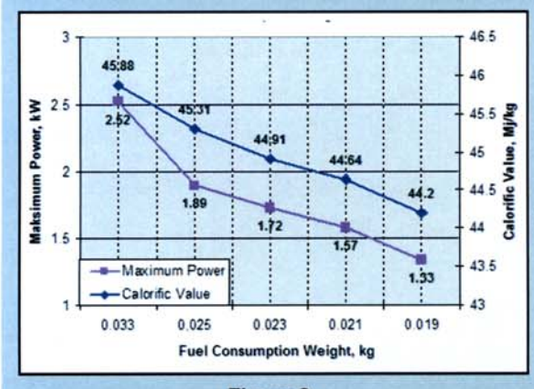


**Figure 2**
**Correlation of Maximum Power to Calorific Value and Fuel Consumption Weight**

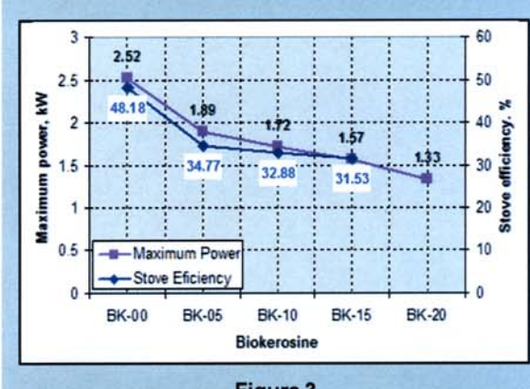


**Figure 3**
**The Relation of Stove Efficiency to the Maximum Power**

**Table 7**
**Analysis result of stove efficiency of Biokerosene**

| No. | Kind of Fuel | Calorie BB (kj/kg) | Efficiency (%) |
|---|---|---|---|
| 1. | BK - 00 | 45880 | 48.18 |
| 2. | BK - 05 | 45410 | 34.77 |
| 3. | BK – 10 | 44810 | 32.88 |
| 4. | BK – 15 | 44740 | 31.53 |
| 5. | BK – 20 | 44206 | - |

**Table 8**
**Analysis result of fuel consumption of Biokerosene**

| No. | Amount of PPO in Kerosene (% vol.) | Time (minute) | Fuel Consumption (kg/Jam) |
|---|---|---|---|
| 1. | 0 | 10 | 0.1976 |
| 2. | 5 | 10 | 0.1497 |
| 3. | 10 | 10 | 0.1377 |
| 4. | 15 | 10 | 0.1257 |
| 5. | 20 | 10 | 0.1138 |

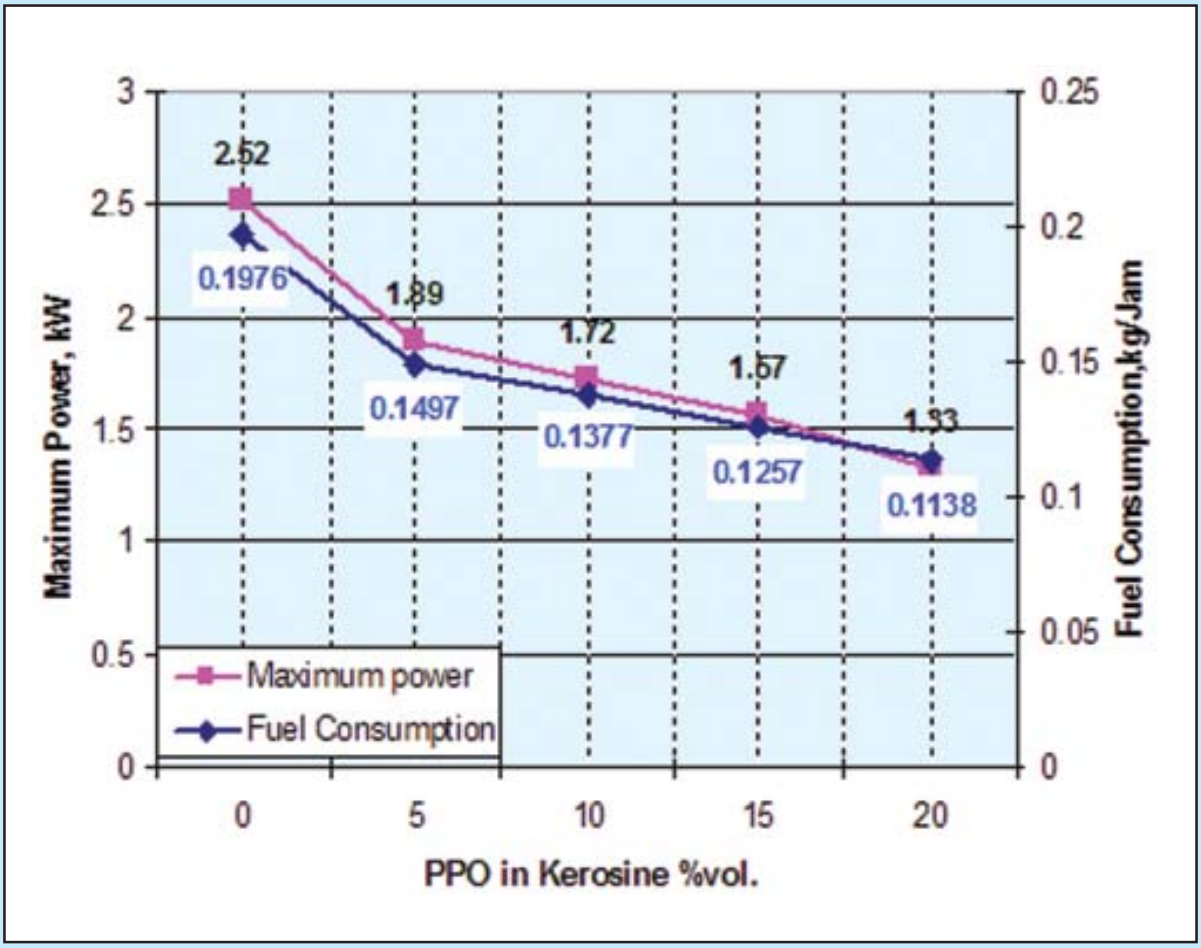


**Figure 4**
**The relation of fuel consumption and maximum power**

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## V. SUMMARY & SUGGESTION

### A. *Summary*

The result of PPO and kerosene mixture performance test as the fuel on multi-wicks stove can be summarized as follow:

1. PPO made from Kisamir seeds has potential to develop as bio fuel material, because it has low viscosity.
2. The mixture of 20% volume PPO in kerosene can reduce the sulfur content to 20% of wt.
3. The mixture with more than 20% volume PPO in kerosene shows lowest maximum power and stove efficiency.
4. The higher amount of PPO being used in the mixture, the lower stove's maximum Power and stove's efficiency.

### B. *Suggestion*

For the best result of stove maximum power and efficiency, it would be better to add PPO that has a lower viscosity (less than 20 Cst)

## REFERENCES

1. *Annual Book of ASTM Standards*. 2006
2. http://www.ybiofuels.org/bio-fuels/hystory-biofuels.html
3. http://id.wikipedia.org/wiki/Minya Nabati
4. La Puppung Pallawagau Ir., 1989, Test Eficiency and Power of Kerosene Wicks Stove, R&D Center for Oil and Gas Technology "LEMIGAS", Jakarta.
5. SII 0135-76, "Quality and Wick Kerosene Stove Test".
6. Specification as declared in Directorate General of Oil and Gas Decree No. 17K/72/DDJM/1999 of April 16, 1999.
7. VITA, Revised May 1985, Testing the Efficiency of Wood-burning Cookstove International. Virginia.ˇ