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Biomass Fuel Performance of *Eichhornia crassipes* and *Pennisetum purpureum* for Boat- fisherman Generator Engine at Bangkalan Madura Island

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ABSTRACT

Limited energy sources, price fluctuations and environmental challenges have triggered the Indonesian government to create anticipative policy. Biofuel policy indirectly increased the usage of biomass-based energy. *Pennisetum purpureum* left over from animal feed and *Eichhornia crassipes* on the surface of the river have been proven as a raw material for bioethanol production. This research was to find out how the performance of a 2000 Watt generator with an alternative concentration of 50% pertalite: 50% bioethanol, 100% bioethanol and 100% pertalite. The biomass substrate was hydrolyzed using a mixture of 20 L water and 7% HCI as much as 200 ml. *Saccharomyces cerevisiae* utilized for fermenting biomass. 4% ethanol (10 L) was obtained from 4Kg *Pennisetum purpureum* dry fermentation. 13Kg of *Eichhornia crassipes* produced 5% (10 L) of ethanol. 95% ethanol was obtained as much as 200 ml after distillation. The process of hydrolysis to obtain ethanol till tested on the generator engine based on previous studies. The result of pertalite viscosity test properties was 1.42 cSt higher than 0.38 cSt of bioethanol so that it affects power. E50 bioethanol (50% bioethanol: 50% pertalite) was show the highest engine performance results, effective power, torque, and average effective pressure.
KEYWORDS: bioethanol, engine performance, biomass

INTRODUCTION

Indonesian population growth and rapid development of industrial fields caused an increase in energy demand and a decrease in environmental quality [1]. The production of petroleum fuel (fossil) in Indonesia has decreased by 10% annually [2], while the average level of oil consumption has increased by 6% per year [3]. Indonesia's fuel reserves are very limited, Indonesia only has proven reserves, namely oil 3.7 billion barrels or 0.3% of the world's proven reserves [4]. Oil import was one way to fill energy consumption [5].

Government efforts to reduce public consumption of fuel are by utilizing alternative energy through the Presidential Regulation of the Republic of Indonesia No. 5 of 2006 concerning National Energy Policy. The government also targets that in 2016 biofuel utilization can reach 5%. Bioethanol utilization as a mixture of additives from gasoline which often referred to as gasohol E-n which has economic value, it was renewable and environmentally friendly [6].

Bioethanol produces lower CO gas emissions compared to fossil fuel which was around 19-25% [7]. Bioethanol produced from plants that contain biomass such as sugar, starch, lignocellulose [8]. The production of bioethanol from cellulose was generally through the stages of pretreatment, hydrolysis, fermentation, and distillation. The pretreatment process was carried out to facilitate the breakdown of starch and cellulose into glucose [9].

In analyzing the properties of fuel standardization is used. The standardization used was issued by the National Standardization Agency, Ministry of Energy and Mineral Resources of the Republic of Indonesia, Directorate General of Energy, Renewable and Energy Conservation, number 7390: 2012, PT 27-04 Bioenergy ICS 27,190 concerning denatured Bioethanol for gasohol [10] It is hoped that the application of biomass-based and fossil-based fuel technology can help fishermen prepare themselves and get used to the use of environmentally friendly renewable fuels.

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METHODS

Pretreatment

The leaves and stems of water hyacinth as much as 13 kg of dry weight were taken from the Kedurus reservoir, Surabaya. *Pennisetum purpureum* amount 4 Kg taken from Kediri area of East Java. Pretreatment conducted physically, water hyacinth leaves and stems are separated from the roots, washed clean, drained, and cut into small pieces measuring 3 cm, then dried in the sun for 14 days.

Hydrolysis Process

The result of pretreatment was added by 25 mL water. It heated to a boil until the ingredients wilt. The material has been cooled, given 1% HCL as much as 1 L, stirred until homogeneous, and allowed to stand for 4 hours to pH 1-2, then heated at 100° C until boiling, then cooled and added 10% NaOH to pH 4 – 4.5 to neutralize pH.

Fermentation

Hydrolysis material added (1.3% of the total volume of solution) urea, NPK and *Saccharomyces cereviseae*, stirred until homogeneous. Fermentation carried out anaerobically. Fermentors are tightly closed with gallon caps and plasticine to prevent contamination. The fermentor uses a gallon with a volume of 18 L, in the perforated portion of the gallon lid to provide a hose inserted in the fermentor and the end of the hose connected to a water filled bottle as an indicator of success or not. Fermentation is carried out for 9 days. The fermentation was successful with the marked appearance of many gas bubbles in the indicator bottle.

Distillation, reducing sugar and ethanol test

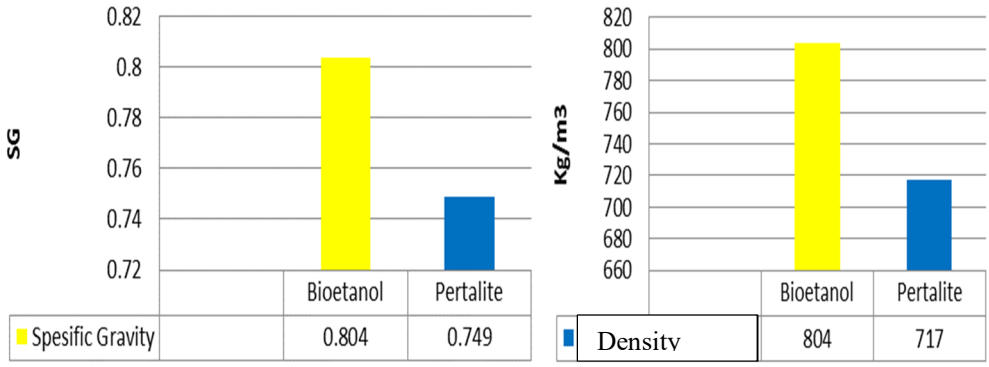
Distillation is required to reach high levels of ethanol by entering the fermentation broth into a distillator at 80˚C to evaporate. The steam results from the condenser will come out through the condenser hole connected to the hose. The result of the distillation is ethanol with a composition of 95%. Measurement of sugar content is determined by applying 2-3 drops of the solution sample before fermentation and after fermentation into the refractometer. To find out the ethanol content from the distillation results, it is done by taking a distillation of 100 ml of ethanol, pour it into a measuring glass and put an alcohol meter to find out the alcohol content obtained.

Properties and Machine Performance Test

After obtaining and measuring 95% ethanol content, bioethanol properties test was conducted to assess the nature or character of the fuel associated with the performance of the generator engine fuel, among others: Density, Specific Gravity, Viscosity and Flash Point. Bioethanol test on the performance of the generator engine with different concentrations of fuel 100% Pertalite, 50% Pertalite + 50% bioethanol, 100% bioethanol. Performance results obtained include Effective Power (Bhp), Torque, Average Effective Pressure (Bmep) and Specific Fuel Consumption (BSFC).

RESULTS AND DISCUSSION

Bioethanol from raw materials containing cellulose requires pretreatment and hydrolysis to produce glucose ($C_6H_{12}O_6$) which will then be fermented to obtain bioethanol [11]. Bioethanol is known to have a high octane number, so it can be used as a mixture of gasoline. This mixture is known as gasohol (En) [12]. The biomass substrate was hydrolyzed using a mixture of 20 L water and 7% HCI as much as 200 ml. *Saccharomyces cerevisiae* utilized for fermenting biomass. 4% ethanol (10 L) was obtained from 4Kg *Pennisetum purpureum* dry fermentation. 13Kg of *Eichhornia crassipes* produced 5% (10 L) of ethanol. 95% ethanol was obtained as much as 200 ml after distillation. The process of hydrolysis to obtain ethanol then tested on the generator engine based on previous studies.



Fugure 1. *Specific Grafity* (SG) and Density of Bioethanol and Pertalite (Kg/m^3)

Based on Figure 1, the value of specific gravity of bioethanol was greater than pertalite. Because it kept contain glycerol and fatty acids which had a high SG value. SG value affected the value of the density of a fuel became larger. Thus bioethanol density was also higher than pertalite. Therefore at the same volume bioethanol mass fuel injected into the cylinder will be more than pertalite [13].

If the viscosity gets higher, the resistance to flow will be higher. This characteristic was very important because it affected the performance of the injector on the engine. Atomization of fuel depended greatly on kinematic viscosity, injection pressure, and injection holes size. Higher viscosity made the atomized fuel become larger droplets with high momentum and have a tendency to collide with relatively cooler cylindrical walls. Relatively higher kinematic viscosity had better lubrication properties [14]. Flash point was the lowest temperature where the heated fuel was able to produce a mixture of air fuel vapor which ignited when a source of fire was brought nearer. Flash point on bioethanol from water hyacinth obtained in Figure 2.

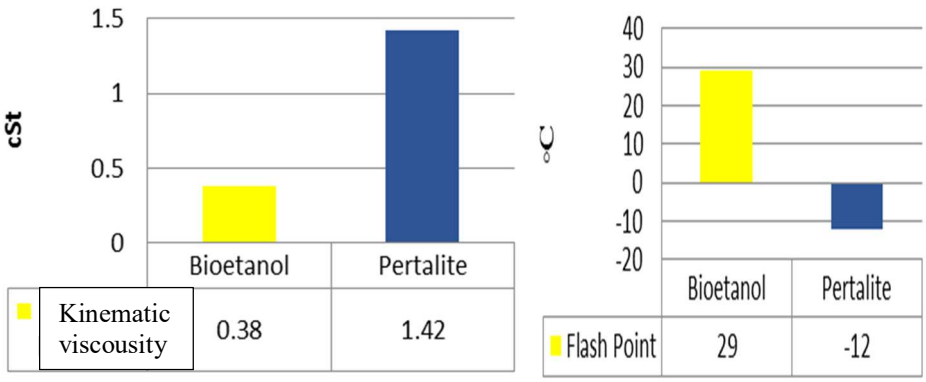


Figure 2. Graph of Kinematic Viscosity (cSt) and Flash Point (◦C) of bioethanol with pertalite

Power indicated the amount of the machine's ability to produce a work of time union. The effective engine power or got seen that the graph of power increase was directly proportional to the increase in load

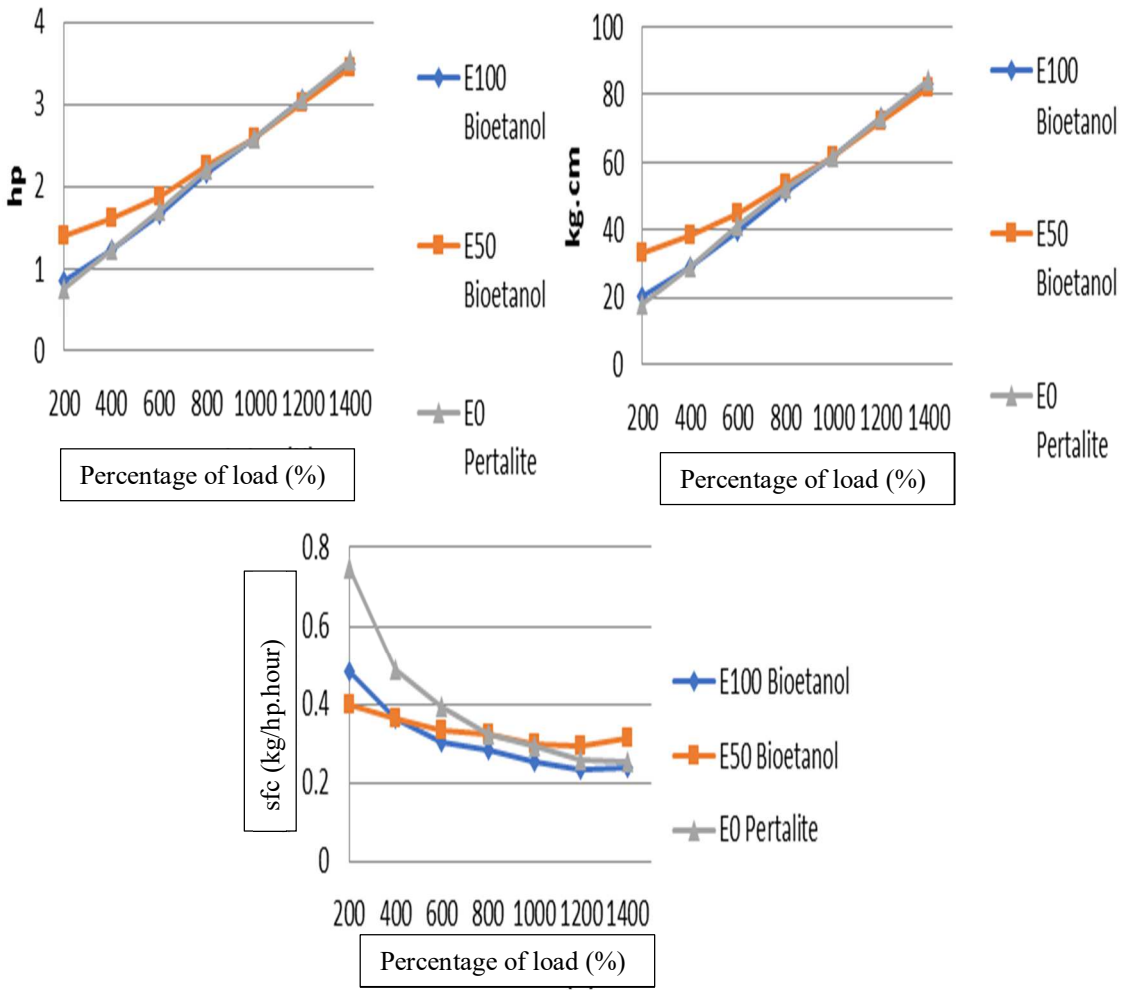


Figure 3. Effective power (hp), torque and specific fuel consumption (sfc) to percentage load graph

On graph 3 it informed that the higher the load given, the more fuel injected into the combustion chamber. The highest effective power derived from E50 bioethanol (50% bioethanol: 50% pertalite) which was by (hp 1.398169278) at a load of 200 watts and the higher the loading of 1400 watts with (hp 3.441647454). This was done to keep the engine speed constant while in E100 bioethanol (100% bioethanol) 19.64% lower than E50 bioethanol and E0 pertalite (100% pertalite) showed the lowest yield. It was due to pertalite heating value (46.5 Mj / Kg) with bioethanol heating value (35.7 Mj / Kg) [14], being higher and bioethanol density value (804 Kg / m3) higher than pertalite (717 Kg / m3). The power released from the operation of the engine will be determined by several factors including the quality of the fuel, especially combustible composition and heating value, the quality of the gas and combustion mixture, the efficiency of the engine to convert combustible fuel to mechanical energy [15]. In Figure 3 was show the increase in torque value was proportional to the load given.

The use of specific fuels (Specific Fuel Consumption) defined as the amount of fuel consumed by the engine to produce effective power of 1 hp for an hour (Figure 3). The use of specific fuels with a load of 200 watts gave the highest yield at E0 pertalite (100% pertalite, 0.748952026 kg / hp. Hours) and it decreased with increasing loading up to 1200 watts. Fuel consumption increased 70% in certain loadings, which is shown in graph 3 at 1400 watts. Sfc (Specific Fuel Consumption) was a representation of the effectiveness of the engine in consuming fuel. As much lower the sfc value, as much higher the level of fuel effectiveness (more efficient) [16]. It inferred that the increasing load, specific fuels usage was tend to decrease. Ethanol production into a mixture of gasoline or pertalite at first glance looks simple. However, the results will have a major impact on large-scale implementation. Indonesia was a petroleum consumer country that imports more than 40% of its fuel needs. The effectiveness of the application of gasohol might save the state budget, so that state expenditure can be allocated for infrastructure development, education, health services and equitable development. The use of raw materials for ethanol production sources derived from non-food ingredients will also guarantee the long-term sustainability of energy conversion without creating a threat to the availability of food.

CONCLUSION

Pennisetum purpureum and *Eichhornia crassipes* were proven produce ethanol. Ethanol reached 95% purity through distillation process. The result of pertalite viscosity test properties was 1.42 cSt higher than 0.38 cSt bioethanol so that it affects power. The highest effective power derived from E50 bioethanol (50% bioethanol: 50% pertalite). The highest torque produced from E50 bioethanol (50% bioethanol: 50% pertalite). The highest average effective pressure got from E50 bioethanol (50% bioethanol: 50% pertalite). The use of specific fuels with a load of 200 watts shows the highest yield at E0 pertalite (100% pertalite).

CONFLICT OF INTEREST

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

AUTHOR CONTRIBUTIONS

SN and AA designed and performed the experiments and also wrote the manuscript. BS, LAW, and TI performed laboratory treatments, experiments, and data analysis. WM, AA and SN designed experiments and reviewed the manuscript. All authors read and approved the final version.

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