ANALYSIS OF BIOETHANOL PROCESSING FROM PAPER WASTE AS GENERATOR FUEL

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Abstract— The high fuel demand in Indonesia has resulted in an increase in the ratio of imported fuels and weakened domestic energy security. In response to this, biofuels (BBN) was developed, one of which was bioethanol. The raw material for making bioethanol can be from a variety of objects, but paper is the most easily obtained bioethanol raw material around us. PT Temprina Media Grafika a subsidiary of Jawa Pos Group produces waste paper every day. From the waste is processed into bioethanol and is used as a generator fuel. From 1 kg of paper waste obtained 30 ml of bioethanol with a concentration of 86%. By mixing bioethanol in gasoline, a mixture of fuels called E85, E60 and E35 is obtained. While pure RON 88 gasoline from Pertamina is called E10. Through testing on the generator set with a load of 600 watts and 900 watts, measurements of voltage, power, frequency, RPM and SOFC were obtained that all parameters decreased when using bioethanol mixed fuels.

Kata Kunci— Bioethanol, Biofuels, Waste Paper, Generator, Renewable Energy.

I. INTRODUCTION

Increased consumption of fuel oil (BBM) in the country and a decrease in petroleum production has caused petroleum exports to decline, while imports of petroleum and fuel continue to increase. This condition can be seen from the increase in the import dependency ratio of fuel oil BBM where the average increased from 35% in 2007 and to 44% in 2015 [1]. This causes domestic energy security to weaken.

To respond to this, BBN (Biofuel Fuel) was developed. Among these biofuels there is bioethanol which currently has increased production in the world. Bioethanol itself is a fuel from plants that has properties resembling premium oil [2]. Bioethanol is ethanol which is produced from glucose fermentation (sugar), which is continued by a distillation process. The raw material for making bioethanol is divided into 3 groups: sucrose ingredients for example are sap and sugar cane, such as corn and cassava, and cellulose for example wood and paper [3]. Judging from the availability of raw materials, the paper is the most easily obtained bioethanol raw material around us. Besides that, because the content of cellulose in HVS paper is about 90% of the weight of the paper this makes paper as a high-potential bioethanol raw material. [4] PT Temprina Media Grafika a subsidiary of Jawa Pos Group which is a company in the printing sector in its production process produces waste paper every day, the waste is various kind but there is one very waste that give a bad

impact on the health of employees, namely paper shavings waste because of its form in the form of paper chops that produce dust that pollutes and disrupts breathing. Because the impact on the environment is so large, a breakthrough is needed so that this waste can be quickly processed or utilized. Because of the content of cellulose in it, the waste can be used as bioethanol raw material. With the form of paper waste in the form of chopped and small in size, it will be easier to make bioethanol.

Bioethanol for fuel can be applied to the otto engine of the invention of Nikolaus Otto which is a type of internal combustion engine that uses spark plugs for the combustion process [5]. At PT. Temprina Media Grafika Bali branch has two generators which are one diesel generator set and the other one has an otto engine which is used when there is a power outage to keep the office operating. Based on the explanation, a study was conducted on the use of paper waste as bioethanol for generator fuel at PT. Temprina Media Grafika.

II. BIOETHANOL

Bioethanol comes from two words, namely "bio" and "ethanol" from these two words, it means that bioethanol is ethanol derived from biological sources. Broadly speaking, the use of bioethanol is as a solvent for organic and inorganic substances, the basic ingredients of the industry are vinegar, ester, methylated, acetal dehyde, antiseptic and as raw material for the manufacture of ether and ethyl ester, for mixed drinks and can be used as fuel (gasohol) [6].

Because bioethanol can be used as fuel, bioethanol is one of the biofuels that is present as an alternative fuel that is more environmentally friendly and renewable. Apart from bioethanol plants can also be made from wood or paper waste because of the cellulose content in it [7].

Judging from the availability of raw materials, the paper is the most easily obtained bioethanol raw material around us. Bioethanol processing from paper material is briefly explained by Meceiras through a flowchart in the journal as follows:

Figure 1. Flowchart bioethanol from paper waste [8]

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PT. Temprina Media Grafika (Java Post Group) as one of the largest printing companies produces various kinds of waste paper in its production process. Paper waste produced per day can reach tens or hundreds of kilograms, depending on how much production is done. Paper waste is usually only sold to collectors for packaging companies, sold again in a smaller form or recycled. But in this type of paper shavings there is no economic value in it because it is difficult to sell and so far it has only been thrown into the trash. However, because of its many volumes which can produce around 98.5 kg per day and can interfere with breathing, therefore a new breakthrough is needed to manage the waste paper so that the economic value increases.

Bioethanol can be produced through cellulose, while materials containing a lot of cellulose, one of which is paper. Cellulose content on HVS paper is able to reach 90% by weight. The higher the cellulose content in the paper, the greater the amount of glucose produced in the enzymatic hydrolysis process will be greater [4]. So in this case the use of waste paper PT. Temprina Media Graphic can be recommended. By utilizing paper waste, it is expected that the impact of paper waste in the company can be reduced, especially in terms of health where paper waste shavings, paper dust will pollute the air and interfere with the breathing of workers in it.

Processing of bioethanol from waste paper has little difference with other ingredients. Because in the processing process, paper has lignin content which must be removed first. Clearly the process includes the following:

8. Pretreatment (delignification): To remove lignin content a delignification process is carried out using a chemical process using NaOH compounds as catalysts

9. Hydrolysis: the process of converting cellulose to glucose in this study the process of hydrolysis is carried out biologically by adding Em4 liquid

10. Fermentation: This fermentation process will convert glucose from the waste paper into ethanol using yeast

11. Distillation: a method of separating chemicals based on differences in speed or ease of evaporation. Because there is still water in the fermentation which can interfere with the ethanol content obtained, distillation is carried out to separate the water and ethanol.

If after distillation and the content is measured using an alcohol meter, the ethanol content still has not reached the minimum limit for the fuel grade then the distillation process is carried out again until it reaches the desired percentage of ethanol content and then the volume of ethanol will be measured.

III. RESEARCH METHODS

In this study using experimental methods and documentation. By recording and observing changes in parameters that occur, so that later data will be obtained and will be compared with the final results.

A. Manufacture of bioethanol from waste paper

Starting with weighing 1 Kg of paper shavings and then delignification process is a process to remove lignin content using chemical processes using NaOH compounds as catalysts. The paper shavings waste is mixed with 15% NaOH solution in

a ratio of 1: 2.5 then allowed to stand for 1 hour to maximize the process.

The next step is hydrolysis which is a process to convert cellulose to glucose starting with preparing an autoclave at a temperature of 1210C and then inserting the paper shavings waste with the NaOH liquid and heating it for 30 minutes. After that it is drained and the paper pulp is washed with running water until the PH is normal then because in this study the hydrolysis process is carried out biologically so the addition of 20 ml Em4 liquid is carried out.

Then a fermentation process is carried out which will convert glucose from the waste paper into ethanol using yeast. Before starting the pulp slurry, the pH of the acid was regulated by adding PH buffer to pH 4.8 and inserted into an airtight glass jar to produce anaerobic conditions. Comparison of yeast used is 1: 0,006 where 1 Kg Waste paper shavings require 6 grams of yeast. This fermentation process lasts for 7 days.

After 7 days then the distillation process is a chemical separation method based on differences in speed or ease of evaporation. Because there is still water in the fermentation which can interfere with the ethanol content obtained, distillation is carried out to separate the water and ethanol. In this process, once the distillation process is obtained that 1 kg of paper shavings produces 120 ml of bioethanol with a level of 14%, this is very far from the level set for bioethanol fuel, then distillation is carried out in stages and obtained 30 ml of bioethanol with 86% content

B. Generator data

The generator used in this study is an otto-powered generator set with the following specifications:

Brand: Tekiro Ryu
Type: RG 1500
Fuel: Gasoline
Power: 1,000 watts (max)
900 watts (rated)
RPM: 3,600 RPM
Phase: 1 Phase

Later, it will be tested with a variety of bioethanol fuel and by loading according to the capacity of its rated power with 600 watts of loading and a maximum of 900 watts.

C. Variation in bioethanol fuel

Because bioethanol 100% has a high latent heat this will cause the start of the engine to be very difficult because the combustion of the engine requires conditions where the fuel must be steam, while bioethanol to become steam requires higher heat than fuel or in this case fuel. So we need mixing with gasoline in this study.

There are 4 fuel mixtures in this study which can be seen in the following table:

Table 1. Variations in fuel in the study

Fuel (v/v)	Percentage	
	Ethanol	Called
Gasoline 100%	10%	E10
Gasoline 85% bioethanol 25%	35%	E35
Gasoline 50% bioethanol 50%	60%	E60

- For the standard specific fuel consumption (SFOC) of gasoline-fueled generators, it is 250 g / (kW. H).

Table 2. Generator parameter standard of EGSA

voltage (volt)		Frekuensi (Hz)		Speed (RPM)	
Upper	Lower	upper	lower	upper	Lower
204,6	235,4	46,5	53,5	2700	4500

IV. RESULTS AND DISCUSSION

From the research carried out obtained various data and the results among them are:

A. Results of bioethanol production

From 1 kg of paper shavings waste obtained 30 ml of bioethanol with 86% levels with a multilevel distillation process. To get 1 liter of bioethanol is needed 33.3 kg of paper dust waste.

B. Performance of the generator set with a variety of fuels

In performance, the results are obtained from variations in fuel and loading, including:

Table 3. Generator test results with variations in fuel

	E10		E35		E60		E85	
Load (watt)	600	900	600	900	600	900	600	900
Power (watt)	611,4	996,3	512	995,4	512	995,2	512	-
RPM	3288	3205	3130	2988	3055	2961	2947	-
Voltase (volt)	228,7	228,7	229	229	228,9	228,9	229	-
Frekuensi (Hz)	55,6	54,32	54,73	54,25	54,06	53,08	50,99	-

At E85 with a load of 900 watts or at the maximum load the generator cannot operate and immediately dies. This is because the heating value at E10 (pertamina gasoline) is estimated at 33.7 MJ / L while in E85 the heating value is 25.2 MJ / L. With this value the generator

cannot be operated with a maximum load of 900 watts because the difference is too far the calorific value between the two. And with conditions like that E85 fuel can only be loaded up to a load of 600 watts (60%) of the total maximum load of the generator.

A. Power

To power the results obtained include:

Gasoline here uses gasoline from Pertamina (Indonesian state-owned oil and natural gas corporation) with RON 88. In Pertamina RON 88 gasoline there is already 10% alcohol content in it. Because through the regulation kementrian ESDM Indonesia number 3674.K / 24 / DJM / 2006 that concerning the standards and quality (specifications) of gasoline types that are marketed domestically. It was explained that the SNI (standart National In Indonesia) bioethanol mixture was officially called gasohol, and in general the use of ethanol in all types of gasoline (types 88, 91 and 95 gasoline) was allowed to mix with ethanol up to a maximum of 10%.

A. Generator performance

Generator performance is obtained by observing voltage, power, frequency, RPM and SFOC through testing the generator with a variety of fuel E10, E35, E60 and E85 then the generator is tested and observed by giving 600 watts and 900 watts. The things observed were: Power, Frequency, Voltage, and RPM were observed using a multimeter, wattmeter and tachometer.

Whereas SFOC (Specific Fuel Oil Consumption) is obtained by calculation using the following formula:

$$SFOC = \frac{mf \times 10^3}{P_B}$$

Where :

SFOC = Spesific Fuel Oil Consumption (g/kWh)

mf = fuel flow rate (kg/jam)

PB = Output power (kilowatt)

for mf calculate with :

$$mf = \frac{sgf \times Vf}{t_f} \times 3600$$

Where:

sgf = Spesific gravity (kg/liter)

Vf = volume fuel (liter)

tf = time for fuel consumption a number Vf (second)

B. Standart Performance Generator

For the results of the measurements will be compared with the standards of the Electrical Generating Systems Association (EGSA) in its guidelines on "Engine Driven Generating Sets Performance Standards EGSA 101P, 1995a" given the standard performance parameters of the generator, among others:

- Voltage cannot be more than or less than 5% of name plate.
- The frequency of the EGSA standard in the 4th classification must not exceed 7% of the name plate.
- For speed (RPM) must not exceed 25% and less than 25% of the name plate.

Figure 2. Graph of power against fuel

Table 4. Generator output power using wattmeter

Power	E10 (watt)	E35 (watt)	E60 (watt)	E85 (watt)
600 watt	611,4	512	512	512
900 watt	996,3	995,4	995,2	-

From the graphs and tables above there is no significant difference in the output power released by the generator when measured using a wattmeter. The difference is seen only when using EON RON 88 gasoline fuel from Pertamina where when it is loaded 600 watts of power is 611.4 watts higher than when using fuel mixed with paper bioethanol.

B. Frequency

For the frequency obtained the following results:

Figure 3. Frequency graph for fuel

Table 5. Frequency of generator set is measured using a multimeter

Frequency	E10 (Hz)	E35 (Hz)	E60 (Hz)	E85 (Hz)
600 watt	55,6	54,73	54,06	50,99
900 watt	54,32	54,25	53,08	-
EGSA	53,5	53,5	53,5	53,5

From the graphs and tables above it can be seen that there is a significant decrease in frequency if the level of bioethanol in the fuel increases. This is because the frequency is

related to the engine rotation where if the engine speed decreases automatically the frequency will also decrease. And when compared with the EGSA parameter standard, the frequency above still tends to be above the standard limit set by EGSA which exceeds 7% of the name plate of the generator.

C. Voltage

For voltage in the generator after being measured using a multimeter and with the use of variations in load obtained:

Figure 4. Graph of stress against variations in fuel

Table 6. Generator voltage measured with a multimeter

Voltage	E10 (Volt)	E35 (Volt)	E60 (Volt)	E85 (Volt)
600 watt	228,7	229	228,9	229
900 watt	228,7	229	228,9	-
EGSA	235,4	235,4	235,4	235,4

From the table and graph above there is no significant difference in the voltage of the generator with different loading only seen when using RON 88 Pertamina gasoline E10, lower voltage than when using a mixture of bioethanol. The voltage is more stable because also the generator used is using AVR (automatic voltage regulator) so that the generator voltage output has been stabilized by the device.

D. SFOC (specific fuel oil consumption)

In terms of fuel savings from the data obtained from the above observations SFOC can be calculated, and explained in the following table:

Table 7. SFOC on generators with variations in fuel

	E10		E35		E60		E85	
Load (watt)	600	900	600	900	600	900	600	900
Sgf	0,72	0,72	0,74	0,74	0,75	0,75	0,76	0,76
Vf	0,25	0,25	0,25	0,25	0,25	0,25	0,25	-
Tf	530	270	560	280	600	320	650	-
Mf	0,12	0,24	0,12	0,24	0,11	0,21	0,11	-
Pb	0,51	1,00	0,51	1,00	0,51	1,00	0,51	-
SFOC	238,80	240,89	232,28	238,96	219,73	211,95	205,53	-

Keterangan :

Sgf = spesifik gravity(kg/liter) ,

Vf = the volume of fuel used (liter),

tf = the time spent consuming the fuel

(seconds), mf = fuel flow rate (kg /

hour), pb = output power (Kilowatt),

sfoc = spesifik fuel oil consumption (g/kWh)