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UTILIZATION OF BLACK STICKY RICE FOR BIOETHANOL PRODUCTION AS GASOLINE FUEL BLENDS FOR MOTORCYCLES

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Despite possessing non-renewable properties, fossil fuel is still widely used as a major energy source. Subsequently, the fossil fuel demand has been increasing while the supply is depleting over time leading to an energy crisis. Fossil fuel also causes associated environmental problems such as emissions as the primary driver of global warming and climate change. Thereby, the development of alternative fuels, such as bioethanol, is beneficial to combat the fossil fuel challenges. Bioethanol is a promising fuel owing to its renewable and environmentally friendly characteristics. In this study, bioethanol was synthesized by a fermentation process over yeast (Saccharomyces Cerevisiae). The feedstock for this process is an abundant resource namely black sticky rice. Bioethanol resulting from this process was mixed with gasoline and applied to a motorcycle machine. The performance of bioethanol was defined by power, torque, and emission. The proportion of the mixture was varied with bioethanol content of 0%, 10 %, 20 %, 30 %, and 40%. The mixture of bioethanol-gasoline produced higher power and torque value compared to gasoline. The E40 mixture had the highest power and torque value with 8.5 hp and 9.2 Nm respectively. However, the combustion of bioethanol-gasoline resulted in more CO_2 emission, while the emissions of O_2, NO, and NO_x were lower. The lowest NO_x emissions content was obtained at E30 and E40 blends, about 7 ppm. Meanwhile, the lowest NO emission content was obtained at E30 and E40 blends, about 6 ppm

Keywords: *Bioethanol, Black Sticky Rice, Distillation, Fermentation, Performance*

1. INTRODUCTION

The use and demand for petroleum energy in Indonesia is increasing rapidly. Especially in the use of fuel oil for transportation. This causes using of fossil fuels to be excessive, which can cause environmental problems, such as climate change, global warming, the greenhouse effect, and air pollution [1], [2]. Petroleum is non-renewable energy source and making process takes tens to hundreds of years. The increase in number of motorized vehicles is proportional to using of petroleum energy sources, while petroleum reserves are dwindling [3]. To overcome the limitations of fuel, the search for alternative fuels is very important. Development of renewable and sustainable energy sources has attracted great attention to researchers. Biofuels, such as bioethanol produced from biomass, are now considered a promising alternative energy for fossil fuels due to their environmentally friendly nature [4]–[7].

Biofuel is promising energy source that can reduce the demand for crude oil, diesel, gasoline and can reduce CO_2 emissions from vehicles [8]. One of them is car engine that can burn gasoline with small mixture of 5% -10% bioethanol [9]. Low Carbon (LC) scenario is prepared with assumption that reduction in greenhouse gas emissions is greater than the target of the Indonesian government. This scenario illustrates Indonesia's greater contribution in supporting global efforts to prevent an increase in the earth's temperature above 2 degrees celsius. In the Low Carbon (LC) scenario, target for using of bioethanol in 2025 is still same as the Business as Usual (BaU) scenario and Sustainable Development (SD) scenario. For the target of using

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bioethanol to be 85% (E85) by 2050 [10]. Bioethanol has been considered the best biofuel because it produces low soot emissions [11]. It should be noted that soot from emissions is additional product of combustion process that can cause diseases in humans include respiratory, cancer and heart disease. Due to current economic conditions and rising oil prices, bioethanol production from plant biomass has attracted considerable attention [12]. On the other hand, the substrates used to produce bioethanol are quite diverse, and the choice of suitable substrate depends on various factors including sugar composition, cost and process advantages [13]. Renewable agricultural resources such as corn, potatoes, sugar cane have been widely used as substrates for bioethanol production [14].

Ethanol is compound that is used in various fields from chemical industry to food industry, the main reason for the growth of ethanol market today is its use as a fuel [15]. Generally, sugars in plants can be converted by microorganisms into various compounds, such as lactic acid, carbon dioxide or even ethanol. In addition to agricultural products, fermented biomass sugars such as lignocellulosic materials such as bagasse, straw, rice, wheat waste, sawdust have been considered as potential raw materials for bioethanol production because they are renewable and abundant in nature [16].

Nouri et al. [17] used sugarcane bagasse for bioethanol production. That study was conducted not only to evaluate the impact of detoxification vs adaptation on ethanologenic fermentation but also to optimize the fermentation conditions to produce bioethanol from Concentrated Sugarcane Bagasse Hydrolysate (CSBH). Another study conducted by Wahyuono et al [18] to produce bioethanol from tapioca solid waste using Saccharomyces Cerevisiae. The results show that the fermentation takes 59 to 62 hours and the overall process takes approximately seven days. Ansar et al [19] investigated the production of bioethanol from oil palm sap through optimization of Saccharomyces cerevisiae. The results showed that a change in pH value of the juice during storage was caused. This is caused by the growth of microorganisms to produce organic acids by releasing hydrogen ions. Bioethanol content obtained from the process, namely before the fermentation process, was 32.3%, and increased to 75.6% after the incubation process for 24 hours. In a study conducted by Khoshkho et al [20] where carrot pulp was used as substrate to produce bioethanol. The production of bioethanol was obtained by using carrot pulp and yeast Saccharomyces Cerevisiae as raw materials which were fermented at 28 ºC for 72 hours. The results showed that the highest amount of alcohol was (10.3 ml (40.63 g/l)) in the sample containing 50 ml of inoculum, 150 ml of water, and 10 grams of dry waste.

Based on the problems above, one of the promising biomass that can be used as alternative for bioethanol production is black sticky rice. Indonesia is one of the countries with very abundant black sticky rice agricultural products. Black sticky rice is one type of pigmented rice plant that has long been consumed by people of Indonesia as food ingredient. Black sticky rice is very potential as source of carbohydrates, antioxidants, bioactive compounds and source of fiber for health. Therefore, in this study, we utilized black sticky rice for bioethanol production using yeast (Saccharomyces Cerevisiae) through fermentation process. Anaerobic fermentation was carried out in this study to produce ethanol at level that can be used as an environmentally friendly substitute for fuel [21], [22]. The bioethanol obtained will be used as alternative fuel source for gasoline blends in motorcycles. The amount of power, torque and emissions resulting from the use of bioethanol were also studied.

2. METHODS AND MATERIALS

2.1 Materials and Tools

The materials used in this study include aquades, black sticky rice, yeast (Saccharomyces Cerevisiae), gasoline fuel. While the tools used in this research for bioethanol production are series of distillation tools, beakerglass, Erlenmeyer, measuring cup, hotplate, thermometer, alcohol meter, Suzuki Shogun Axello 125 cc motorcycle, toolkit, dynamometer test and gas analyzer.

2.2 Bioethanol production from black sticky rice

Composition of black sticky rice used in this study were 100 grams of black sticky rice, 800 ml of distilled water and 10 grams of yeast. Black sticky rice is first cooked until it becomes porridge. After cooking, the black sticky rice mixture is allowed to cool. After cooling, yeast is put into bottle and tightly closed, then stored for 4 days at room temperature (± 30℃) for fermentation process. The Figure of black sticky rice fermentation for bioethanol production can be seen in Figure 1. That picture shows the difference in fermentation time, namely for 2, 3 and 4 days. After 4 days, the fermented black sticky rice was then continued with distillation process. The first step is to filter the black sticky rice using filter. The next step is to prepare distillation apparatus. Filtered water from fermentation process of mixture is then put in distillate flask that has been installed in distillation apparatus and heated at temperature of 70 ºC. The resulting distillate is accommodated in erlenmeyer. Distillation process was stopped when there was no more distillate dripping in the erlenmeyer.

2.3 Bioethanol testing on motorcycles

In this study, the testing of bioethanol (torque and power) on motorcycle was carried out at engine speed of 5500 to 8500 rpm. Torque and power testing are measured using dynamometer test. Meanwhile, emission testing is carried out at engine speed of 500 to 4000 rpm using gas analyzer. Testing was carried out with variations of the bioethanol-gasoline fuel blends as shown in Table 1. After fuel was mixed, then performance test was carried out on Suzuki shogun axello 125 cc motorcycle. Torque and power testing scheme using dynamometer test tool is shown in Figure 2.

Table 1: Composition of bioethanol-gasoline blends

VARIABLE	COMPOSITION	
	GASOLINE (%)	BIOETHANOL (%)
E0	100	0
E10	90	10
E20	80	20
E30	70	30
E40	60	40

Figure 1: Black sticky rice fermentation process for two days (1), three days (2) and four days (3)

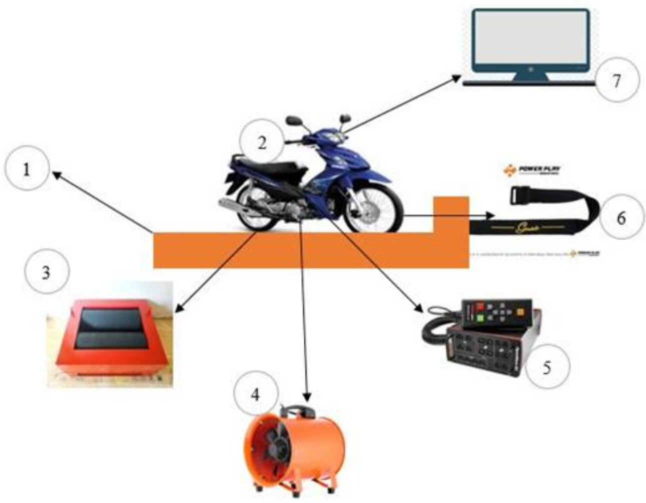

Figure 2: Schematic of testing using dynotest

Description: 1. Engine dyno test 2. Suzuki Shogun Axello 125 cc motorcycle 3. Rollers 4. Blowers 5. CPU dynojet 6. Front wheel retaining belt 7. Monitor

3. RESULTS AND DISCUSSION

Figure 3 shows the power generated on E0 or pure gasoline, at 7000 rpm obtained 7.7 hp. Amount of power in E10 blends has decreased at 7000 rpm by 7.4 hp. This can be caused because the combustion that occurs in E10 is still not perfect. Then E20 blends has increase in power of 7.9 hp at 7000 rpm. E30 blends also saw a power increase of 8 hp at 6500 rpm. This is due to increase in the value of the octane number ratio, due to addition of bioethanol so that the increase in octane value affects complete combustion, for compression ratio of Suzuki Axello 125 cc vehicle, so that an increase in power is obtained. E40 blends, greater power is obtained, which is 8.4 hp at 7500 rpm when compared to E0, so E40 blends can still be used at 9:1 compression ratio. The increase in power at higher engine speed indicates better vehicle performance.

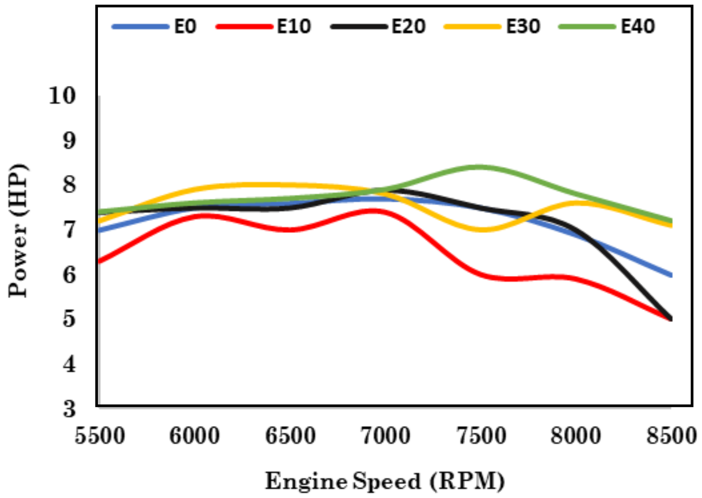

Figure 3: Variation of power with engine speed for bioethanol-gasoline blends

Figure 4 shows the variation of torque with engine speed for bioethanol-gasoline blends. That figure shows the engine speed of 5500 rpm for E0 or pure gasoline, obtained torque of 9 Nm. Then E10 blends was obtained torque of 8.4 Nm at 6000 rpm, this mixture experienced decrease in torque compared to E0, but experienced shift in peak torque at higher engine speed (rpm). In E20 blends, the result is 8.8 Nm at 6000 rpm, in this mixture there increase in torque again compared to the E10. In E30 blends, the torque value was obtained is same as E20 blends, which is 8.8 Nm at 6000 rpm. In this case combustion process is still going perfectly. Meanwhile, in E40 blends, torque value has increased by 8.9 Nm at 6000 rpm, but E40 blends has decrease in torque at higher rpm. This is due to E40 blends combustion process needed to burn does not occur completely. This can be caused by inappropriate compression ratio, so the torque decreases at higher rpm. In this study, the highest torque value for the E40 blends was 9.2 Nm. Overall, the results of the bioethanol-gasoline blends produce higher torque than pure gasoline. This happens for several reasons, one of which is that the oxidized fuel allows better fuel combustion results, resulting in increased torque. In addition, the bioethanol-gasoline blends have more oxygen content, it can produce more efficient combustion than pure gasoline. Large torque is required for good acceleration, so moment of inertia at crankshaft rotation is greater, which results in more efficient fuel consumption.

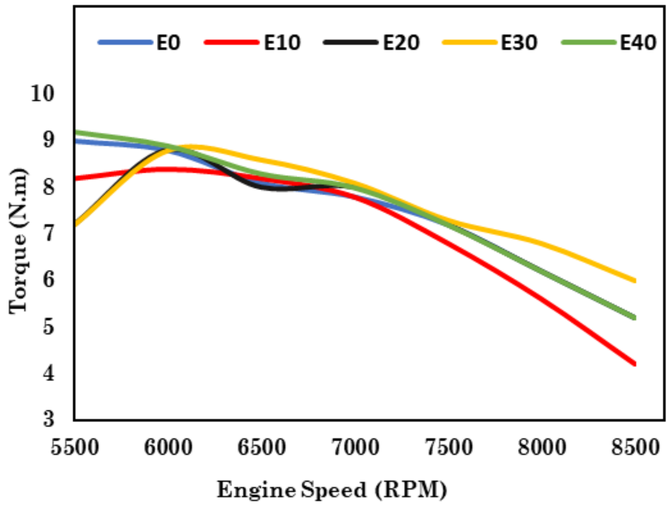

Figure 4: Variation of torque with engine speed for bioethanol-gasoline blends

The results of measuring CO_2 emission content from exhaust gas at engine speed of 500 rpm to 4000 rpm with variations in bioethanol-gasoline blends is shown in Figure 5. More CO_2 emissions are produced for bioethanol-gasoline blends compared to pure gasoline. The higher of engine speed, the higher of CO_2 emissions produced. Based on the graph, CO_2 emission content for bioethanol-gasoline blends is higher than pure gasoline and increases with amount of bioethanol used. The highest CO_2 emissions content was obtained in E40 blends, which was 10.2%. Meanwhile, the lowest CO_2 emissions content was obtained in E10 blends, which was 5.4%. The increase in CO_2 emissions is due to the higher oxygen content in fuel mixture [23]. If the fuel-air mixture is perfect (stoichiometric), it will produce CO_2 compounds. CO2 emissions have increased, this is caused by the higher the engine speed (rpm), the less air that enters the combustion chamber. So that the ratio of fuel to air is not appropriate, it will increase CO_2 emissions. This is also caused by the mismatch of ignition timing with RPM speed in the combustion process. Because the combustion process in the gasoline engine does not occur perfectly for the following reasons: short combustion time, overlapping valves, the incoming air is not pure only oxygen, compression is not guaranteed perfect tightness

Figure 6 shows the O_2 emissions content with variations in engine speed. The oxygen content produced slowly decreases with increasing engine speed. Oxygen allows combustion because it is capable of generating heat. The highest O_2 emission value was obtained in E20 blends, which was 13.9%.

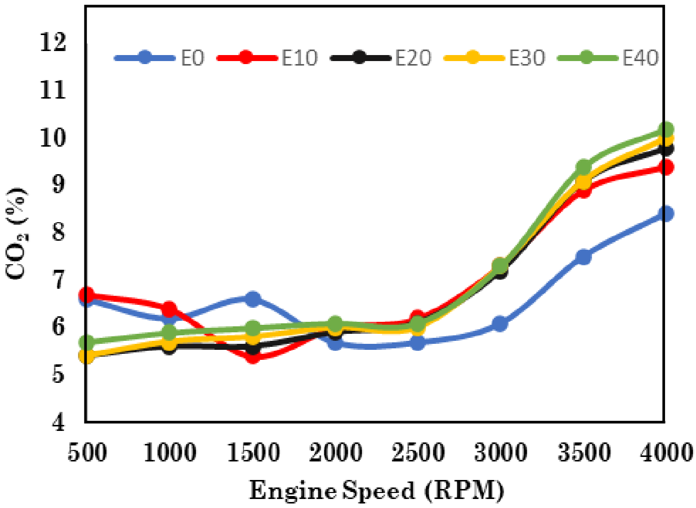

Figure 5: Variation of CO_2 with engine speed for bioethanol-gasoline blends

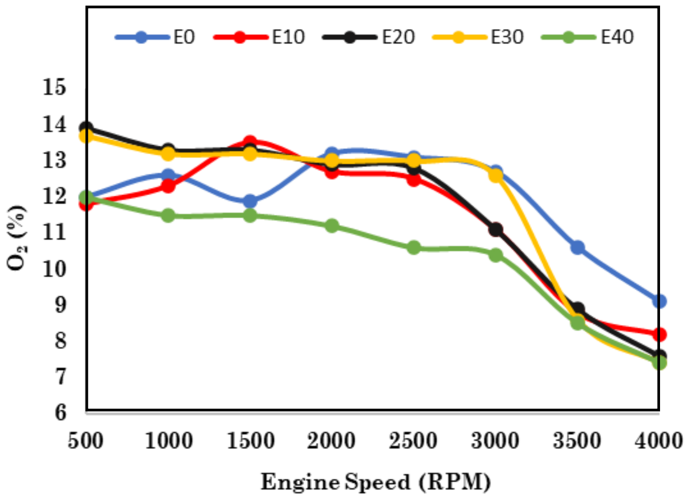

Figure 6: Variation of O_2 with engine speed for bioethanol-gasoline blends

The effect of engine speed on NO_x emissions content is shown in Figure 7. NO_x compound is a combination of nitric oxide (NO) and nitrogen dioxide (NO_2) which is formed from reaction of nitrogen gas and oxygen in air during combustion. Burning flame temperature, oxygen concentration and duration of combustion are three important parameters that affect the formation of NO_x [24]. Based on Figure 7 shows trend of higher engine speed resulting in smaller NO_x gas produced, then NO_x content rose again along with the increase in engine speed. NO_x emissions from all bioethanol-gasoline blends are generally lower than pure gasoline. The lowest NO_x value was obtained in E30 and E40 blends, which was 7 ppm. In addition to excess air, oxygen-rich bioethanol provides oxygen during combustion reaction which causes the formation of NOx which reacts with abundant nitrogen in reaction system [25].

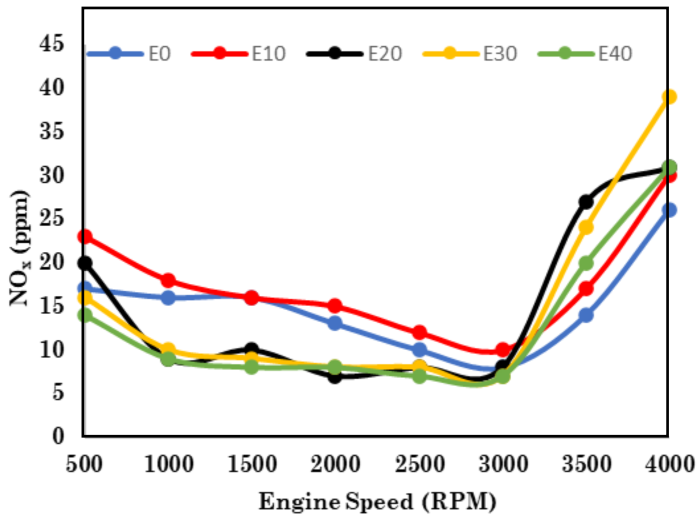

Figure 7: Variation of NO_x with engine speed for bioethanol-gasoline blends

The formation of nitric oxide (NO) in fuel is generally caused by excess oxygen, higher temperatures and nitrogen dioxide (NO_2), which is often identified as NO_x in combustion chemistry (Ilkilic, 2015). Figure 8 shows the effect of NO emissions content on engine speed. NO emissions content showed downward trend with increase in engine speed but rose again after 3000 rpm. NO emissions produced from bioethanol-gasoline blends are lower when compared to pure gasoline fuel. The lowest NO emission content was obtained in E30 and E40 blends, which was 6 ppm.

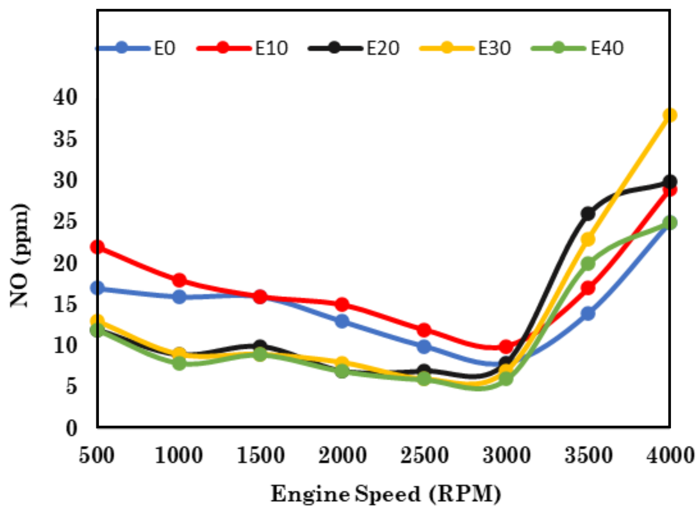

Figure 8: Variation of NO with engine speed for bioethanol-gasoline blends

4. CONCLUSION

The performance of bioethanol-gasoline blends were successfully investigated in this study. Bioethanol can be made from black sticky rice which is abundant in Indonesia. Based on the test results, it was found that the highest power was obtained at 8.4 hp in E40 blends. While the highest torque was obtained at 9.2 Nm in E40 blends. The highest CO_2 emission test results were obtained in E40 blends, which was 10.2%. The highest O_2 emission was obtained in the E20 blends, which was 13.9%. The lowest NO_x content was obtained in E30 and E40 blends which was 7 ppm, and the lowest NO content was also obtained E30 and E40 blends, which was 6 ppm.

5. ACKNOWLEDGMENT

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