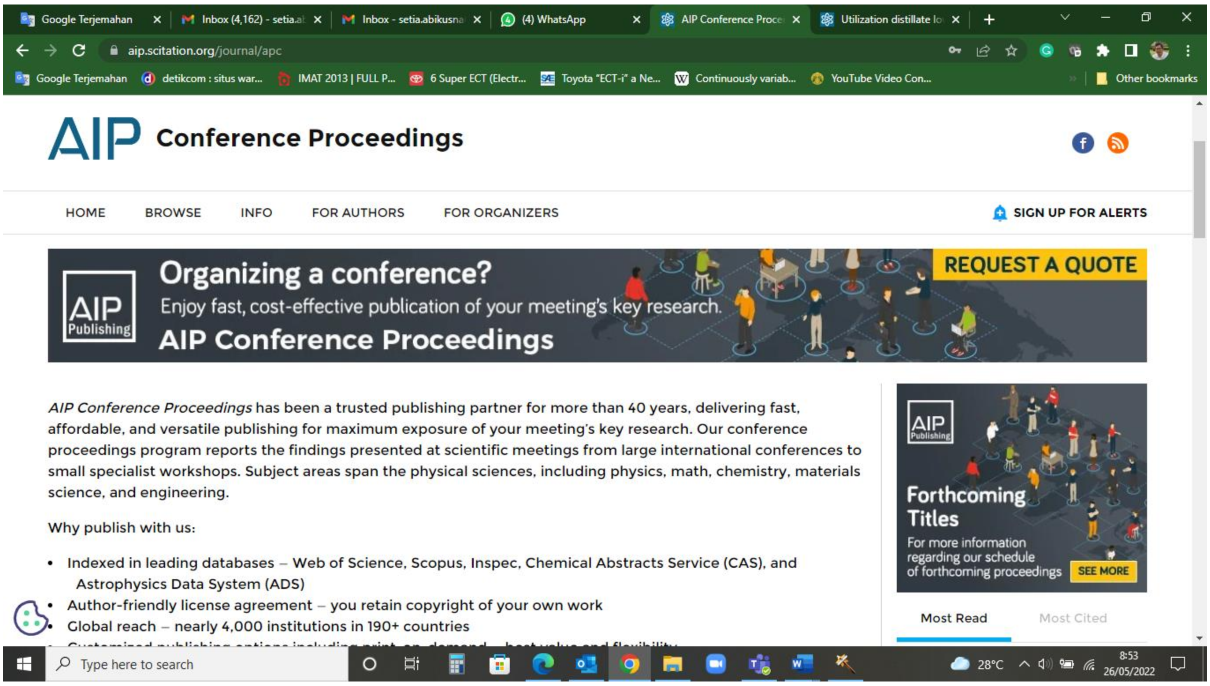

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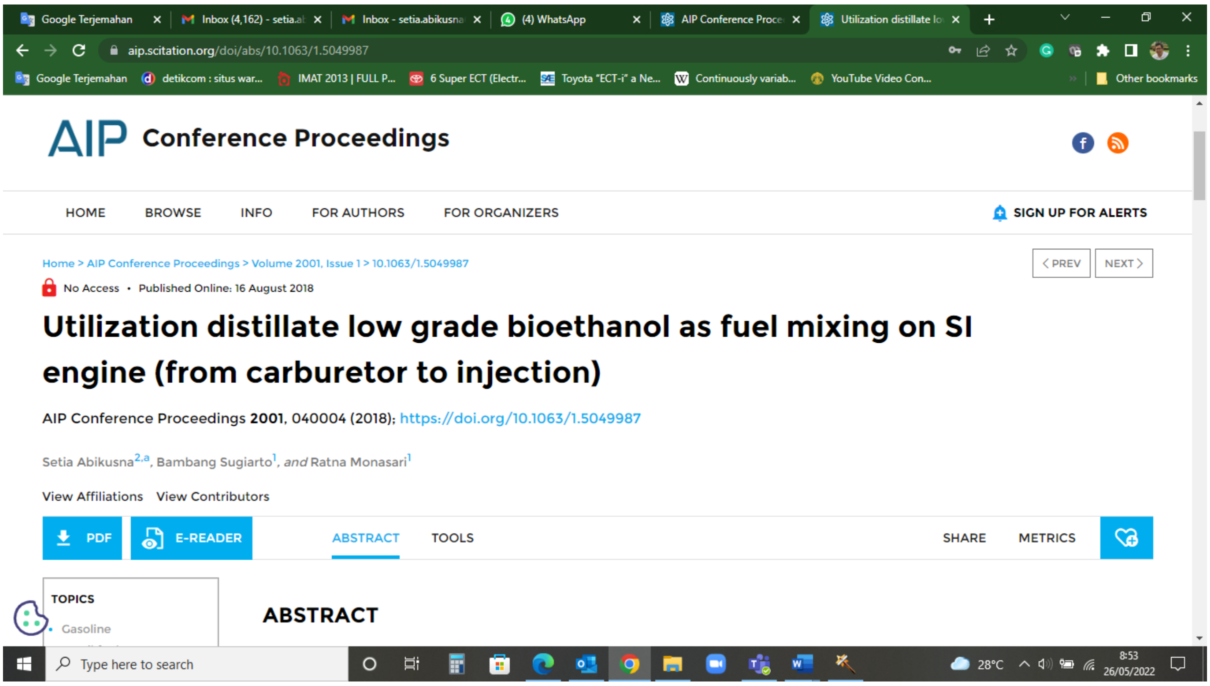

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Utilization distillate low grade bioethanol as fuel mixing on SI engine (from carburetor to injection)

AIP Conference Proceedings **2001**, 040004 (2018); https://doi.org/10.1063/1.5049987

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- Biofuels
- Global warming
- Energy conservation
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- Gasoline
- Fossil fuels

ABSTRACT

Currently, the main energy source is heavily dependent on fossil energy. The current transportation technology also uses fossil-derived energy sources to make vehicle engines are ignited. In addition, the electricity that is currently enjoyed by billions of people resulted enormously from the use of fossil energy. Limitations of existing fossil energy sources and the issue of global warming have led

Utilization Distillate Low Grade Bioethanol as Fuel Mixing on SI Engine (From Carburetor to Injection)

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Abstract. Currently, the main energy source is heavily dependent on fossil energy. The current transportation technology also uses fossil-derived energy sources to make vehicle engines are ignited. In addition, the electricity that is currently enjoyed by billions of people resulted enormously from the use of fossil energy. Limitations of existing fossil energy sources and the issue of global warming have led many to expand on renewable energy and energy conservation to maintain energy availability. One of alternative energy source that is currently being developed is the use of bioethanol as a mixture or replacement of fossil fuel. This paper is a series of advanced research on the utilization of low-grade bioethanol from SI carburetor engine to the SI Injection engine. The research phases are begun by designing compact distillator on a dynamic engine, and then optimization is done on the compact distillator and followed by performance testing and exhaust gas emission. The low-grade bioethanol distillation process is carried out independently by utilizing heat from flue gas to produce high-grade bioethanol. The research was then developed on an SI injection engine to determine the performance and exhaust emissions in some bioethanol fuel mixtures with gasoline. From this continuation study was obtained some results, the first is the use of appropriate fuel mixing method in each study. In addition, optimization performed on the compact distillator will result in an increase in distillation rate and concentration of ethanol of 96.91%. And the last is an analysis of the performance and exhaust emissions generated in each study.

INTRODUCTION

Increasingly the current technology, energy sources will be required more. For example, in the development of transportation technology, energy sources are needed to make the vehicle engines work. In addition, the current electricity demand to increase continuously annually that causes the use of energy is getting enormous. The problems that occur today, almost all energy sources are used to support the development of technology that depends on the fossil energy availability diminished over time. Source of fossil energy is a limited resource where its availability cannot be created or renewed, therefore the use of renewable energy and energy conservation are starting to be done nowadays as an effort to prevent the depletion of fossil energy [1, 2].

In addition to the issue of the limited amount of energy that comes from fossils currently, global warming is also the reason for the development of environmentally friendly renewable energy. The use of fossil fuels can increase CO_2 levels in the atmosphere. In recent years the amount of CO_2 has increased to 400 ppm. As atmospheric CO_2 increases, it automatically raises the temperature and this is certainly being an unexpected thing for human survival on earth. Besides, the combustion of fossil fuels will also produce NO_x gas. NO_x is known as one of the most harmful pollutants for human health because it can interfere with the respiratory system, it is revealed by the Environmental Protection Agency (EPA) [3, 4].

Based on these two issues, the utilization of renewable energy continues is encouraged continuously and become the object of interest to be developed. Indonesia is a country that has the highest potential to develop alternative energy [5]. Large plantation and food crops have the potential to contribute sufficiently to the management of biofuels and biogas as an alternative fuel to fossil fuel [6]. However, the utilization of bioethanol as a fuel is still relatively low. This is different from the production of bioethanol (low-grade bioethanol) which is consumed in a certain way by society, both traditionally and industrially [7]. Then low-grade bioethanol is used to be something that has more value. Utilization of low-grade bioethanol as fuel will require further technology to accommodate low-grade bioethanol to high-grade bioethanol. This process is called distillation. With the utilization of heat from the exhaust gases, the distillation process can be carried out directly on the vehicle.

Bioethanol (C_2H_5OH) is ethanol produced from glucose fermentation and followed by a distillation process to obtain suitable levels as fuel. Bioethanol has the properties like a gasoline, so it can be used as a mixture or substitute gasoline as fuel [8]. For using bioethanol as a fuel is required purification at least 95% or commonly called high-grade bioethanol.

This paper is a roadmap that the author did some recent research on the utilization of bioethanol as a fuel. The research was begun by designing a compact distillator on a carburetor SI engine by utilizing heat from the exhaust gases in the exhaust manifold. Without making any design changes to the vehicle, this allows a Road Test. The next research is to optimize machine speed on low, medium, and high variation with feed volume variations, feed grade bioethanol and comparative performance of compact distillator to the distance between low and high tray so as to produce high-grade bioethanol. Further, testing of bioethanol as a fuel mixture on SI injection engine with a variation of ethanol volume, and rotation speed were done. Based on the knowledge that the authors have, the elaboration of the bioethanol roadmap as fuel is a thing that has not been made excessively.

RESEARCH METHODOLOGY

Roadmap research on bioethanol as a fuel mixture that has been done by the author consists of 2 research methodology stages. The first research was begun with a distillation process that utilized heat from the exhaust gases to produce high-grade bioethanol. Subsequent studies optimized the compact distillator to provide better tool performance so that the resulting bioethanol concentration increased from previous studies. In this stage, the research was done on motor SI engine with a carburetor. The last research was conducted on SI engine motor with the injection system.

Compact Distillator Set Up on Carburetor Engine

Technologies are required that can accommodate low-grade bioethanol to convert to high-grade bioethanol and the results can be applied as a mixture of fuel for vehicles directly through the distillation process. The distillation process is carried out on a compact distillator mounted on the engine. The evaporator of the compact distillator is installed directly into the vehicle's exhaust manifold by utilizing the existing space without changing the design of the vehicle. This allows for Road Test. Set up the research tool can be seen in Figure 1 [9].

FIGURE 1. Experimental Set up on Motorcycle

To get a temperature value in compact distillator that can be measured directly by using digital thermometer infrared (noncontact infrared thermometer). Temperature that we want to feed out namely in evaporator exhaust manifold, separator intake manifold, and condenser intake manifold, and then the value that is read on infrared thermometer digital display is noted in every minute. In addition, to feed out the temperature in evaporator is mounted probe apparatus which is connected to temperature control as controlling evaporator temperature. When the temperature has reached 80 ºC, namely ethanol vapor temperature, exhaust gas intake that is through evaporator and closed by using valve butterfly, setting open-close valve butterfly is regulated by choke to handle motor, to close exhaust gas manifold in order not to pass evaporator so choke on handle is pulled down, in contrast to open it, choke on handle is pushed upward

Firstly, low-grade bioethanol 30% (means 30% bioethanol and 70% water) is delivered into the evaporator. When engine works, it will produce heat exhaust gases from chamber to area through muffler. It will be exploited by an evaporator to evaporate two kinds of liquid fluid that have a different heating point (bioethanol 78.32 - 80°C and water 100°C). In here, occurs changing phase which is formed liquid to vapor.

The fluid has a lower heating point that will evaporate early and drain into the separator. Separator functions to a separate fluid which is not soluble each other because of the different densities. Water, its density is (1 kg/l) than bioethanol (0.785 kg/l) will be under position. Nets are installed to the separator that will obstruct water particles passing. So that the bioethanol level as result of distillation is higher.

After through separator, heat vapor from bioethanol will pass heat exchanger, which has a function to remove bioethanol heat by vapor phase, so bioethanol phase returns to the liquid phase. After that, liquid bioethanol will be retained and used again as mixer fuel and gasoline.

The gate valve is used to control heat exhaust gas from the muffler. The gate valve is installed to the manifold into evaporator and bypass manifold. In normal condition, gate valve in bypass manifold will close but the evaporator manifold will open. Yet, when the thermocouple is installed to the evaporator, it sends a signal to the temperature control which is a condition of temperature in evaporator has reached bioethanol heating point, so tap on gate valve on evaporator manifold will close. Then manifold that connects between evaporator to separator and from separator to heat exchanger, is used an isolated copper pipe, it means that to prevent convection removing caloric

Compact distillator system testing scheme presented in figure. 2. Experiments were performed by varying the engine speed at the compact distillator with spacing between tray 100 mm and 70 mm. Varied engine rev 1.800 rpm, 3.600 rpm and 5.400 rpm in accordance with the use of motors in general. In addition to knowing characteristics and performance of compact distillator also be tested by varying the volume and content of ethanol feed is entered in the evaporator. The volume of bioethanol varied 1.000 ml, 900 ml and 800 ml based on the maximum volume that can be accommodated in the evaporator. While the feed varied ethanol levels of 30%, 20% and 10%.

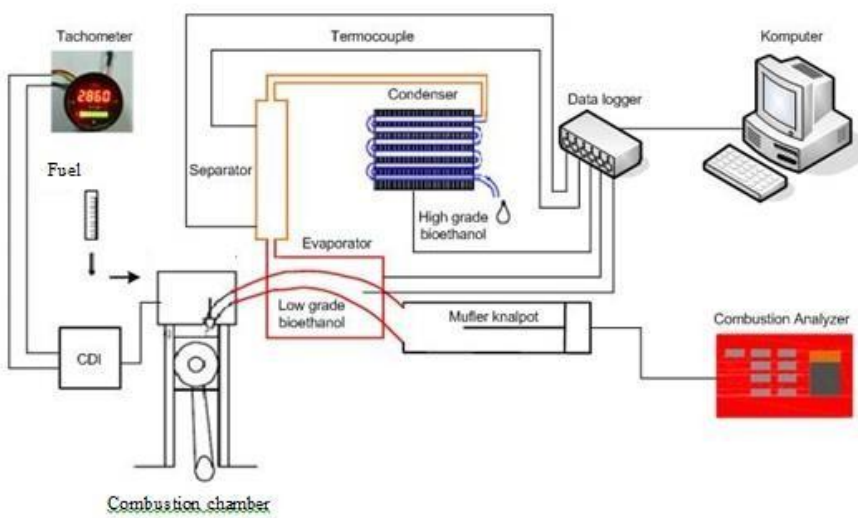

FIGURE 2. Compact Distillator Testing Scheme

The separator in compact distillatory is 1.5 inches stainless steel pipe based on standardization of ANSI/ASME B36.10-1995 which has outside diameter 48.3 mm, thickness of wall 3.68 mm and inside diameter is 40.94 mm. Sort of tray in the separator is sieve tray. The thickness of metal sheet tray is based on calculation is 1 mm and the amount of pit for each tray is 128 pieces for diameter 1 mm. Separator is made of stainless steel 316 L in order to corrosion resistance.

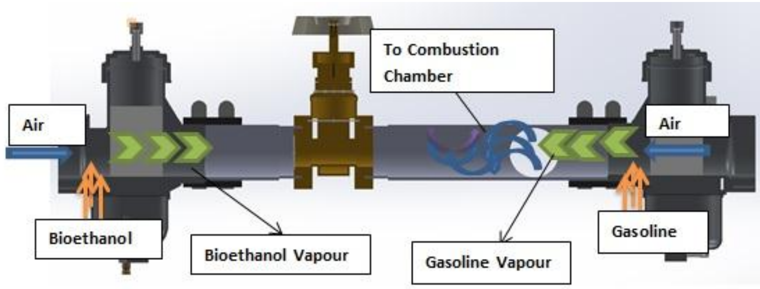

FIGURE 3. Fuel Mixture Design

Bioethanol levels were measured using a density meter where conditions test at temperature of 20° C, measured as % v/v – OIML-ITS-90 (Organization Internationale de Métrologie Légale). Principle of measurement is based on comparison of the density of the standard sample (pure ethanol) that have been stored on the device after calibration. Density measurement is based on electronic measurement of the oscillation frequency of the samples density analyzed. The sample density in the form of a mixture of bioethanol and water levels correlated with ethanol level. The higher levels of ethanol, the density gets smaller. The distillation rate is a distillate volume amount of ethanol produced from the distillation process per time unit. Measurements carried out by observing bioethanol distillate volume collected in the measuring cup each particular time.

Fuel mixer is installed with two carburetors that work to insert the two types of fuel into the combustion chamber. The carburetor will atomize the fuel to be delivered into the combustion chamber. The fuel is separated in respective valves to gasoline and bioethanol. On the instrument for bioethanol, installed valve that serves to regulate the amount of bioethanol to be streamed. Fuel mixer can be seen in figure 3.

Injection System

Subsequent research was conducted on machines with fuel injection system. The test was performed on SI engine 150 cc single cylinders. Gasoline engines with fuel injection systems will produce a direct air-fuel mixture in the combustion chamber. The air stream will enter the combustion chamber through the intake valve when the open position, while the fuel will be injected into the combustion chamber by the high-pressure injector controlled by the ECU. The engine will achieve the best performance when the air-fuel ratio is in the right conditions. When the fuel mixture is in leaner condition, the resulting engine performance will decrease. However, when the mixture is in richer condition, the fuel will be wasted and will increase the exhaust emissions. Electronic fuel injection system consists of several sensors to determine the actual engine condition. Sensors will provide information about the condition of the engine to the computer. After comparing the information with some known parameters, the ECU will determine certainly the amount of fuel needed to maximize power by producing low emissions.

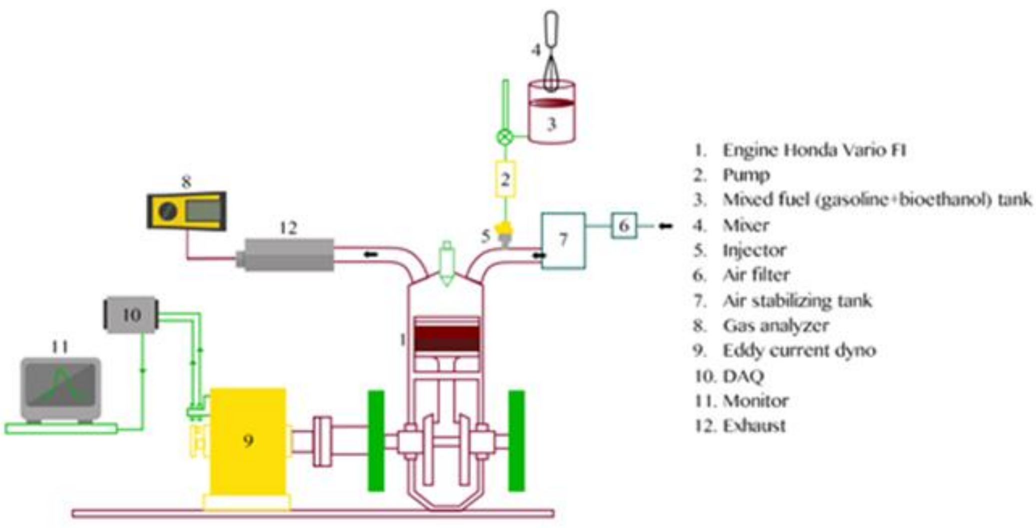

FIGURE 4. Experimental Set up Engine

In this research, there are four types of variations of gasoline fuel mixture with bioethanol which are E0, E5, E10, and E15. Fuel system modification was done on fuel tank system with a pre-mixed fuel mixture of gasoline and bioethanol using the mixer on a fuel tank. Gasoline and bioethanol put into the tank with the appropriate comparison as the variation set. The mixer on the fuel tank was turned on by pressing on/off valve, by using this method the fuel mixed perfectly before streaming to the injector.

Testing was done on the SI engine that was mounted on a dynamometer chassis type MCD400L series by mainline dyno log and connected techno motor gas analyzer to exhaust manifold. Dynamometer Calibration process was done by adjusting the rotation of the wheels of the vehicle with the round roller drum to obtain corresponding values between rpm engine and the results of the readings on a dynamometer. Further, testing was done at 100% throttle position variation rounds of 4000 rpm to 10000 rpm. The test machine has the final gear specification 18/53. The final reduction gear ratio matches with the weight and characteristic of the machine. The final gear comparison on the test machine is 2.94. Set up experimental can be seen in Figure 4.

The results of the power and torque testing were issued in the form of a graph and its value on the monitor that were connected to the dynamometer. The results of the emission gas were issued in the gas analyzer monitor. The fuel consumption test performed by using the rate of fuel consumption divided of the time. The time was counting when the rotation holding 4.000 Rpm and 25 ml of fuel used in constant rotation. The time is takes to consume 25ml of fuel will be calculated to get the specific fuel consumption. The test was performed four times for each variation of the fuel mixture. That was intended to get more accurate data.

DISCUSSION

Distillation Rate

The utilization of heat from the exhaust gases as a heat source distillation process can affect to fuel consumption and gas emission. The research was conducted on carburetor engine produce distillation rate with the following discussion.

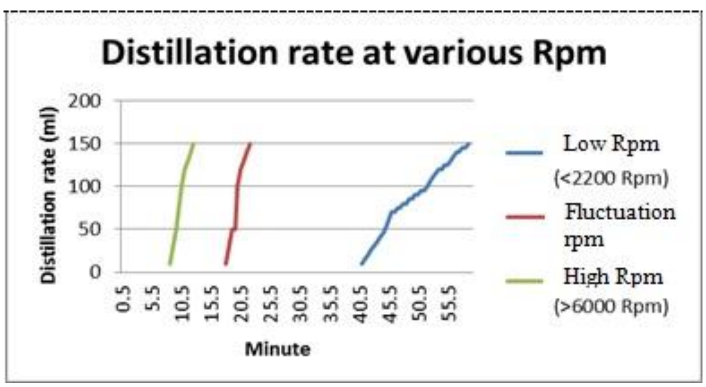

FIGURE 5. Distillation Rate vs Various Rpm without Temperature Control

In figure 5, high speed on the engine (> 6,000 Rpm) is capable of produce a short distillation rate. Based on the data obtained, the duration is required converting low-grade bioethanol to high-grade bioethanol and distillation rate is proportional to engine speed when testing with compact distillator. The high engine rotation speed will produce high exhaust heat and this will give the evaporating effect of distillation of bioethanol will also be high. An unexpected rise in the temperature of the exhaust gas will affect the evaporation process more quickly and the moisture content in bioethanol will also evaporate resulting in high levels.

Distillate

Based on figure 6, can be seen that the concentration of bioethanol produced depends on the speed of the engine. High alcohol concentrations were obtained when the engine spin at low speed, the concentration obtained was 83%. At low engine speed, the heat is generated in the exhaust manifold for the distillation process has not been able to change the water phase contained in bioethanol. Because of the difference in the boiling point between water and ethanol, the low-yield heat generated can only convert ethanol into a vapor phase.

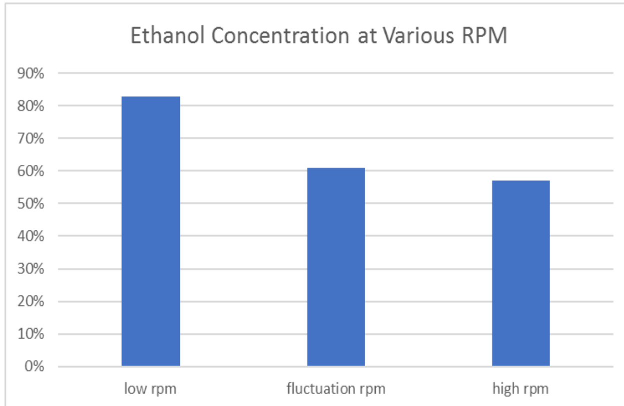

FIGURE 6. Ethanol Content at Various Rpm

Optimization Results of Distillation Rate and Distillate

Optimization is done in subsequent research on the comparison between fuel consumption with distillation rate and its relation to engine speed. The highest distillation rate that can be produced in this study is 364 ml / hour using separator at 70 mm. While for the highest concentrate capable of producing compact distillator of 96.91% with feed volume of 800 ml at 3,600 Rpm.

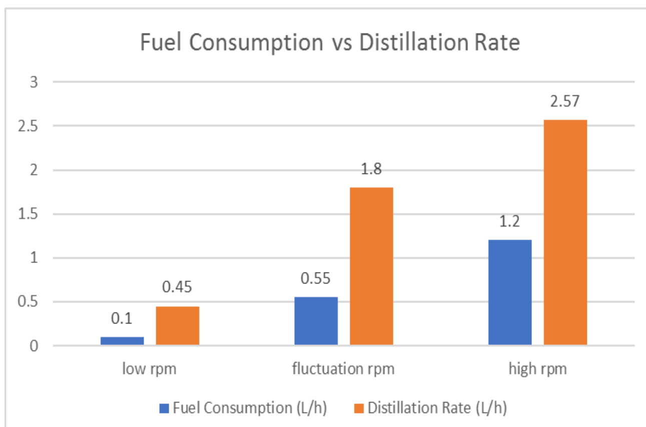

FIGURE 7. Fuel Consumption VS Distillation Rate at Various Rpm

In figure 7 can be seen that the distillation rate is comparable to the fuel consumption of the engine speed variation. The distillation rate at each engine is higher than the fuel consumption in the same rotation. Thus, the result of the distillation can be stored in the bioethanol tank for use as a gasoline mixture. Given the time-consuming distillation process, it is considered efficient, since bioethanol will always be available for use as a fuel mixture.

Testing by Different Tray Spacing

Figure 8 shows distillation rate before the exhaust valve is closed whereas in figure 9 total distillation rate for one hour experiment with closing the valve. Based on the engine speed, the distillation rate with higher engine speed is faster than the lower engine speed. The maximum distillation rate with the closing valve was 188 ml/hour on a separator B at 3.600 Rpm. While the distillation rate before the maximum valve closure occurs at separator B testing at 5.400 Rpm was 364 ml/hour. Higher concentration of ethanol produced from separator A. The higher engine speed will reduce the concentration of ethanol in both of separator as shown in figure 10.

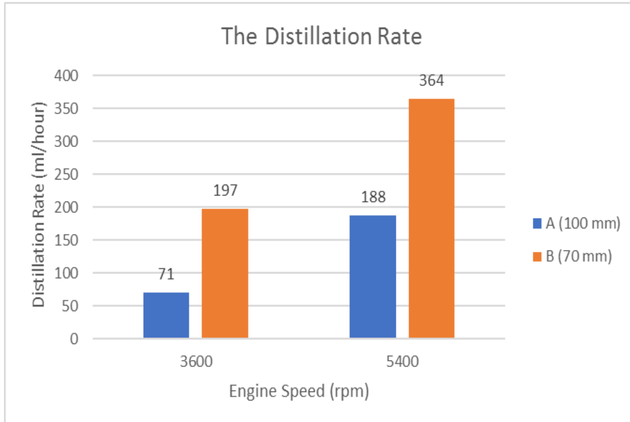

FIGURE 8. Comparison Distillation Rate Before Valve Closed Based on Tray

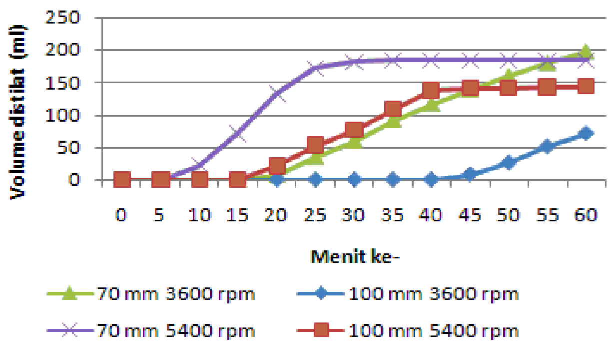

FIGURE 9. Comparison Total of Distillation Rate Based on Tray

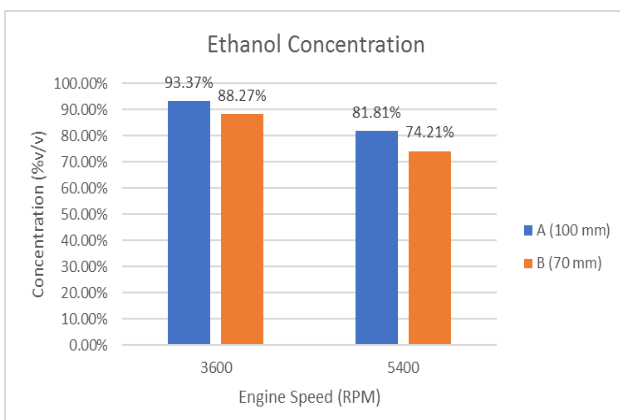

FIGURE 10. Comparison of Ethanol Concentration Based on Tray

Testing by Various Feed Volume Ethanol

Distillation rate increase for feed volumes more less as shown in figure 11 and figure 12. Total feed volume getting little faster than the temperature increase so bioethanol in the evaporator more evaporates faster. At 5.400 rpm the distillation rate is also determined by the valve timing so that the distillation rate look up and down. Levels of ethanol distillate are shown in figure 13 where the less feed volume tend higher levels. The maximum ethanol concentration of 96.91% occurred when the engine turns 3.600 rpm with feed volume 800ml.

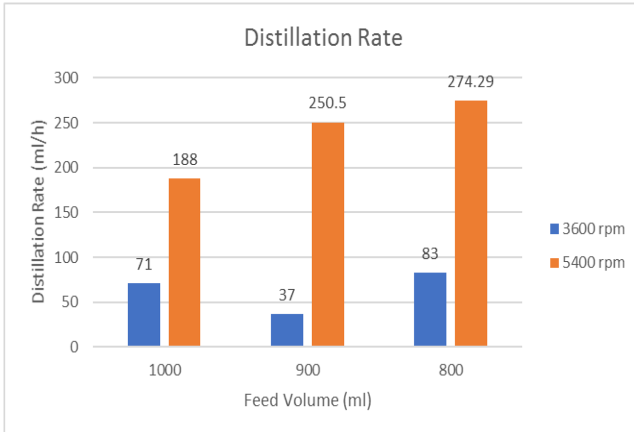

FIGURE 11. Comparison of Distillation Rate Before Valve Closed with Feed Volume Variations

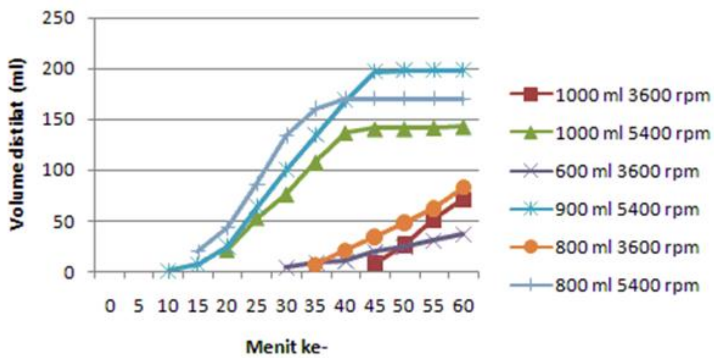

FIGURE 12. Comparison Total of Distillation Rate with Feed Volume Variations

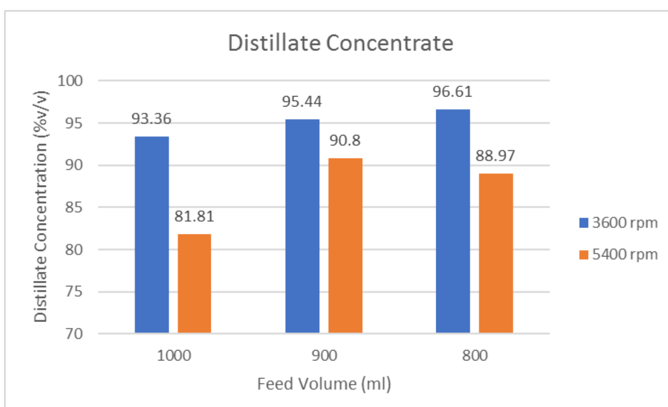

FIGURE 13. Comparison of Ethanol Concentrate with Feed Volume Variations

Performance (Wheel Power and Torque)

Overall, the analysis of the engine performance on this test included two things, namely power, and torque. Based on the study, the test results in the form of a comparison between the power and torque of the engine rotation variations for each variation of the fuel that was tested and presented in the form of tables and charts.

Engine with Carburetor System

Test result of wheel power in varied rotation from 3.000 rpm up to 11.000 rpm, is visible directly in figure 14.

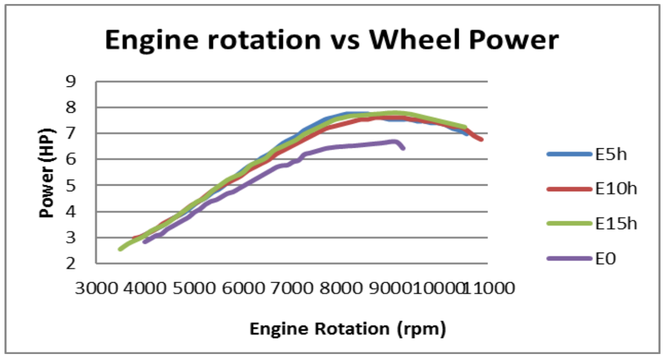

FIGURE 14. Wheel Power on Carburetor System

For the result of power performance, the usage of hydrous bioethanol mixture with gasoline produces higher wheel power than only uses pure gasoline. They do not have significant power value range but higher than gasoline from low rpm up to high rpm. In high rpm, can be seen the greater ratio between gasoline and bioethanol mixture. The maximum value that can be resulted by E5 bioethanol mixture is about 7.8 Hp, then E10 is about 7.6 Hp, E15 is about 7.8 Hp and gasoline is about 6.7 Hp. The power peak value is reached at a range of 8.000 – 9.000 rpm. If it is averaged by using hydrous bioethanol with gasoline that is capable to increase power about 15%. The value shows the significant ratio from bioethanol mixture with gasoline, from the graph, wheel power that is produced by gasoline can reach 10.000 rpm only.

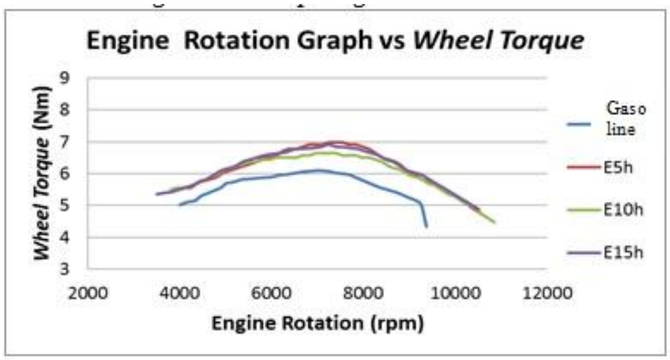

FIGURE 15. Wheel Torque on Carburetor System

From the figure 15, can be seen by using hydrous bioethanol mixture fuel with gasoline is also capable to increase torque. In ratio of E5, E10 or E15, they produce the higher value than gasoline. From low rpm is about 3.000 rpm up to 5.000 rpm, torque value always shows the significant differences. At 7.000 – 8.000 rpm, maximal torque can occur. For E5, maximal torque value is 6.92 Nm, for E10, 6.643 Nm ranged in value, then for E15 is about 6.92 Nm, and for gasoline is about 6.1 Nm. Torque decreases after it has passed the peak value and equal to gasoline power which has more incisively derivation and torque cannot reach up to 11.000 rpm.

Engine with Fuel Injection System

Testing gains value from the round wheel which is measured on a chassis dynamometer. Wheel horsepower is the actual value of the resources obtained through several components such as couplings, transmission and more.

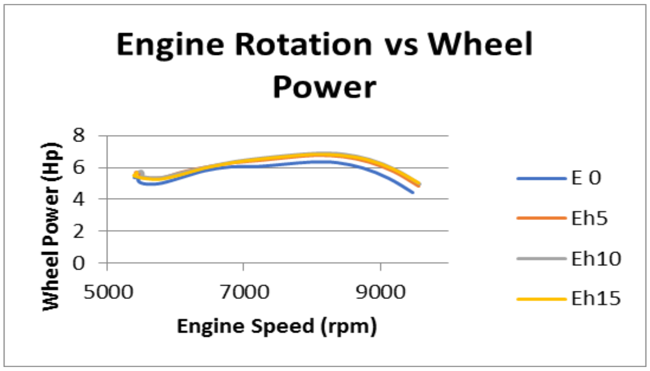

FIGURE 16. Wheel Power on Injection System

Figure 16 is the result obtained in the test wheel power variation rounds until 10.000 rpm for a wide variety of fuel tested. The maximum power is capable to result of E0 equal to 6.33 HP at 8000 rpm with an average difference between E0 – and the variation of fuel mixture of 9%. The difference is caused by the difference in air-fuel ratio (AFR), AFR affected the amount of fuel entering the combustion chamber. In addition to the AFR, other things that affected to the power generated by the engine, namely a heat value of fuel, fuel efficiency, volumetrics and conversion of energy. The efficiency of volumetrics on some variation of fuel will be different, besides the round value also affects the efficiency of the machine volumetric. Maximum power is generated on E5(5% bioethanol) equal to 6.78 HP, On E10 (10% bioethanol) produces power equal to 6.90 HP, and E15(15% bioethanol) generates the power equal to 6.83HP.

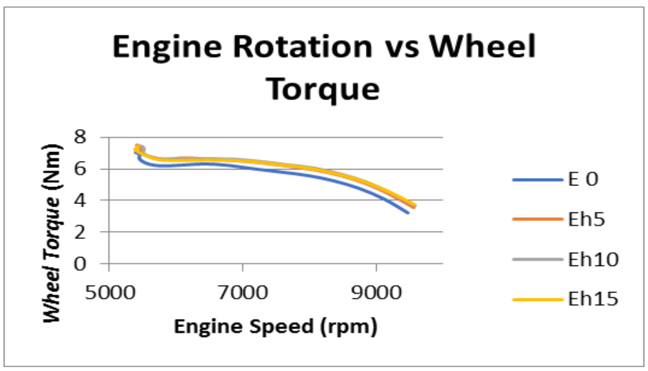

FIGURE 17. Wheel Torque on Injection System

In figure 17 shows that torque results on the variation of fuel mixture gasoline with bioethanol have a higher value than gasoline (E0). The maximum torque value occurs at 5.000-6.000 rpm engine. The maximum torque value that can be generated by E0 fuel variation equal to 7.08 Nm at 5.400 rpm. The torque resulted in each fuel variations in sequence on E5, E10, and E15 is 7.48 Nm, 7.43 Nm, and 7.45 Nm.

Emission Gas in Carburetor Engine

The greater content of CO contained in the exhaust gases of combustion shows that happens increasingly is not complete. In Figure 18 shows that at the system when using the premium fuel without mixed bio-ethanol, there are large contents of the most CO that is between 2.5%-3%. This shows that the air and fuel mixture lean when compared with fuel that has been mixed with bio-ethanol. The larger the addition volume of bio-ethanol, it can be seen that the content of CO generated also is getting smaller. And the lowest CO content is in the addition of bio-ethanol about 20% that could lower CO gas emission until 0.1% at 5.000 rpm. This is because the ethanol has –OH molecule that helps force the occurrence of the perfect combustion reactions. The more fuel that binds with oxygen helps the process of oxidation so that CO can be turned into CO_2.

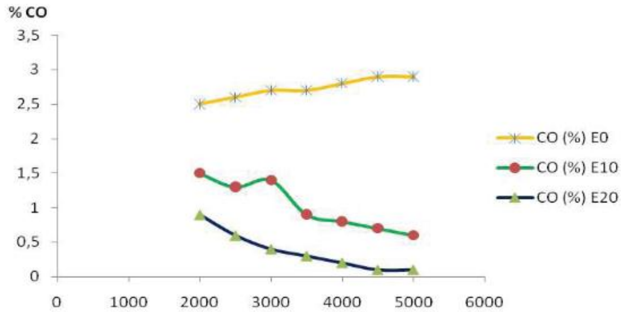

FIGURE 18. CO Emission in Engine Carburetor

The levels of CO and CO2 have a very close relationship. CO_2 is the combustion reaction product components. In other words, the CO2 is a gas that is desired as a reaction product of combustion if compared to the CO. The higher the level of CO2 in the combustion processes the more perfect combustion process.

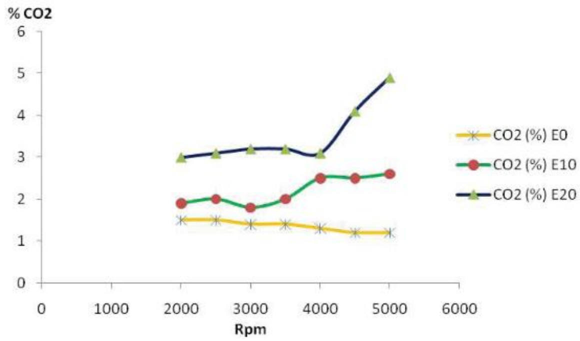

FIGURE 19. CO_2 Emission in Engine Carburetor

When gasoline vapor is heated at high temperature, will be occurred oxidation, the consequence is incomplete combustion. This unburned gasoline is out from combustion chamber in HC raw gas.

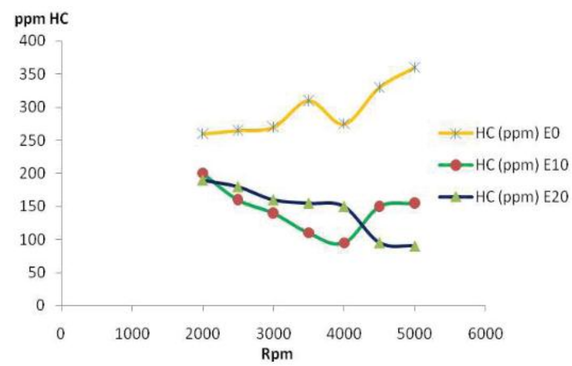

FIGURE 20. HC Emission in Engine Carburetor

Figure 20 shows that addition of bio-ethanol does not give so many changes in the HC exhaust emissions. It is due to the HC exhaust emissions is added ethanol only decrease amounting to 250 ppm.

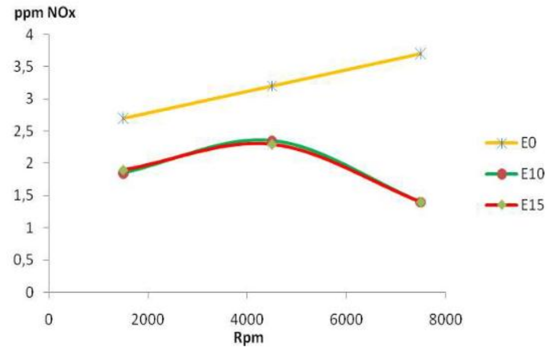

FIGURE 21. NO_x Emission in Engine Carburetor

The addition of ethanol will reduce NO_x amounted to 42% when compared to the NO_x produced when using gasoline only. This is because ethanol has a higher heat of evaporation on premium, resulting in energy is used to evaporate the ethanol is higher than the premium. The next consequence is the exhaust gas temperature will be lower and so the formed NO_x will be down [10].

Emission Gas in Fuel Injection Engine

These tests include exhaust emissions in the form of CO, CO_2, and O_2. Here is the result of emission test results and fuel consumption of each fuel mixture variation [11].

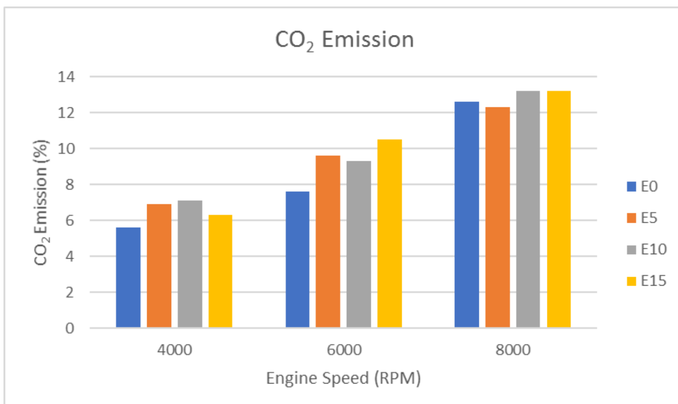

FIGURE 22. CO_2 Emission in Engine Injection

As the engine rotation increases, the CO_2 emission increase. This indicates that complete combustion in the combustion chamber. Based on the figure 22 shows that the addition of bioethanol can increase the CO_2 level. In the variation of E5, E10, and E15 obtained the average of each rotation with a percentage respectively amounting to 9.6%, 9.87%, and 10%. For the percentage of gasoline (E0) at each rotation equal to 8.6%.

Mustafa Koc and friends [12] from Karabuk and Gazi University in Turkey suggest their research results that the influence of the addition of ethanol on CO emissions. This is the product of combustion is not complete because not enough oxygen in the air-fuel mixture or combustion time enough within one cycle. Emissions concentration CO greatly depends on the operating conditions of the engine and the air fuel ratio. Some CO always appears on the exhaust even on lean mixture but the concentration decreases with decreasing temperature.

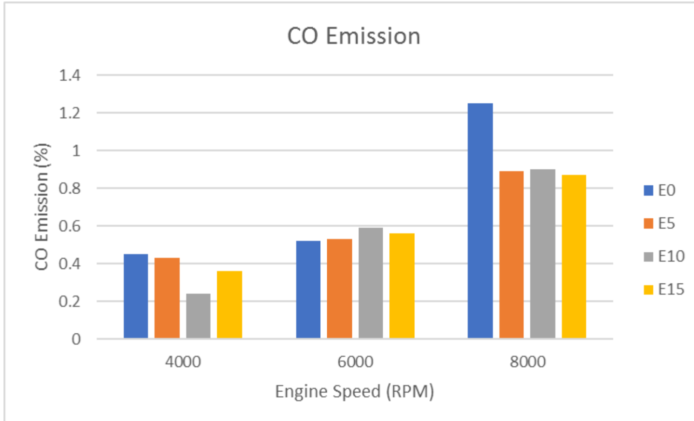

FIGURE 23. CO Emission in Injection Engine

The results of the CO exhaust test in each fuel are averaged to represent the percentage of emissions in each rotation. Bioethanol is able to reduce CO emissions by up to 24%. CO comes from incomplete combustion products because of insufficient oxygen in the air-fuel mixture in the combustion cycle. The air-fuel ratio for ethanol is lower, in the stoichiometric conditions about 8.95:1, while for gasoline is 14.7:1. Therefore, the addition of ethanol and oxygenates into gasoline leads effective leaning on the mixture. The higher bioethanol mixture on the fuel can reduce CO. This because of the -OH molecules are in bioethanol and additives produces complete combustion. Mixed fuels that contain lots of oxygen will help the process oxidation of CO to CO_2. The percentage of CO emissions also depends on the operating conditions of the engine.

CONCLUSION

Based on the study has been done by the author in some research. The author takes some conclusion below:

- It takes technology in the use of bioethanol as a fuel to convert low-grade bioethanol into high-grade bioethanol. The distillation system on the compact distillatory mounted on the motorcycle with carburetor system will utilize heat from the exhaust gas. The distillation rate produced by the compact distillatory reached 274.3 ml/hour with the bioethanol concentration results of 83%. After optimizing the compact distillator, the bioethanol concentration reached 96.91% with the test conducted based on feed volume variations. This is accordance with the use of bioethanol as a fuel that has a concentration above 90%. With the compact distillator design in this research, the road test can be allowed.
- Engine performance analysis with the carburetor system includes two things, namely power, and torque. The results obtained by testing each variation of fuel on the engine speed. Power peak value generated at engine speed around 8.000 rpm – 9.000 rpm and produce wheel power with higher fuel mixture compared with gasoline fuel (E0). If the power from fuel mixture averaged, it can increase power by 15% from the use of pure gasoline (E0). Meanwhile, the torque generated by the fuel mixture also increases. Maximum torque obtained when the engine speed around 7.000 rpm – 8.000 rpm.
- In engine research with an injection system, fuel system used premixed mechanisms before entering the combustion chamber. During the testing process, mixing process continuously working, it helps the fuel mixed perfectly before stream into the combustion chamber. Performance analysis of the injection system also includes two things (power and torque). The power generated by the fuel mixture variation is higher than of gasoline (E0). The value of the power produced by fuel variation E0 – E15 is 6.33 HP, 6.78 HP, 6.90 HP and 6.83 HP. This is same to the resulting torque, fuel mixture variation yielding higher torques. Maximum torque value occurs at 5.000 – 6.000 rpm.
- Fuel variations with bioethanol have an impact on the emission of exhaust gases produced. In the engine with the system carburetor and injection, harmful gas emission (CO, HC, and NOx) produced decrease. The fuel mixture between gasoline and bioethanol contains the -OH molecules that will react with CO. This increase the production of CO_2, as an indicator that the combustion process perfectly.

ACKNOWLEDGMENTS

The authors would like to thank DRPM UI for providing the grant PITTA 2017 in this research so that it can be completed well

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