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# Comparison Thermal Efficiency and Fuel Consumption of Electric Supercharger Variations For Otto Engine E70

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## ABSTRACT

A Pressure Wave Supercharger (PWS) is a technical way to increase the incoming pressure on a diesel engine. PWS utilizes hot cylinder exhaust gas energy to build in air pressure such as conventional turbo filling. In normal combustion the air and fuel mixture will burn perfectly if a stoichiometric mixture, gasoline fuel can be said to be stoichiometric if to burn 1 kg of fuel requires 14.7 kg of air. While the engine rotation is high, it requires a lot of fuel while the intake air is limited in number. Based on this description, an examination of air intake into the intake manifold is required with an Electric Supercharger which functions as an air compressor. Using the Otto engine with modifications to the piston, compression ratio, ignition timing, injection duration and E70% bioethanol fuel. With the installation of these tools, can get the characteristics of combustion and improve the problems that occur associated with a rich mixture so that the engine performance becomes optimal and exhaust emissions become minimal. The result of variations in Electric Supercharger voltage at 6 volts, 8 volts and 10 volts can be seen that the best performance such as bmep, thermal efficiency has increased respectively by 14.73%, 22.87%, and sfc has decreased by 23, 84%.



## INTRODUCTION

Renewable alternative fuels, as defined by ACT Energy Policy 1992 (EPACT), include alcohol (biomethanol, bioethanol and others), natural gas, liquefied natural gas, hydrogen, liquid fuels derived from coal, biofuels (including biodiesel, gas synthesis and others), and electricity, Sudarmata at al [1]. The use of renewable alternative fuels is an effort to reduce consumption of fossil fuels and environmental impacts (including hazardous pollutants and exhaust emissions) in the transportation sector, Sudarmata at al [2]. Burning fossil fuels not only produces carbon dioxide, but also emissions of CO, HC and NOX. Pollutants endanger human survival and all ecosystems on Earth Paloboran at al [3].

Alcohol fuels, especially ethanol, can be produced from renewable sources, such as sugar cane, cassava, corn and many other types of biomass waste materials. Ethanol has several advantages over gasoline, such as the reduction of CO, volatile organic compounds (VOCs) and the emission of unburned hydrocarbons (UHC) and better anti-knock characteristics, which allows the use of higher engine compression ratios. Because ethanol is a liquid fuel, ethanol storage and removal is the same as Hywood gasoline [4,9,11]. In the study Sudarmanta et al [2,10] showed that bioethanol has a lower heating value of 60% and a value of Research Octane Number (RON) which is higher than

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gasoline. E50 with CR 9.6 has an initial combustion time range of 20 ° -26 ° BTDC and results in a torque drop of 4.12%, while E50 CR 11.6 has an initial combustion time range of 17 ° -23 ° resulting in torque rising 3,68%.

Jeuland et al. [5,8, 11] examined pure ethanol on gasoline motors equipped with turbochargers and modified motors in the fuel line system, cylinder geometry and increased compression ratio from 9.5 to 12.5. Actually a higher compression ratio can be applied. This parameter requires a higher compression ratio, requires higher pressure, and requires synchronization between injection time and ignition time. For this purpose, ECU (Electronic Control Unit) is needed which can be programmed to adjust between injection and ignition times. Fikri [6,7,12] conducted an X research focused on adding combustion air by adding a blower to the engine input. The engine used is Honda CB150R with a compression ratio of 12.5 using 100% bioethanol fuel. From the experimental results obtained the best performance results in the addition of 10% combustion air. In the addition of air 10% torque, power, load and thermal efficiency produced increased by 12.52%, 9.25%, 12.52%, 35.18%, and BSFC decreased by 29.15%. While the exhaust gas emissions of CO and HC produced decreased by 2.84% and 10.54% respectively.

Based on the description above, we want to do an air intake test into the intake manifold with an Electric Supercharger which functions as an air compressor. Using the Otto engine with modifications to the piston, compression ratio, ignition timing, injection duration and E70% bioethanol fuel. With the installation of these tools can get the combustion characteristics and improve the problems that occur associated with a rich mixture so that the engine performance becomes optimal and exhaust gas emissions become minimal.

## EXPERIMENTAL METHOD

This research was conducted using experimental methods. The Engine used is the Otto Engine with a compression ratio of 12.5. The fuel used is bioethanol E70, Dynamometer, Torque Scales, Electric Supercharger, Stop Watch, Tube Measure, Strobotester, Exhaust Gas Analyzer, Digital Thermocouple, Blower, Voltage Regulator, Digital Manometer.

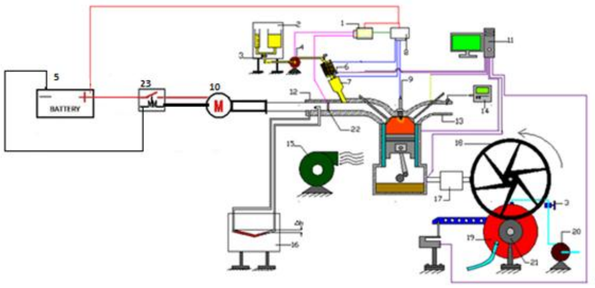

**Fig. 1**. Testing Scheme, 1. ECM, 2. table measuring cup, 3. Fuel valve, 4. Fuel pump, 5. 12 Volt battery, 6. Temperature sensor, 7. Injector, 8. Trigger, 9. Spark plug, 10. Electric motor supercharger, 11. Computer, 12. Intake manifold, 13. Exhaust manifold, 14. Gas analyzer, 15. Blower, 16. Table manometer, 17. Transmission, 18. Wheel back

Engine Testing Using a Programmable ECU Fueled by E70 Bioethanol with an Electric Supercharger

1. Prepare an engine that is equipped with an electric supercharger as the air intake system, as well as check the electrical system, cooling system, fuel system, ignition system, and measuring instrument condition.
2. Fill the fuel tank with Bioethanol 70
3. Turn on the engine for 10 minutes at idle rotation to achieve optimum working temperature conditions.
4. Run the engine by including the addition of 1-2-3-4-5-6 transmission gear, then open the butterfly valve to full open throttle. In this condition the engine will spin at maximum rotation. During maximum rotation, the water load does not flow to the water dynamometer.
5. Flowing water to the water brake dynamometer until the engine turns down. After the engine rotation is at 8000 rpm, activate the non-control electric supercharger for additional air. Then do the data retrieval for every 1000 rpm to the last round of 2000 rpm. Data retrieval is done when the engine speed is stable Data obtained include engine speed data (rpm), torque (Nm), consumption time of 25 ml of bioethanol E70 fuel (second), CO emissions (% volume), HC emissions (ppm volume), exhaust gas temperature

(°C), temperature cylinder block (°C), and lubricating temperature (°C).

6. At each stage of the reduction in engine speed data recording is carried out as in point 5 (five).
7. Repeating steps in points 1 (one) to 7 (seven) with variations in the addition of voltage 6 volts, 8 volts and 10 volts.

## RESULTS AND DISCUSSION

In this study discuss Average Effective Pressure, Specific Fuel Consumption, Thermal Efficiency, Volumetric Efficiency which is influenced by variations in electric supercharger voltage at each engine speed (rpm).

### a. Graph of Average Effective Pressure (BMEP)

The amount of pressure experienced by the piston changes along the piston step. If a constant pressure is applied which works on the piston and produces the same work, then the pressure is the average effective pressure of the piston. Figure 2 shows the average effective pressure trendline for each engine rotation. Bmep generated from the engine all increases with increasing engine speed from 2000 to the highest peak of 5000 rpm, and will decrease at 6000 rpm and above. This is greatly influenced by the ignition time of the spark plug. In the modified 70% bioethanol fuel, the maximum compression ratio to 12.5 bmep produced is 531 Kpa at 7000 rpm. Whereas the compression ratio engine of 12.5 with 70% bioethanol fueled by installing an electric supercharger in a variation of 6 volts, 8 volts and 10 volts found the maximum load of 641.40 Kpa, 606.15 Kpa and 593.79 respectively, at engine speed 5000 Rpm.

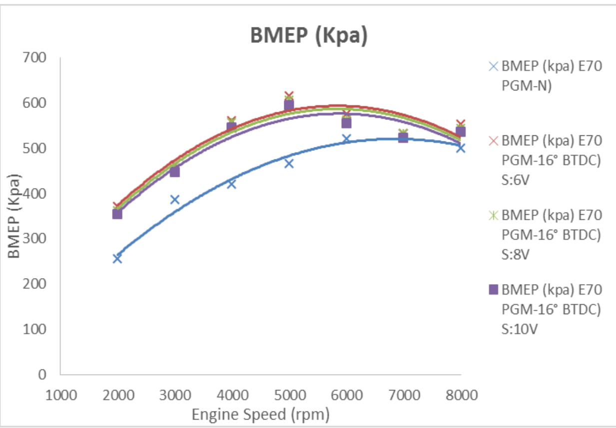


**Fig. 2.** Graph of BMEP RPM function.

In trendline graph 2 shows that there is an average trend of effective pressure increase starting from low rotation to reach maximum effective pressure at 7000 rpm without installing an electric supercharger and maximum effective pressure at 5000 rotation with electric supercharger, then average effective pressure decreases at higher engine speed. This occurs because the pressure in the combustion chamber will increase with the amount of combustion that occurs. However, after reaching a certain peak point it will decrease, because the explosion produced by combustion is not only beneficial to produce power, but also used to overcome the losses that occur.

Figure 2 shows that at the same rotation, there is a difference in the bmep value for each voltage variation. With the increase in voltage on the electric supercharger the resulting mass will decrease. This is because with the increase of the electric supercharger voltage, the combustion air also increases, the fuel in the combustion chamber decreases, or it can be said that the fuel is poor in the combustion chamber. So that the power produced is small as a result the value of BMP is also getting smaller. But overall the bmep produced by increasing the voltage is greater than that produced before the addition of voltage.

### b. Graph of Specific Fuel Consumption (BSFC)

Specific fuel consumption can be defined as the fuel flow rate to obtain effective power. The specific fuel consumption value depends on the mixture of air and fuel burning in the combustion chamber. With the more perfect combustion, the better the resulting SFC. Figure 3 shows the fuel-specific consumption trendline at each engine rotation on 70% bioethanol fuel which has been modified the compression ratio to 12.5. The specific consumption of minimum fuel produced is 0.236 kg / kW.Hours. While the engine with a compression ratio of 12.5 bioethanol 70% fueled by installing an electric supercharger variations of 6 volts, 8 volts and 10 volts obtained the minimum specific fuel consumption of 0.179 kg / kW.Hours, 0.180 kg / kW.Hours and 0, 126 kg/ kW.Hours.

In general, the specific fuel consumption from low to high rpm will decrease until a certain engine rotation will increase again. This is caused by the higher flow turbulence along with the increase in engine speed, so that the homogeneity of the mixture of fuel and air is better and produces a more perfect combustion. The high and low fuel consumption in theoretical is influenced by the amount of power produced by the engine. The higher power is the divider in calculating fuovvvvvvvel consumption.

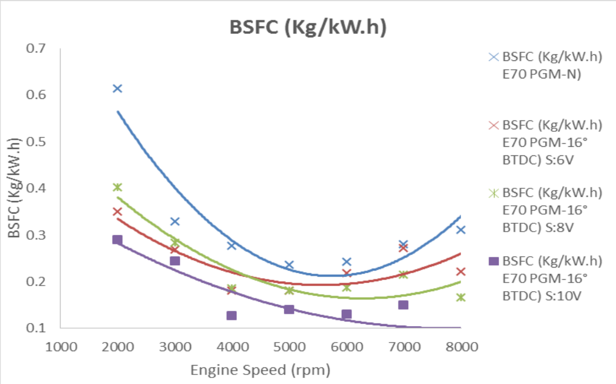


**Fig. 3.** Graph of BSFC RPM function.

In the trendline shows that at the same rotation, there is a difference in the specific fuel consumption value for each addition of combustion air. With increasing combustion air, the specific consumption of fuel produced by the engine will increase. This is because the more air is added, the less power that results in an increase in the sfc value.

### c. Graph of Thermal Efficiency

Thermal efficiency is a measure of the amount of heat energy stored in the fuel to be converted into effective power in the internal combustion motor. The value of thermal efficiency depends on the mixture of air and fuel burning in the combustion chamber. Figure 4 shows the trendline of thermal efficiency of the engine at each engine rotation. In standard conditions with 70% bioethanol fuel which has been modified the compression ratio to 12.5 maximum thermal efficiency is generated at 37.9. While the engine with a compression ratio of 12.5 bioethanol 70% fueled by installing an electric supercharger variations of 6 volts, 8 volts and 10 volts obtained the maximum thermal efficiency of 48.451, 48.468 and 59.689.

When the voltage is 6 volts and the engine speed is low, the fuel and air mixture is less optimal, because the intake air produced by the electric supercharger is very little and the turbulence of the mixture that enters is too rich, so the combustion is not perfect. Along with increasing the supercharger electric voltage from 8 volts to 10 volts and increasing engine speed, there will be times when turbulence and combustion time reach the best conditions so as to get the most optimal efficiency and high efficiency. At a very high engine speed when combustion occurs very quickly so that combustion is not perfect, which causes the efficiency to decrease again.

With the addition of an electrical supercharger voltage, the thermal efficiency generated by the engine will increase. This is due to the increase in combustion air so that the fuel mixture in the combustion chamber is more perfect so that the heat stored in the fuel to be converted into effective power becomes large which results in increased thermal efficiency.

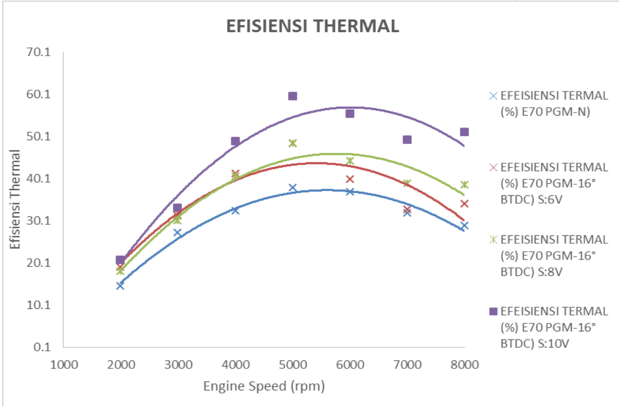


**Fig. 4.** Graph of Thermal Efficiency RPM.

## CONCLUSION

The conclusion of the study the effect of the use of Electric Supercharger on E70 bioethanol fueled on the otto engine is: Electric Supercharger voltage variation at 6 volts, 8 volts and 10 volts can be seen that at 6 volt voltage produces BMM, thermal efficiency has increased by 14, 73%, 12.14%, 14.73%, 22.87%, and SFC decreased by 23.84%.

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