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Page 40 - 48

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Performance Analysis of Diesel Engine Fueled by 2-Ethylhexyl Nitrate Mixed Biodiesel and the Use of XPower Fuel Ionizer with Injection Timing Variations

Daffa Satya Roziqi[1*], Hadromi[1]

1 Department of Automotive Engineering Education, Faculty of Engineering, Universitas Negeri Semarang, Indonesia

*satyadaffa06@gmail.com

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Abstract
Rapid technological developments encourage the use of diesel engines in transportation and industry due to greater efficiency and power. The cetane number is an important indicator of the quality of diesel fuel, where the addition of additives such as 2EHN can increase the cetane number and improve combustion. Tools such as Fuel Ionizers are also developed to improve fuel efficiency through molecular decomposition. This study aims to determine the power, torque, and specific fuel consumption values in the 4D56 diesel engine when using 2EHN as a fuel mixture and the use of Fuel Ionizer. The power value increases by 1.2 Hp with a mixture of 0.4% 2EHN and the use of Fuel Ionizer at the 8^{O} ATDC Timing Injection setting. The torque value increases by 2 Nm with a mixture of 0.4% 2EHN and the use of Fuel Ionizer at the 9^{O} ATDC Timing Injection setting. The lowest specific fuel consumption value is 0.000084 Kg/Hph with a mixture of 0.4% 2EHN and the use of Fuel Ionizer at the 8^{O} ATDC Timing Injection setting.

1 Introduction

Diesel engines are a type of internal combustion engine in which a process of combustion of fuel and air occurs in the system. The internal combustion engine itself plays an important role in transportation, engineering machinery, agricultural machinery, power generators and other fields [1]. However, the internal combustion engine itself is widely criticised for its limited efficiency improvement potential, excessive primary energy consumption, large greenhouse gas production, and high pollution emissions [2].

Biodiesel is the best alternative to conventional fossil fuels. However, it can worsen engine characteristics and must be modified [3]. The use of vegetable oils directly in diesel engines has undesirable consequences due to the typical physicochemical properties of vegetable oils. The use of pure, unmodified vegetable oils requires mandatory dilution with petroleum fuels, usually diesel. However, diesel fuel blends with vegetable oils have significantly higher density and viscosity than pure diesel fuel [4]. Compression ratio, proper fuel blending and improving volumetric efficiency are ways to improve the performance of a piston engine [5]. Fuel blending to improve diesel engine performance is by adding additives to the fuel; the addition of additives in the fuel will vary the fuel ignition reactivity without changing the characteristics of the fuel [6].

Biodiesel fuel can be added with additives to diesel engines that have low engine speed or to engines that have high speed. The addition of additives has the aim that the calorific value of combustion has

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increased, resulting in the use of fuel that is economical and friendly to the environment. The additives or cetane boosters used are in liquid or pill form [7].

2-Ethylhexyl Nitrate (2-EHN) is an additive that can be added to diesel fuel to increase the cetane number in diesel fuel. 2-Ethylhexyl Nitrate (2-EHN) has been produced commercially. 2-Ethylhexyl Nitrate (2-EHN) is an organic compound that has a nitrate group at the end of its carbon chain. 2-Ethylhexyl Nitrate (2-EHN) is used because it is thermally unstable and decomposition aids the start of fuel combustion, with shorter ignition times compared to fuels without the additive. The addition of 2-Ethylhexyl Nitrate (2-EHN) to diesel fuel at a dose of 0.05% - 0.4% will give an increase in cetane number of 4 - 7 [8].

The development in improving fuel quality is very rapid, so in addition to treatment by adding fuel mixture, there is also the development of tools to improve fuel quality. Power Ioniser is a modern technology tool that functions as an improvement in fuel quality, where good fuel quality will increase fuel consumption efficiency and improve performance, including engine power and responsiveness. Fuel Ioniser is a tool that functions to break down fuel molecules to bind more easily with oxygen so that the combustion quality is better or increased. The tool used is X-Power. This tool works supported by the Neodyne Magnet (a magnet with a large power of about 100,000 Gauss, which plays an active role in influencing the fuel so that the molecules are decomposed/ionised so that they are more optimal in binding oxygen) and the Induction Energy Close Circuit Positive Micro Frequency (IECCPMF) system, which is a system that converts the large magnetic force into active waves which will then streamline the magnetic power to influence and ionise the fuel and change the molecular structure of the fuel to be more reactive and then be able to provide quality improvement in fuel [9].

2 Research Methods

This research design uses a true experiment with a posttest control design form. This research design can control external variables that affect the course of the experiment. Thus, internal validity becomes high. In this design there are two groups, each of which is randomly selected (R). The first group is given treatment (X), and the other group is not. The treated group is called the experimental group, and the untreated group is called the control group [10].

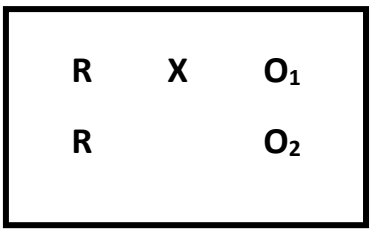

Figure 1. Posttest-only control group design used in the experimental research.

This research was conducted at the Mechanical Engineering Performance Laboratory of Universitas Negeri Semarang for performance testing and at the Chemistry Department laboratory of the Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, for fuel density testing with 2-Ethylhexyl Nitrate. The tools used were:

- Tool Set
- Measuring Cup
- Dynamometer
- Blower
- Themogun
- Burrete
- Anemometer
- Prestroke Tool

The materials used are:

- Mitsubishi Kuda Diesel 2.5 2001
- 2-Ethylhexyl Nitrate
- Biodiesel Fuel
- Fuel Ionizer

Research parameters:

1. Independent variable
   In this study, the independent variable is the Boshpump timing injection adjustment, with variations:
   a. 8^{O} ATDC: fuel injection at an angle of 8^{O} ATDC.
   b. 9^{O} ATDC: fuel injection at the angle of 9^{O} ATDC.
   c. 10^{O} ATDC: fuel injection at an angle of 10^{O} ATDC.
   d. Variation of fuel mixture and use of Fuel Ionizer.
2. Bound variable
   In this study, the power, torque and specific fuel consumption of Mitsubishi Kuda Diesel 2001 are the dependent variables.
3. Control variables
   In this study the control variables are as follows:
   a. Engine temperature 70-80^{O}C when testing
   b. Air temperature 25-35^{O}C
   c. Testing using Mitsubishi Kuda Diesel 2001

This study uses structured observation data collection techniques. Structured observation is an observation that has been systematically designed and prepared using the help of a data table or instrument about the variables observed in the study [11]. Descriptive statistical data analysis is the data analysis technique in this study,

3 Result and Discussion

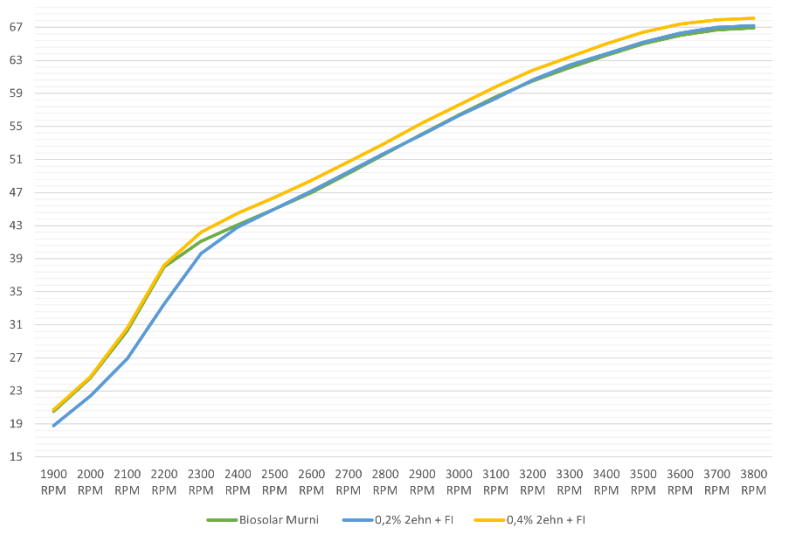

Figure 2. Results of Power Testing on Injection Timing at 8^{O} ATDC

Figure 2. shows the results of power testing on Timing Injection at 8^{O} ATDC. Power testing at Timing Injection at 8^{O} ATDC using biodiesel fuel mixed with 0.2% 2-Ethylhexyl Nitrate and the use of Fuel Ionizer has the highest power at 3800 rpm with a power increase of 0.4% compared to power testing using pure biodiesel and without the use of Fuel Ionizer. Power testing at Timing Injection at 8^{O} ATDC using biodiesel fuel mixture of 0.4% 2-Ethylhexyl Nitrate and the use of Fuel Ionizer has the highest power at 3800 rpm

with a power increase of 2% compared to power testing using pure biodiesel and without the use of Fuel Ionizer.

From various variations of the mixture, it gets a higher power value compared to using pure biodiesel fuel and without the use of Fuel Ionizer. The highest power value from the test results above is 67.2 hp at 3800 rpm engine speed when adding 0.4% 2-Ethylhexyl Nitrate to biodiesel fuel and installing Fuel Ionizer.

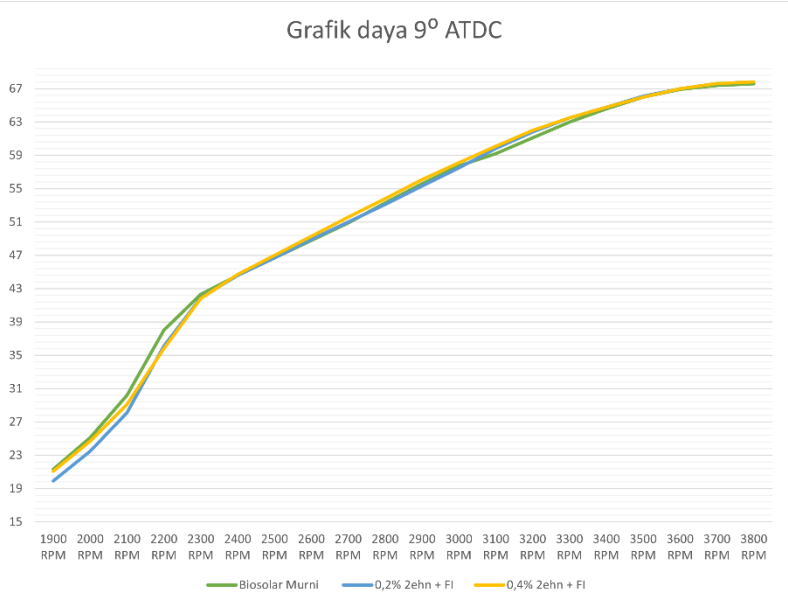

Figure 3. Power Testing Results at 9^{O} ATDC Injection Timing

Figure 3 shows the results of power testing at 9^{O} ATDC Injection Timing. Power testing at Timing Injection 9^{O} ATDC using biodiesel mixed with 0.2% 2-Ethylhexyl Nitrate and the use of Fuel Ionizer has the highest power at 3800 rpm with a power increase of 0.3% compared to power testing using pure biodiesel and without the use of Fuel Ionizer. Power testing at 9^{O} ATDC Injection Timing using 0.4% 2-Ethylhexyl Nitrate mixed biodiesel fuel and the use of Fuel Ionizer has the highest power at 3800 rpm with a power increase of 0.3% compared to power testing using pure biodiesel and without the use of Fuel Ionizer.

From various variations of the mixture, it gets a higher power value compared to using pure biodiesel fuel and without the use of Fuel Ionizer. The highest power value from the test results above is 67.8 hp at 3800 rpm engine speed when adding 0.4% 2-Ethylhexyl Nitrate to biodiesel fuel and installing Fuel Ionizer.

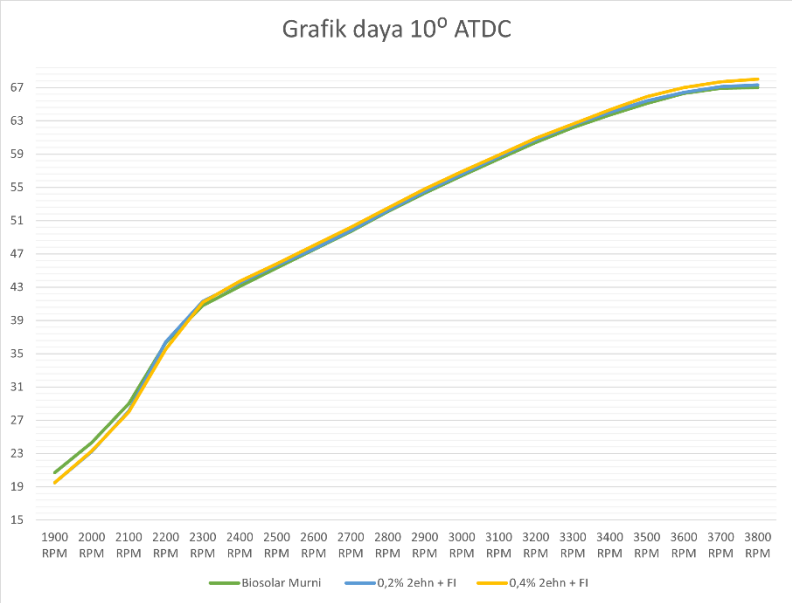

Figure 4. Power test results at 10^{O} ATDC Injection Timing

Figure 4 shows the results of power testing at 10^{O} ATDC Injection Timing. Power testing at Timing Injection 10^{O} ATDC using biodiesel mixed with 0.2% 2-Ethylhexyl Nitrate and the use of Fuel Ionizer has the highest power at 3800 rpm with a power increase of 0.4% compared to testing using pure biodiesel and without the use of Fuel Ionizer. Power testing at 10^{O} ATDC Injection Timing using 0.4% 2-Ethylhexyl Nitrate mixed biodiesel fuel and the use of Fuel Ionizer has the highest power at 3800 rpm with a power increase of 1% compared to power testing using pure biodiesel and without the use of Fuel Ionizer.

From various variations of the mixture, it gets a higher power value compared to using pure biodiesel fuel and without the use of Fuel Ionizer. The highest power value from the test results above is 68 hp at 3800 rpm engine speed when adding 0.4% 2-Ethylhexyl Nitrate to biodiesel fuel and installing Fuel Ionizer.

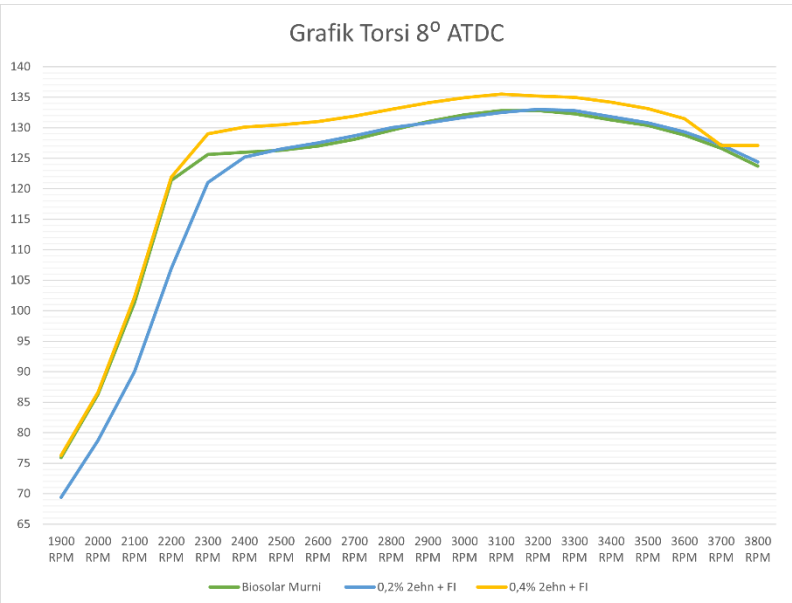

Figure 5. Torque Testing Results at Injection Timing 8^{O} ATDC

Figure 5 shows the results of torque testing at 8^{O} ATDC Injection Timing. Torque testing at Timing Injection 8^{O} ATDC using biodiesel mixed with 0.2% 2-Ethylhexyl Nitrate and the use of Fuel Ionizer has the highest torque at 3200 rpm engine speed with an increase in torque of 0.2% compared to testing using pure biodiesel and without the use of Fuel Ionizer. Torque testing at 8^{O} ATDC Injection Timing using a 0.4% 2-Ethylhexyl Nitrate biodiesel mixture and the use of Fuel Ionizer has the highest torque at 3100 rpm engine speed with a torque increase of 2% compared to testing using pure biodiesel and without the use of Fuel Ionizer.

From various variations of the mixture, it gets a higher torque value compared to using pure biodiesel and without using Fuel Ionizer. The highest torque value from the test results above is 135.5 Nm at 3100 rpm when adding 0.4% 2-Ethylhexyl Nitrate to biodiesel fuel and installing Fuel Ionizer.

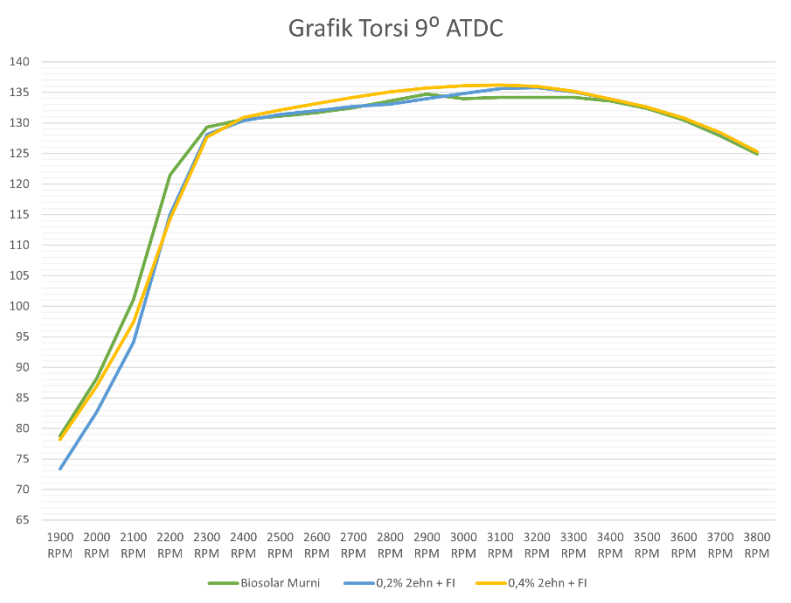

Figure 6. Torque Testing Results at 9^{O} ATDC Injection Timing

Figure 6 shows the results of torque testing at 9^{O} ATDC Injection Timing. Torque testing at Timing Injection 9^{O} ATDC using biodiesel mixed with 0.2% 2-Ethylhexyl Nitrate and the use of Fuel Ionizer has the highest torque at 3200 rpm engine speed with a torque increase of 1% compared to testing using pure biodiesel and without the use of Fuel Ionizer. Torque testing at 9^{O} ATDC Timing Injection using a 0.4% 2-Ethylhexyl Nitrate biodiesel mixture and the use of Fuel Ionizer has the highest torque at 3100 rpm with a torque increase of 1% compared to testing using pure biodiesel and without the use of Fuel Ionizer.

From various veriations of the mixture, it gets a higher torque value compared to using pure biodiesel and without the use of Fuel Ionizer. The highest torque value from the test results above is 136.2 Nm at 3100 rpm when adding 0.4% 2-Ethylhexyl Nitrate to biodiesel fuel and installing Fuel Ionizer.

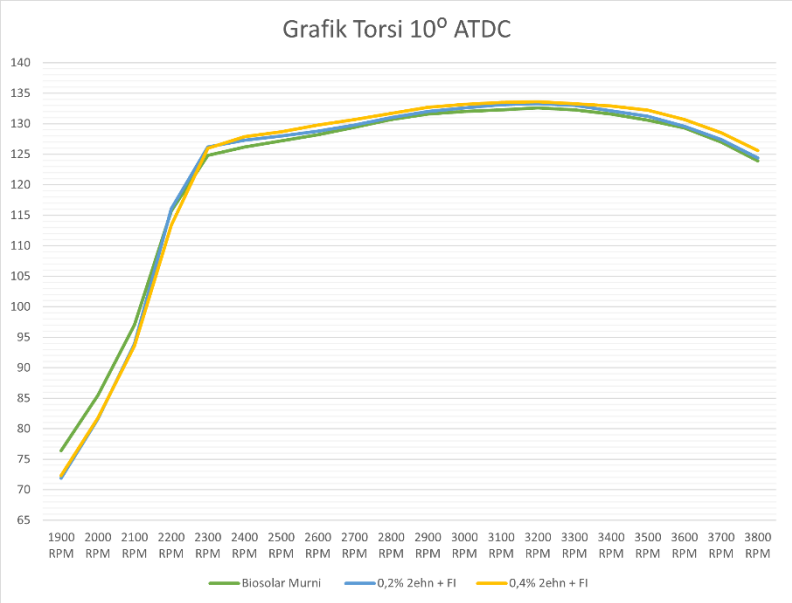

Figure 7. Torque Testing Results at Injection Timing 10° ATDC

Figure 7 shows the results of torque testing at 10° ATDC Injection Timing. Torque testing at Timing Injection 10° ATDC using biodiesel mixed with 0.2% 2-Ethylhexyl Nitrate and the use of Furel Ionizer has the highest torque at 3200 rpm engine speed with a torque increase of 1% compared to testing using pure biodiesel and without the use of Fuel Ionizer. Torque testing at 10° ATDC Injection Timing using a 0.4% 2-Ethylhexyl Nitrate biodiesel mixture and the use of Fuel Ionizer has the highest torque at 3200 rpm with a torque increase of 1% compared to testing using pure biodiesel and without the use of Fuel Ionizer.

From various variations of the mixture, the torque value is higher than using pure biodiesel and without the use of Fuel Ionizer. The highest torque value from the above test is 133.6 Nm at 3200 rpm when adding 0.4% 2-Ethylhexyl Nitrate to biodiesel fuel and installing Fuel Ionizer.

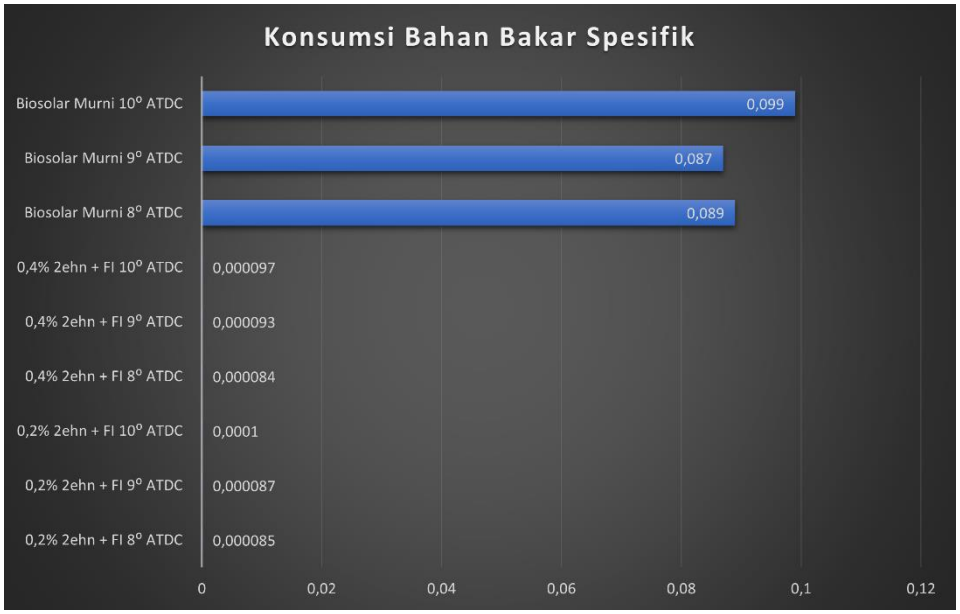

Figure 8. SFC Testing Results

Figure 8 shows the specific fuel consumption test for each variation. Specific fuel consumption at setting the Injection Timing at 8^{O} ATDC decreased when using bio-diesel fuel blends of 0.4% 2-Ethylhexyl Nitrate and 0.2% 2-Ethylhexyl Nitrate and the use of Fuel Ionizer compared to using pure bio-diesel fuel without the use of Fuel Ionizer. The lowest specific fuel consumption using 0.4% 2-Ethylhexyl Nitrate blended biodiesel fuel and the use of Fuel Ionizer and get a result of 0.000084 kg/HPh.

Specific fuel consumption at setting the Injection Timing at 9^{O} ATDC decreased when using 0.4% and 0.2% 2-Ethylhexyl Nitrate blended bio-diesel fuel and the use of Fuel Ionizer compared to using pure bio-diesel fuel without the use of Fuel Ionizer.The lowest specific fuel consumption using 0.2% 2-Ethylhexyl Nitrate blended biodiesel fuel and the use of Fuel Ionizer and get a result of 0.000087 kg/HPh.

Specific fuel consumption at 10^{O} ATDC Injection Timing setting decreased when using 0.4% and 0.2% 2-Ethylhexyl Nitrate blended biodiesel fuel and the use of Fuel Ionizer compared to using pure biodiesel fuel without the use of Fuel Ionizer. The lowest specific fuel consumption using 0.4% 2-Ethylhexyl Nitrate blended biodiesel fuel and the use of Fuel Ionizer and get a result of 0.000097 kg/HPh.

4 Conclusion

There is an influence of the power generated on the performance testing, namely the increase in power generated by the addition of 2-Ethylhexyl Nitrate as a mixture of biodiesel fuel and the use of Fuel Ionizer. performance testing using a mixture of 2-Ethylhexyl Nitrate biodiesel fuel and the use of Fuel Ionizer resulted in the highest increase of 68.1 Hp at the Injection Timing adjustment at 8^{O} ATDC, an increase of 1.8% compared to power testing with pure biodiesel without the use of Fuel Ionizer.

There is an effect of torque produced on performance testing, namely the increase in torque produced by the addition of 2-Ethylhexyl Nitrate as a mixture of biodiesel fuel and the use of Fuel Ionizer. torque performance testing using a mixture of 2-Ethylhexyl Nitrate biodiesel fuel and the use of Fuel Ionizer resulted in the highest increase of 127.1 Nm at Timing Injection adjustment at 8^{O} ATDC, an increase of 2% compared to power testing with pure biodiesel without the use of Fuel Ionizer.

There is an effect of specific fuel consumption produced on performance testing, namely by decreasing the specific fuel consumption produced by adding 2-Ethylhexyl Nitrate as a mixture of biodiesel fuel and the use of Fuel Ionizer. specific fuel consumption testing using biodiesel fuel mixed with 2-Ethylhexyl Nitrate and the use of Fuel Ionizer resulted in the lowest decrease of 0.000084 Kg / Hph.

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