Diesel engine performance test using solar-dex and biodiesel (B30) on power and torque

A Setiyawan¹, A Novianto¹, N B A Afkar¹, F Chabib¹, F R Amelia¹ and I Pratiwi²

¹Dept. of Mechanical Engineering, Universitas Negeri Semarang, Semarang, Indonesia
²Dept. of Civil Engineering, Universitas Negeri Semarang, Semarang, Indonesia

andrisetiyawan@mail.unnes.ac.id

Abstract. Biodiesel as renewable alternative energy produced from vegetable and animal oils can be used to fuel diesel engines. Pertamina has officially release Biodiesel B30, which sells on fuel stations in Indonesia. The purpose of this study is to investigate the diesel engine performance on Solar-Dex and Biodiesel blend. Testing the performance of a diesel engine by mixing Solar-Dex and Biodiesel on power and torque produces different data and can be concluded: (1) Pure Solar-Dex without the addition of Biodiesel gives the lowest power yield of 49.55 kW, while the data fluctuates when adding Biodiesel and it is known that the most considerable average power occurs when a mixture of Biodiesel is 30% with 70 Solar-Dex and 40% biodiesel with 60% Solar-Dex which is 54 kW. (2) Pure Solar-Dex without the addition of bio-diesel gives the lowest torque yield of 120.45 Nm, while the data fluctuates when adding Biodiesel and it is known that the most considerable average torque occurs when a mixture of 20% bio-diesel with 80 Solar-Dex is 122, 8 Nm.

1. Introduction

The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation[1]. Vehicles in Indonesia, which are increasing in number, are caused by people's living standards that are getting better and better. By 2015, Indonesia has proven petroleum reserves of 3.7 billion barrels, natural gas 100.3 TSCF and coal reserves of 32.27 billion tons which will be exhausted in 11 years, 36 years and 70 years for petroleum, natural gas and coal, respectively[2]. In addition, the various conveniences obtained to buy a vehicle are the cause of the increasing number of motorized vehicles today. The increase in population and needs over time have led to higher energy demands, including in Indonesia[3]. Biofuels are receiving a lot of attention in the public, private, and scientific domains[4]. Renewable liquids bio fuels for transportation have recently attracted huge attention in different countries all over the world because of its renewability, sustainability, common availability, regional development, rural manufacturing, jobs, reduction of greenhouse gas emissions and its biodegradability[5]. The rising public need for cars as a means of transportation for daily activities is also the cause of the increasing number of motorized vehicles. So this impacts the use of cars in Indonesia and in various countries it is difficult to limit it. The development of technology in the automotive world will produce vehicle products with large engine capacities. Vehicles that have a large engine capacity must be balanced with the suitability of fuel use. If the use of fuel is not following the engine's needs, it will interfere with the combustion process so that which can cause symptoms of knocking or detonation [6].
This machine was later improved and refined by Charles F. Kettering. The diesel engine is a type of engine with internal combustion, which is a process of burning fuel and air in the system. Diesel engines are very popular in the world of transportation and industry. This is because the diesel engine can produce a large amount of power. The use of diesel engines is relatively more fuel efficient than the use of gasoline engines [7].

Diesel engines have the best thermal efficiency compared to other internal and external combustion engines, due to their very high compression ratio. Low-speed diesel engines (as in ship engines) can have a thermal efficiency of more than 50%. Diesel engines were developed in two-stroke and four-stroke versions. This engine was originally used as a replacement for the steam engine. Since the 1910s, these machines began to be used for ships and submarines, followed by locomotives, trucks, power plants, and other heavy equipment. In the 1930s, diesel engines began to be used for cars. Since then, the use of diesel engines has continued to increase and according to the British Society of Motor Manufacturing and Traders, 50% of new cars sold in the European Union are diesel-engined cars, even 70% in France.

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This closed explosion causes the gases in the combustion chamber to expand rapidly, pushing the piston down and generating linear force. The connecting rod transmits this motion to the crankshaft, and the linear power is converted into rotary power by the crankshaft. The high compression allows combustion to occur without the need for a separate ignition system (in gasoline engines, a spark plug is used), so a high compression ratio increases engine efficiency. Raising the compression ratio in gasoline engines is limited to preventing pre-ignition damage.

Diesel fuel is produced from the petroleum processing process; basically, crude oil is separated from its fractions in the distillation process. It produces a diesel fraction with a boiling point of 250°C to 300°C. The quality of diesel is expressed by the cetane number (in gasoline, it is called octane), which is a number that indicates the ability of diesel fuel to burn in the engine and the ability to control the number of knocks.

The higher the cetane number in diesel, the better the quality of diesel fuel. Solar has various types, namely, 1) Biodiesel; 2) Dexlite / Solar-Dex; 3) Pertadex. Pertamina Dex or solar-dex is non-subsidized diesel fuel produced by Pertamina. One of the Dex series variants, launched on August 12, 2005, is a diesel fuel type with a cetane number of 53 and a sulfur content of less than 300 ppm. SolarDex specifications: Cetane number 53, Sulfur content max 300 ppm, maximum density 860kg/m3 & minimum 820 kg/m3 (at a temperature of 15 degrees Celsius), clear and bright visual appearance. Biodiesel is diesel engine fuel made from renewable materials or specifically diesel engine fuel consisting of alkyl esters of fatty acids made from vegetable oil, animal oil, or used/recycled cooking oil through a certain process (liquid fuel from plant processing).

Biodiesel has a lower calorific value than diesel, but has a higher cetane number [3][8]. Biodiesel produced from oil or fat through transesterification process is a liquid that has composition rather similar to diesel [9]. Other than being delivered from plants, biodiesel can likewise be created from squanders, like waste cooking oil or normally called utilized cooking oil. Biodiesel has a lower warming worth than diesel, but has a higher cetane number [10]. There are abundant sources of renewable energy, one of which is biofuel [8]. The purpose of this study is to investigate the diesel engine performance on solar-
dex and bio-solar blends. With this, the impact of using biodiesel will be known as an effort to use fuel that is more friendly to the environment.

2. Methods

This study use material were diesel fuel and biodiesel blends, namely B30. Diesel fuel was obtained from the PT Pertamina gas station. Table 1 shows the density and kinematic viscosity of the fuel.

| Fuel          | Density at 15°C (kg/m³) | Kinematic Viscosity at 40°C (mm²/s) |
|---------------|-------------------------|-------------------------------------|
| Solar-Dex     | 860                     | 4.5                                 |
| Biodiesel (B30)| 880                     | 5.0                                 |

2.1 Research Procedures

This research consists of three stages. First, prepare the tools and materials used for mixing biodiesel with solar using a stirrer. The next stage is the study of engine performance on various biodiesel blends (0%, 10%, 15%, 30%, 40%, and 50). After all the equipment is prepared and installed according to the designs and standards that have been carried out, the next process is the process of taking research data, which can be seen through the flow chart as in Figure 1.

![Figure 1. Test Data Retrieval Schematic Diagram](image-url)
3. Results

After data collection by mixing Solar Dex and Biodiesel fuel on power and torque, the data is processed and analysed. In this experiment, each performance test was carried out to collect data twice. Before this experiment, it was ensured that the supporting materials and equipment were prepared, and their condition checked. The data obtained from this experiment are then inputted into Table 2 as average test results. Figure 2 describes test results average power and torque.

| Biodiesel (%) | Averages |
|---------------|----------|
|               | Power (kW) | Torsion (Nm) |
| 0             | 49.65     | 120.45       |
| 10            | 53.75     | 122.6        |
| 20            | 53.95     | 122.8        |
| 30            | 54        | 121.4        |
| 40            | 54        | 121.2        |
| 50            | 53.55     | 121.6        |

Figure 2. Test Results Average Power and Torque
This experiment uses a dyno test engine media with power and torque analysis tools configured with a dyno test engine. Based on the experiments that have been carried out, the average value of the diesel engine power using a mixture of Biodiesel and Solar Dex fuels with variations in the presentation of the mixture amount is obtained. Mixing Solar Dex with Biodiesel is very influential on increasing the power produced, as seen from Figure 3, the power generated with 100% Solar Dex fuel obtained maximum power with an average of 49.55 kW; compared to the addition of a mixture of Biodiesel, the engine can produce a maximum power of above 53 kW. As in mixing 90% Solar Dex with 10% Biodiesel, the average maximum power is 53.75 kW. The maximum power produced in this diesel engine performance test is found in mixing 70% Solar Dex with 30% Biodiesel and 60% Solar Dex with 40% Biodiesel with a maximum power of 54 kW (average of 2 trials). However, the maximum power produced decreases when mixing 50% Solar Dex fuel with 50% Biodiesel, the maximum power produced in this mixing is 53.55 kW. Pure Solar Dex without the addition of bio-diesel gives the lowest power yield of 49.55 kW, while when adding Biodiesel, the data fluctuates, and it is known that the most significant average power occurs when a mixture of 30% bio-diesel with 70 Solar-Dex and 40% bio-diesel with 60% solar dextro which is 54 kW. Figure 4 describes test results average power and torque.

![Figure 3. Test Results Average Power and Torque](image1)

This experiment uses a dyno test engine media with a power and torque analysis device configured with a dyno test engine. Based on the experiments that have been carried out, the maximum torque value
is obtained. The maximum torque of a diesel engine with 100% Solar Dex fuel is 120.45 Nm. The addition of Biodiesel fuel affects the increase in the maximum torque value produced by the diesel engine. Based on Figure 3, torque increased by 122.6 Nm at a fuel composition of 10% Biodiesel - 90% Solar Dex. Torque at the fuel composition of 80% Solar Dex – 20% Biodiesel is 122.8 Nm. In this fuel composition, the largest maximum torque is obtained. However, at a fuel composition of 70% Solar-Dex – 30% Biodiesel, the maximum torque decreases with a value of 121.4 Nm. The decrease in torque value since the highest torque value was obtained at the fuel composition of 80% Solar-Dex – 20% occurs until testing with a fuel composition of 50% Solar-Dex – 50% Biodiesel. Pure Solar Dex without the addition of Biodiesel gives the lowest torque yield of 120.45 Nm, while the data fluctuates when adding Biodiesel, and it is known that the most significant average torque occurs when a mixture of 20% biodiesel with 80 Solar-Dex is 122.8 Nm.

4. Conclusion

Based on the research and observation of the data above, it can be concluded that in testing the performance of a diesel engine by mixing Solar-Dex and Biodiesel on power and torque, it produces different data and can be concluded: (1) Pure Solar-Dex without the addition of bio-diesel gives the lowest power yield of 49.55 kW, while the data fluctuates when adding bio-diesel. It is known that the largest average power occurs when a mixture of bio-diesel is 30% with 70 Solar-Dex and 40% biodiesel with 60% solar dex, which is 54 kW. (2) Pure Solar Dex without the addition of bio-diesel gives the lowest torque yield of 120.45 Nm, while the data fluctuates when adding bio-diesel, and it is known that the largest average torque occurs when a mixture of 20% bio-diesel with 80 Solar-Dex is 122, 8 Nm. The addition of biodiesel has a positive impact on increasing torque. Some biodiesel is also produced from used vegetable oils or animal fats, including recycled restaurant oil and grease. In some parts of the world, sizeable natural vegetation and forests have been cleared and burned to grow soybeans and palm oil trees to make biodiesel. The adverse environmental effects of this land clearing and burning may be greater than the potential benefits of using biodiesel produced from soybeans and palm oil trees.

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