The Effect Of Magnetic Field And Heater In Biodiesel Fuel Line Toward Torque, Power, and Fueld Consumption Of One Cylinder Four Stroke Diesel Engine At Maximum Load

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Abstract. Depletion of petroleum reserves causing scarcity and higher prices has lead to the rise of biodiesel fuel as a renewable alternative fuel source for diesel engine. Biodiesel has higher viscosity and flash point compared to that of diesel that it influences the combustion process in diesel engine. This research aims finding out the effect of integration of magnetic field and heating techniques in biodiesel exhaust toward torque, power and fuel consumption of one-cylinder R 175-A diesel engine, with B5 biodiesel fuel (95% diesel + 5% biodiesel from used cooking oil), with varying engine rotation of 1200, 1500, 1700, 2100, and 2500 rpm, with temperature heater set to 70°C, and with magnetic field strength of 0.0314 Tesla. The results show that the effects of magnetic field and heater were able to increase the performance of the optimum torque engine obtained at 1700 rpm and with the highest optimum torque from the use of marketed biodiesel fuels market with magnetic field and heater was 17.16Nm. The use of both with B5 biodiesel fuel at maximum load produced power of 4.081kw at the highest at 2500 rpm engine speed. It is concluded that the application of both can reduce fuel consumption to 10%. The magnetic field and heater in the fuel line affect the torque, power and fuel consumption of one cylinder four stroke diesel engine.

Keywords: *biodiesel, torque, power, diesel engine*

1. Introduction

Fossil fuel is one of the non-renewable natural resources. The results from recent study of the Department of Energy and Mineral Resources (ESDM) shows that without discovery of new sources, our oil reserves are only up to 18 years, natural gas 60 years, and coal 150 years. [1]. The increase in world crude oil prices peaked in mid-2008 broke down the economy and many aspects of life in Indonesia.

1.1. Biodiesel

Biodiesel is a very potential material for diesel fuel substitute since its raw material is from vegetable oil which is renewable and produces periodically. It is also environmentally friendly for it does not contain sulfur so it can reduce environmental damage caused by acid rain. Biodiesel as a substitute for diesel has several advantages, among which are cleaner exhaust emissions and better lubrication, [2].

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Tabel 1. Physical/chemical properties of biodiesel

Physical/chemical properties	Biodiesel	Diesel
Composition	Alkyl Esters	Hydrocarbon
Density, g/ml	0.8624	0.8750
Viscosity, cSt	5.55	4.6
Flash Point, °C	172	98
Cetane Number	62.4	53
Energy Produced	40.1 MJ/kg	45.3 MJ/kg

Source: Internasional Biodiesel, 2001

To produce a perfect combustion process within the combustion chamber of a diesel engine using biodiesel fuel, some treatments of biodiesel are required before it enters the combustion chamber including: heating which will affect viscosity and flash point. Initial heating of fuel is estimated to improve the performance of combustion engines . This is possible because by preheating the fuel, it becomes saturated and causes the fuel temperature to rise near its flash point, thus very flammable, or in other words preheating can improve combustion. Other treatment is magnetic field ionization. It is required to help fuel increase oxygen number more easily during the combustion process, so that the fuel and oxygen mixture can burn completely. Therefore, with a more perfect combustion, it can save fuel consumption [3].

Figure 1. Magnetic Ionization Process [4]

2. Research Methodology

2.1. Location of Study

This study was carried out in two stages: first was the construction of measuring parameter measuring instrument of the testing and second was of testing and data collection. The activities were carried out in the following stages:

a. Literature study, discussion and consultation related to topic (bio mass, biodiesel, new and renewable energy sources).
b. Instrument construction including the manufacturing of prony brake, fuel line with heater and magnetic field. They were carried out in the laboratory of Maintenance and Repair Engineering Study Program Politeknik Negeri Sriwijaya Palembang.
c. Raw materials preparation and biodiesel production from used cooking oil in chemical industry laboratory of chemical engineering department Politeknik Negeri Sriwijaya Palembang.
d. Engine performance testing which was carried out in laboratory of Maintenance and Repair Engineering Study Program Politeknik Negeri Sriwijaya Palembang.

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2.2. Reserach Materials

Biodiesel oil from used cooking oil, which was a result from a master's program research in Renewable Energy Engineering Department Politeknik Negeri Sriwijaya Palembang, which was mixed with diesel oil (95%); and biosolar B5 bought from public gas stations 24-301-03.

2.3. Research Instruments

- Diesel engine with the following specifications:

Type	: R175-A Single cylinder, Horizontal
Displacement	: 353 (cc)
Combustion Chamber	: Direct Injection
Diameter x Stroke	: 75 x 80 mm
Engine speed max	: 2600 rpm
Compression comparison	: 23: 1
Cooling system	: Water cooling-circulation

- Prony Brake Dynamometer
  It was designed and coupled with a single cylinder plywheel drum diesel engine as a test object. Prony-Brake was one of the tools used to measure the performance of combustion motor fuel. The main parameters of combustion motor performance include torque, power, rotation and fuel efficiency.

Figure.2. Prony-Brake Dynamometer coupled with engine flywheel

The basic principle used in the Prony-Brake type dynamometer is the utilization of the resistance from mechanical friction of the brake belt with the flywheel drum. The magnitude of mechanical resistance can be adjusted based on the weight of the load supported by the lever. Furthermore, the torque was known from the multiplication of the opposite direction force generated by each variation of rotation by the distance of the lever to the spindle of the rotating axis which was 0.3 meter. The multiplication of energy or torque per unit time or rotation per minute produces power [5].

2.4. Testing Procedures

Preparation

Before performing the test, to ensure the smoothness of the process and prevent accident or other problems from occurring, the following caution must be taken into attention: read carefully the SOPs in working in laboratory/workshop and in using tools, wear safety equipment, and then prepare and adjust test instrument. The whole process includes:

a. Preparing biodiesel fuel,
b. Checking the engine lubricant amount and quality,
c. Checking the condition of the test instrument, and inspect the entire fuel system,
d. Ensuring that the volume of cooling water at sufficient level,
e. Self-calibrate the measuring instrument,

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f. Installing the measuring instrument, trying out the electrical system of the instruments and tools,
g. Preparing tools for documentation and recording systems,
h. Installing a set of prony brakes coupled with a plywheel machine as a torque and power test tool, and
i. Turning on magnetization system and heater of the fuel line.

Data collection procedures

Data were collected with the following procedures:

a. Rotating the crankshaft for ± 10 minutes to operate the engine as an initial warm up in order to obtain a stable normal working temperature condition when taking data,
b. Turning on the biodiesel fuel line heating system, the temperature was set to 70 ° C [6],
c. Turning on the magnetic field ionization system,
d. Conducting testing with variations of engine speed: 1200, 1500, 1700, 2100 and 2500 rpm,
e. Providing a prony brake load force on the engine flywheel up to maximum load. Data collections were performed when the engine turns were stable. The data collected were: engine rotation data [rpm], torque [lbf.ft, kg, Nm], and fuel consumption [ml / min],
f. Carrying out each test three times with variations of engine rotation with or without heating and ionization of the magnetic field in the fuel line, and
g. Recording and labeling Test results for analysis and then proceeding with calculation and data analysis.

3. Result and Analysis

3.1. Testing Procedures

Prony brake dynamometer was used to find out the torque. Therefore the magnitude of torque is proportional to the force and can be calculated with the following formula:

$$T = F \, x \, L \, (kg.m) \quad (1)$$

The calculation result is:

F = 3kg L = 0.3m
= 3kg x 9.81m / s² x 0.3m T = 8.829Nm

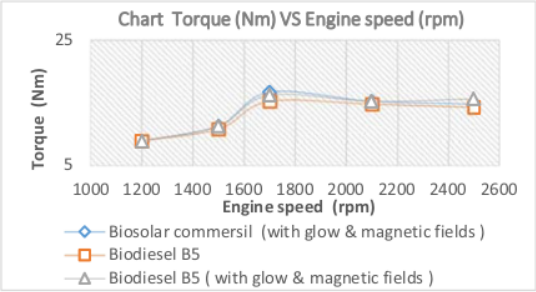

Figure.3. Comparison chart of torque vs. engine speed with maximum load

Figure 3 above shows that at maximum brake load, optimum torque was obtained at 1700 rpm engine speed by using marketed biosolar fuel with heater and magnetic field, and the lowest maximum torque occurs at 1200 rpm engine speed by using B5 biodiesel fuel without heater and magnetic field and with heater and magnetic field.

3.2. Power

Multiplication of torque per unit of rotation per minute produces power.

Power calculation: $P \; bhp = \frac{2\pi.n.T}{60}$

In which : n = engine rotation (rpm)
T = torque (Nm)

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Data from marketed biosolar fuel with heater & magnetic field show that the engine rotation, n = 1200 rpm, and torque = 9,329 Nm, it was calculated that:

$$P = \frac{2 \times 3{,}14\ (9{,}329)}{60} = 1{,}171 \text{kw} \quad (2)$$

As for the comparison of average power generated on each variation of engine rotation is displayed in the following graph:

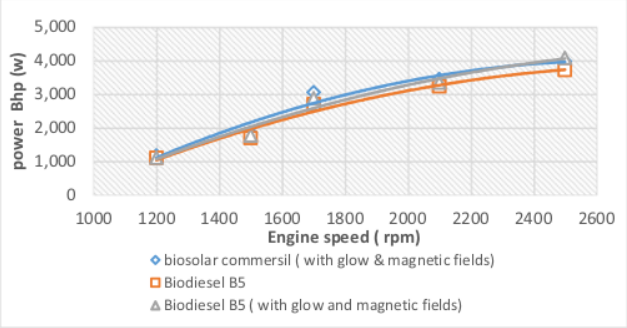

Figure.4. Power comparison chart vs engine speed with maximum load

The graph shows that the higher the engine speed the greater the power generated. The highest power is generated from the marketed biosolar fuel with heater and magnetic fields and it appears that biodiesel fuel with heater and magnetic fields ranks second in power generation. This indicates that heater and magnetic fields affect the effectiveness of combustion.

3.3. Fuel Consumption

In this study, the fuel consumption data were obtained from the volume of fuel used at the operation of one cylinder four stroke diesel engine with a maximum load on each variation of engine speed per unit of time. The charts below indicates that the higher the engine rotation the greater the fuel consumption of the diesel engine. Thus, these are in accordance with results of previous studies.

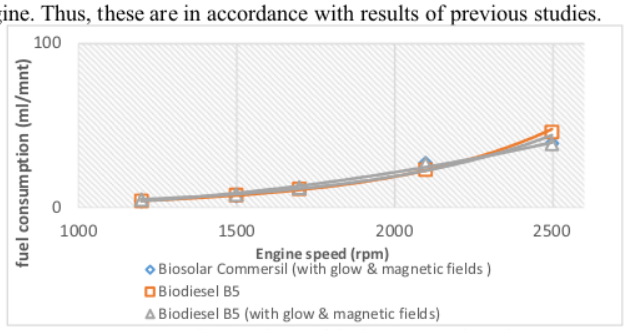

Figure 5. Comparison of fuel consumption chart

Naif F, et al, 2011 and Prasetyo et al., 2017 also produced similar results that fuel consumption increases as engine speed increases [7,8].

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4. Conclusion and Suggestion

4.1. Conslusion

From the results, it can be concluded that:

a. The magnetic field and heater in the fuel line affect the torque, power and fuel consumption of one cylinder four stroke diesel engine
b. Magnetic field and heater in the use of marketed biosolar fuel produces the highest torque.
c. The use of diesel fuel + 5% biodiesel from used cooking oils given with magnetic field and heaters produces the greatest power and in its normal use without magnetic fields and heater results in the highest fuel consumption.
d. Effectiveness of marketed B5 biosolar fuel combustion B5 without magnetic field and heater compared to diesel fuel + 5% biodiesel from used cooking oil with magnetic field and heater does exist but it is not significant.

4.2. Suggestion

- Unavailability of supporting tools is usually encountered as problem, therefore it is expected that the Mechanical Engineering Department and the Energy Engineering Department pay more attention in providing the tools.
- For further research development, it is suggested to use mixed fuel of diesel and biodiesel especially from used cooking oil with a more varied ratio to get the result of combustion and optimal performance of one cylinder four stroke diesel engine.

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