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The Effect of Using Various Magnetic Materials on Diesel Engines using Biodiesel Fuel

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***Abstract*— one of method to improve engine performance and reduce fuel consumption is to use exposure to magnetic fields in the fuel lines. Several studies have proven that magnetic field exposure can improve diesel engine performance. This research aims to test the performance of a diesel engine using fuels that are given a magnetic field from 3 types of permanent magnets, namely magnets made from Neodymium Iron Boron (NdFeB), Aluminum Nickel Cobalt (AlNiCo), and Ferrite (Fe). Performance tests on the Yanmar TF85MH diesel engine include power and torque. The fuel used in this research is Biodiesel B20. The results showed that neodymium magnets (NdFeB) are the best magnets of the 3 types of magnets tested with an average increase in power of 2.30%, an average increase in torque of 2.35%.**

Keywords—biodiesel B20, diesel engine, magnet, power, torque.

I. INTRODUCTION

Diesel fuel is a fuel produced from fossils or microorganisms that have been buried for millions of years. Diesel fuel contributes 80% to the world's energy needs [1]. Indonesia's oil and gas reserves over the past ten years have tended to decline in Petroleum Reserves from 8.21 billion barrels in 2008 down to around 7.5 billion barrels in 2018. Reserve to Production (calculated against Proven Reserves) is in the range of 10-11 years [2]. Therefore, a solution is needed to minimize the consumption of fuel, one of which is by using a permanent magnetic field in the fuel channel.

According to Jain in his research entitled "Experimental Investigation of Magnetic Fuel Conditioners (MFC) in I.C. Engine ", using MFC can enhance the internal energy of the fuel to cause particular changes at the molecular level which results in complete combustion. The fuel produced burns more completely, resulting in higher engine performance, better fuel economy, and a reduced amount of HC, CO, NOx in the exhaust. MFC increases vehicle mileage by 10% to 40%, reduces hydrocarbon emissions and other pollutants, prevents clogging of diesel engines, and reduces engine maintenance costs [3].

Other research was also conducted by Patel with the title "Effect of magnetic fields on performance and emission of single cylinder four stroke diesel engines". This research is about the effect of Ferrite (Fe) magnetized material on thermal efficiency, fuel consumption, hydrocarbon emissions (HC), carbon monoxide (CO), nitrogen oxides (NOx), and carbon dioxide (CO2). The results showed that diesel engine fuel consumption was reduced at low loading and high loading, thermal efficiency increased by 2%, NOx emissions reduced by an average of 27.7% at all loading levels, HC emissions decreased by an average of 30 % at all loading levels, CO emissions are reduced at low and high loading, and CO2 emissions are reduced by an average rate of 9.72% at all loading levels [4].

Neodymium magnets (NdFeB) are the most powerful permanent magnetic materials available today. The NdFeB magnet has the highest energy product approaching 52 MGOe. NdFeB is more expensive per weight as compared to Ferrite or AlNiCo but produces the highest amount of flux per unit mass or volume. The advantage of NdFeB magnets is that the energy products are very high, have very high coercivity, and have good temperature resistance. The disadvantages of NdFeB magnets are lower mechanical strength, and it has low corrosion resistance when it is not coated or not properly coated [5].

AlNiCo magnets consist of aluminum (Al), nickel (Ni), and cobalt (Co) alloys with small amounts of other elements added to increase their magnetic properties. The magnetic strength of AlNiCo can be reduced due to collisions with other objects. The advantages of AlNiCo magnets are high corrosion resistance, high mechanical strength, and it has very high-temperature resistance. The disadvantages are higher costs, low coercivity, and low energy products [5].

II. METHOD

The method used in this research is an experiment to obtain results. The following are the steps in an experiment.

A. Design Experiments

At this steps the design of the biodiesel fuel B20 system modeling will be carried out, with exposure to the magnetic field by referring to theories of the magnetic field to biodiesel B20. This design experiments has the following variables:

Fixed variable:

1. Engine speed (1800, 1900, 2000, 2100, and 2200 RPM).
2. The level of engine load (1 kw, 1.5 kw, 2 kw, 2.5 kw, 3 kw, 3.5 kw and 4 kw).

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3. Types of magnetic fields: Aluminum Nickel Cobalt (AlNiCo), Neodymium Iron Boron (NdFeB), and Ferrit (Fe).

Control variables:
1. The fuel temperature is the same (ambient temperature ~ 30C).
2. The same volume of fuel tested (20 ml).
3. Magnetic dimensions are the same (Diameter 10 mm and Length 10 mm).

Dependent variables:
1. Engine power.
2. Engine torque.

B. Engine Set-up

In the preparation of the test the initial checking and calibration on the engine setup is first about the physical condition, basic performance, full load to determine the initial condition of the diesel motor before conducting research. The diesel engine used in data retrieval is the YANMAR Diesel Engine with TF 85 MH-type with a capacity of 493 cc. The engine set up is shown in figure 1 below.

C. Data Analysis

In the analysis of the data proved one hypothesis, permanent smagnetic material that has a higher magnetic field intensity will have a greater influence on the performance of diesel engines.

The results of the analysis will be in the form of a graph comparing the level of difference in power and torqueof diesel engines that use 3 types of magnets with different materials and without using magnets.

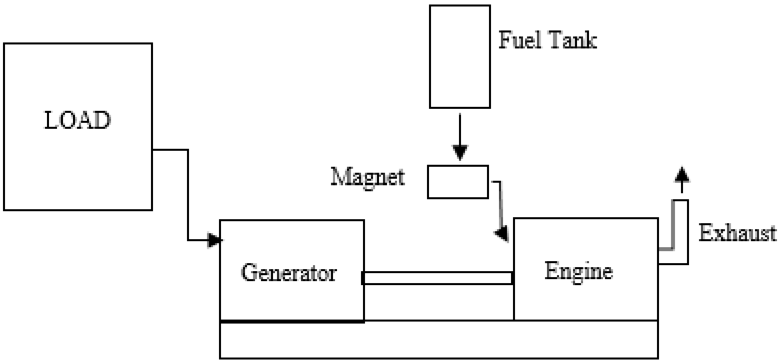

Figure. 1. Engine setup.

III. Results and Discussion

In this part, will be discussed about the results of experiments and data of experimental displayed in graphs & tables and then analyzed.

A. Power at Full Load condition at Constant Speed

The results are that fuels with the influence of neodymium magnets have the highest power value of all fuel variables, which is 4.169 Kw at 2200 RPM. For variable fuels with the influence of Ferrite magnets, AlNiCo and without magnets have the highest power of 4,147 KW, 4,155 KW, and 4,072 KW at 2200 RPM. Under full load conditions, fuels with Neodymium magnetic field effects have the greatest power among all fuel variables. The data shown in figure 2.

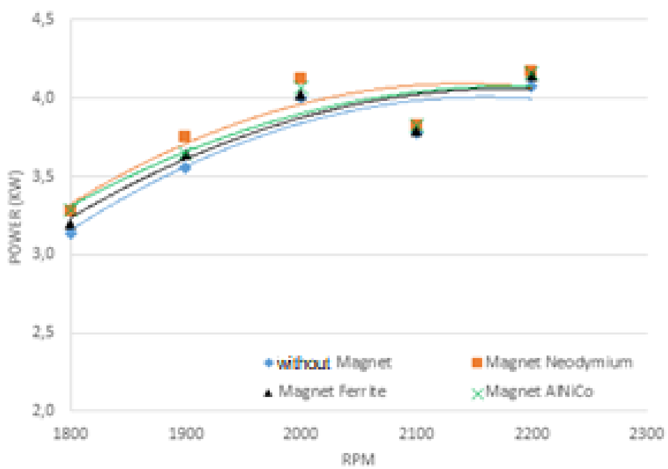

Figure. 2. Power analysis at full load per RPM.

B. Torque at Full Load condition at Constant Speed

The results are that a fuel with Neodymium magnetic influence has the highest torque value of all fuel variables, which is 19.667 Nm at 2000 RPM. For fuel variables with the influence of Ferrite magnets, with the influence of AlNiCo magnets, and without the influence of magnets have the highest torque of 19,198 Nm, 19,440 Nm, and 19,067 Nm at 2000 RPM. Under full load conditions, fuels with Neodymium magnetic field effects have torque the biggest among all fuel variables. The data shown in figure 3.

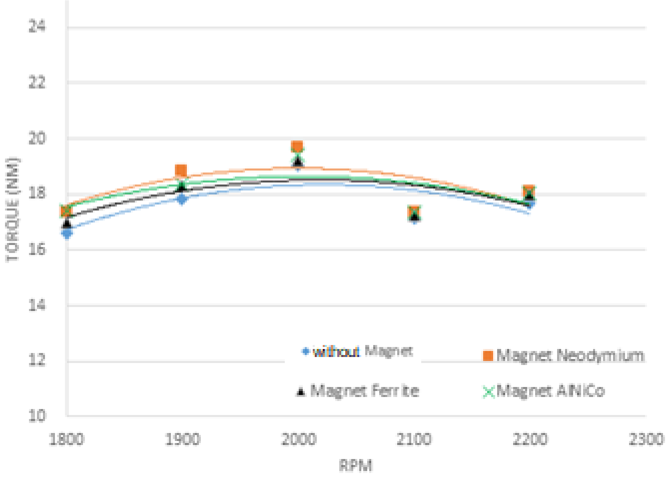

Figure. 3. Torque analysis at full load per RPM.

C. Comparative Analysis of Diesel Engine Power On Each Magnet Type

At this step, an analysis of the average value of the power of each RPM is carried out to determine how much increased power is given by the magnetic fields of 3 different types of material. Table 1 shows the average value of the power of each RPM, table 2 shows a comparison of the level of increase in diesel engine power per RPM of each magnet, and table 3 shows the average value of the overall increase in power of each magnet.

TABLE. 1.
POWER AVERAGE AT CONSTANT SPEED

Power Average (kW)				
RPM	**Non-Mag**	**Neody**	**Ferrit**	**AlNiCo**
1800	2,242	2,329	2,279	2,323
1900	2,519	2,593	2,545	2,570
2000	2,822	2,891	2,843	2,878
2100	2,783	2,813	2,790	2,808
2200	2,709	2,741	2,718	2,734

TABLE. 2.
PERCENTAGE OF INCREASED POWER TO BIODIESEL WITHOUT MAGNETS

Power Average (%)			
RPM	**Neody**	**Ferrit**	**AlNiCo**
1800	3,89%	1,65%	3,63%
1900	2,91%	1,00%	2,01%
2000	2,42%	0,73%	1,98%
2100	1,10%	0,25%	0,91%
2200	1,18%	0,32%	0,90%

TABLE. 3.
TOTAL AVERAGE OF POWER INCREASE

Total Power Average (%)			
RPM	**Neody**	**Ferrit**	**AlNiCo**
2200	2,30%	0,79%	1,88%

In table 3, the Neodymium magnetic field produces the average value of the greatest overall increase in power among the 3 types of magnets. Neodymium magnetic fields produce an average increase in overall power value of 2.30%, AlNiCo magnetic fields produce an average increase in overall power value of 1.88%, and Ferrit magnetic fields produce an average increase in overall power value of 0.79 %. The magnetic fields can change the order of hydrocarbon molecules from the state of "para" to "ortho" [6-7].

Under ortho conditions, intermolecular strength decreases and widens the distance between hydrogen atoms. This hydrogen fuel earnestly locks in with oxygen and produces better combustion in the combustion chamber, so that power increases [3].

D. Comparative Analysis of the Torque of Diesel Engine on Each Magnet Type

At this stage, the average value of the torque per RPM is analyzed to find out how much the increase in torque is given by the magnetic fields of 3 different types of material. Table 4 shows the average value of torque for each RPM, table 5. shows a comparison of the rate of increase in the torque of a diesel engine per RPM of each magnet, and table 6. shows the average value of the increase in overall torque of each magnet.

TABLE. 4.
TORQUE AVERAGE AT CONSTANT SPEED

Torque Average (Nm)				
RPM	**Non-Mag**	**Neody**	**Ferrit**	**AlNiCo**
1800	11,879	12,346	12,082	12,316
1900	12,648	13,029	12,780	12,908
2000	13,461	13,793	13,566	13,738
2100	12,642	12,784	12,677	12,760
2200	11,751	11,896	11,797	11,862

TABLE. 5.
PERCENTAGE OF INCREASED TORQUE TO BIODIESEL WITHOUT MAGNETS

Torque Average (%)			
RPM	**Neody**	**Ferrit**	**AlNiCo**
1800	3,93%	1,70%	3,67%
1900	3,01%	1,05%	2,06%
2000	2,47%	0,78%	2,06%
2100	1,13%	0,28%	0,93%
2200	1,23%	0,39%	0,94%

TABLE. 6.
TOTAL AVERAGE OF TORQUE INCREASE

Total Torque Average (%)			
RPM	**Neody**	**Ferrit**	**AlNiCo**
2200	2,35%	0,84%	1,93%

In table 6, the Neodymium magnetic field produces the average value of the greatest overall increase in power among the 3 types of magnets. Neodymium magnetic fields produce an average value of an increase in overall torque of 2.35%, an AlNiCo magnetic field produces an average value of an increase in overall torque of 1.93%, and a Ferrit magnetic field produces an average value of an increase in overall torque of 0.84 %. The magnetic fields can change the order of hydrocarbon molecules from the state of "para" to "ortho" [6-7].

Under ortho conditions intermolecular strength decreases and widens the space between hydrogen atoms. This hydrogen fuel earnestly locks in with oxygen and produces better combustion in the combustion chamber, so torque increases [3].

IV. CONCLUSION

Based on the results of calculations and analyzes that have been carried out related to the influence of the magnetic field on biodiesel B20 fuel on the performance of diesel engines, it can be concluded that:

Neodymium magnets (NdFeB) are permanent magnets that improve the performance of diesel engines best among the 3 tested magnets. Neodymium magnets produce an overall average power increase of 2.30% and an overall average torque increase of 2.35%.

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