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Effect of Using Magnetic Coil in Fuel Pipeline on Multi-Cylinder Gasoline Engine Performance

Febrian Arif Budiman[1*], Alfin Miftakhul Huda[1], Sonika Maulana[1]

1 Department of Mechanical Engineering, Faculty of Engineering, Universitas Negeri Semarang, Indonesia

*febrian.arif.budiman@mail.unnes.ac.id

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Abstract
The increase in automotive technology, especially cars, has caused the availability of fuel to decrease. This is because more and more fuel are needed by vehicles while the amount of fuel on earth is dwindling because petroleum is a non-renewable natural resource. Motorized vehicles must not only save fuel but also have good performance. The better the fuel quality, the better the combustion process so that the greater the power and torque produced. So there needs to be an ideal fuel mixture for good combustion of multi-cylinder gasoline engine performance. Several things can be done to improve engine performance and fuel economy ranging from creating fuel saving devices, changing engine construction, hybrid technology to finding alternative fuels. This research uses an experimental research method with a descriptive quantitative approach to determine the effect of using magnetic coils on fuel pipelines on engine performance. The results showed the largest increase in power value of 12.89% in the use of magnetic coil with a copper wire diameter of 0.40 mm using first fuel at 2500 rpm. While the largest increase in torque value of 70.60 Nm to 79.70 Nm on the use of magnetic coil with a copper diameter of 0.40 mm at 2500 rpm using first fuel.

1 Introduction

Technology and science are developing rapidly. The automotive field is one of them that has experienced this development. With the development of technology and science in the automotive field, humans began to make various kinds of vehicles to meet their needs and mobility. The existence of these vehicles is expected to increase productivity and time efficiency. The development of technology encourages the production of more vehicles. According to data from the Association of the Indonesian Automotive Industry (GAIKINDO) and the Indonesian Motorcycle Industry Association (AISI) in the Central Statistics Agency [1], the total national vehicle production in 2016-2020 reached 215,100,850 units, with the number of car production reaching 112,745,987 units.

The increase in automotive technology, especially cars, has caused the availability of fuel to decrease. This is because more and more fuel are required by vehicles while the amount of fuel on earth is depleting because petroleum is a non-renewable natural resource. In addition, petroleum continues to be the main source of fuel. Petroleum currently makes up 95% of transportation fuels, in addition 60% of petroleum production is used for transportation fuels [2]. According to the Director General of Oil and Gas [3]. In 2008 oil production in Indonesia amounted to 312,484 thousand barrels, decreased to 301,663 thousand barrels in 2009, in 2010 again decreased to 300,923 thousand barrels, the decline also occurred in 2011 to 289,899 thousand barrels and in 2012 again decreased to 279,412 thousand barrels.

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In the last ten years, there has been a decrease in domestic fuel production while the amount of domestic consumption continues to increase, resulting in a deficit that causes fuel imports from abroad to meet domestic fuel needs.

In addition to saving fuel, motorized vehicles must also have good performance. Good performance is needed so that the engine can work optimally. Engine performance is directly correlated with torque and power. The amount of rotating moment that occurs on the engine output shaft due to loading with mass (kg) is called torque, while power is defined as the power produced by the motor per unit time [4]. The combustion process and the fuel used affect the power and torque produced by the engine. The more perfect the combustion process, the greater the power generated. Likewise with fuel, the better the quality of the fuel, the better the combustion process so that the greater the power produced. There needs to be an ideal fuel mixture for good combustion. "The method that can be used is the application of magnetic fields (electromagnets) because it uses a fairly simple coil" [5]. This tool is installed on the fuel line pipe and serves to break up the hydrocarbon molecules that clump together by utilizing the resonance effect of the electromagnetic field. With the rupture of hydrocarbon molecules, oxygen will react more easily so that the combustion process is better and improve the exhaust gas combustion results [6] with better combustion, the power generated will be greater and fuel consumption will be more efficient.

Several things can be done to improve engine performance and fuel economy ranging from creating fuel saving devices, changing engine construction, hybrid technology to finding alternative fuels. Adding a fuel-saving device is something that is often done by people because it is easier, more practical and does not change the engine construction directly compared to other methods. Various treatments on the vehicle can also be done to improve engine performance and save fuel consumption such as treating the ignition system, lubrication system, and fuel system. One method that is claimed to improve engine performance and save fuel consumption is to treat the fuel before it enters the intake manifold. One method that can be used to improve fuel efficiency is by treating the fuel before combustion using an electromagnetic field [7].

Fuhaid, et al [8] in their research on the Effect of Electromagnetic Fields on Fuel Consumption and Exhaust Gas Emissions on Gasoline Motors using permanent magnets wrapped around a wire with a diameter of 0.25 mm stated that the use of magnetic fields can save 20.3% fuel consumption if the use of the vehicle does not exceed the load and according to its use. Vehicle exhaust gases become more environmentally friendly because CO and HC decrease. Tests conducted with and without a magnetic field at 1000-2500rpm show that the use of magnets reduces fuel consumption and produces higher power and efficiency than tests without magnets.

Previous research only discussed the effect of electromagnets on power, torque and fuel consumption when electromagnets were installed and not installed, without changing the power of the electromagnets. As a result, the magnitude of the more effective electromagnet field is unknown. Therefore, when a magnetic field is added to the fuel line, the magnetic field of hydrocarbon compounds will also change. As a result, the hydrocarbon compounds become more active and easily bind to oxygen when the fuel enters the chamber. This can result in more complete combustion and can reduce exhaust emissions produced during combustion in the combustion chamber.

Based on the background that has been described above, the researcher is interested in taking the title of "The Effect of the Use of Magnetic Coil in the Fuel Pipe Channel on the Performance of a Multi Cylinder Gasoline Engine".

2 Research Methods

This research was designed as a type of experimental research. Experimentation is a research method designed to investigate a phenomenon by engineering circumstances or conditions, seeing the results, and interpreting them [9]. The design used in this study used a pre-experimental design category design. Thyer [10] says that pre-experimental design, which means that if manipulations are carried out and

repeated measurement or control groups are used, although inconsistent and randomization is not used. The purpose of the pre-experimental design is to show the causal relationship.

The test equipment in this study is a tool used in research to determine the results of the influence of the tools used in the study. In this study to examine engine performance using a dynotest tool. The tool used can determine the results of power and torque generated from motorized vehicles and can determine the engine speed and temperature of the vehicle being tested. This test uses a 1300 cc Daihatsu Granmax vehicle with the aim of knowing the effect of using a magnetic coil on the fuel line pipe on the performance of a multi-cylinder gasoline engine. The magnetic coil variation used is 4000 turns using copper wire diameters of 0.30 mm, 0.35 mm, 0.40 mm and the fuels used are pertalite and firstx.

The data collection method used in the research is the observation method. The observation method in the research is to test the power and torque without using a fuel magnetization device as a comparison of performance and turn off the engine and then install a megnetization device between the fuel filter and injector, after making variations with coil windings. The variations used in this study are 0.3 mm, 0.35 mm, 0.4 mm. The measurement process for each variation was repeated twice.

In this study, the data analysis technique used was descriptive. Descriptive statistics are used to analyze data by describing or describing the data as it is without intending to make general conclusions or generalizations [11]. This descriptive analysis method will explain the current data and make systematic, actual, and accurate descriptions of matters relating to the use of electromagnets with significant variations in copper diameter in fuel pipelines on the performance of multi-cylinder gasoline engines.

3 Result and Discussion

3.1 Power and Torque Testing

Table 1. Power and torque using pertalite fuel

Electromagnetic Field	RPM	Power (HP)	Torque (Nm)
Without Electromagnetic Field	2500	28.03	79.60
	3000	44.25	104.65
	3500	51.80	105.05
	4000	59.51	105.65
	4500	71.52	112.80
	5000	78.32	111.20
	5500	84.50	109.05
	6000	89.32	105.65
Electromagnetic Field	**RPM**	**Power (Hp)**	**Torque (Nm)**
Electromagnetic Field 0.30 mm	2500	26.51	75.20
	3000	44.50	105.15
	3500	52.56	106.45
	4000	60.78	107.70
	4500	73.45	115.75
	5000	79.58	112.85
	5500	85.26	109.90
	6000	89.57	105.80
Electromagnetic Field	**RPM**	**Daya (Hp)**	**Torque (Nm)**
Electromagnetic Field 0.35 mm	2500	28.38	80.80
	3000	43.90	103.70
	3500	51.65	104.85
	4000	59.66	105.95
	4500	72.64	113,95
	5000	79.23	112.45

	5500	84.55	108.90
	6000	89.01	104.90
Electromagnetic Field	**RPM**	**Power (Hp)**	**Torque (Nm)**
Electromagnetic Field 0.40 mm	2500	27.62	78.60
	3000	44.55	105.60
	3500	52.51	106.55
	4000	60.68	107.80
	4500	73.10	115.40
	5000	79.74	113.30
	5500	85.62	110.65
	6000	90.18	106.80

Table 2. Power and Torque using Pertamax fuel

Electromagnetic Field	**RPM**	**Power (Hp)**	**Torque (Nm)**
Without Electromagnetic Field	2500	24.83	70.60
	3000	45.21	107.15
	3500	53.07	107.80
	4000	61.33	109.10
	4500	74.06	117.05
	5000	80.55	114.55
	5500	86.12	111.30
	6000	90.63	107.40
Electromagnetic Field	**RPM**	**Power (Hp)**	**Torque (Nm)**
Electromagnetic Field 0.30 mm	2500	24.43	69.65
	3000	44.81	106.00
	3500	52.67	106.75
	4000	60.83	107.95
	4500	73.45	115.80
	5000	80.39	114.05
	5500	86.28	111.35
	6000	90.84	107.45
Electromagnetic Field	**RPM**	**Power (Hp)**	**Torque (Nm)**
Electromagnetic Field 0.35 mm	2500	27.22	77.35
	3000	44.86	106.25
	3500	52.77	107.10
	4000	60.98	108.35
	4500	73.80	116.60
	5000	80.34	114.20
	5500	85.77	110.85
	6000	90.23	106.85
Electromagnetic Field	**RPM**	**Power (Hp)**	**Torque (Nm)**
Electromagnetic Field 0.40 mm	2500	28.03	79.70
	3000	44.25	105.7
	3500	52.16	105.8
	4000	70.36	107.05
	4500	73.25	115.65
	5000	80.19	113.95
	5500	85.87	110.95
	6000	90.43	107.10

1. Test results without using electromagnetic fields using fuel using Pertalite

Table 3. Power and Torque without Electromagnetic Fields

Electromagnetic Field	RPM	Power (Hp)	Torque (Nm)
Without Electromagnetic Field	2500	28.03	79.60
	3000	44.25	104.65
	3500	51.80	105.05
	4000	59.51	105.65
	4500	71.52	112.80
	5000	78.32	111.20
	5500	84.50	109.05
	6000	89.32	105.65

To make it easier to understand the test results without a magnetic coil, table 3 above will be changed into a graph and can be seen in graph figure 1 below:

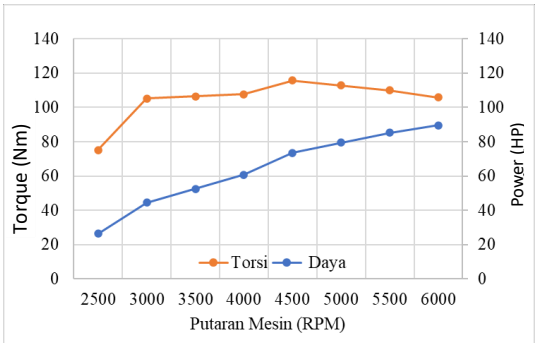

Figure 1. Power and Torque Graph Without Magnetic Coil

Figure 1 is the result of power and torque testing without using a magnetic coil on a Daihatsu Granmax car. The blue graph is power, and the orange graph is torque. The power graph experiences a stable increase from 2500 rpm to 6000 rpm. The torque obtained tends to experience a significant increase at 2500 rpm to 3000 rpm and is stable but begins to decrease at 4500 rpm to 6000 rpm.

2. Test results with an electromagnetic field with a diameter of 0.30 mm using Pertalite fuel

Table 3. Power and Torque of Electromagnetic Field with Diameter 0.30 mm

Electromagnetic Field	RPM	Power (Hp)	Torque (Nm)
Electromagnetic Field 0.30 mm	2500	26.51	75.20
	3000	44.50	105.15
	3500	52.56	106.45
	4000	60.78	107.70
	4500	73.45	115.75
	5000	79.58	112.85
	5500	85.26	109.90
	6000	89.57	105.80

In order to make it easier to understand the results of magnetic coil testing with a copper wire diameter of 0.30 mm, table 4 above will be changed into a graph and can be seen in graph image 2 below:

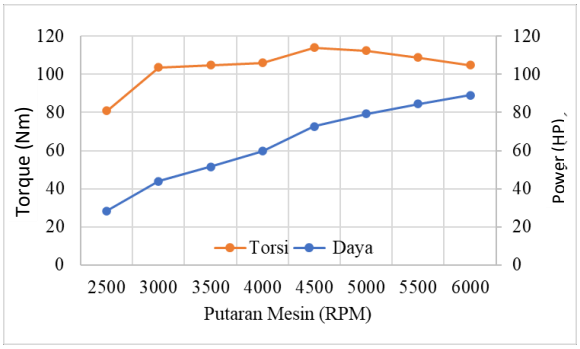

Figure 2. Power and Torque Graph of Magnetic Coil Diameter 0.30 mm

Figure 4.3 is the result of testing a magnetic coil with a diameter of 0.30 mm, the power generated in this test experienced a stable increase. The torque generated experienced a significant increase at 2500 rpm to 3000 rpm and was stable then decreased at engine speeds of 4500 rpm to 6000 rpm.

3. Test results with an electromagnetic field diameter of 0.35 mm using Pertalite fuel

Tabel 5. Power and Torque Electromagnet diameter 0,35 mm

Electromagnetic Field	RPM	Power (Hp)	Torque (Nm)
Electromagnetic Field 0.35 mm	2500	28.38	80.80
	3000	43.90	103.70
	3500	51.65	104.85
	4000	59.66	105.95
	4500	72.64	113.95
	5000	79.23	112.45
	5500	84.55	108.90
	6000	89.01	104.90

To make it easier to understand the results of magnetic coil testing with a copper wire diameter of 0.35 mm, table 5 above will be changed into a graph and can be seen in the graph image 3 below:

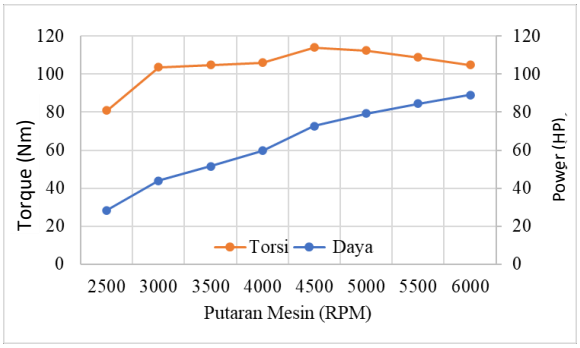

Figure 3. Power and Torque Graph of Magnetic Coil with a diameter of 0.35 mm

Figure 4.4 shows that power increases steadily at engine speeds of 2500 rpm to 6000 rpm. The torque generated in this test increases at 2500 rpm to 3000 rpm and decreases at 4500 rpm to 6000 rpm.

4. Test results with an electromagnetic field diameter of 0.40 mm using Pertalite fuel

Table 6. Power and Torque of Electromagnetic Field diameter 0.40 mm

Electromagnetic Field	RPM	Power (Hp)	Torque (Nm)
Electromagnetic Field 0.40 mm	2500	27.62	78.60
	3000	44.55	105.60
	3500	52.51	106.55
	4000	60.68	107.80
	4500	73.1	115.40
	5000	79.74	113.30
	5500	85.62	110.65
	6000	90.18	106.80

To make it easier to understand the results of magnetic coil testing with a copper wire diameter of 0.40 mm, table 6 above will be changed into a graph and can be seen in graph image 4 below:

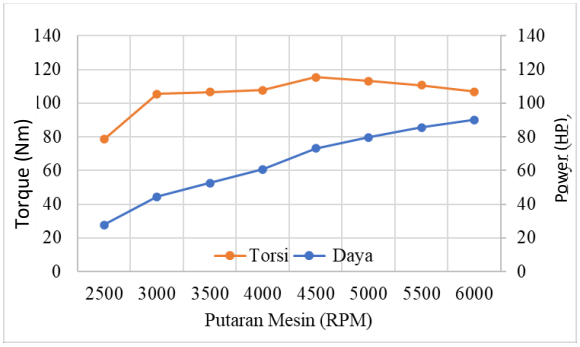

Figure 4. Power and Torque Graph of Magnetic Coil with a diameter of 0.40 mm

Figure 4 The power generated in this test experienced a stable increase from engine speed of 2500 rpm to 6000 rpm. The torque generated experienced a drastic increase at 2500 rpm to 3000 rpm and tended to experience a decrease at 4500 rpm to 6000 rpm.

5. Test results without using an electromagnetic field using Pertamax fuel

Table 7. Power and Torque without an Electromagnetic Field

Electromagnetic Field	RPM	Power (Hp)	Torque (Nm)
Without Electromagnetic Field	2500	24.83	70.60
	3000	45.21	107.15
	3500	53.07	107.80
	4000	61.33	109.10
	4500	74.06	117.05
	5000	80.55	114.55
	5500	86.12	111.30
	6000	90.63	107.40

To make it easier to understand the test results without using a magnetic coil tool, table 7 above will be changed into a graph and can be seen in graph image 5 below:

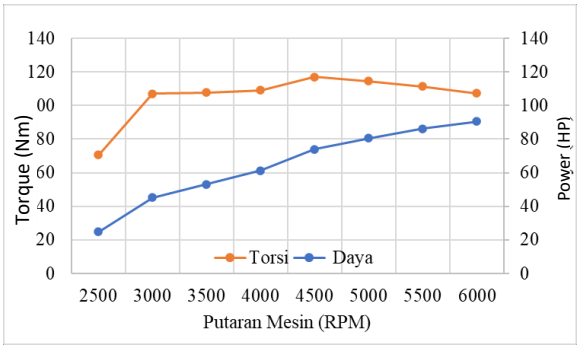

Figure 5. Power and Torque Graph Without Magnetic Coil

The graph above explains a significant increase at 2500 rpm to 3000 rpm and experiences a stable increase at engine speeds of 3000 rpm to 6000 rpm. The resulting torque increases drastically at 2500 rpm to 3000 rpm and experiences a stable increase up to 4500 rpm. At 4500 rpm to 6000 rpm it decreases.

6. Test results with an electromagnetic field diameter of 0.30 mm using Pertamax fuel

Table 8. Power and Torque of Electromagnetic Field Diameter 0.30 mm

Electromagnetic Field	RPM	Power (Hp)	Torque (Nm)
Electromagnetic Field 0.30 mm	2500	24.43	69.65
	3000	44.81	106.00
	3500	52.67	106.75
	4000	60.83	107.95
	4500	73.45	115.80
	5000	80.39	114.05
	5500	86.28	111.35
	6000	90.84	107.45

In order to make it easier to understand the results of magnetic coil testing with a copper wire diameter of 0.30 mm, table 8 above will be changed into a graph and can be seen in the graph image 6 below:

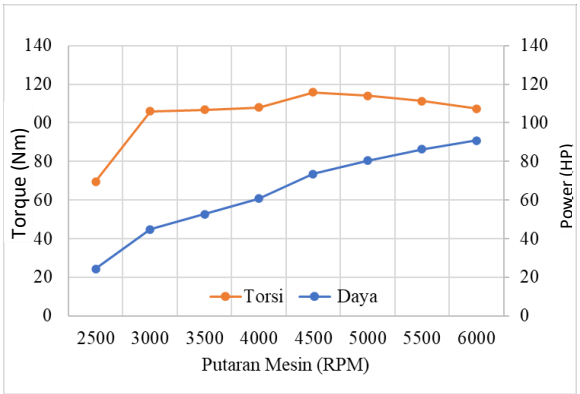

Figure 6. Power and Torque Graph of Magnetic Coil with a diameter of 0.30 mm

Figure 6 shows that the power generated increases at 2500 rpm to 3000 rpm and then at 3000 rpm to 6000 rpm there is a stable increase. Torque increases significantly at 2500 rpm to 3000 rpm, tends to be stable at 3000 rpm to 4500 rpm and decreases at 4500 rpm to 6000 rpm.

7. Test results with an electromagnetic field with a diameter of 0.35 mm using Pertamax fuel

Table 9. Power and Torque of an Electromagnetic Field with a diameter of 0.35 mm

Electromagnetic Field	RPM	Power (Hp)	Torque (Nm)
Electromagnetic Field 0.35 mm	2500	27.22	77.35
	3000	44.86	106.25
	3500	52.77	107.10
	4000	60.98	108.35
	4500	73.8	116.60
	5000	80.34	114.20
	5500	85.77	110.85
	6000	90.23	106.85

To make it easier to understand the results of magnetic coil testing with a copper wire diameter of 0.35 mm, table 9 above will be changed into a graph and can be seen in the graph image 7 below:

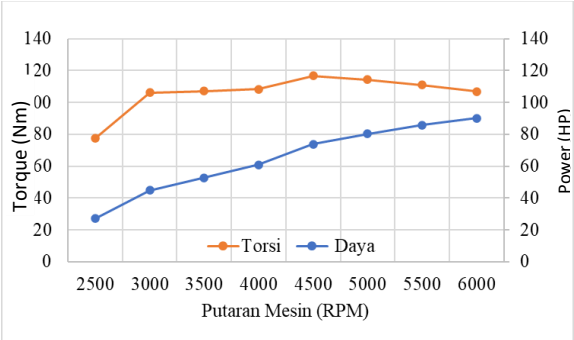

Figure 7. Power and Torque Graph of Magnetic Coil with a diameter of 0.35 mm

Figure 7 power in this test experienced a stable increase at engine speeds of 2500 rpm to 6000 rpm. The resulting torque increased at engine speeds of 2500 rpm to 3000 rpm tended to be stable until 4500 rpm and decreased from 4500 rpm to 6000 rpm.

8. Test results with an electromagnetic field with a diameter of 0.40 mm using Pertamax fuel

Table 10. Power and Torque of Electromagnetic Field with a diameter of 0.40 mm

Electromagnetic Field	RPM	Power (Hp)	Torque (Nm)
Electromagnetic Field 0.40 mm	2500	28.03	79.70
	3000	44.25	105.7
	3500	52.16	105.8
	4000	70.36	107.05
	4500	73.25	115.65
	5000	80.19	113.95
	5500	85.87	110.95
	6000	90.43	107.10

To make it easier to understand the results of magnetic coil testing with a copper wire diameter of 0.40 mm, table 10 above will be changed into a graph and can be seen in the graph image 8 below:

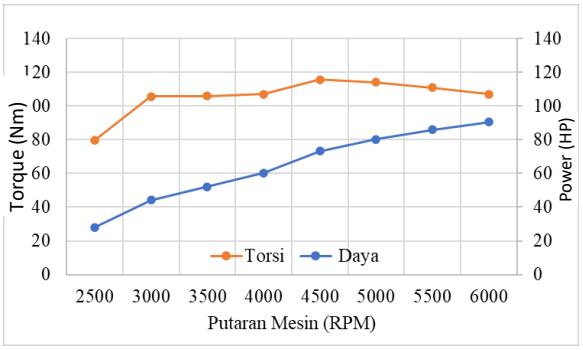

Figure 8. Power and Torque Graph of Magnetic Coil with a diameter of 0.40 mm

Figure 4.9 the power test produced experienced a stable increase at 2500 rpm to 6000 rpm. The torque in this test experienced a significant increase at 2500 rpm to 3000 rpm tending to be stable until 4500 rpm and decreased at 4500 rpm to 6000 rpm.

1. Power Test Data Analysis

Power data analysis aims to make it easier to determine the effect of using a magnetic coil on the power produced by the Daihatsu Granmax car. From the test results, the power value is obtained after getting the value, then an average is carried out, then a graph is made containing engine rotation parameters and power values in order to compare and prove the differences in power test results for each magnetic coil variation.The conclusion should be short and clear.

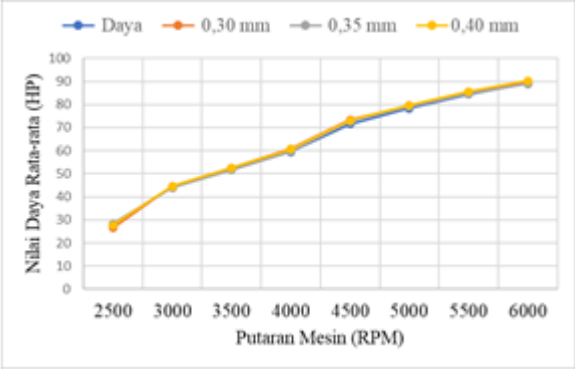

Figure 9. Power Analysis Graph using Pertalite Fuel

Figure 9 shows that there is a difference in the results of the Daihatsu Granmax car power test without using a magnetic coil and using a variation of the magnetic coil with Pertalite fuel. The test results without using a magnetic coil are represented by a blue diagram, a magnetic coil with a copper wire diameter of 0.30 mm is orange, a magnetic coil with a copper wire diameter of 0.35 mm is gray, and a magnetic coil with a copper wire diameter of 0.40 mm is yellow.

Based on the graph 9, it shows that the use of a magnetic coil can increase the maximum power of the Daihatsu Granmax car. The magnetic coil with a copper size of 0.30 mm has increased with the highest power value from the standard, namely 71.52 HP to 73.45 HP with a percentage increase of 2.70% at an engine speed of 4500 rpm. Meanwhile, in the electromagnetic field test with a large copper wire diameter of 0.35 mm, namely 84.50 HP to 84.55 HP, the power increase was 0.06% at an engine speed of 5500 rpm. In this test, there was also the largest power decrease of 5.42%, which was originally a standard power value of 28.03 HP to 26.51 HP at an engine speed of 2500 rpm. This decrease occurred in the power test using an electromagnetic field with a large copper diameter of 0.30 mm. The lowest decrease occurred at an engine speed of 3500 rpm of 0.29%, which was originally a power of 51.80 HP to 51.65 HP.

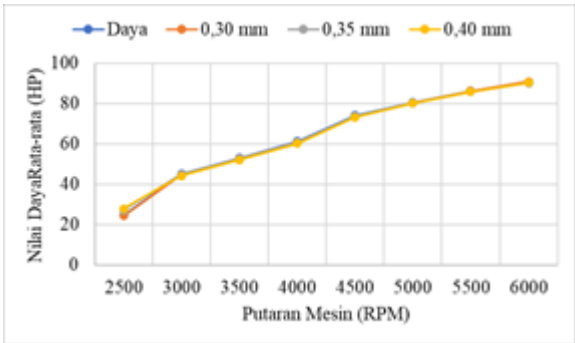

Figure 10. Power Graph Using Pertamax Fuel

Figure 10 shows the highest power value obtained in the magnetic coil test with a large copper wire diameter of 0.40 mm, which is 24.83 HP to 28.03 HP at an engine speed of 2500 rpm. The data shows an increase of 12.89% and the lowest power increase occurs in the magnetic coil test with a copper wire size of 0.30 mm, which is 0.19% at an engine speed of 5500 rpm.

While in other magnetic coil variations there are several test values that experience a decrease in power. The largest power decrease is found in the magnetic coil test with a copper wire size of 0.40 mm, which is 45.21 HP to 44.25 HP, which shows a power decrease of 2.12% at an engine speed of 3000 rpm. While the lowest power decrease is at 5000 rpm with a power value of 80.55 HP to 80.39 HP, a decrease of 0.20% on the 0.30 mm copper wire.

2. Torque Test Data Analysis

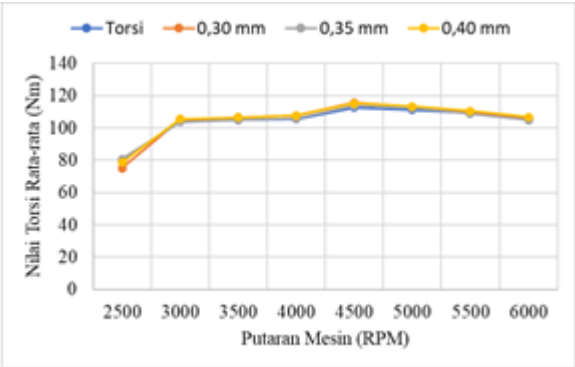

Figure 11. Torque Graph Using Pertalite Fuel

Figure 11 shows the highest torque increase at 4500 rpm using an electromagnet with a copper wire size of 0.30 mm, which is 112.80 Nm from 115.75 Nm, an increase if expressed as a percentage reaches 2.62%. The torque with the lowest increase is found in the electromagnetic with a copper wire size of 0.30 mm of 105.65 Nm which was previously 105.80 Nm at 6000 rpm, which shows a large increase of 0.14% from the standard torque.

The graph also shows the largest decrease in torque using an electromagnet with a copper size of 0.30 mm from 79.60 Nm to 75.20 Nm. This shows a decrease of 5.53% at 2500 rpm. Meanwhile, the electromagnet with a copper wire size of 0.35 mm showed the lowest decrease, namely 0.14% at an engine speed of 5500 rpm with a standard torque test value of 109.05 Nm to 108.9 Nm.

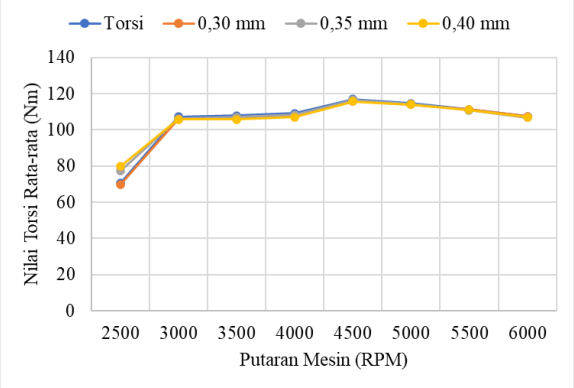

Figure 12. Torque Graph using Pertamax Fuel

Figure 12 shows an average decrease in torque value. The highest decrease experienced was 1.88% which occurred in the use of an electromagnetic with a copper wire size of 0.40 mm which was initially 109.10 Nm to 107.05 Nm at an engine speed of 4000 rpm. The lowest decrease occurred at 6000 rpm with a standard test data value of 107.4 Nm to 107.10 Nm which showed a percentage value of 0.28%.

The highest increase in torque also occurred in testing an electromagnetic with a copper wire size of 0.40 mm, namely 12.89% at an engine speed of 2500 rpm with standard test results of 70.60 Nm to 79.70 Nm. The lowest increase occurred at an engine speed of 5500 rpm in testing an electromagnetic with a copper wire size of 0.30 mm of 0.04%.

Discussion

1. The effect of using magnetic coils on the power of the Daihatsu Granmax car

Based on the results of the study that have been tested and analyzed, it shows that the use of magnetic coils has an effect on increasing power. The highest power increase shows the use of magnetic coils with a large copper wire diameter of 0.40 mm in testing using Pertamax fuel. The standard power value of 24.83 HP becomes 28.03 HP and shows an increase of 12.89% at 2500 rpm. While the lowest power increase is found in testing magnetic coils with a copper wire size of 0.35 mm in testing using Pertalite fuel. The increase in power with an initial value of 84.50 HP to 84.55 HP is 0.06% at an engine speed of 5500 rpm. According to Mara, et al. (2018), the effective power produced is greater because the engine speed is greater than the number of combustions per minute. Hamdhani and Sudarmanta (2017), stated that the power value will increase along with the torque when magnetic field induction is applied to the fuel flow.

The average power test graph shows that the magnetic coil can affect the decrease in power value. The largest decrease in power value in the electromagnetic field test with large pertalite fuel with a copper diameter of 0.30 mm from 28.03 HP to 26.52 HP with a percentage decrease of 5.42% at 2500 rpm engine speed. While the lowest decrease with a power value of 80.55 HP to 80.39 HP, if presented to 0.20% at 5000 rpm. This occurs in the power test using pertamax fuel. Majedi and Puspitasari (2017), explained in their research that when the engine speed increases, the power and torque values will decrease.

2. Effect of Using Magnetic Coil on the Torque of Daihatsu Granmax Car

Based on torque testing using electromagnetic field variations, there is an increase in torque value. The highest increase in torque value of 12.89% occurred in testing with an electromagnetic field using Pertamax fuel. Testing using an electromagnet with a copper size of 0.40 mm at an engine speed of 2500 rpm. The data presented states the lowest torque increase with a value of 111.35 Nm from the standard 111.30 Nm at 5500 rpm. This shows an increase of 0.04% which was tested with an electromagnetic field of 0.30 mm

using Pertamax fuel. Mara, et al (2018) In their research, the electromagnetic fuel magnetization tool on the performance of a four-stroke single-cylinder engine produced the highest torque of 0.82 kgf.m (an increase in torque value of 12.50%) at an engine speed of 6000 rpm with a variation of 4000 turns.

The torque value test also decreased in testing using Pertalit and Pertamax fuel. The highest torque value reduction using an electromagnetic field with a copper size of 0.30 mm using pertalite fuel with a standard torque value of 79.60 Nm to 75.20 Nm at 2500 rpm, if presented it becomes 5.53%. While the lowest torque value reduction occurred in testing using pertalite fuel with a copper wire size of 0.35 mm, namely 109.05 Nm to 108.90 Nm at 5500 rpm. The percentage of torque reduction was 0.14% when using pertalite fuel. Majedi and Puspitasari (2017), explained in their research because of the nature of gasoline engines when the mixture of fuel and air enters the cylinder space at high speed, the piston speed cannot be balanced when the torque and power reach their highest conditions at higher engine speeds. Mulyono, et al. (2014), stated the relationship between torque and engine speed if the engine speed is higher, the torque is more likely to decrease.

Mara, et al. (2018) In his research, the electromagnetic fuel magnetization device on the performance of a four-stroke single-cylinder engine produced the highest torque of 0.82 khf.m (an increase in torque value of 12.50%) at an engine speed of 6000 rpm with a variation of 4000 turns. Khasbullah, (2019) has studied how variations of 2 electromagnetic fields in the fuel pipe affect engine performance and fuel consumption, and found that the variation test provided the highest torque (0.0143-Neutral-0.0143 Tesla) of 3.04% of the standard test at an engine speed of 8500 rpm

4 Conclusion

Research on the effect of using magnetic coils on fuel pipelines on the performance of multi-cylinder gasoline engines has been conducted. Based on the results of the research and discussion that have been carried out, it can be concluded that:

1. The use of variations in magnetic coils affects the power produced by the Daihatsu Granmax 1300 cc car. The results obtained in the test using magnetic coils obtained the highest power value of 24.83 HP with an increase of 12.89% from the standard test with a power value of 28.03 HP at 2500 rpm. This occurred in the test using an electromagnet with a large copper wire diameter of 0.40 mm with pertamax fuel. In the magnetic coil variation test using pertalite fuel, the power value tends to increase from the power value of the standard test. While in the magnetic coil variation test using pertamax fuel, the power value tends to decrease from the power value of the test without an electromagnetic field.
2. The use of variations in magnetic coils affects the torque produced by the Daihatsu Granmax 1300 cc car. The torque data value with the largest increase occurs in the use of an electromagnetic field with a large copper wire diameter of 0.40 mm with pertamax fuel. The results shown in this study are 79.70 Nm from the standard test results of 70.60 Nm. The data shows an increase of 12.89% at 2500 rpm engine speed. In the electromagnetic field variation test using pertalite fuel, the torque value shows an increase from the standard torque test data value. While in the magnetic coil variation test using pertamax fuel tends to decrease from the standard torque data value.

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