The Effect of Magnetic Intensity on the Characteristics of a Mixed LPG and Gasoline + Bioethanol Engine

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Abstract: LPG fuel has a high calorific value, is widely available in the market and has low exhaust emissions of CO, CO2 and HC. However, NOx levels are high due to high combustion temperatures so that engine performance decreases. To overcome this, this machine is equipped with magnets and LPG fuel combined with a mixture of bioethanol-gasoline. The purpose of this study was to analyze the magnetic field strength of the engine performance using a mixture of LPG and bioethanol-gasoline. The object of this research is a gasoline engine. The composition of the bioethanol-gasoline fuel is (10:90, 15:85, 20:80). The magnet used has a magnetic intensity of 1500 Gauss. The independent variable is the variation of the fuel mixture and magnetic field, while the fixed variable is engine performance (exhaust emissions, power and torque). As a result, the average engine power increases by 8-16%, engine torque increases by 5-15% and exhaust emissions of HC, NOx and CO are reduced by 47%, 44% and 62%, respectively. In the future, LPG and gasoline-bioethanol mixtures can be used in vehicles as an alternative to electric vehicles. The drawback, the aesthetics of this LPG-fueled vehicle is less attractive.

1 INTRODUCTION

Several research results show that the use of a magnetic field in the engine can improve combustion efficiency and reduce emissions of combustion products (Cetin, 2011). Increased combustion efficiency can maintain energy security because it can save the amount of fuel used. Reducing emissions can make combustion more environmentally friendly. In addition to the use of magnets in the engine, the use of alternative fuels such as LPG and bioethanol is one of the efforts to improve combustion quality and environmentally friendly exhaust emissions.

The selection of LPG fuel as one of the objects of research is because LPG exhaust emissions are environmentally friendly, abundant in market availability and relatively cheap prices. The use of LPG in engines can provide engine life up to twice that of gasoline engines and is relatively safe (Sayin Kul and Ciniviz, 2020). The disadvantage of LPG is that it produces high levels of NOx because it has a fairly high combustion temperature (Dhande, Sinaga and Dahe, 2021). To overcome this deficiency, one of them is mixing LPG with bioethanol. In certain compositions, the addition of bioethanol to the engine has been proven to not cause technical problems and is very environmentally friendly (Silitonga *et al.*, 2018). The combustion temperature of bioethanol is low so that it can neutralize NOx formed from LPG gas. On the other hand, the performance of engines fueled by bioethanol is lower than that of engines fueled by LPG because bioethanol has a low calorific value.

The description above shows the lack of these two fuels, namely that they have not been able to produce optimum engine performance, therefore the presence of a magnetic field is very necessary, because the magnetic field through the cluster-decluster effect is proven to improve the quality of

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combustion which in turn increases engine performance. In addition, mixing the two fuels is carried out with the aim of improving engine performance, so the purpose of this study is to analyze the effect of magnetic fields on engine performance using a mixture of LPG and bioethanol. In the future, this research will be used as an engine model with maximum performance and minimum exhaust emissions using environmentally friendly fuels.

2 LITERATURE REVIEW

Excellent fuel structure for internal combustion engine is the most challenging approach to achieve good engine performance and lower gas emissions. Therefore, some researchers have made efforts to modify the characteristics of the fuel to increase combustion efficiency and reduce pollutant products using a magnetic field. Among the fuels structural modification method, utilizing electromagnetic field is one of the powerful techniques that has been used to produce better fuel conditioning (TH. Nufus, R. P. A. Setiawan, W. Hermawan, 2017). Strategy facilitates the alternation of fuel properties with changes in molecular structure. Magnetic fuel treatment affects better atomization which reduces the amount of HC, CO and NOx.

The study reveal that, a significant improvement in performance of coated engine operating on dual fuel mode (LPG-biodiesel) with additive by an increase in efficiency of 4.5% and decrease in brake specific fuel consumption of 4.2% at 80% of full load, HC and CO emissions are reduced between 9% and 12% at entire load spectrum compared to uncoated engine operating on diesel fuel. NOx emission is drastically reduced up to 32% for dual fuel with additive compared to without additive in coated engine operation and very close to diesel fuel in uncoated engine operation (Musthafa, 2019).

In this study; an experiment was carried out to examine the effects of LPG-ethanol fuel blends on the emission performance of a four cylinder SI engine.

Performance tests were conducted to determine the correct air/fuel ratio (lambda = 1). Exhaust emissions were analyzed for CO, CO2, NOx, HC, O2 using LPG-ethanol blends with different percentages of fuel blends at variable engine speeds ranging between 1000 and 5000 rpm. It was observed that depending on the rate of ethanol increase in mixture, the CO2, CO, NOx and HC emission concentrations in the engine exhaust gases decreased (TH Nufus *et al.*, 2020).

Automobile fuel system created with the concept of dual fuel, which allows the car can be operated with gasoline or LPG and bioethanol mixture alternately. The result is the lowest CO emission is obtained at 30% gas valve opening and 750 rpm engine speed. The lowest HC emission is obtained at 50% gas valve opening and 3000 rpm engine speed. Optimum torque is obtained at 50% gas valve opening and 3000 rpm engine speed. While the bioethanol valve opening has no significant effect (Nibin, Raj and Geo, 2021).

The present investigation was conducted on a 4-cylinder diesel engine fueled with either pilot diesel, or pilot waste cooking oil biodiesel (WCOB), and fumigated liquified petroleum gas (LPG) at three loads. The LPG addition is expressed in terms of a LPG power substitution percentage (LPSP), ranging from 10 to 30% at each load. the result that both types of dual fuel operation can lead to reduction in both NOx and PM emissions, with LPG-Diesel operation being more effect in reducing NOx emissions while LPG-WCOB operation more effective in reducing particulate emissions (Duc and Duy, 2018).

Diesel engine using diesel/biodiesel mixture with liquefied petroleum gas (LPG) and cooled exhaust gas recirculation (EGR) inducted in the intake port. The optimal operating factors for acquiring the largest fuel consumption time, the lowest smoke and NOX are decided for 1500 rpm and different loads. The results display that predictions by Taguchi method are in fair consistence with the confirmation results, and this method decreases the number of experimental runs in this study. The best fuel consumption time, smoke, and NOX at each load is acquired at a combination of B10 (A1), 40% LPG (B3) and 20% EGR ratio (C1) (Vinoth *et al.*, 2017).

3 RESEARCH METHODS

The materials used in this study were bioethanol from cassava with a content of 98% and gasoline with an octane number of 90 as a mixture of bioethanol. The fuel system is made with a dual fuel concept that can be operated with gasoline or with fuel mixture of LPG and bioethanol alternately. the test engine is a 125cc motorcycle. The engine performance test is carried out using a dynamometer with the scheme shown in Figure 1. The parameters measured in this test are torque, engine power at various percentages of mixtures, and exhaust emissions. Measurements were made in the engine speed range of 1500-3500 RPM. The magnitude of the magnetic field used The strength of the magnetic field used is 1500 Gauss. As a control is an engine without fuel magnetization.

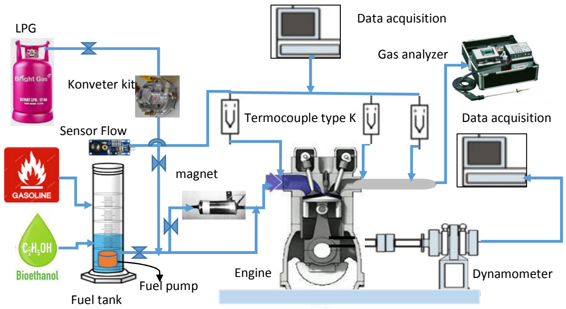


Figure 1: Gasoline engine performance testing installation.

The tools and materials used in this study are specified in Tables 1 and 2. The composition of a mixture of gasoline and bioethanol E0, E10, E15 and E20. other tools, namely the combustion quality improvement device and a 12 volt battery voltage source. Motorcycle performance testing using a dynamometer connected to data acquisition. The research begins with the calibration of the required equipment, inspection of diesel engine components such as: lubricating oil, lubricating oil filter, fuel filter. Parameters observed are Torque, Power and fuel consumption. The test starts by starting the engine at 1000 rpm and then holding it for ± 10 minutes to get a normal engine working temperature. After the machine is operating normally, data retrieval begins. Data collection is done by looking at the measuring instrument and taking notes on the note sheet.

Table 1: Engine Specification (TH Nufus *et al.*, 2020).

Parameter	Value
Diameter x Stroke	52.4 x 57.9mm
Cylinder Volume	125 cc
Compression ratio	9.5 : 1
Maximum Power	7 kW / 8000 rpm
Maximum Torque	9.6 Nm / 5500 rpm
Engine oil	0.84 liter
Transmission System	CVT Outomatic
Tipe Kopling	dry, Centrifugal Automatic
Ignation System	TCI/ Fuel Injection

Data processing

Power (break horse power) Brake horse power is the power generated from the engine output shaft [13].

$$bhp = .\ \omega . T$$
$$bhp = 2\pi\ .\ n\ .\ T / 746\ (hp)$$

with:

T = Torque (N.m)
n = rotation of the waterbrake dynamometer shaft (rps)

Fuel consumption is the amount of fuel used by the engine for a certain unit of time. While sfc (specific fuel consumption) is the amount of engine fuel consumption during a certain unit of time to produce effective power. If in the test data is obtained regarding the use of fuel m (kg) in s (seconds) and the power produced is bhp (hp), then the fuel consumption per hour is: Power (end horsepower), Brake horsepower is the power generated of the engine output shaft. Specific fuel consumption (specific fuel consumption)

SFC= (3600. mbb)/bhp (kg/kW.hr)
with:
mbb = fuel consumption per unit time (kg/hour)
s = fuel consumption time (seconds)
sfc = specific fuel consumption (kg/kW.hour)

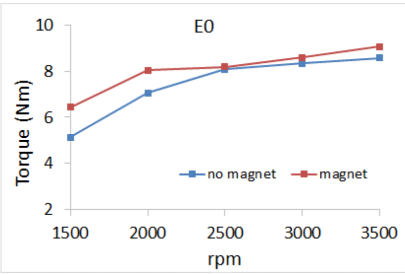
Table 2: Properties of gasoline and bioethanol (Silitonga *et al.*, 2018).

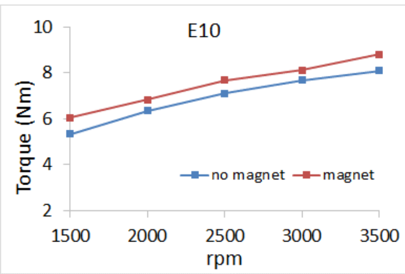
Fuel Type	Gasoline	Bioethanol
Formula (liquid)	C_8H_{18}	C_2H_5OH
Molecular weight (g/mol)	11.15	46.07
Density (kg/m3)	765	785
Viscosity (cSt)	9.792	6.891
Heat of vaporization (kJ/kg)	305	840
Specific heat (kJ/kgK) liquid	2.4	1.7
Specific heat (kJ/kgK) vapour	2.5	1.93
Lower heating value	44000	26900
Stoichiometric air-fuel ratio by mass	14.6	9
Research octane number	92	108.6
Motor octane number	85	89.7
Enthalphy of formation (MJ/kmol) liquid	259.28	224.10

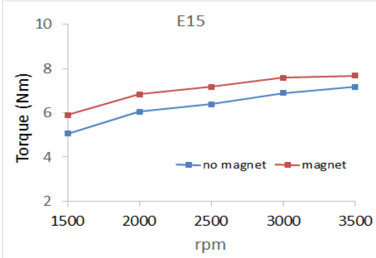
4 RESEARCH RESULT

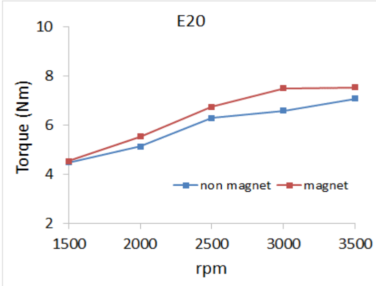
Figure 2 presents a graph of the relationship between torque and engine torque, it appears that the increase in torque is proportional to the increase in engine speed until it reaches the maximum value so that the amount of fuel entering the combustion chamber increases as a result of which the fuel energy is converted into the mechanical energy (torque) generated through the combustion process is getting bigger. After reaching the maximum value, the torque produced by the engine decreases because the time available for combustion at high rpm is very short. However, in the graph above, there is no visible decrease in torque, this is because the engine speed has not reached a critical or maximum speed due to the limited capabilities of the testing equipment in the laboratory.

The torque generated by the engine with the magnetized fuel is higher than that of the unmagnetized fuel. For E0 fuel (100% gasoline) there is an increase of around 6-15%. For E10 fuel, the increase in torque is around 5-11%, for E15 fuel, the torque increase is around 6-12%, for E20 fuel, the torque increase is around 5-10%. The increase in torque due to fuel magnetization is due to the magnetic field affecting the molecular structure of the hydrocarbons contained in the fuel causing the breakdown of the hydrocarbon chain into smaller parts or the fuel molecules changing from cluster to de cluster. In addition, the arrangement of the fuel atoms is parallel to the direction of the given external magnetic field or the fuel molecules are neatly arranged, so that it will be easier to react with oxygen obtained from the outside air and produce a more complete combustion. Complete combustion will result in increased torque.









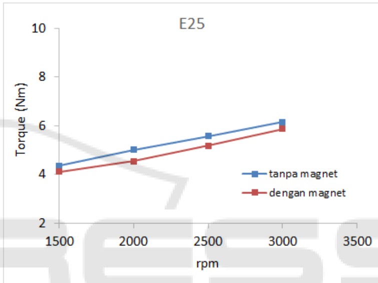


Figure 2: Torque testing result: *a* – E0; *b* – E10; *c* – E15; *d* – E20, *e* – E25.

Figure 3 presents a graph of the relationship between power and engine torque, it appears that the increase in power is proportional to the increase in engine speed until it reaches the maximum value so that the amount of fuel that enters the combustion chamber increases as a result of which the fuel energy is converted into The mechanical energy (power) produced through the combustion process is greater. After reaching the maximum value, the power produced by the engine decreases because the time available for combustion at high rpm is very short. However, in the graph above, there is no visible decrease in power, this is because the engine speed has not reached a critical or maximum speed due to the limited capabilities of the testing equipment in the laboratory. Figure 3 shows the power generated by an engine with a magnetized fuel being higher than that of an unmagnetized fuel. For E0 fuel (100% gasoline) there is an increase in power ranging from 8-17%. The increase in E10 fuel is around 6-10%, E15 fuel increases in power by 5-13%, and E20 fuel has an increase in power of 5 - 10%.

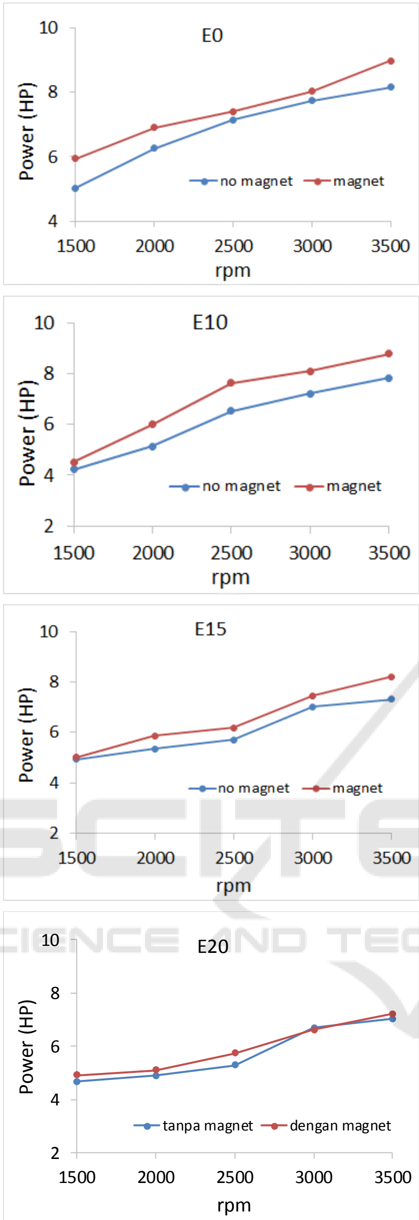


Figure 3: Power testing result: *a* – E0; *b* – E10; *c* – E15; *d* – E20.

The increase in power due to fuel magnetization is due to the magnetic field affecting the molecular structure of the hydrocarbons contained in the fuel causing the breakdown of the hydrocarbon chain into smaller parts or the fuel molecule changing from cluster to de cluster. In addition, the arrangement of the fuel atoms is parallel to the direction of the given external magnetic field or the fuel molecules are neatly arranged, so that it will be easier to react with oxygen obtained from the outside air and produce a more complete combustion.

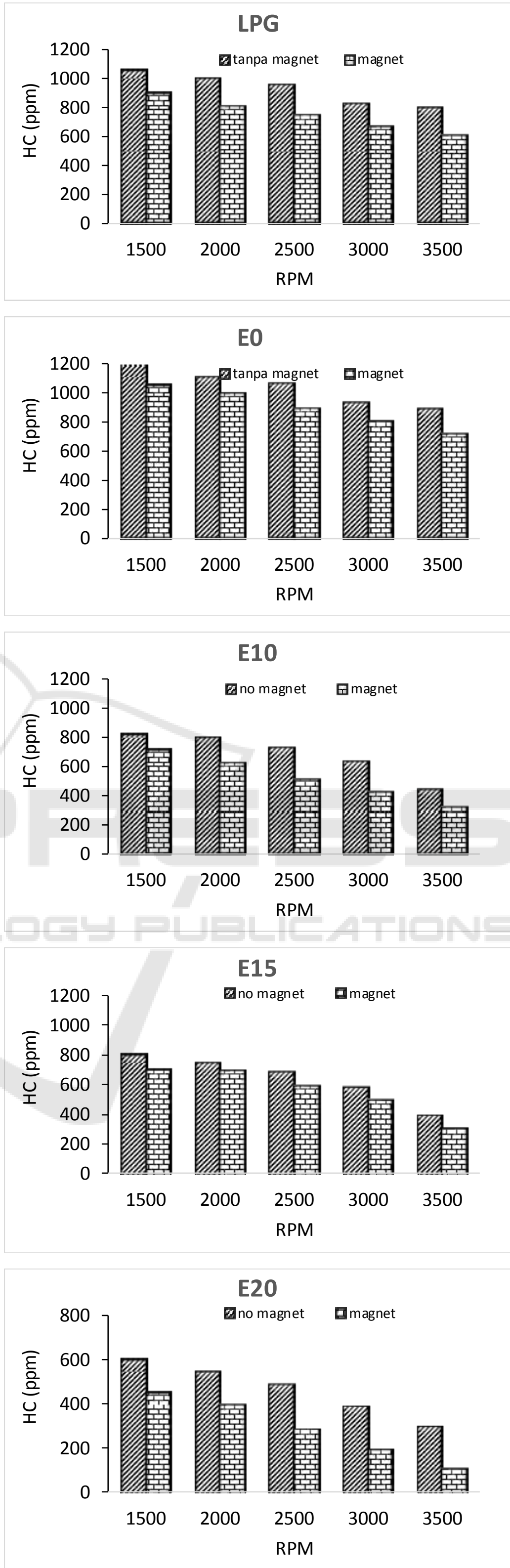


Figure 4: Emission HC testing result: *a* – LNG; *b* – E0; *c* – E10; *d* – E15; *e* – E20.

Complete combustion will result in increased torque. Based on the description above, the largest increase in torque is experienced by gasoline fuel compared to other fuels mixed with bioethanol, considering that bioethanol has lower energy than gasoline, however, bioethanol has a higher octane value than gasoline, while a mixture of gasoline and Bioethanol which experienced the largest increase was E15, the same as torque.We strongly encourage authors to use this document for the preparation of the camera-ready. Please follow the instructions closely in order to make the volume look as uniform as possible (Lee and Park, 2020).

Figure 4 shows the results of the HC emission test, it appears that the HC value in an LPG-fueled engine is smaller than that of gasoline. This is because LPG is an environmentally friendly gas and the difference is around 9.43-22.04%. On the other hand, an LPG-fueled engine when compared to a mixture of gasoline and bioethanol, the HC level is lower in a mixture of gasoline + bioethanol, this is because the molecular bonds of bioethanol contain oxygen which causes the combustion to become more complete so that HC exhaust emissions are reduced, the difference is around 22-46 %. The higher the bioethanol content, the lower the HC emission level. Likewise, if the fuel, either LPG, gasoline or bioethanol, is passed through a magnetic field, the HC content will be even smaller, this is due to the cluster-decluster effect which is reduced by up to 47%.

Air consists of 80% by volume of nitrogen and 20% by volume of oxygen. At room temperature, there is little tendency for nitrogen and oxygen to react with each other. Nitrogen contained in the combustion air can be oxidized and form toxic NOx, if the combustion process occurs at a high enough temperature.

Figure 5. Showing the results of the NOx emission test, it appears that the NOx value in the LPG-fueled engine is smaller than that of gasoline. This is because LPG is an environmentally friendly gas and the difference is around 10-34%. On the other hand, an LPG-fueled engine when compared to a mixture of gasoline and bioethanol, the NOx level is lower in a gasoline + bioethanol mixture, this is because the molecular bonds of bioethanol contain oxygen which causes the combustion to become more complete so that NOx exhaust emissions are reduced, the difference is around 9-24 %. The higher the bioethanol content, the lower the NOx emission level. Likewise, if this fuel is passed through a magnetic field, the NOx content will be even smaller, this is due to the cluster-decluster effect, which reduces to 44.61%.

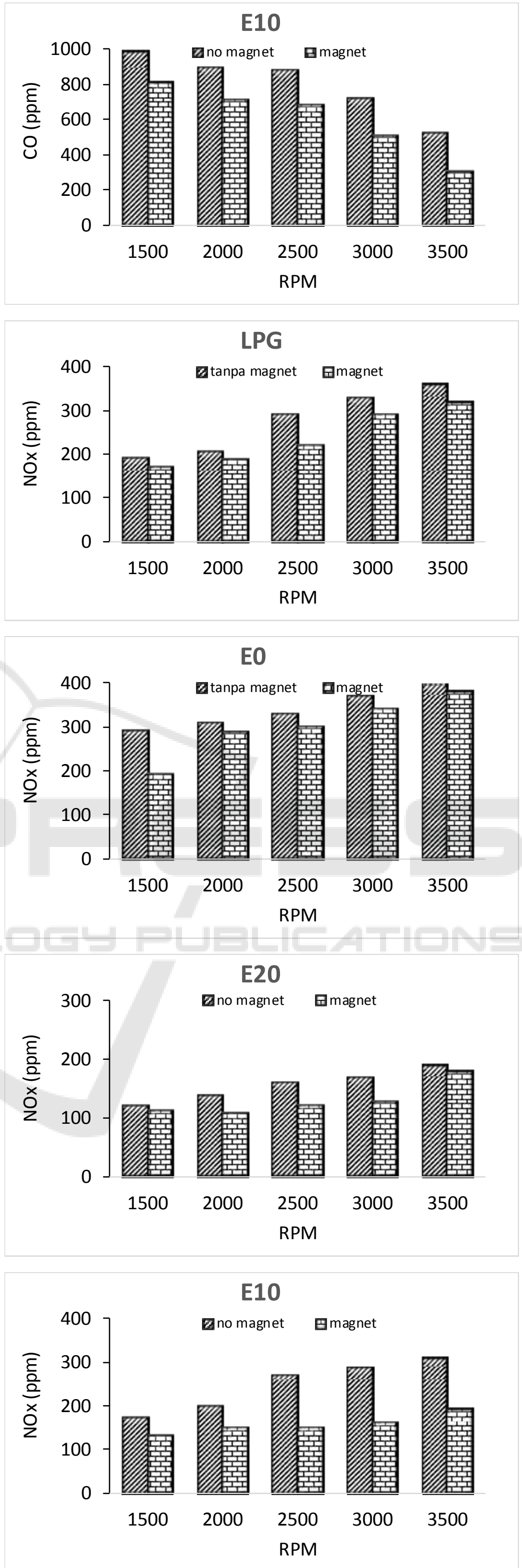


Figure 5: Emission NOx testing result: *a* – LNG; *b* – E0; *c* – E10; *d* – E15; *e* – E20.

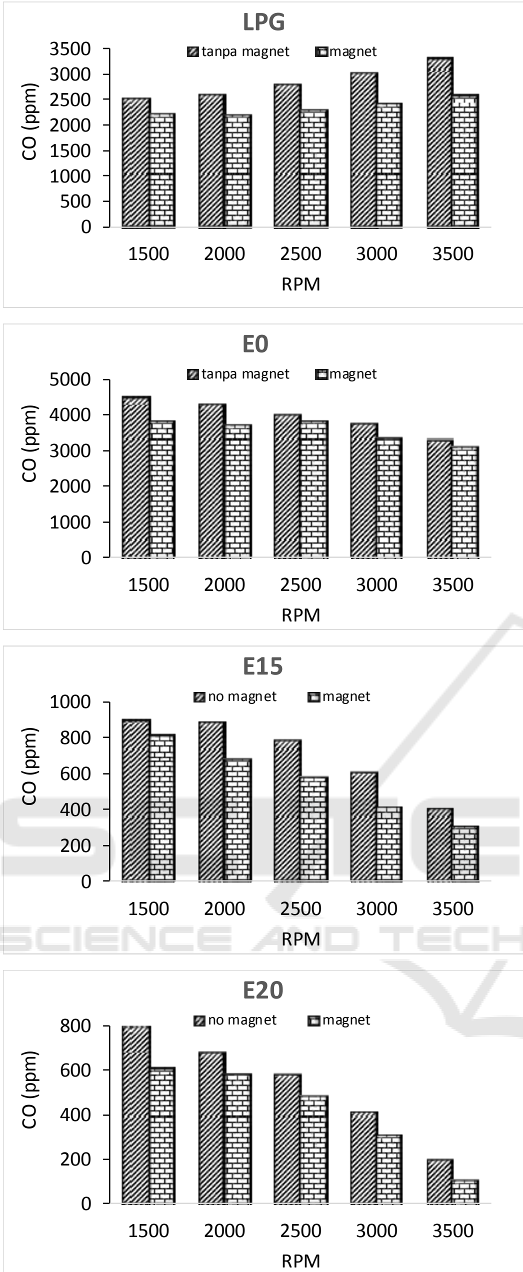


Figure 6: Emission CO testing result: *a* – LNG; *b* – E0; *c* – E10; *d* – E15; *e* – E20.

Figure 6. Showing the results of the CO emission test, it appears that the value of CO in the LPG-fueled engine is smaller than that of gasoline. This is because LPG is an environmentally friendly gas and the difference is 18-44%. On the other hand, an LPG-fueled engine when compared to a mixture of gasoline and bioethanol, the CO content is lower in a gasoline + bioethanol mixture, this is because the molecular bonds of bioethanol contain oxygen which causes the combustion to become more complete so that CO exhaust emissions are reduced, the difference is around 6-47 %. The higher the bioethanol content, the lower the CO emission level. Likewise, if this fuel is passed through a magnetic field, the HC content will be even smaller, this is due to the cluster-decluster effect which is reduced by up to 62%.

In addition, LPG's carbon-hydrogen ratio is lower thangasoline and LPG gas state actually burns more homogeneously mixture. As a result, CO and HC emissions are reduced. moreover,volumetric calorific value of LPG is lower than gasoline and reduced energy supplied contribute to the reductionNOx emission. In addition, the LPG. carbon-hydrogen ratio low fuel and LPG in a gaseous state burns effectively with a more homogeneous fuel mixture. At low speed, when the engine speed is increased, NOx Emissions are gradually increasing for gasoline and LPG due to increased of the temperature inside the cylinder; On the other hand, HC and CO. emissions reduced as high temperatures contribute to combustion process. On the other hand, at high speed, restrictions in the air line increased dramatically. This causes a reduction in of the volumetric efficiency, so that the combustion temperature reduced due to a decrease in the air-fuel mixture quantity. As a result, when the engine speed overtakes the value of speed, NOx emissions are reduced but HC and CO. emissions slightly increased.

The magnetic field used in the fuel, gas emissions reduced to lesser, and the value keeps decreasing with increasing engine speed as shown on picture. 5. It is well known that hydrocarbon molecules is a diamagnetic molecule. So, the presence of magnets the field on the hydrocarbon molecule can interfere and affect H-C bond. It can pull and stretch the bond between molecules, even though the bonds between the H–C atoms are not separate from each other. Bond strength will weaken slightly due to the stretching of the bond so that,hydrogen and carbon atoms will be more easily attracted into oxygen in the combustion process (Sayin Kul and Ciniviz, 2020). Next up, gasoline fuel is made up of molecules that are bonded to each other long hydrocarbon chains. For this reaction to take place simultaneously in the combustion chamber, the first thing that all you have to do is break the chemical bonds in the hydrocarbons [16]. Therefore, sparks are needed by spark plugs as a spark plug external energy source to break chemical bonds.

5 CONCLUSION

At low to medium speed there is an increase in torque and power generated by the engine from all types of mixed fuel tested compared to gasoline fuel. The greatest torque and power are obtained in mixed fuels with a percentage of 15% bioethanol. The performance of gasoline engines (motorcycles) with a mixture of gasoline-bioethanol fuel (E0, E10, E15, E20) and being magnetized causes

a. The average engine power increased by 8-16%,

b. Engine torque increased by 5-15%

c. HC emission levels reduced by up to 47%

d. NOx emission levels reduced by up to 44 .61%

e. CO emission levels reduced by up to 62%

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