Effect of variation concentrations of cajuput oil and magnets on engine performance and flue gas emissions

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ARTICLE INFO	ABSTRACT
  	This study proposes the effect of variations concentration of cajuput oil and magnetic field of attraction on internal combustion engine performance and flue gas emissions. The increasing demand for petroleum energy is increasing, in line with the rising levels of flue gas emissions produced using transportation and the industrial world. Therefore, environmentally friendly alternative fuels are needed. Because the availability of fossil fuels cannot be renewed and their existence is increasingly depleting. There problems can overcome by saving fuels consumption. One way to save fuels are by adding bio-additives from cajuput oil and a magnetic field to the fuel line. This research has found the effects of variation of concentrations in cajuput oil and the tensile magnetic field significantly impacted engine performance and flue gas emissions. A mixture of eucalyptus 10 ml with a magnetic field of attraction produced the highest maximum power and torque of 8.35 Hp and 11.77 Nm, respectively. Meanwhile, CO emissions had a level of 0.1%, but the highest CO_2 level was 9.6% compared to other concentrations. The importance of this research is related to the sustainable use of natural resources to minimize the use of fossil energy in transportation equipment, which is the main issue of sustainable energy in a future perspective.

1. Introduction

The increasing world energy demand, which is mainly dependent upon population growth and industrial development has become a very critical global issue [1]. Energy demand is mainly supplied by petroleum, gas and coal; however, the burning of petroleum has created pollution, later on becoming significant problems for health and the environment [2]. Though there has been continual efforts to switch to alternative energy sources, internal combustion engines (ICE) still uses petroleum fuel that will remain the main energy source for transportation in the future [3]. However, with the increasing concern about global environmental damage, exhaust emissions from Internal Combustion Engines (ICE), such as CO, NOX, CO_2, and hydrocarbons (HC) are increasingly subject to strict regulations [4].

Many researchers have conducted studies with an aim to reduce pollution produced by fossil-based fuels. In this case, various fuel additives and renewable alternative fuels such as alcohol, biodiesel and fuel additives are used to improve the properties of conventional fuels to reduce the pollution of exhaust gas and to make combustion characteristics in internal combustion engines better [5]. The types of bio-additives mixed with fuel include: citronella oil, eucalyptus (cajuput), cloves, sandalwood, pepper and nutmeg. (Cajuput), cloves, sandalwood, pepper and nutmeg. The additives added to fuel function to reduce increasing pollution emissions. Essential oil

is one of the additives to be mixed into fuel [6]. Terpene contained in essential oil dissolves quickly and can remove carbon deposits in the engine cylinder chamber and exhaust emissions [7]. Lemongrass oil, turpentine, clove terpene, and rhodinol evaporate quickly and dissolve in fuel. A number of studies have examined the use of lemongrass oil to determine the effect on gasoline engine performance [8], and exhaust emissions of CO and HC [9].

Other researchers found that turpentine bio - additives reduce emissions in the form of CO, HC and CO_2 gases, and make the combustion occurred in the engine more complete [10]. A research showed that the addition of the concentration of 0.1% eugenol-lemongrass caused a reduction in fuel consumption of 7.55% [11]. Testing the performance of 1%, 0.6% and 0.3% clove bio-additive mixed with engine gasoline from the total volume of RON 90 gasoline found a reduction in fuel consumption for each mixture [12]. There have been a number of studies on the use of eucalyptus oil mixed with pertalite. Variations in the mixture of eucalyptus oil with concentrations of 0%, 7% and 8% on Honda CS1 150 PGM-FI motorbikes showed that the 8% mixture experienced an increase in torque of 2.22% and power of 2.53 %, while exhaust gas emissions decreased respectively for CO by 34.15%, HC by 14.59% and fuel consumption by 35.78% [13]. Pertalite fuel mixed with eucalyptus oil with the concentrations of 3%, 6%, 9% at engine speed variations of 3500 – 8000 rpm showed that 6% concentration increased engine power by 3.34% from 10.76 to 11.10 HP [14]. The mixture of pertalite fuel with eucalyptus oil varying concentrations of 10%, 15%, 20% on a 4 stroke

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motor with a rotation variation of 3000-5000 rpm showed that exhaust emissions and fuel consumption at a concentration of 20% decreased. The highest acceleration in pure pertalite was 15468 rpm/second, while the 20% concentration produced the lowest acceleration of 13050 rpm/second [15].

In addition to the techniques mentioned above, magnetic ionization of fuel is another new technique that has not been widely explored by researchers. Most of liquid fuels contain hydrocarbons that have strong physical tensile force enabling them to form solid structure called as pseudocompounds that can be further organized into groups. Magnetic fields have a positive effect on fuel in the combustion process [16] in which it then causes some changes in its physical-chemical properties [17]. The magnetic field reduces viscosity as the declustering of hydrocarbon molecules occurs and results in better atomization and efficient combustion of the air-fuel mixture. This then increases thermal efficiency and saves fuel consumption [18]. Several researchers have studied the impacts of gasoline and diesel magnetization on engine performance and emission characteristics. Diesel engines determined by magnetic fields produced brake-specific fuel consumption (BSFC) by 3.5%, particulates, CO, HC, and CO_2 by 21.9–33.3%, 5.4-11.3%, 29.4–64.7%, and 2.68–4.18%, respectively, and each of which reduced, but NOx increased by 1.24-13.4% [19]. Research on the addition of eucalyptus oil as a bio-additive and magnetic field to reduce exhaust emissions and increase engine performance so far is found rare. Our hypothesis is that the more the oxygen content in the fuel mixture with bioadditives, the more perfect the combustion process in the engine. It means better engine performance and exhaust emissions. The aim of this research is to find out the effects of the addition of eucalyptus oil concentration as a bio-additive and a magnetic field on the combustion characteristics and exhaust emissions of gasoline engines.

2. Research Method

2.1. Method

This is a true experimental research that mixed the variation in the concentration of eucalyptus oil (cajuput oil) with pertalite and magnetic fields regarding engine performance and exhaust emissions levels of motor vehicles. The research used various variables are dependent and independent variables. The dependent variables included the maximum power and torque produced; the CO and CO_2. The independent variables incolved the variations in the concentration of eucalyptus oil at 6 cc, 8 cc and 10 cc of pertalite volume per 1000 cc; the engine speed variation at 4000-8000 rpm; and the tensile magnetic field as well as without magnetic field.

2.2. Materials

The materials used in this research included eucalyptus

oil (cajuput oil), pertalite fuel and a nickel-plated N45 permanent bar magnet 40 x 25 x 10 (mm) with a magnetic field intensity of 10,000 Gauss. Eucalyptus at 6 cc, 8 cc and 10 cc was mixed with pertalite and a tensile magnetic field was placed in the fuel line.

2.3. Testing installation

The test equipment was divided into two types: the QROTECH-401 gas analyzer as shown in Figure 1 to measure exhaust emissions and the chassis dynamometer as shown in Figure 2 to test engine performance in the form of power and torque on the 2022 motorcycle Genio 110 cc.
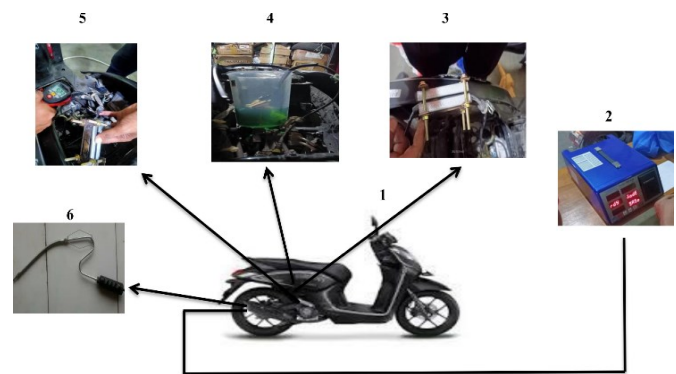

Fig. 1. Installation of testing the exhaust gas emission

Remarks:
1. Motorcycle Genio 110cc
2. *Gas analyzer*
3. Magnetic bracket
4. External Fuel
5. Engine temperature between 50-60°
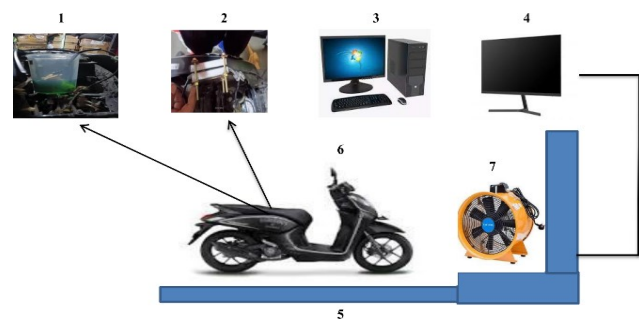6. Connector of exhaust to gas analyzer

Fig. 2. Installation of testing the engine performance

Remarks:
1. Motorcycle Genio 110 cc
2. *Chasis dynamometer*
3. *Blower*
4. Monitor
5. PC/Computer
6. *Magnetic Bracket*
7. *External fuel pump*
8. Temperature of 50-60°

2.4. Testing process

Observations in this study was conducted to CO, CO_2 emission levels, maximum power and torque in the engine speed used (4000, 4500, 5000, 5500, 6000, 6500, 7000, 7500, 8000 rpm) by taking data 3 times for each engine rotation and the data used were the average value

3. Results and Discussion

3.1. Effects of eucalyptus concentration and magnetic field on maximum power

Figure 3 shows the relationship between variations in the concentration of eucalyptus oil with and without tensile magnetic field on the power produced by the engine. The figure shows that each variation in the concentration of eucalyptus oil with and without the tensile magnetic field produced maximum power which tended to increase as the engine rotation speed increased, but after reaching 7500 rpm the maximum power produced decreased. The highest maximum power of 8.35 Hp was produced by adding a concentration of 10 cc of eucalyptus oil to the area of the tensile magnetic field with an engine rotation speed of 7500 rpm. It was then followed by a concentration of 10 cc without magnets, 8 cc with tensile magnet, 8 cc without magnet, 6 cc with tensile magnet and 6 cc without magnets by 8.06, 7.89, 7.4, 7.17 and 6.93 Hp respectively. These results are identical to those carried out by [20]. The addition of a concentration of 6 cc without a magnet at the start of the engine speed of 4000 rpm produced a maximum power of 3.58 Hp, as the lowest compared to the addition of other concentrations. Meanwhile, the addition of 10 cc concentration with the tensile magnet produced the highest maximum power of 5.45 Hp. This showed that the maximum power in the engine was determined by the increasing concentration of eucalyptus oil, and the increasing O_2 content in cineol (cajuput) [10], causing the reaction of the mixture of pertalite fuel with O_2 to produce more explosions in the engine. Thus, the pressure generated was also greater. The two magnetic fields produced a repulsive force between hydrocarbon molecules, resulting in the formation of an optimal distance between hydrocarbon molecules thus resulting in maximum space for oxygen molecules to combine with fuel molecules. As a consequence, hydrocarbon molecules would react more reactively with oxygen and burnt more easily.
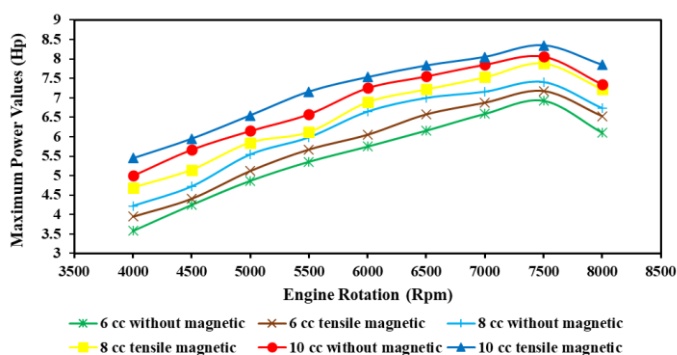

Fig. 3. Relationship between maximum power values and variations in eucalyptus oil concentration with and without the tensile magnetic field

3.2. Effects of eucalyptus concentration and magnetic field on torque

Figure 4 shows the differences in torque values produced by variation of the concentrations of eucalyptus oil with and without the tensile magnetic field. The highest torque was 11.77 Nm produced by a concentration of 10 cc of eucalyptus oil with the tensile magnetic field at an engine rotation speed of 7000 rpm. It was followed by the concentrations of 10 cc without a magnet, 8 cc with an attractive magnet, 8 cc without a magnet, 6 cc with an attractive magnet and 6 cc without a magnet by 11.22, 10.82, 10.25, 9.91 and 5.56 Nm respectively. At a rotation speed of 4000-7000 rpm, it produced torque, which tended to increase. This was because the higher the rpm number, the higher the volumetric efficiency. Thus, the time for mixing fuel and air to fill the combustion chamber was shorter. When the fuel and air burnt, it caused an explosion with high pressure, so that the piston head got a very high pushing force and the torque more increased. After passing 7000 rpm, the torque value at all concentrations decreased. This is because when the engine speed increases, volumetric efficiency decreases. When the mixture lacks of fuel and causes a decrease in the pressure pushing the piston head, the torque produced is very low.
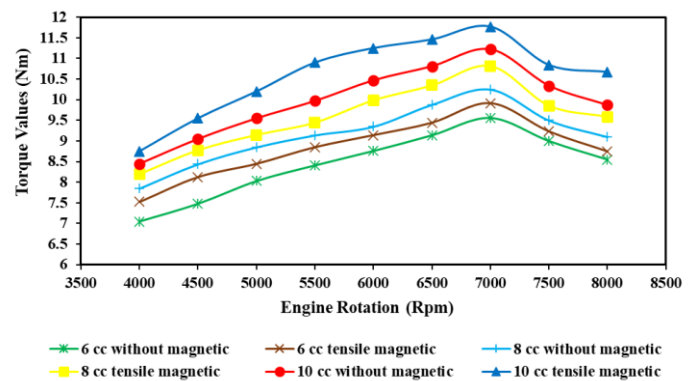

Fig. 4. Relationship between torque values and variations in eucalyptus oil concentration with and without the tensile magnetic field

3.3. Effects of eucalyptus concentration and magnetic field on CO levels

Figure 5 shows the relationship between variations in the concentration of eucalyptus oil, tensile magnetic field without a fuel channel on CO exhaust gas. The addition of the tensile magnetic field to the fuel channel produced the lowest CO levels compared to the one without a magnet. The tensile magnet with a concentration of 10 cc of eucalyptus oil produced CO levels of 0.1%, followed by 8 cc and 6 cc of 0.15% and 0.24% respectively. While, without a magnetic field, the highest CO levels produced 6 cc of 0.41%, followed by 8 cc and 10 cc of 0.37% and 0.31% respectively. These high CO levels were caused by a mixture that was rich in fuel but lacked the air; as a consequence, CO levels continued to increase. This was because the carbon atom (C) lacked oxygen (O_2) to react chemically in the combustion chamber. To determine whether combustion in the cylinder is perfect or not, it can be characterized by the CO levels produced. The greater CO levels produced from combustion indicates that the combustion reaction is incomplete. A high concentration of eucalyptus oil produces low CO levels as eucalyptus oil

contains 60% cineol ($C_{10}H_{18}O$) with oxygen-rich content [21]. The magnetic field makes fuel compounds to break down into several molecules enabling them to easily react with oxygen molecules during combustion. As a results, the combustion reaction runs perfectly.
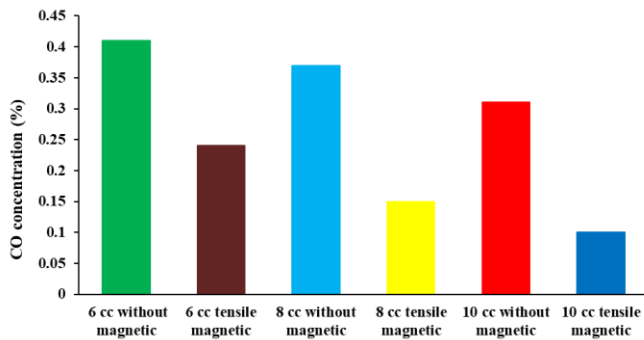

Fig. 5. Relationship between CO exhaust gas variations in Eucalyptus oil concentration with and without a magnetic field

3.4. Effects of eucalyptus concentration and magnetic field on CO^2 levels

Figure 6 illustrates the relationship between variations in eucalyptus oil concentration, tensile and non-tensile magnetic fields in the fuel channel on CO exhaust gas. The 6 cc concentration of eucalyptus oil without a magnet produced the lowest CO_2 gas content of 8.8% compared to increasing concentration using a tensile magnetic field. The highest CO_2 levels were produced by a concentration of 10 cc of eucalyptus oil with a tensile magnetic field of 9.6%. This difference in CO_2 levels was related to the effects of eucalyptus oil in which the higher the concentration of eucalyptus oil, the higher the CO_2 levels produced. This was due to the excessive oxygen content in high concentrations of eucalyptus oil. The results of research are similar with the one in the research conducted by (Prasetyo and Nasabi [22]) finding that high CO_2 was caused by the reaction of burning CO changing to CO_2 due to excessive oxygen from bioadditives.
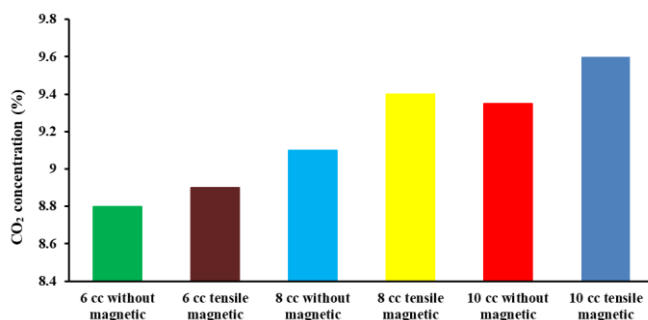

Fig. 6. Relationship between CO_2 exhaust gas variations in eucalyptus oil concentration with and without a magnetic field

4. Conclusion

The increase of the concentration of eucalyptus oil bioadditive mixed with pertalite by placing a tensile magnetic field in the fuel channel had an effect on increasing engine performance in the form of maximum power and torque of 8.35 HP and 11.77 Nm respectively. While, CO exhaust emissions decreased by 0.1% but there was an increase of 9.6% in CO_2. The CO level of 0.1% indicated that the combustion reaction in the combustion chamber occurred perfectly. The results of this research provide sustainable impacts and benefits for obtaining data for industrial progress, electrical energy generation, aerospace and transportation using vegetable oil fuel mixed with bioadditives and magnetic fields.

References

[1] A.K. Azad, M.G. Rasul, M. Masud K. Khan, S.C. Sharma, M.M.K. Bhuiya, A review on socio-economic aspects of sustainable biofuels, International Journal of Global Warming, 10 (2016) 32 – 54.

[2] J. Milano, H.C. Ong, H.H. Masjuki, W.T. Chong, M.K. Lam, P.K. Loh, V. Vellayan, Microalgae biofuels as an alternative to fossil fuel for power generation, Renewable and Sustainable Energy Reviews, 58 (2016) 180 – 197.

[3] L. Zhao, A. Moiz, S. Som, N. Fogla, M. Bybee, S. Wahiduzzaaman, M. Mirzaeian, F. Millo, J. Kodavasal, Examining the role of flame topologies and in-cylinder flow fields on cyclic variability in spark-ignited engines using large-eddy simulation, Int. J. Engine Res., 19 (2018) 886-904.

[4] Y. Pei., J. Qin, X. Li, D. Zhang, K. Wang, Y. Liu, Experimental investigation on free and impingement spray fueled with methanol, ethanol, isooctane, TRF and gasoline, Fuel, 208 (2017) 174-183.

[5] T. Shaafi, R. Velraj, Influence of alumina nanoparticles, ethanol and isopropanol blend as additive with diesel-soybean biodiesel blend fuel: Combustion, engine performance and emissions, Renewable Energy, 80 (2015) 655-663.

[6] Harianingsih, R. Wulandari, C. Harliyanto, C.N. Andiani, Identifikasi GC- MS ekstrak minyak atsiri dari sereh wangi (cymbopogon winterianus) menggunakan pelarut methanol, Techno, 18 (2017) 23-27.

[7] R.A. Saputra, N.A. Wigraha, G. Widayana, Pengaruh pencampuran bahan bakar pertalite dengan minyak terpentin dan minyak atsiri terhadap penurunan emisi gas buang sepeda motor supra x 125, Jurnal Pendidikan Teknik Mesin, 5 (2017).

[8] J.S. Sibarani, A. Alfansuri, Analisa pengaruh penambahan bioaditif minyak serai wangi pada bahan bakar premium terhadap konsumsi bahan bakar dan emisi gas buang sepeda motor absolute revo 110, Jurnal Invotek Seri Mesin, 1 (2020) 1-8.

[9] I.K.S. Arimbawa, I.N.P. Nugraha, K.R. Dantes, Analisis pengaruh campuran bahan bakar pertalite dengan naphthalene terhadap konsumsi bahan bakar, torsi dan daya pada sepeda motor 4 langkah, Jurnal Pendidikan Teknik Mesin Undiksha, 7 (2019) 1-6.

[10] B. Sulistyo, Pemanfaatan terpentin untuk mengurangi emisi gas buang pada sepeda motor, Jurnal Pendidikan Teknik Otomotif, 6 (2015) 233-244.

[11] D. Setyaningsih, M.N. Faiziin, N. Muna, Pemanfaatan minyak atsiri sebagai bioaditif penghemat bahan bakar biosolar, Indones. J. Essent. Oil, 3 (2018) 45-54.

[12] D.G.C. Alfian, R.A. Prahmana, D.J. Silitonga, A. Muhyi, D. Supriyadi, Uji performa gasoline engine menggunakan bioaditif cengkeh dengan bensin berkadar oktan 90, Journal of Science and Applicative Technology, 4 (2020) 49-53.

[13] R.A. Utomo, Pengaruh penambahan bioaditif minyak kayu putih pada bahan bakar pertalite terhadap performa, konsumsi bahan bakar dan emisi gas buang sepeda motor honda CS1 150 PGM-FI, Jurnal Pendidikan Teknik Mesin, 9 (2020) 29-36.

[14] Winoko, Y.A., & Nugroho, W. A. (2021). "Penggunaan bioaditif sebagai upaya meningkatkan kinerja mesin bensin". TRANSMISI, 17(2), 154–159.

[15] Z.R.E. Putra, H. Suryanto, Pengaruh campuran bahan bakar pertalite dengan minyak kayu putih terhadap emisi gas buang dan performa mesin sepeda motor empat Langkah, Jurnal Mekanika dan Energi, 1 (2021) 32-38.

[16] H.A. Abdul-Wahhab, H.H. Al-Kayiem, A. Aziz, A.R. A. Aziz, M.S. Nasif, Survey of invest fuel magnetization in developing internal combustion engine characteristics, Renewable and Sustainable Energy Reviews, 79 (2017) 1392-1399.

[17] E.A. Melo-Espinosa, R. Piloto-Rodríguez, R. Sierens, S. Verhelst, Emulsification of waste cooking oils and fatty acid distillates as diesel engine fuels: An attractive alternative, IJSEPM, 9 (2016) 3-16.

[18] K. Golibrzuch, F.-E. Digulla, S. Bauke, H. Wackerbarth, O. Thiela, T. Berg, Optical sensor system for time-resolved quantification of methane densities in CH4-fueled spark ignition engines, Applied Optics, 56 (2017) 6049-6058.

[19] C.Y. Chen, W.J. Lee, J.K. Mwangi, L. C. Wang, J.H. Lu, Impact of magnetic tube on pollutant emissions from the diesel engine, AAQR, 17 (2017) 1097-1104.

[20] M.S. Rusli, G. Ramadhan, H. Setiapraja, O. Farobie, Pengaruh penambahan bioaditif minyak atsiri pada bahan bakar biosolar terhadap kinerja mesin diesel, Jurnal Teknologi Industri Pertanian, 32 (2022) 65-73.

[21] Muyassaroh, Steam destillation eucalyptus trees to the variation of operating pressure and treatment materials to optimize sineol content in eucalyptus oil, Jurnal Teknik Kimia, 10 (2016) 36-40.

[22] I. Prasetyo, M.A. Nasabi, Pengaruh penambahan minyak atsiri pada bahan bakar pertalite terhadap hasil emisi gas buang, SJME Kinematika, 5 (2020) 129-137.