IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

Performance Characterization of Gasoline Engine with Patchouli Oil as Bio-Additive for Gasoline with an Octane Number 90

To cite this article: D G C Alfian *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **258** 012010

Performance Characterization of Gasoline Engine with Patchouli Oil as Bio-Additive for Gasoline with an Octane Number 90

D G C Alfian[1], R A Prahmana[1], D J Silitonga[1], A Muhyi[1], D Supriyadi[2]
[1] Mechanical Engineering Department, Institut Teknologi Sumatera, Lampung Selatan, Lampung
[2] Chemical Engineering Department, Institut Teknologi Sumatera, Lampung Selatan, Lampung

Abstract. Nowadays, Indonesia as the largest country in ASEAN has a huge fuel consumption due to the increasing numbers of vehicles using fossil fuel. Considering the limited national and global oil reserves as well as environmental issues, efforts are needed to reduce fossil fuel consumption. One of the solutions to this problem is by utilizing the abundantly available natural resources in Indonesia such as essential oils. In this study, patchouli oil as bio-additive and gasoline with an octane number of 90 with a volumetric percentage of 1%, 0,6%, and 0,3% were used. The mixtures of these gasoline and bio-additive were tested on a generator-set engine at varied output electrical load of 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, and 2000 Watt at a constant engine speed of 2500 rpm. Output power, fuel consumption and exhaust temperature were measured, while torque, BMEP, SFC and fuel consumption were calculated. Results showed that the addition of 1%, 0.6%, and 0.3% patchouli oil into a 90 octane gasoline reduced fuel consumption by 21%, 16%, and 19%, respectively. Maximum reduction of fuel consumption was 33% at 1200 W electrical load with 1% of patchouli oil additive.

1. Introduction

The primary energy supply in Indonesia is mainly based on fossil fuels like oil, gas, and carbon. Indonesia's energy consumption increased by 5.0%, well above the 10-year average growth of 2.9%. It is considered as an index of economic growth and social development. Consumption has doubled over the past 20 years. In 2015, 41% of Indonesian energy consumption was based on oil. Oil remained Indonesia's dominant fuel (44.1% of primary energy consumption), followed by coal (32.6%) and natural gas (19.2%). Energy use in the transport sector remains dominated by oil products, with policy efforts to diversify the mix focusing on fuel savings. One of the solutions to this problem is by utilizing the abundantly available natural resources in Indonesia such as essential oils. The potential of using these oils as bio-additive for improving fuel economy has been shown by researchers [1]. The main purposes of these additives are to improve engine performance and decrease fuel consumption. Most of the additives are fuel-soluble chemicals that can be added into the petrol with a certain volume fraction. Now, the researchers and manufacturers are starting to look for the additive with environmentally friendly and reduced fuel consumption .

Several oxygenated fuels are known to have the potential to be used as alternatives to gasoline and diesel fuel [2,3]. These fuels can be classified as alcohol, ether, ester, carbonate and acetate compounds. The most promising bio-fuels to mix with fossil liquid fuels are vegetable oils, bio-diesels, bio-alcohols, and bio-ethers. In order to investigate the actual performance of these biofuels, various diesel blends and alternative fuels have been tested in diesel engines of various capacities at various loads, and the emissions and performance results have been analyzed [4]. The analysis showed that 10–20% blends with any biofuel give the optimum performance and emissions close to that of mineral diesel operation.

Yao ChunDe et.al studied a matter extracted from palm oil and used as a gasoline additive [5]. The effect of various percentages (0.2%, 0.4%, and 0.6%) of the bio additives on the fuel economy of SI engine respectively running on prime gasoline, gasoline with known components, ethanol gasoline, and methanol gasoline under typical urban operation condition at 2000 r/min was investigated. The results showed that the bio-additives can remarkably improve the fuel economy of SI engine while operating on all kinds of fuel. The optimal ratio of bio additive to gasoline depends on the fuel used and on the different engine operating conditions. Moreover, the experiments of constant volume combustion bomb, analysis of in-cylinder processes, the synchrotron radiation, and high-temperature friction were conducted to probe into the mechanism of the bio-additive impact on fuel economy. It indicated that the bio-additives increase the maximum cylinder combustion pressure, improve exhaust emissions and largely reduce the friction coefficient.

Bote et.al studied the performance analysis of a single cylinder four stroke petrol engine using petrol blended with Thumba oil [6]. Results showed that the brake specific fuel consumption for Thumba biodiesel blend with petrol is higher than that of pure petrol because of lower calorific value and delay in the ignition process. It was also observed that at a constant speed as load increases there is an increase in brake thermal efficiency for petrol and for all blends of Thumba oil.

Asep Kadarohman et.al in their study on the potency of essential oils as diesel fuel bio-additives reported that clove oil has a better performance than turpentine oil on decreasing Brake Specific Fuel Consumption (BSFC) and reducing the exhaust emissions of the engine [7]. Clove oil is an essential oil which contains eugenol as the main component. The result of this experiment gives information about the potency of the bio-additive based on clove oil and eugenol and the influence of oxygen enrichment by eugenol on the performance of the diesel fuel bio-additive. It also showed that clove oil, eugenol and eugenyl acetate decrease Brake Specific Fuel Consumption (BSFC) and reduce the exhaust emissions of the engine. Moreover, it revealed that oxygen enrichment helps in reaching optimal fuel combustion.

Kadarohman [8] found that some essential oils used as bio-additive improve engine performance by reducing fuel consumption. His research studied the addition of clove oil, turpentine oil, nutmeg oil, cajuput oil and citronella oil which revealed that the highest fuel reduction was resulted by the clove oil (4.43% at 0.6% mixture).

Those previous works of some researchers mentioned before demonstrated evidence of fuel consumption reduction by using various essential oils as a fuel additive. Still, there are essential oils that have not been studied for the purpose of fuel-economy improver additive. One of them is Patchouli oil, which becomes the object of the study presented in this paper. Patchouli oil is an essential oil largely composed of patchoulol, eugenol, benzaldehyde, and sinamaldehid as the main component. As discussed before, eugenol has a favorable impact on fuel economy through oxygen enrichment into the associated pure fuel. Another important thing of essential oil is related to its compound which forms a cyclic and open chain structure. That type of structure is expected to reduce the bond strength between the molecules of gasoline that can increase the effectiveness of the combustion process.

The objective of the present study is to investigate patchouli oil as bio additives of gasoline to characterize its performance at different mixture ratios and to find out the optimum ratio that yields maximum reduction of fuel consumption.

2. Experimental Setup

The performance tests were carried out on a test bench consisted of a set of bulbs as electrical loads connected to an electrical generator set powered by a single cylinder, four strokes, air cooled gasoline engine, as depicted in Fig 1. The engine was run at a constant speed of 2500 rpm. The exhaust gas temperature was measured using thermocouple. The speed of engine rotation was indicated using tachometer. The engine specifications are shown in Table 1. Measuring cylinder was used to make measurements of specified fuel volume (5 ml) consumed over time for each data collection, to provide fuel consumption data for various loadings. Electrical circuits were used to provide connections to electrical loads and measuring instruments. The electrical loads were 100 watt and 200 watt of electric bulbs which were arranged in parallel such that total load can be regulated from 0 W to 2000 W with an increment of 200 W.

This experiment used patchouli oil as bio-additives and gasoline with an octane number of 90 with a volumetric percentage of 0.3%, 0.6% and 1% (Table 2). This work investigated the performance of mixtures of gasoline and patchouli oil. The purpose of this study was to analyze the fuel consumption of gasoline engine fuelled with 0%, 0.3%, 0.6% and 1% patchouli oil-gasoline mixtures. The mixtures of gasoline and bio-additive were then tested on a generator-set engine at varied output electrical load of 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800 and 2000 watt at a constant engine speed of 2500 rpm. Output power, fuel consumption, and exhaust temperature were measured while torque, BMEP, SFC and efficiency were calculated.

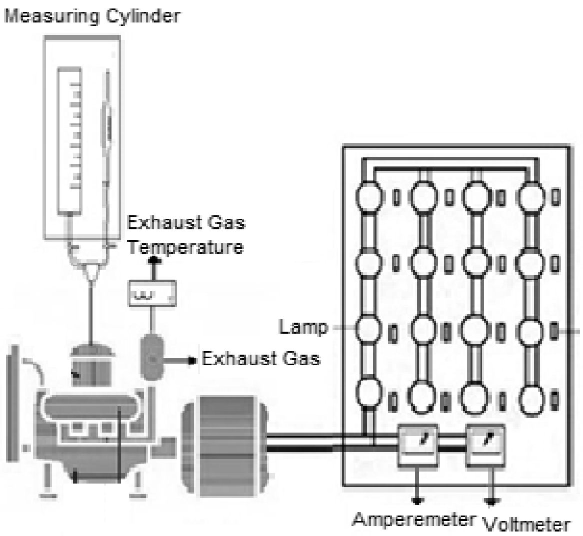

Figure 1 Test Engine

Table 1. Engine Specification

Specification	
Power Input (Maks)	2.2 KVA (at 50 Hz)
Power Output (Average)	2.0 KVA (at 50 Hz)
Frequency	50 Hz
Voltage	220 V/ 1 Phase
Type	Single cylinder, 4 strokes and air cooled
Starter System	Recoil Starter
Ignition System	Transistorized Magneto
Fuel Capacity	14.5 L
Lubricating Oil Capacity	0.6 liter
Noisy Level	95 dB
Dimension	591mm x 432mm x 462mm
Cylinder volume	196 cc

Table 2. Formulation of tested fuels

Formulation
Pure gasoline
Gasoline + 0.3% of patchouli oil
Gasoline + 0.6% of patchouli oil
Gasoline + 1% of patchouli oil

3. Results and discussion

The experimental study was conducted on 4 strokes, single cylinder, gasoline engine. The general specifications of the engine are shown in Table 1. The experiments were performed under variable volumetric percentages of 0%, 0.3%, 0.6% and 1% of patchouli oil by varying the electrical load at a constant speed of 2500 rpm.

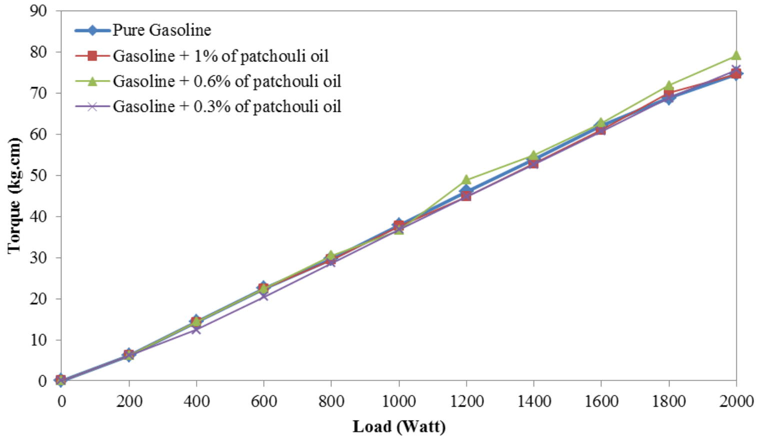

Figure 2 Engine torque of of pure gasoline, and mixtures of patchouli oil (1%, 0.6%, 0.3%)

Fig. 2 reports the trend of the torque over the electricity load range for the four studied gasoline-additive mixtures. It can be inferred that the trend of the torque for the pure gasoline resembles the values of that with additives, reaching a maximum value of 75 kg.cm at 2000 W. With 0.6% mixture the engine shows a small increase of the torque, albeit limited to the electrical loads of 1000-1400 W and 1600-2000 W. This is due to the higher heat input determined by pure gasoline with additives mixture.

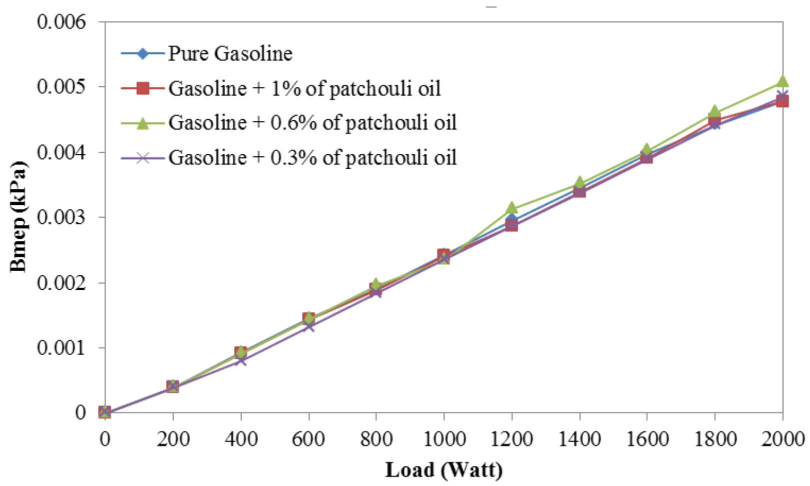

Figure 3 Brake Mean Effective Pressure (BMEP) of pure gasoline, and mixtures of patchouli oil (1%, 0.6%, 0.3%)

The variation of brake mean effective pressure with respect to load for each gasoline-additive mixture (0%, 03%, 0.6%, and 1%) is presented in Figure 3. Brake Mean Effective Pressure vs Load graph indicates that Brake Mean Effective Pressure increases (linearly) for load 0 to 2000 W for every mixture (0%, 0.3%, 0.6%, and 1%). The speed is kept constant at 2500 rpm for all experiments.

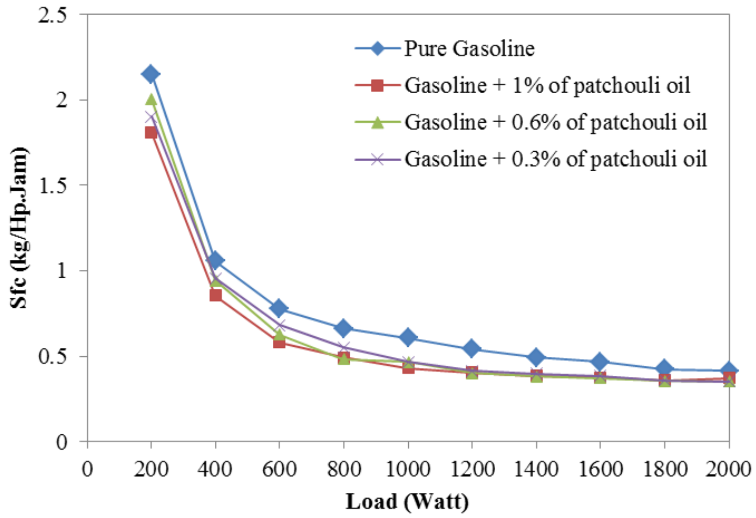

Figure 4 Specific Fuel Consumption (SFC) of of pure gasoline, and mixtures of patchouli oil (1%, 0.6%, 0.3%)

The variation of specific fuel consumption with electricity load for various ratios of patchouli oil as bio additive operation and gasoline is described in Fig. 4. It can be observed that the specific fuel consumption in gasoline-additive mixture operation is lower compared to that of pure gasoline operation. This is due to the low heating value and high viscosity of additive compared to pure gasoline which creates more heterogeneity in air-fuel mixture. Consequently, it results in an increase in specific fuel consumption [9]. Fig. 4 shows the gasoline with different ratios of bio additives posses lower fuel consumption in all engine loads and the best mixing ratio for the fuel consumption is 1% of the additive.

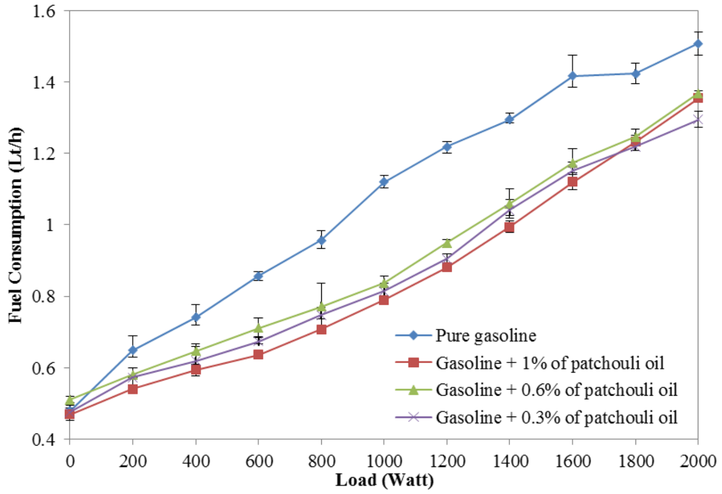

Figure 5 Fuel Consumption of of pure gasoline, and mixtures of patchouli oil (1%, 0.6%, 0.3%)

The existence of bio-additive in the gasoline affects the fuel economy, the fuel consumption of gasoline with and without the addition of bio-additive, as shown in Figure 5. One can see that the gasoline with different ratios of bio-additive has lower fuel consumption on all engine loads. The reduction of fuel consumption varies with the ratios of bio additive and engine loads. Within the range of the tested engine load, lower fuel consumption was obtained with fuel containing 1% of bio-additives. Although 1% of bio-additive have not significantly saved more fuel compared to that of 0.3% and 0.6% of bio-additives in gasoline, it obviously has lower fuel consumption than gasoline without bio-additives.

As a rough financial impact calculation, if the generator set is run at a constant electrical power of 1200 VA (a typical middle-class household's peak electrical power), there will be fuel saving of 0.338 liters/hour by adding 1% bio additive into the gasoline. Assuming gasoline price of IDR 8.000/liter (USD 0.57/liter) and the generator-set run for 8 hours per day, fuel cost will be reduced by IDR 649.052 (USD 46.04) per month.

4. Conclusion

In this study, the effects of using pure gasoline and mixture gasoline-additive on engine performance were investigated by varying the electrical load. Based on the experimental study, the addition of 1%, 0.6% and 0.3% patchouli oil into a 90 octane gasoline reduced fuel consumption by 21%, 16%, and 19% respectively. Maximum reduction of fuel consumption was 33% at 1200 W electrical load with 1% of patchouli oil additive. For further study, it is proposed to run a set of experiments with other mixture percentage to find the optimum reduction of fuel consumption.

Acknowledgments

The authors are grateful to Institut Teknologi Sumatera (ITERA) for providing the necessary support. This work was supported by ITERA-SMART grant 2018 with contract number: 134y/IT9.C1/PP/2018.

References

[1] E. Sadeghinezhad, S. N. Kazi, F. Sadeghinejad, A. Badarudin, M. Mehrali, R. Sadri, and M. Reza Safaei, "A comprehensive literature review of bio-fuel performance in internal combustion engine and relevant costs involvement," Renewable and Sustainable Energy Reviews, vol. 30. pp. 29–44, 2014.

[2] Misra C, Kumar N, Chauhan BS, Lim HC. Some experimental investigation on use of methanol and diesel blend in a single cylinder diesel engine. Int J Renew Energy Technol Res, vol 2(1):1–16, 2013.

[3] No SY. Inedible vegetable oils and their derivatives for alternative diesel fuels in CI engines: a review. Renew Sustain Energy Rev, 15(1):131–49, 2011.
[4] Rakopoulos Dimitrios C, Rakopoulos Constantine D, Giakoumis Evangelos G, Dimaratos Athanasios M. Characteristics of performance and emissions in high-speed direct injection diesel engine fueled with diethyl ether/diesel fuel blends. Energy,43(1):214–2, 2012.
[5] Yao Chunde, Zhang Zhihui, Xu Yuanli & Huang Yu Experimental investigation of effects of bio-additives on fuel economy of the gasoline engine. Sci China Ser E-Tech. 51 (8) 1177-1185, 2008.
[6] M.A.Bote , H.M.Dang. Performance analysis of single cylinder four stroke petrol engine using petrol blended with Thumba oil. IJIRSET. vol. 3, 2, 2014.
[7] Asep Kadarohman, Hernani, Fitri Khoerunisa, Rizki Maryam Astuti. A Potential Study On Clove Oil, Eugenol And Eugenyl Acetate As Diesel Fuel Bio-Additives And Their Performance On One Cylinder Engine Transport. 25, 66–76, 2010.
[8] Kadarohman A. Exploration of essential oils as diesel fuel bio-additive. Jurnal Pengajaran MIPA. 14(2):121–41, 2009.
[9] A. F. Kheiralla, Mohamed El-Awad, Mathani Y. Hassan, M. A. Hussen, and Hind I. Osman. Effect of Ethanol–Gasoline Blends on Fuel Properties Characteristics of Spark Ignition Engines. UofKEJ, Vol. 1, 2 pp. 22-28, 2011.