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RINGKASAN PENELITIAN

Currently, the problem has occurred is increasing pollution and leading to increasingly high levels of global warming. This level of pollution will create an uncomfortable environment and create new problems. The problem is that public health will be disturbed, besides the rise in the price of fuel will result in the difficulties of people to buy goods because the value of goods will be rising due to the increase in fuel. The purpose of this research is to help deal with the problems that exist in the community so that we can solve the pollution problem that exists in the environment. The aim of this study is to obtain new fuels by using additive mixtures made of essential oils that can reduce fuel emissions in vehicles. The benefit of this research is that new fuel mixture of essential oil can be used to the public as an additional alternative to reducing the emissions of exhaust gases in vehicles, as well as expected to save in its use in cars. The research method that will be used is by mixing the additive into the diesel oil (solar) using some percentage differences and will see the effect on the fuel properties, engine performance and emissions. This research topic corresponds to the road map of the head of research into part of one of the fields of excellence in the FTI road map that is included in green and energy with the research cluster in green engineering technology. The results show that with the addition of essential oil additives (clove oil, citronella oil and eucalyptus oil) the oil density will decrease by 17.53 % (mixture of eucalyptus and clove oil) compared to diesel oil (B30). Furthermore, at a load of 36 % it can save fuel by 2.963% (mixture of citronella oil and clove oil) than diesel oil (B30). The resulting emissions will also reduce CO_2 and NOx by 57.49% and 1.36 %, a load by 36 % compared with diesel oil (B30). The results from test drive represents by blending 3ml citronella oil in 15 litre fuel can save cost to Rp 2.610,- km/litre. The output of this research is an Intellectual Property Rights in the form of copyright and one article will be published in the International Journal, status for the paper is submitted.

Kata Kunci :
Essential oils, Fuel Properties, Fuel Consumption, Emissions, Pollution

BAB 1. PENDAHULUAN

1.1. Latar Belakang

The background of this research is the environmental pollution levels grow and gasoline prices rise, it will become more difficult for individuals to purchase fuel due to its unpredictable pricing. As a result, a fuel solution that lowers emissions and has a reasonable price that people can afford is required. Reducing air pollution with the use of additives derived from vegetable oils can enhance engine performance at a reasonable cost.

1.2. Perumusan Masalah

The fuel we use every day is the fuel that comes from petroleum or hydrocarbon fuels. Petroleum fuels contain the elements hydrogen (H) and carbon (C) so when incinerated imperfectly will produce elements such as CO (Carbon Monoxide), C (Carbon), HC (Hydrocarbon).

The problems currently faced must be solved well. The solution to produce good quality fuel is to mix the fuel with other fuels that have different boiling points [1]. Apart from that, the choice of mixing fuel using additives made from vegetable oil is because vegetable oil contains oxygen [2] which can help reduce emissions produced during combustion. The vegetable oil that will be used is essential oil. This oil will be used as an additive, which is not used too much but has a good effect on the engine. Essential oils can come from clove oil [3], eucalyptus oil [4], citronella oil [5], and so on.

Essential oils have a higher boiling point value when compared to diesel and/or gasoline. Essential oils are a source of renewable energy that has not been thoroughly researched. Essential oils can be obtained by extraction techniques such as distillation or solvent extraction [6]. Essential oils usually produce fragrances and rubbing oils for health [7]. The difference between vegetable oils and essential oils is that vegetable oils (triglycerides) are usually obtained from fatty parts of plants, such as the core, seeds or nuts, while essential oils are obtained from non-fatty parts, such as roots, bark, leaves, stems, and aromatic parts (flowers, petals and buds) [8].

Essential oils have several main properties that are very different from conventional biodiesel. Essential oils contain terpene-related hydrocarbons and highly oxygenated compounds, while biodiesel is fatty acid methyl esters produced through transesterification of vegetable oils or animal fats. Biodiesel has a much higher viscosity, lower heating value, and higher cetane number [9] compared to essential oils. However, the disadvantage is that the cetane number in essential oils is generally quite low. Therefore, essential oils have properties comparable to diesel such as the same calorific value, as well as lower viscosity so that they can be used as alternative fuels in the future [10].

1.3. Tujuan Penelitian

1. Finding a new blend of essential oils that have better characteristics than other fuels.
2. Finding a new blend of essential oil that have better engine performance than other fuels
3. Finding new fuels that have less emissions compared to other fuels
4. Calculate the costs that can be saved by using essential oil in the engine.

1.4. Batasan Penelitian

This study was carried out by analyzing fuel and engine performance. Fuel analysis will be carried out at the Petrolab Services laboratory test and engine performance analysis will be carried out at the Department of Mechanical Engineering, Trisakti University.

1.5. Kaitan Penelitian dengan Road Map Penelitian Pribadi dan Road Map Penelitian Fakultas

This research is part of one of the areas of excellence on the FTI road map, namely green and energy with research clusters in green engineering technology.

BAB 2. TINJAUAN PUSTAKA

Discussions about additives used as blending fuel have been studied by several researchers. The mixing of essential oils with fuel is done with or without the addition of other materials. In this study, the fuel will be added with essential oil in different percentages without any additional materials. Here are some literature discussing some of the essential oils that have been tested as a fuel substitute.

Purushothaman dan Nagarajan [11] researched the effect of using orange oil with a blend of fuels that were tested for characteristics, emissions and performance in a single cylinder diesel engine. Experimental results show that emissions of carbon monoxide (CO), hydrocarbons (HC) and smoke have decreased while emissions of nitrogen oxides (NOx) have increased for orange oil and its mixtures compared to diesel oil. The peak cylinder pressure and heat release rate for orange oil are higher compared to diesel oil operation.

Vallinayagam, et al. [12] conducted research on pine oil biofuel (essential oil) and its mixture of 25%, 50%, and 75% with diesel tested in a single-cylinder, four-stroke direct injection diesel engine, and the combustion results, emissions, and performance were compared with diesel. The results show that under full load conditions, 100% pine oil reduces CO (carbon monoxide), HC (hydrocarbon) and smoke emissions by 65%, 30% and 70% respectively. The brake thermal efficiency and maximum heat dissipation rate are increased by 5% and 27% respectively. However, NOx (nitrogen oxide) emissions are higher than diesel at full load conditions.

Utomo [13] studied mixing pertalite fuel with additives from eucalyptus oil and tested it on a Honda motorbike engine. The results obtained are that mixing 8 ml of white oil can reduce exhaust emissions and can reduce fuel consumption so that it is more economical.

Nanthagopal, et al. [14] conducted research on mixing 20% citronella oil with diesel. The experimental results revealed that the thermal efficiency of 20% citronella oil was slightly higher than that of diesel at higher loads. Significant reductions also occur in unburned carbon monoxide hydrocarbon emissions and smoke. However, the nitrogen oxides in citronella oil are 20% higher relative to diesel oil at rated power output. In addition, the gas pressure in the 20% citronella oil cylinder follows a similar trend to that of diesel oil. In addition, a higher heat release rate was also observed for 20% citronella oil from the test results.

Bhaskar, et al. [15] tested cymbopogon citratus, pine sylvestris and Syzygium cumini oils to analyze their fatty acid composition using gas chromatography assisted by mass spectrometry. Based on GC-MS analysis, fifteen types of fatty acids in cymbopogon citratus, Pinus sylvestris and Syzygium cumini oil methyl esters were analyzed and defined; all of these esters are a combination of saturated and unsaturated fatty acids. Variations in fatty acid composition influence the properties of esters. GC–MS synthesis showed that methyl, ethyl ester was free from impurities for all three raw materials. Some impurities such as mono-, di- and triglycerides were found.

Gad, et al. [16] studied the impact of adding mandarin essential oil to diesel oil on engine performance operated at various loads and a fixed speed of 1500 rpm. There are two mixing ratios, namely 10% and 20% mandarin essential oil and 80% and 90% diesel oil, which are marked as MO10 and MO20 respectively. Then the Diesel-RK model was used to predict the effect of adding propanol (10% by volume) to (90%) mandarin essential oil by applying the 1%, 3% and 5% EGR approach. Egyptian mandarin essential oil was characterized using gas chromatography-mass spectrometry analysis, and its physical properties were measured according to ASTM standards. Experimental findings showed that cylinder pressure and HRR decreased by 3% and 2.5%, respectively, with the addition of mandarin essential oil to diesel oil. CO, UHC, and smoke opacity were reduced by (17%, 30%), (20%, 40%), and (27%, 44%) for the MO10 and MO20 combinations, respectively, compared with the base fuel, while NOx intensity increased respectively. -25% and 45% respectively. Specific fuel consumption is reduced by 5% and 22% for MO10 and MO20 blends, respectively.

Ayu, et al. [17] studied the effects of blending eucalyptus oil with diesel in diesel engines. The results show that the brake torque decreases along with the load at each engine rotation. The brake power value increases from 1700 rpm to 1900 rpm then decreases to 2300 rpm. Brake fuel consumption increases as engine speed increases, and brake thermal efficiency decreases as engine speed increases. CO emissions remained the same, but in the B20 biodiesel sample with 0.1% eucalyptus oil additive, CO emissions increased to 2100 rpm. CO_2 and HC emissions fluctuate with an increasing trend as engine speed increases. O2 emissions fluctuate with a decreasing trend as engine speed increases, the O_2 content produced by pure B20 biodiesel is lower than B20 with additives.

Muhyi, et al. [18] analyzed the performance of clove oil as an additive, with the aim of reducing fuel consumption. The experiment was carried out by mixing clove oil and diesel with a percentage of 1%, 0.5% and 0.1% of the total volume. The generator is operated at varying loads, namely 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800 and 2000 W at a constant engine speed of 1500 rpm. The variables measured and calculated in this experiment are Power, Torque, BMEP, SFC, and fuel consumption per hour. The results show that the addition of clove oil to diesel oil with a volume percentage of 1%, 0.5% and 0.1% reduces fuel consumption to an average of 2.94%, 6.12% and 4.74% respectively. A maximum fuel consumption reduction of 7.7% was achieved at a load of 800 W with 0.5% clove oil.

In this study, the essential oils will be mixed with diesel oil in engines and will be examined by the percentage composition of the mixture. The results obtained will be compared with mixing essential oils with diesel oil without the mixture. The results that will be analyzed are fuel savings, engine performance and emissions.

BAB 3. METODOLOGI PENELITIAN

3.1. Waktu dan Tempat Penelitian

Length of Research	: 8 months 15 dayss
Month/Year Start	: October 2023
Month/Year End	: June 2024
Place of Research	: Gedung F & G Jurusan Teknik Mesin Universitas Trisakti Jakarta

3.2. Metode Penelitian

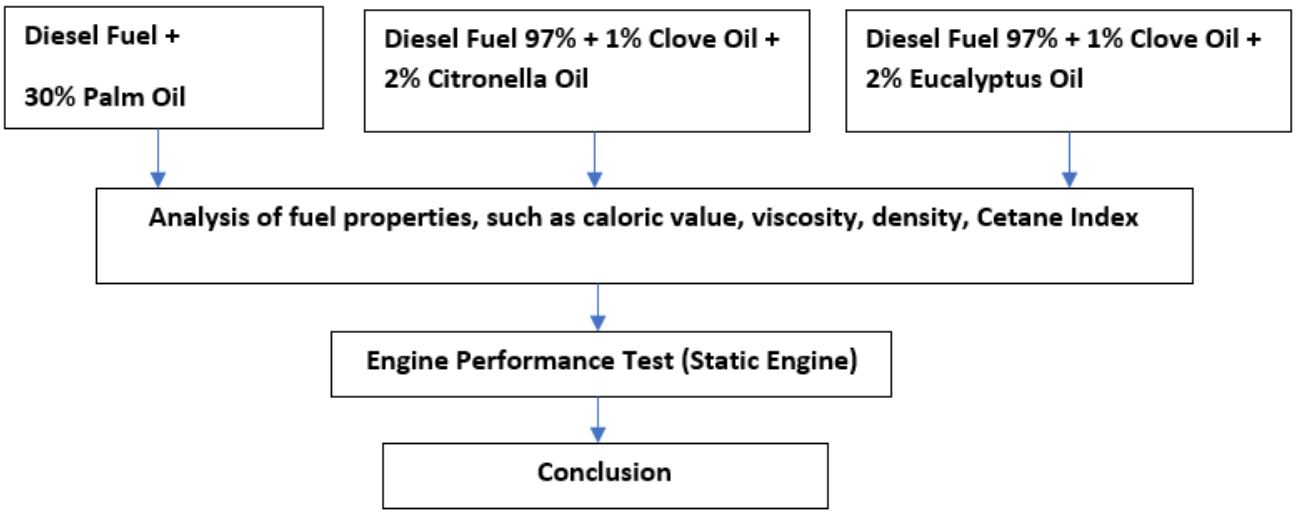

Figure 3.1. Research Flow Diagram

In Figure 3.1 is a research flow diagram. In this research, three mixtures will be made, namely:
1. Blending diesel oil with the addition of 30% palm oil (B30)
2. Mix 97% diesel oil with 1% clove oil and 2% citronella oil
3. Mix 97% diesel oil with 1% clove oil and 2% eucalyptus oil

After the mixture is made, the fuel properties are analyzed, namely by calculating the heating value, viscosity value, density value and cetane index. After that, an engine performance with engine static test will be carried out and data will be taken such as fuel consumption and exhaust emissions. Then analyzed and conclusions are drawn.
Test drive engine for dynamic test was carried by using 3 ml citronella oil blended with 15-liter fuel. The distance for running engine test drive was 10 km include Toll in road or off road.

3.3. Metode Analisis

The analytical method used is to use existing literature regarding blending essential oil fuels with fossil fuels. After that an analysis will be carried out regarding fuel quality which includes calorific value, viscosity, specific gravity, flash point. After that, tests are carried out on the diesel engine to

determine the performance and emissions produced by each fuel and after that they are compared, analyzed and making some conclusions

3.4. Indikator Capaian Penelitian

The indicator of research achievement is established an Intellectual Property Rights in the form of copyright, submitted article in International Journal indexed Scopus (Sinta 1) and create posters that can be used for lecture activities.

BAB 4. HASIL DAN PEMBAHASAN

The fuels that will be analyzed are diesel oil with 30% palm oil (B30), a mixture of 97% diesel oil with 1% cloves and 2% citronella oil (C1S2) and a mixture of 97% diesel oil with 1% cloves and 2% eucalyptus oil. (C1E2).

4.1 Analysis of Fuel Characteristic

4.1.1 Density

Density is an important fuel characteristic because it is related to the process of injecting fuel into the combustion chamber. Fuel must undergo evaporation so that it can mix with oxygen [2]. The evaporation process depends on the boiling temperature of each fuel. The higher the boiling point of a substance, the more difficult it is to evaporate and of course the more difficult it is to react with oxygen.

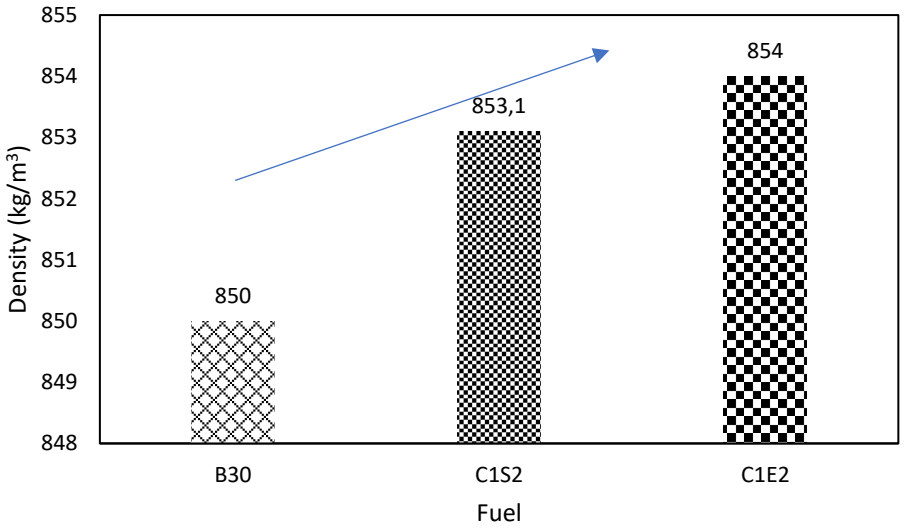

Figure 4.1. Density of Fuels

In Figure 4.1, it can be seen that C1E2 has a density value that is 0.10% and 0.46% greater than C1S2 and B30. This is because eucalyptus oil has a greater density value, namely 926.7 kg/m3 [19]. The density value of citronella oil is 855 kg/m3 [20]. Meanwhile, the density of clove oil is 1,019 kg/m3 [21].

4.1.2 Viscosity

Viscosity is the resistance value of a liquid flowing through a capillary tube to gravitational forces. If the viscosity value is higher, the flow resistance of a liquid will be higher. [2]. Characteristics like this are very important because they can affect the performance of the diesel engine injector pump.

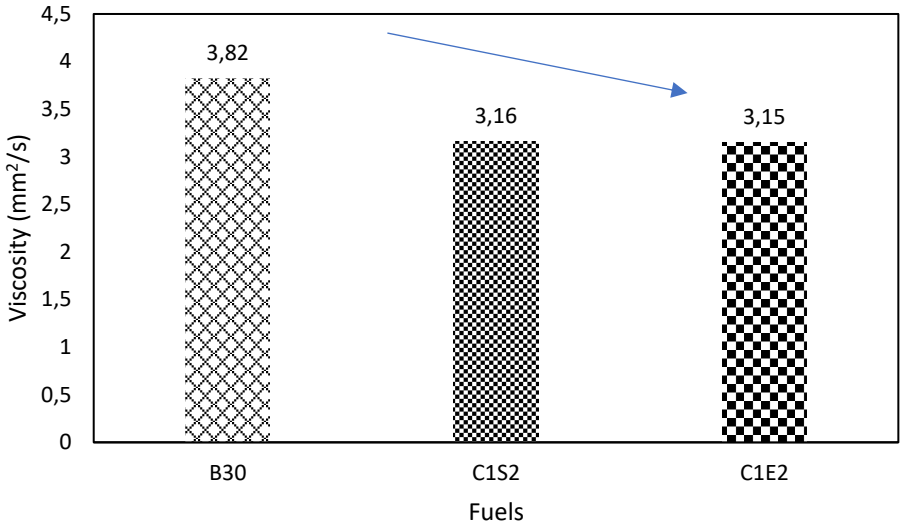

Figure 4.2 Viscosity of Fuels

Figure 4.2 is the fuel viscosity value. It can be seen that by adding clove oil, citronella oil and eucalyptus oil, the viscosity of the fuel decreases. The reduction in viscosity in C1S2 and C1E2 was 17.27% and 17.53% compared to B30.

4.1.3 Caloric Value

To find out the amount of heat energy produced from each unit of fuel that burns completely, where the heating value is directly proportional to the energy value produced from the combustion process. The higher the calorific value of the fuel indicates the less fuel used. Figure 4.3 shows that the addition of vegetable oil additives, the calorific value of C1S2 and C1E2 can increase by 4.43% and 5.73% compared to B30.

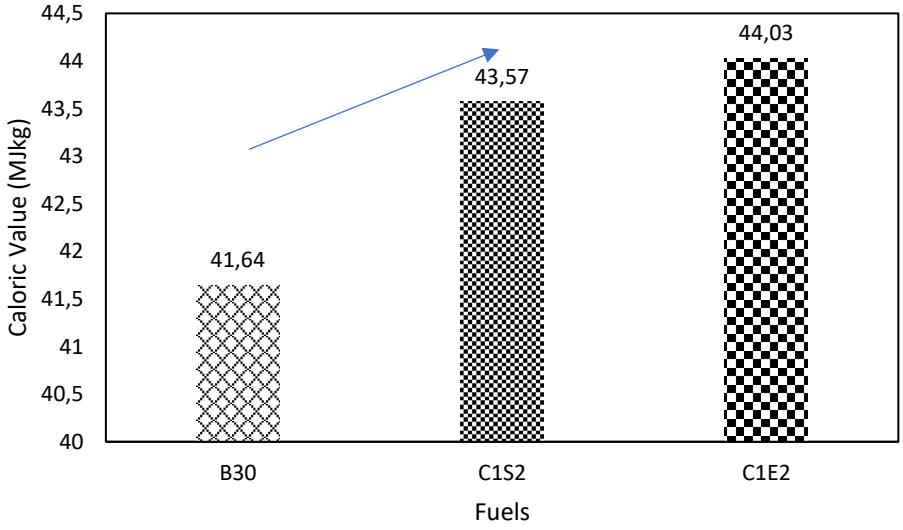

Figure 4.3. Caloric Value of Fuels

4.1.4 Flash Point

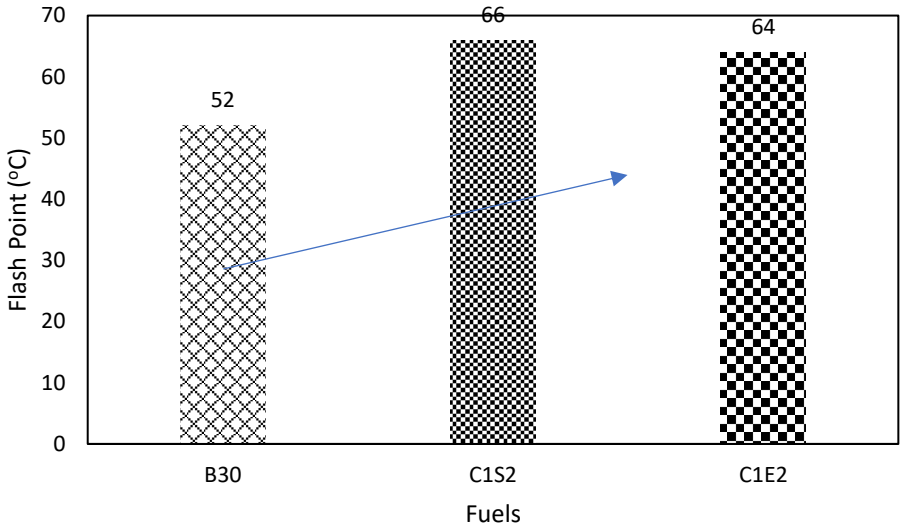

Figure 4.4. Flash point of Fuels

Flash point is a value that shows whether or not a liquid fuel can evaporate and burn by itself [2]. In Figure 4.4, it can be seen that the more essential oil is added, the more the flash point value increases. This is because the flash point value of essential oils is higher than that of diesel fuel. The increases were around 18.75% and 21.21%.

4.2 Analysis of Engine Perform

Engine testing was carried out using a Yanmar, diesel engine, with the specifications below:

Tabel 4.1 Engine Specification

Merek	*YANMAR 4TNV84T-GGEA*	
Engine type	*Inline, water-cooled, 4 stroke diesel*	
Bore x stroke	*84 x 90*	mm
Total displacement	*1.995*	cc
Combustion type	*Direct Injection*	
Aspiration	*Turbocharged Aspiration*	
Valve per cylinder	*4*	
Compression ratio	*18,9*	
Firing order	*1-3-4-2*	

Data collection was carried out at 1500 rpm engine speed with three loads, namely: no load, 36% load and 67% load.

4.2.1 Specific Fuel Consumption (SFC)

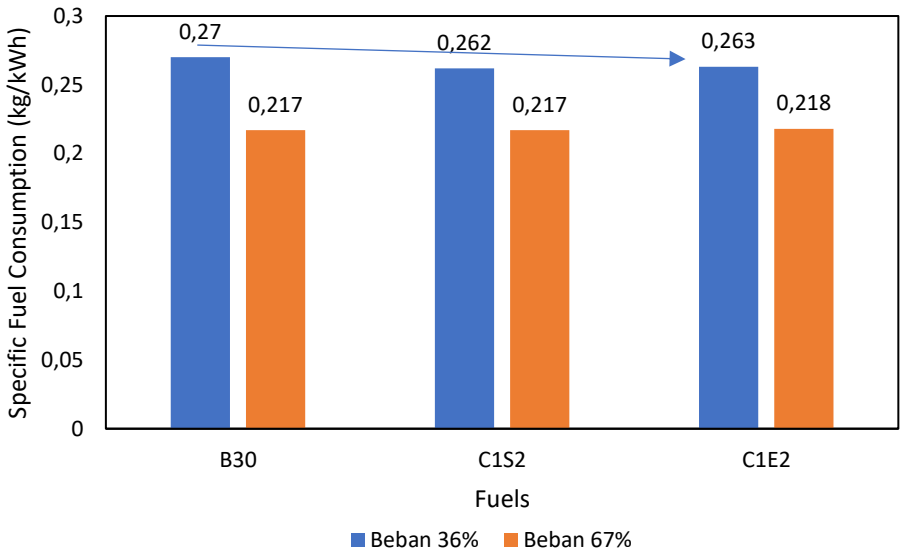

Figure 4.5 Specific Fuel Consumption of Fuels

Figure 4.5 is the fuel consumption on C1S2 and C1E2. In Figure 4.5 it can be seen that at a load of 36%, adding C1S2 and C1E2 essential oil additives fuel consumption can be down by 2.963% and 2.59% compared to B30. This is because C1S2 and C1E2 have a higher heating value than B30 which will maximize combustion in the diesel engine.

4.3 Analysis of Emissions

4.3.1 CO_2

In Figure 4.6 it can be seen that adding additives to C1S2 and C1E2 will reduce CO2 emissions. This is caused by oxygen levels originating from vegetable oil which can reduce CO2 levels in combustion products in diesel engines [2]. In Figure 4.6 it can be seen that CO2 emissions will be reduced at a load of 36% for C1S2 and C1E2 by 57.49% and 52.26% respectively for B30. Meanwhile, for a load of 67%, CO2 emissions will be reduced in C1S2 and C1E2 by 19.13% each.

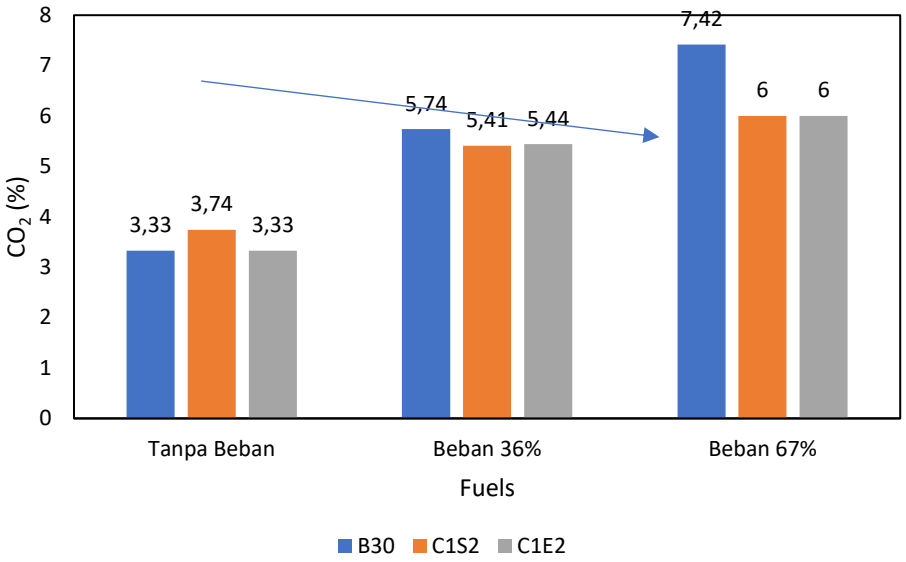

Figure 4.6 CO_2 Emissions of Fuels

4.3.2 CO

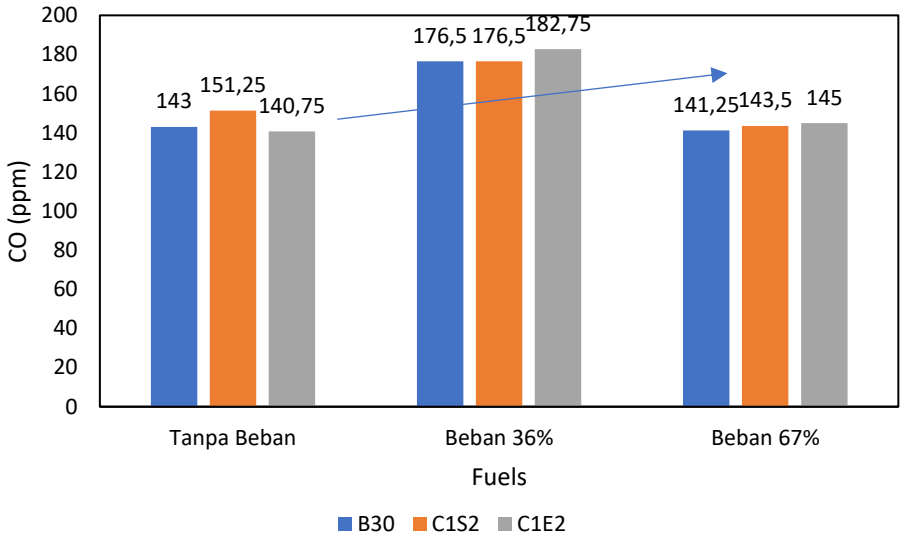

Figure 4.7 CO Emissions of Fuels

In Figure 4.7 are CO emissions in fuel. It can be seen in Figure 4.7 that CO emissions will tend to increase at a load of 36% for C1E2 respectively at 34.19%. Meanwhile, at a load of 67% CO emissions will increase for C1S2 and C1E2 by 15.67% and 25.86% respectively.

4.3.3 NOx

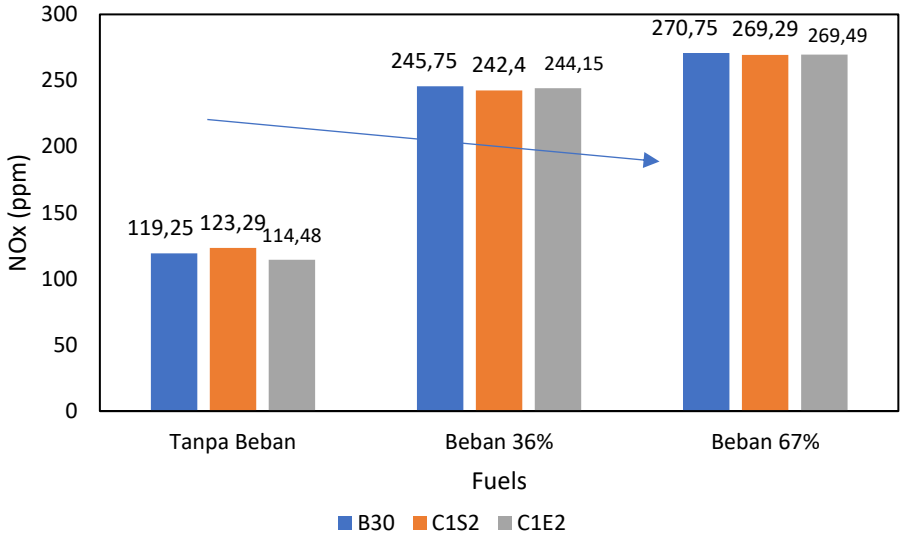

Figure 4.8 NOx Emissions of Fuels

Figure 4.8 shows the results of NOx emissions when adding vegetable additives. It can be seen that there is a decrease in NOx emissions in C1S2 and C1E2. At 36% load, NOx emissions for C1S2 and C1E2 will decrease by 1.36% and 0.65% compared to B30. At a load of 67% NOx emissions for C1S2 and C1E2 will decrease by 0.53% and 0.46% compared to B30. This happens because C1S2 and C1E2 contain additives made from vegetable oil which have oxygen levels so they help reduce NOx emission levels compared to without additives from vegetable oil.

4.4 Economic Analysis

4.4.1 Test Drive

Test drive was taken in order to find the effect of essential oil blended with fuels. Citronella oil was used as additive in blending fuels. Table 4.2 shows the engine specification for test drive. Test drive was taken for the distance of 10 km and it was taken for 5 times. The amount of citronella oil is 3 cc blended with 12 liter fuel. Test drive conditions are on and off the toll road.

Table 4.2 Engine Specification for Test Drive

Engine Type	4 Cylinder Inline, 16 Valve
Cylinder (cc)	1300
Bore x Stroke (mm)	72 x 79,7
Maximum Power (Ps/rpm)	92/6000
Maximum Torque (kgm/rpm)	12,2/4400

4.4.2 Fuel Consumption for Test Drive

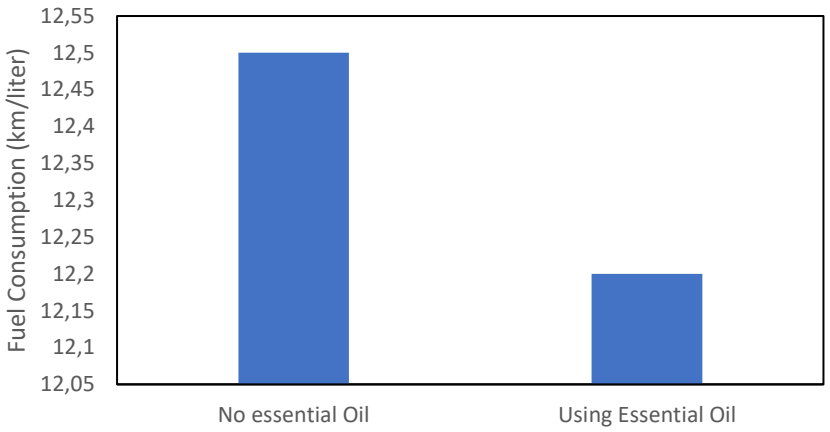

Figure 4.9 Fuel Consumption for Test Drive with Citronella Oil

Figure 4.9 represents the test drive for fuel consumption in using blending Citronella into fuel in the engine. As can be seen in Figure 4.9 using Citronella oil can reduced fuel consumption to 2,4% compared without using citronella oil. Moreover, the characteristics using citronella oil can reduce knocking in the engine. The basic fuel was using RON number 90-92. So, it is very possible, this will happen knocking due the quality of fuel is not very good. However, using the citronella oil as an additive will reduce knocking due to the power in the engine increased and reducing the knocking in the engine. This believed because the oxygen content in essential oil can make improve in combustion to be a perfected combustion in the engine [23].

4.4.3 Economic Analysis (Cost Analysis)

Citronella oil price / liter (1000 ml)	= Rp 160.000,-
Citronella oil 3 ml	= (3/1000) x Rp 160.000,- = Rp 480,-
Fuel Prices/liter (1000 ml)	= Rp 10.000,-
Total Fuel without citronella oil 15 liter	= Rp 150.000,-
Total Fuel with citronella oil	= Rp 150.000,- + Rp 480,- = Rp 150.480,-
Fuel Price without using citronella oil	= (12,5/15) x Rp 150.000,- = Rp 125.000,-
Fuel Price with using citronella oil	= (12,2/15) x Rp 150.480,- = Rp 122.390,4,-

Blending essential oil (citronella oil) 3 ml into 15 liter fuels can reduced the cost Rp 2.610,- km/liter of fuels.

Although using the essential oil as additive in fuel can reduce very small amount of cost but the benefit is the knocking in the engine can be reduced and the power in the engine is higher than without using essential oil as additive in fuel.

BAB 5. KESIMPULAN DAN SARAN

In this research it can be concluded that:

1. By adding clove oil, citronella oil and eucalyptus oil, the viscosity of the fuel decreases. The decrease in viscosity in C1S2 and C1E2 is 17.27% and 17.53% compared to B30.
2. C1E2 has a greater density value of 0.10% and 0.46% compared to C1S2 and B30
3. By adding vegetable oil additives, the heating value of C1S2 and C1E2 can increase by 4.43% and 5.73% compared to B30.
4. By adding vegetable oil additives, the flash point values of C1S2 and C1E2 can increase by 18.75% and 21.21 compared to B30.
5. At 36% load, adding C1S2 and C1E2 essential oil additives can save fuel by 2.963% and 2.59% compared to B30.
6. CO2 emissions will be reduced at 36% load for C1S2 and C1E2 by 57.49% and 52.26% respectively for B30. Meanwhile, for a load of 67%, CO2 emissions will be reduced in C1S2 and C1E2 by 19.13% each.
7. At 36% load, NOx emissions for C1S2 and C1E2 will decrease by 1.36% and 0.65% compared to B30. At a load of 67% NOx emissions for C1S2 and C1E2 will decrease by 0.53% and 0.46% compared to B30
8. In test drive using blending Citronella oil in fuel can reduced fuel consumption to 2,4% compared without using citronella oil.
9. In test drive, using citronella oil can eliminate knocking in the engine due to the oxygen content that can improve the combustion.

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LAMPIRAN 1. ROAD MAP PENELITIAN

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LAMPIRAN 2. LUARAN PENELITIAN

LUARAN 1 :

Kategori Luaran : Hak Kekayaan Intelektual
Status : Tercatat/Tersedia
Jenis HKI : Hak Cipta
Nama HKI : Karakteristik Campuran Bahan Bakar Solar Dengan Minyak Atsiri
No. Pendaftaran : EC002024188095
Tanggal Pendaftaran : 2024-09-18
No. Pencatatan : 000760575
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LUARAN 2 :

Kategori Luaran : Artikel Ilmiah
Status : Submitted
Jenis Publikasi Jurnal : Jurnal Internasional Bereputasi
Nama Jurnal : Mechanical Engineering for Society and Industry
ISSN : 27985245
EISSN : 27985245
Lembaga Pengindek : Scopus
Url Jurnal : https://journal.unimma.ac.id/index.php/mesi
Judul Artikel : Essential Oils to Fuel in The Engine – Perspective Bibliometrics and Review
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Status : Tersedia
Jenis Bahan Ajar : Poster
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