Investigation Emissions in Small Pickup Truck Diesel Common Rail Fuel Supply System with ECU Modification using Blended Palm Biodiesel

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Abstract

The effectiveness and emission levels from tile pipe exhaust small engine pickup using palm biofuel are presented in this study. By volume, palm blended biodiesel at levels of 20-40-60-80 and-100 percent. Diesel engines with common rail system capabilities were assessed using the chassis dynamometer at a constant speed 90 km/h. Test ambient temperature conditions of 30-32 °C with the test conditions on a chassis dynamometer. The Engine Control Unit (ECU) modification by remapping the ECU control unit in the common rail fuel injection engine of Injection pressure and EGR demanding are the main parameters. These measurements included gas pollution; Carbon Monoxide (CO), Carbon Dioxide (CO_2), Hydrocarbons (HC), Oxygen (O_2), and Nitrogen dioxide (NO_2). According to the experimental findings, a result of the high concentration mixed Palm biodiesel ratio and measure gas pollution of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC), and nitrogen dioxide (NO_2). The higher oxygen concentration and lower carbon content are to blame for these results.

Keywords: Biodiesel blend diesel, Car performance, Emission

Introduction

One of the most important economic sectors is transportation, which directly employs around 10 million people, contributes roughly 5% of the EU's GDP, and leads all private sectors in R&D spending with annual investments of 41.5 billion euros. Even though, emissions of pollutants and greenhouse gases (GHG) have been significantly reduced, air quality and climate change continue to be two of the most urgent problems confronting society today. Initially, Regulation 70- 220 of EEC for light-duty cars [2] and changes following the release of the succeeding Euro levels, which are increasingly stringent, regulated pollutant emissions in road transportation (PM, NOx, THC, and CO). To meet this standard, the automotive industry has invested a significant amount of money in the development of complex emission control systems. Data from the research [3] show that between Euro-1 and Euro-6, emissions control technologies increased the price of diesel light-duty cars by more than 30 times. This is important to fuel technology, especially when contrasted to the cost of gasoline, which has only climbed twice and is now 4 times less expensive than the cost of diesel's equivalent emissions control technology under Euro-6. The problem that has surfaced regarding the gap between certification and actual driving NO_x emissions is another obstacle for diesel technology. This fact emphasizes how challenging it is to manage emissions while an engine is operating transiently. Once more, gasoline-powered vehicles have not been associated with the NOx emissions issue. A quarter or so of the EU's greenhouse gas emissions are related to transportation. Only road

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transportation specifically accounts for around 1/10 of the total carbon dioxide (CO_2) emissions in the EU, which is the principal greenhouse gas. The EU has created measures, such as CO_2 emissions objectives for new passenger automobiles, to lower emissions associated with transportation. Due to its greater efficiency, diesel technology has an edge over gasoline technology in this case. However, modern innovations like hybrid gasoline are capable of producing fewer CO_2 emissions than comparable diesel technology. In this context, energy corporations have reformulated fuels to optimize the fuel qualities to emissions control systems or to reduce engine exhaust emissions, in addition to the car industry's numerous attempts to address environmental issues [4]. According to the most recent update of the Fuel Quality Directive (FQD) [5], which demonstrates important technical requirements for health and the environment for fuels to be used with otto and diesel engines, fuel suppliers are required to reduce the GHG emissions of transport fuels by at least 6% in 2020, compared to a baseline of 2010. Furthermore, the renewable energy directive mandates that by 2020, 10% of the energy used to power transportation fuels must originate from sustainably renewable sources [6]. This percentage can be increased by using bio-based ingredients in blends, renewable energy sources for car recharging, biogas produced from trash, and other actions. Biodiesel impacts emissions and performance has been discussed in a variety of research papers and critical literature studies [7], [8]. The fuel bulk of these tests, though, were performed in steady-state conditions with engines that were tuned to use regular diesel fuel. Transient conditions, which are a significant problem when managing emissions and drivability concurrently [9], are far from steady-state conditions when both diesel and biodiesel fuels are used. This fact emphasizes the need for future research to look into further compatibility between biodiesel and engine control under transient conditions. It also points out the possibility of optimizing existing engine management when using biodiesel at high concentrations.

Therefore, this is a crucial setting for conventional powertrains and, specifically, for diesel passenger vehicles in previous research [10], given that it must optimize pollutant emissions (such as NOx and particulates) without compromising CO_2 emissions. Future generations' access to clean, efficient, and accessible transportation will depend on the ability of modern diesel engines to act as one of the fundamental low CO_2 technologies. For both the CO_2 equilibrium and pollutant emissions, the transient operation is becoming more crucial, and biofuels like FAME could significantly impact. This research investigates how Fatty Acid Methyl Ester (FAME) and its blend (30% v/v FAME) affect pollutant and CO_2 emissions during a transient cycle.

This research focuses on investigating modification of the ECU mapping of engines for palm biodiesel blended fuels to optimize their emission of CO_2, Hydrocarbon (HC) Lambda remaining oxygen after combustion, Nitrogen dioxide (Nox), Smoke level intensity black smoke of biodiesel blending ratio and correct the gaseous emissions, on the real condition driving conditions on the chassis dynamometer were discussed.

Experimental setup

This experiment is divided into the first step to tuning the ECU by using a program to adjust the operating conditions of the ROM in a small pickup engine via the OBD2 portpass computer programming. The second step, the chassis dynamometer, MAHA model MSR 500, simulates the function of resistance forces the car such as slope resistance, air resistance, and rolling resistance at the test wheels. Third step measure pollution from the tailpipe of a car by using a gas analyzer AVL DITEST GAS 1000 AK, which can measure both CO NOX and HC gas emissions and gas left after combustion such as oxygen lambda as well as black smoke levels, AVL gas analyzer. All of the data samples were 5 times repeatability and average data before analysis and report.
A typical layout of the engine test bench and the experimental tools utilized in this work are shown in Fig. 1. Table 1 illustrate a diesel engine with four cylinders, four strokes, turbocharging, an intercooler, and a common rail injection system was used as the experimental unit.

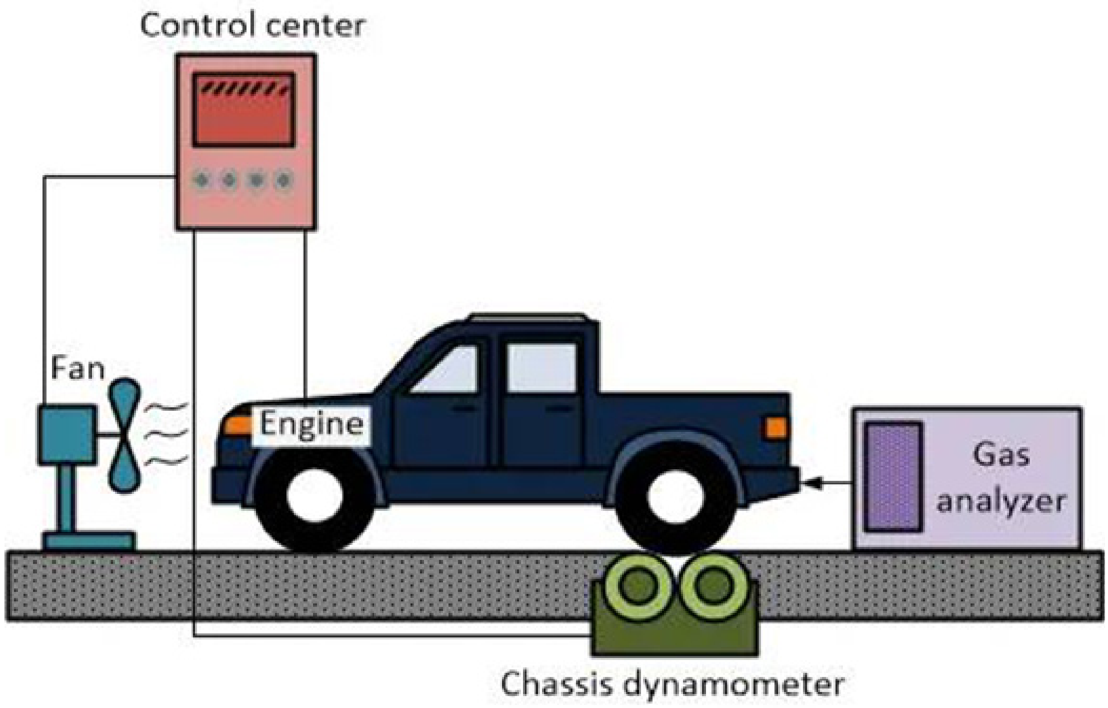

Figure 1 Experimental setup

Table No. 1 Engine specification

Specifications	Details
Displacement volume (cm^3)	1,893
Maximum output (PS/rpm)	150/3600
Fuel system	Direct Injection Common Rail
Compression ratio	16.1:1

Table No. 2 Test fuel property

Blended biodiesel by % vol.	LHV; (MJ)	Flash point; (°C)	Density; (kg/m^3)	Surface tension; (mN/m)	Viscosity; (CST)
7 (Commercial Diesel)	45.13	68.5	823.48	26.22	3.254
20	44.41	76.5	828.79	27.17	3.35
40	43.44	82	837.5	27.38	3.653
60	42.45	90	846.14	27.68	3.895
100	39.89	170.5	862.79	28.69	4.447

The fuel properties are shown in Table 2. Physical properties compare Lower Heating Value (LHV), kinematic viscosity, density, ignition point, the cetane number of diesel fuel (Diesel) and palm oil transesterification (PBDF) mixed at 4, the ratio by volume. The LHV value decreased due to the increase in biodiesel oxygen molecules. Similarly, flashpoint, density, surface tension, and viscosity increased with higher ratios of palm biodiesel. Due to the tighter bonding molecules of bonder molecules in test fuel.

The essential constituents of petroleum can be divided into three categories: First, the paraffin base is mainly composed of paraffinic hydrocarbons. After refining, the residue is paraffin wax. and provides high-quality lubricant. Second, an asphaltic base, mainly composed of naphthenic hydrocarbons. After distillation, it yields residue as asphalt. Third, mixing bases are composed of many hydrocarbons, such as paraffinic, asphaltic, aromatic, and telephonic residues. The result will be a mixture of paraffin wax and asphalt. The vast majority of crude oils are mixed base types.

The elemental analysis of diesel fuel and biodiesel fuel using an elemental analyzer (CHN/S), LECO-628 series under ASTM D5291 testing standard is shown in Table 3. The measurement results, it was found that when the blending ratio of biodiesel was increased, carbon, hydrogen and nitrogen had a decreasing volume, but the oxygen mixture, on the other hand, had an increased blended palm biodiesel volume. The octane rating and combustion process are both greatly improved by the oxygenated additions. In order to blended with different diesel and biodiesel fuels in any ratio without separating their two phases, oxygenated additives must be able to mix with diesel fuels. In order for the mixture of oxygenated additives in biodiesel and diesel to enhance the cetane number, there must be a sufficient amount of cetane in the oxygenated additives [11].

Experimental test conditions on a chassis dynamometer

The results of recording values from On Board Diagnostic (OBD) used to record data of engine parameter operation as a constant parameter are shown in Table 4. Cal-load is the percentage of workload that the vehicle has been calculating from Engine Control Unit (ECU) demands. Manifold pressure is the pressure at the

Table No.3 CHN/S analysis

Blended biodiesel by % vol.	Carbon; (%)	Hydrogen; (%)	Nitrogen; (%)	Oxygen; (%)
7 (Commercial Diesel)	85.177	14.047	0.55491	0.22109
20	82.019	14.142	0.01265	3.82635
40	80.521	13.695	0.01552	5.76848
60	79.009	13.692	0.0994	7.1996
100	78.332	13.081	0.221	8.366

Table No.4 Constant variable on OBD data

Conditions	Map0	Map1
Cal load (%)	47.5	48.1
Manifold pressure (kPa)	126	255
RPM (rpm)	1513	1519
Advance injection timing Before Top Dead Center (BTDC) (Degree)	-5	-5
Airflow (kg/s)	29.25	29.30
Rail pressure (kPa)	76680	80200
Command (EGR)	24.3	25.1
Command Accretor pedal position (%)	83.5	83.5

manifold after turbocharging compresses the air in the engine cylinder. Engine RPM is the real-time engine revolutions at constant load. Advance injection timing Before Top Dead Center (BTDC) timing is the fuel injected preceding before top dead center. Airflow is the rate of airflow entering the intake manifold. Command EGR is the required percent of opening the EGR exhaust valve. The degree accelerator pedal position is the throttle position percentage controlled by the driver's demand.

Conditions for ECU, as in Table 4 modified namely by adjusting the fuel injection pressure to increase the amount of fuel injected into the combustion chamber and increasing fuel pressure. The atomization separation of biodiesel with a high yield ratio, can be collapsed into a nebulizer and fast ignition flame propagation into the spray cornel. And then, increase EGR opening percent to reduce combustion temperature causing NOX during the combustion process. The LHV value decreased due to the increase in biodiesel oxygen molecules. Similarly, flash point, density, surface tension, and viscosity increased with higher ratios of palm biodiesel. Due to the tighter bonding molecules of bonder molecules in test fuel. To separate the test conditions, Map0 is the original ECU setting from the default factory and Map 1 which is the modification under the remapping process.

Results and discussion.

To examine the emissions and particulates, conventional common rail diesel engines in small pick-up engines were carried out in this research at various injection pressure and manifold pressure. Using a four-cylinder engine with a steady engine speed at 90 km/hr with constant engine revolution and percent throttle position.

Seven categories of results from conventional CI testing experiments on the chassis dynamometer are related as follows.

1. Carbon (CO)

The results of measurements of carbon emissions from exhaust pipes at a constant speed of 90 km/h in Fig. 2 showed that the carbon dioxide emissions of B7 fuel were 10%vol. The increase in bio-diesel decreases the carbon dioxide proportion of the biodiesel produced up to B100 biodiesel higher due to biodiesel containing a mixture of oxygen in the fuel (Oxygenate) and carbon composition according to the composition of biodiesel fuel in Table 2. Resulting in complete combustion in the fuel, carbon dioxide reduced volume on blending ratio 80 and pure palm biodiesel. The extra oxygen content in the fuel, which enhances combustion in the cylinder, maybe the cause of the decrease in CO emissions from biodiesel and its blends. Additionally, biodiesel is less compressible (high fuel density) than diesel fuel and has a higher cetane number.

A higher cetane number in biodiesel fuel reduces the likelihood of fuel-rich zones emerging and advanced injection timing. All of these lead to a reduction in the ignition delay, an extension of combustion, and an increase in the areas of complete combustion response. Less compressible fuels start the injection process earlier and result in longer combustion times. These findings concur with the majority of those reported in the literature previous works [12], [13], [14], [15].

2. Hydrocarbon (HC)

The results of measurements of hydrocarbon emissions from exhaust pipes at a constant speed of 90 km/h in Fig. 3 showed that the carbon emissions of B7 fuel were 5 %vol. The increase in diesel causes hydrocarbon to decrease in proportion to the biodiesel obtained until reaching biodiesel and B100 remaining until 30 ppm. Biodiesel is a mixture of oxygen in the fuel (oxygenate) and has a poor mix of fuel and air due to the increased kinematic viscosity of the fuel resulting in increased combustion temperature and unburnt fuel implement with cylinder wall and generating the hydrocarbon emission combustion mechanism.

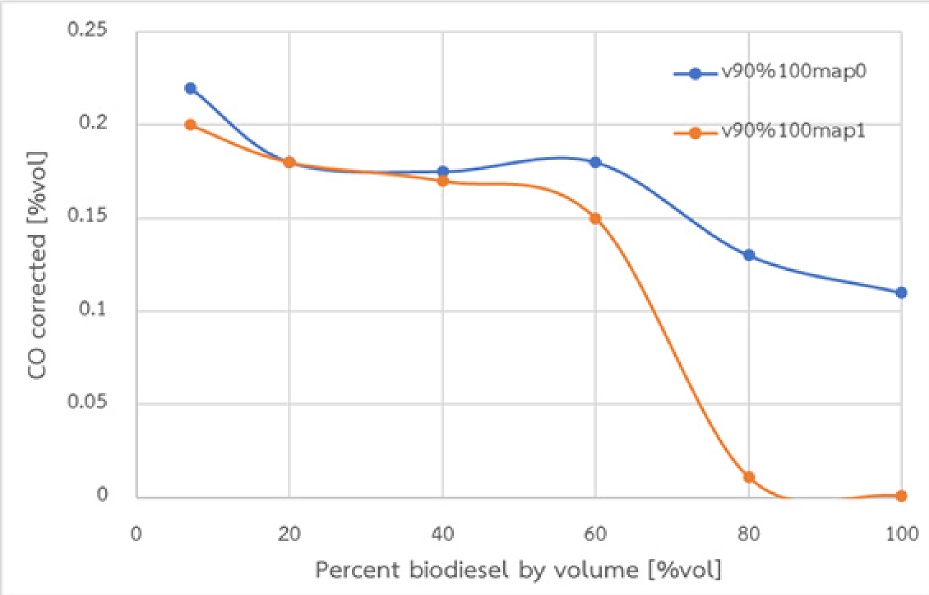

Figure 2. Carbon various percent blended biodiesel by volume.

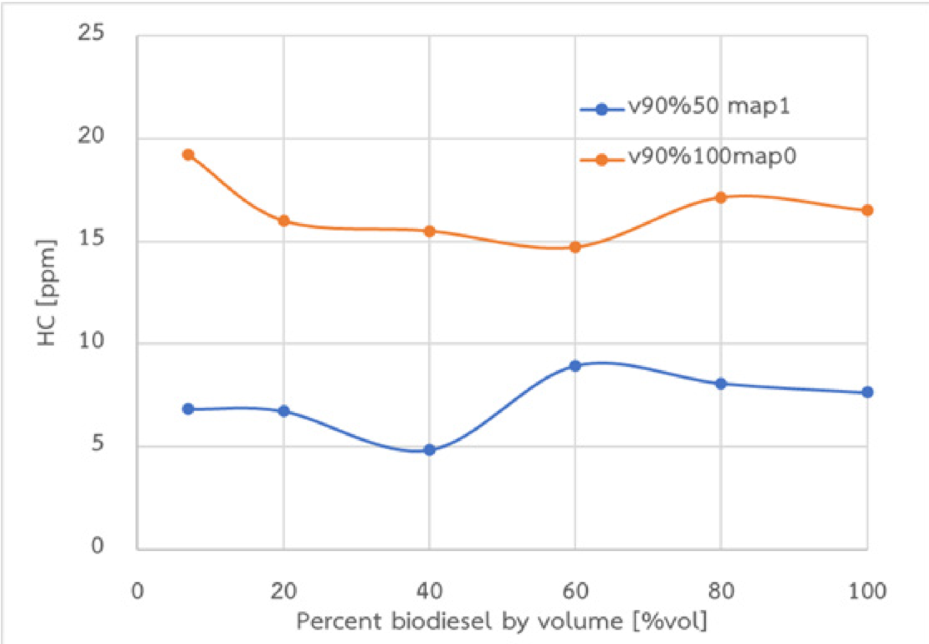

Figure 3. Hydrocarbon various percent blended biodiesel by volume.

3. Lambda

The effect of the inverse of the combustion residue of the fuel-air equivalence (Lambda) exhausts the pipe at a constant speed of 90 km/hr. In Fig. 4, it was found that the Lambda value of B7 fuel was 1.55 and when the value was higher, the proportion of biodiesel increased. Increasing the proportion of biodiesel equivalent until reaching biodiesel B100 equal to 1.74 to 1.79. Lambda form gaseous after combustion in this case higher blended ratio of biodiesel releases slightly oxygen producing more lambda. Due to biodiesel containing oxygen in the fuel (Oxygened) and the mixture of fuel and air increases the residual air after combustion.

In the engine ECU tuning (Map1), the lambda value tends to increase with all kinds of test fuel load than in the non-engine tuning case conditions. Increasing the pressure of the intake manifold (Manifolds pressure) increases the amount of air required to burn the engine. The residual air from combustion increases accordingly, the lambda tends to increase, and the increasing injection pressure increases the velocity of the fuel and air resulting in the fuel-air mixture. Over-excess air improving combustion results in complete combustion and improved residual air.

As for biodiesel fuels at higher fuel concentration ratios, the trend of lambda tended to be constant across higher biodiesel mixtures due to the excess of air in the fuel mixture.

4. Remaining oxygen after combustion

Increasing the proportion of biodiesel makes the mixture of oxygenate (O_2). Fig. 5 tends to increase because the mixture of biodiesel leads to more complete combustion and increases the air residual ratio that contains oxygen. According to the proportion of biodiesel mixed up accordingly with oxygen content in the fuel as in Table 2.

ECU mapping (Map1), both in terms of adjusting the pressure in the intake manifold and increasing the injection pressure, accelerates the air-fuel mixture, resulting in the tendency of residual oxygen after combustion.

5. Nitrogen dioxide

Increasing the proportion of biodiesel makes the nitrogen mixture shown in Fig. 6 tend to increase due to the biodiesel mixing resulting in more complete combustion, then NO bonds to become NOx increased according to the proportion of biodiesel mixed up accordingly. In the case of tuning (Map1), both in terms

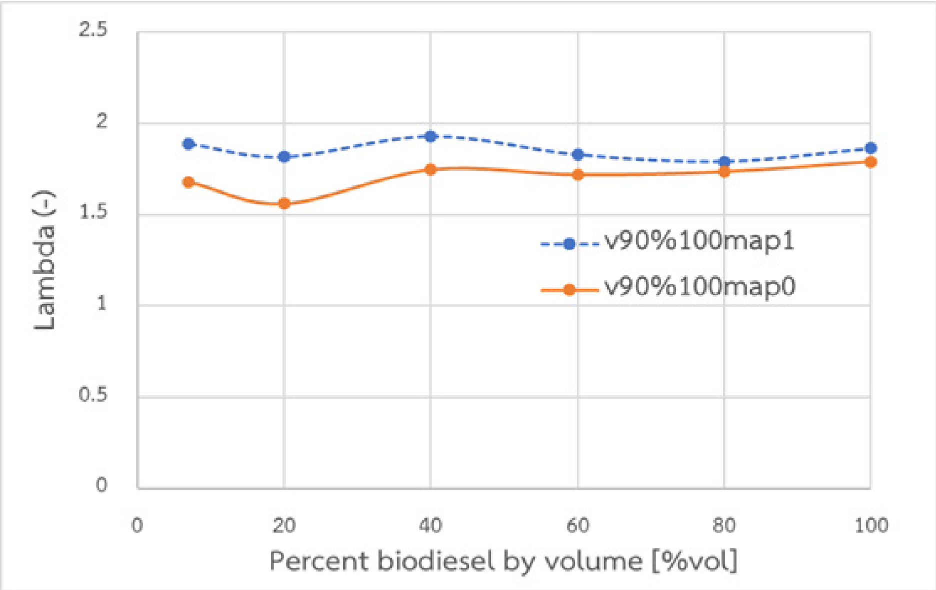

Figure 4. Lambda various percent blended biodiesel by volume.

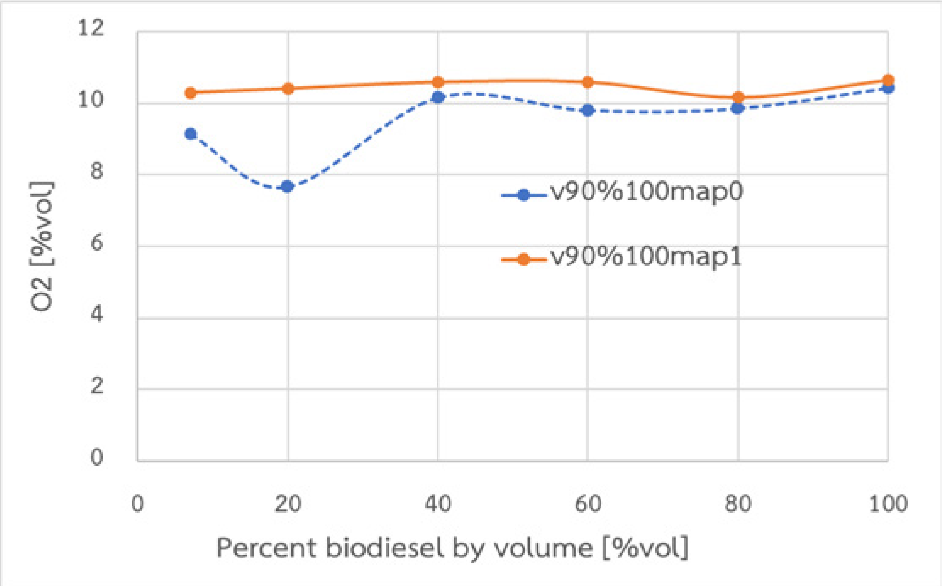

Figure 5. Remaining oxygen after combustion of various percent blended biodiesel by volume

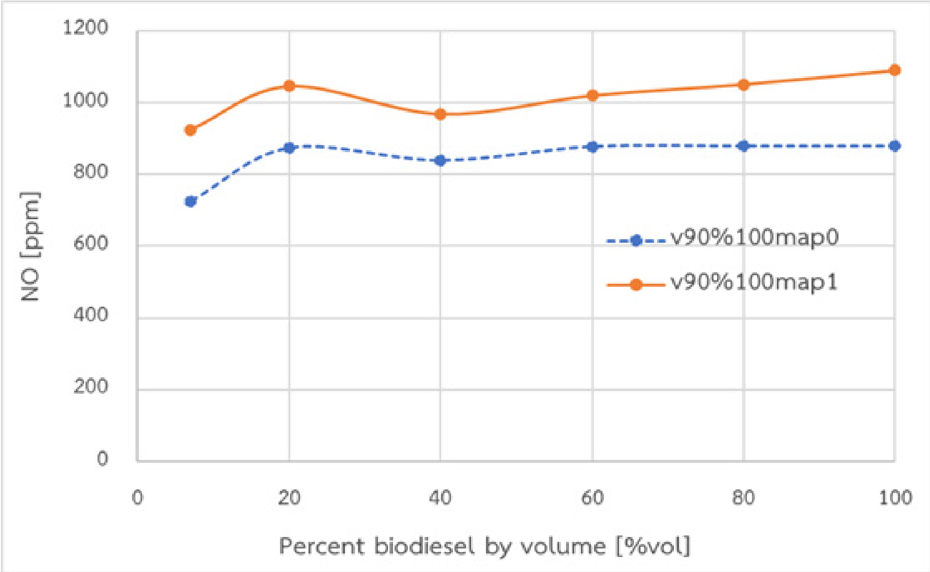

Figure 6. Nitrogen dioxide various percent blended biodiesel by volume

of adjusting the pressure in the intake manifold and increasing the fuel injection pressure, has accelerated the mixture of fuel and air, resulting in the trend of NO_x tending to increase.

6. Smoke level intensity

Increasing the proportion of biodiesel causes the density of black smoke to increase because biodiesel is mixed with more complete combustion and makes the combustion better and exhausted in proportion blended biodiesel based on as shown in Fig. 7.

In the case of tuning (Map1) both adjust the pressure in the intake manifold and increase the injection pressure, thus increasing the acceleration of the fuel atom in case of increasing the injection pressure and increasing the fuel injection pressure. Initial pressure on the fuel-air mixture combustion results in the tendency for the density of black smoke has increased. The oxygen concentration in the biodiesel blend and its blend with diesel fuel may be more successful in improving better combustion, resulting in a decrease in smoke opacity as compared to commercial diesel, as smoke is created due to incomplete combustion of those reported in the literature previous works [17].

7. Black smoke intensity

Increasing the proportion of biodiesel causes the density of black smoke to increase, due to biodiesel is mixed with more complete combustion and makes the combustion better and exhausted in proportion blended biodiesel based on as shown in Fig. 8.

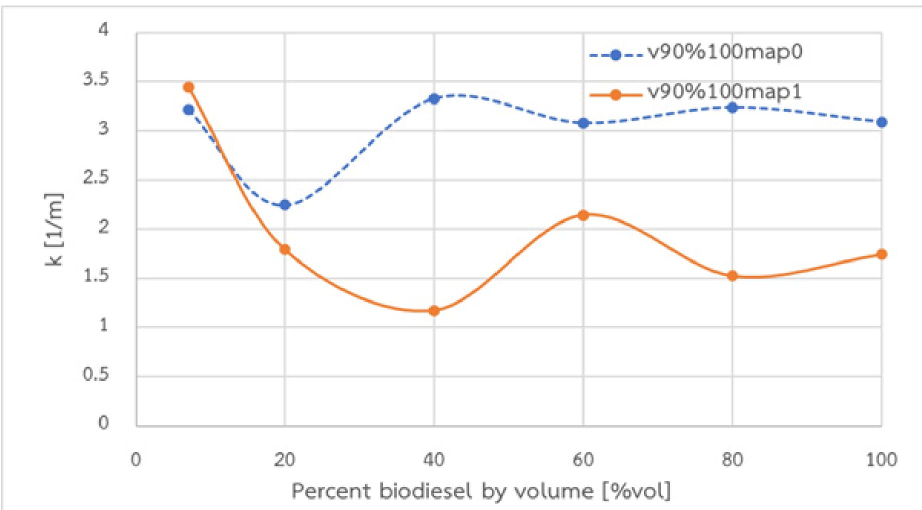

Figure 7. Smoke level intensity various percent blended biodiesel by volume

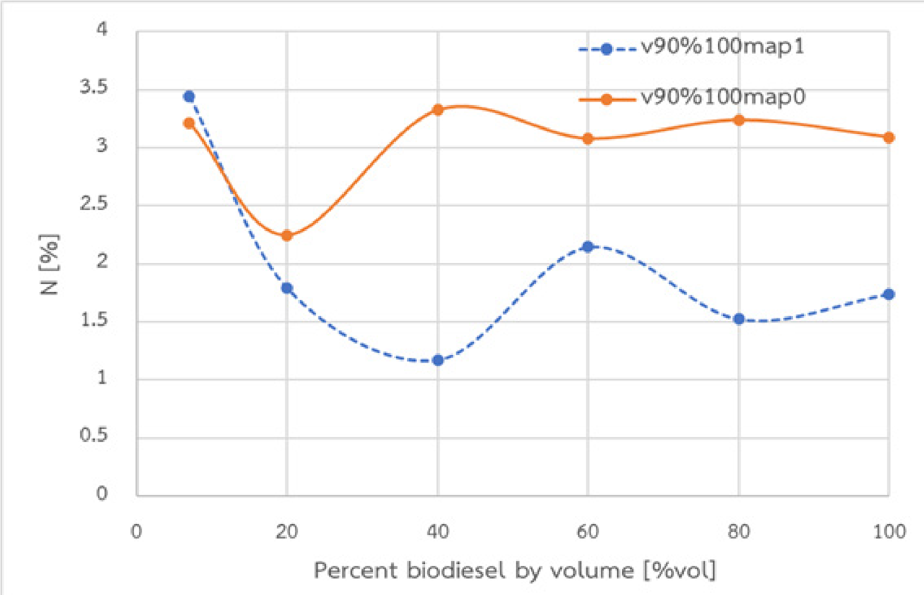

Figure 8. Black smoke various percent blended biodiesel by volume

ECU adjustments in both intake manifold pressure adjustment and fuel injection pressure increase the initial combustion pressure and increase the amount of fuel delivered together with the speed of the engine. Fuel spray collides with the air in the combustion chamber, increasing aerosolization and accelerating the air-fuel mixture, resulting in a decreasing tendency for the density of black smoke.

Conclusion

Based on real road driving conditions, these conditions have been brought back to simulate the workload, including air resistance. Wheel rolling resistance and steep resistance to create driving conditions at a speed of 90 km/hr. When adding a mixture of biodiesel, the pollution emitted from exhaust pipes such as carbon dioxide hydrocarbons decreases and increases the residual oxygen from combustion.

Summary of experimental results in a common rail diesel engine that has been changed by a modified engine control unit.

Increasing the mixture of biodiesel to diesel reduced the effect of exhaust emissions such as carbon dioxide, which was the main parameter in this research, and engine tuning by modifying it. And the modified engine control unit producing the carbon monoxide value decrease accordingly. As for other pollution values such as hydrocarbons decrease and emitted the residual oxygen from combustion higher, due to biodiesel contains a mixture of oxygen in the fuel, resulting in residual air from combustion. The last point is the increased value of nitrogen dioxide from biodiesel blending at the ratio, biodiesel has a high ratio more oxygenated add-in, improving the combustion reaction increases the combustion flame temperature and results in no bond to NO_x from complete combustion.

Recommendations for further research

1. Perform a combustion pressure testing in the combustion chamber to analyze the range of various pollutants from the engine.

2. Perform emission testing according for diesel engines such as Euro and ECE test cycle standards.

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