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At Present Scenario Real-Time Effect of Biodiesel on C I Engine To Estimate The Performance And Efficiency of Diesel Engine By Using WVO and Biodiesel Blended Oil

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Abstract:

Growing concern regarding energy resources and the environment has increased interest in the study of alternative sources of energy. So to meet increasing energy requirements, there has been growing interest in alternative fuels like biodiesel to provide a suitable diesel oil substitute for internal combustion engines and also diminishing source of fossil fuels, increasing world population that corresponds to increasing energy needs and the burden of pollution control have been considered great challenges that con-fronted human beings in developing energy and pollutant-producing machines. Assuming the consumption will not increase the world oil reserves are expected to last for 42 yrs [1]. Currently, alternative fuels are being investigated in detail for application in compression ignition (CI) engines resulting in exciting potential opportunities to increase energy security and reduce gas emissions.

Biodiesel is one of the alternative fuels which is renewable and environmentally friendly and can be used in diesel engines with little or no modifications. The objective of this study is to investigate the effects of biodiesel types and biodiesel fraction on the emission characteristics of a CI engine. The experimental work was carried out on a four-cylinder, four-stroke, direct injection (DI) and turbocharged diesel engine by using biodiesel made from waste oil, rapeseed oil, corn oil and comparing them to normal diesel. The fuels used in the analyses are B10, B20, B50, B100 and neat diesel The engine was operated over a range of engine speeds. Based on the measured parameters, detailed analyses were carried out on major regulated emissions such as NOx, CO, CO2, and THC. It has been seen that the biodiesel types (sources) do not result in any significant differences in emissions. The results also clearly indicate that the engine running with biodiesel and blends have higher NOx emission by up to 20%. However, the emissions of the CI engine running on neat biodiesel (B100) were reduced by up to 15%, 40% and 30% for CO, CO2 and THC emissions respectively, as compared to diesel fuel at various operating conditions.

Keywords:
c.i engine; carbon dioxide; carbon monoxide; biodiesel blend; nitrogen oxides; total hydrocarbon; emission etc.

1. Introduction:

Diesel engines are the major sources of transportation power generation , marine application etc . Although more fuel efficient than their spark ignited counter part,they have relatively higher emissions and noise level. hence , diesel is being used extensively , but due to gradual depletion of fossil fuel reserves and the impact of environmental pollution of increasing exhaust emissions there is an urgent need for suitable alternative fuels for use in C.I. engines. Vegetable oil is one obvious fuel particularly because their fuel properties are closer to diesel fuel. Two important properties, the cetane number and the calorific value are similar to diesel. Hence diesel engines can be operated on vegetable oil without modification [2]. Of the various alternate fuels under consideration, biodiesel, derived from vegetable oils, is the most promising alternative fuel to conventional diesel fuel (derived from fossil fuels; hereafter just “diesel”) due to the following reasons [3].

(a)Biodiesel is an oxygenated fuel; emissions of carbon monoxide and soot tend to be reduced compared to conventional diesel fuel.

(b)Biodiesel is produced from renewable vegetable oils/ animal fats and hence improves fuel or energy security and economy independence.

(c)The use of biodiesel can extend the life of diesel engines because it is more lubricating than petroleum diesel fuel.

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(d)Biodiesel can be used in existing engines without any modifications.
(e)The Occupational Safety and Health Administration classify biodiesel as a non-flammable liquid.
(f)Unlike fossil fuels, the use of biodiesel does not contribute to global warming as CO2 emitted is once again absorbed by the plants grown for vegetable oil/biodiesel production. Thus CO2 balance is maintained.
(g)Biodiesel is made entirely from vegetable sources; it does not contain any sulfur, aromatic hydrocarbons, metals or crude oil residues.
A lot of research work has been carried out using vegetable oil both in its neat form and modified form. Studies have shown that the usage of vegetable oils in neat form is possible but not preferable [4]. The high viscosity of vegetable oils and the low volatility affects the atomization and spray pattern of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking. Methods such as blending with diesel, emulsification, pyrolysis and transesterification are used to reduce the viscosity of vegetable oils. Among these, the transesterification is the most commonly used commercial process to produce clean and environmentally friendly fuel.A large number of studies on performance, combustion and emission using raw vegetable oils and methyl/ethyl esters of sunflower oil [5], rice bran oil, palm oil [6], mahua oil, jatropha oil, karanja oil [7], soybean oil, rapeseed oil and rubber seed oil have been carried out on Compression Ignition(CI) engines. The purpose of this paper is to review previous studies that look into the effect of bio-diesel on CI engine from the viewpoint of performance, combustion and emissions.

1.1.Production of biodiesel:

Vegetable oils are chemically complex esters of fatty acids. These are the fats naturally present in oil seeds, and known as tri-glycerides of fatty acids. The molecular weight of these tri-glycerides would be of order of 800 kg/m3or more. Because of their high molecular weights these fats have high viscosity causing major problems in their use as fuels in CI engines. These molecules have to be split into simpler molecules so that they have viscosity and other properties comparable to standard diesel oils. Modifying the vegetable oils (to make them lighter) can be achieved in many ways, including; Pyrolysis, Micro emulsification, Dilution and Transesterification. Among these, transesterification is the most commonly used commercial process to produce clean and environmentally friendly light vegetable oil fuel i.e. biodiesel.

At the time the study was conducted, the Philippines has not yet acquired any equipment for monitoring diesel engine performance in real-time condition. While this study investigates the instanta-neous diesel engine performance, refining processes of waste vegetable oil were also given emphasis due to the nature WVO properties that are found in the Philippines shown in fig.

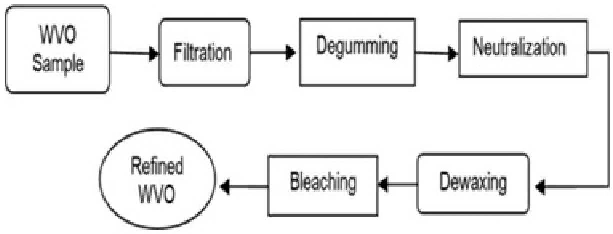


Fig.1 Refining processes of WVO

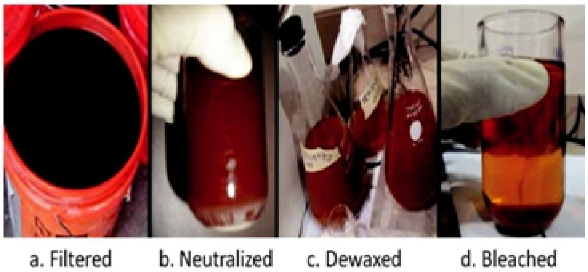
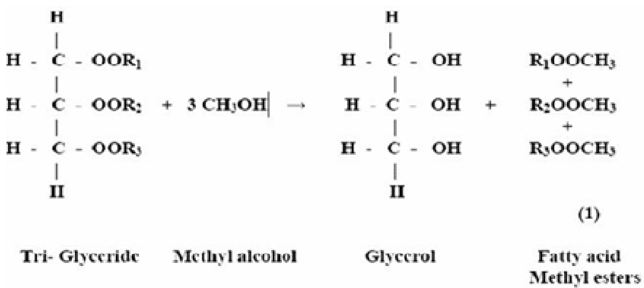


Fig. 2 WVO colour and appearance during refining

1.2 Transesterification:

The fatty acid triglycerides themselves are esters of fatty acids and the chemical splitting up of the heavy molecules, giving rise to simpler esters, is known as Transesterification. The triglycerides are reacted with a suitable alcohol (Methyl, Ethyl, or others) in the presence of a catalyst under a controlled temperature for a given length of time. The final products are Alkyl esters and Glycerin. The Alkyl esters, having favorable properties as fuels for use in CI engines, are the main product and the Glycerin, is a by-product. The chemical reaction of the Tri-glyceride with Methyl alcohol is shown below. With higher alcohols the chemical equation would change correspondingly



1.3 Properties of biodiesel:

The fuel properties of raw vegetable oil as listed in Table 1 indicate that the kinematic viscosity of vegetable oil varies in the range of 30–40 cSt at 38°C. The high viscosity of these oils is because of their large molecular mass in the range of 600–900 kg/m3. This is about 20 times higher than that of diesel fuel. The flash point of vegetable oil is very high (above 200°C). The heating values are in the range of 39–40 MJ/kg compared to 45 MJ/kg for diesel fuel. Heating values of various vegetable oils are nearly 90% of diesel fuel. The presence of chemically bound oxygen in vegetable oil lowers their heating values by about 10%. The cetane numbers are in the range of 35–50 [8] and is similar or close to that of diesel fuel. Long chain saturated, unbranched hydrocarbons are especially suitable for conventional diesel fuel. The long, unbranched hydrocarbon chains in the fatty acids meet this requirement. The above unique properties of vegetable oils help us to replace the conventional diesel fuel. Wang et al. [9] reported that the major disadvantage of vegetable oils is their inherent high viscosity. Modern diesel engines have fuel injection systems that are sensitive to viscosity change. A high viscosity may lead to poor atomization of the fuel, incomplete combustion, choking of the injectors, ring carbonization and accumulation of the fuel in the lubricating oils. A way to avoid these problems and to improve the performance of the fuel in an engine is to reduce the viscosity of vegetable oil. Methods that reduce the viscosity of vegetable oil include transesterification and fuel blending. These have the advantages of improving the use of vegetable oil as fuel with minimum processing and engine modification.

Table .1 Properties of vegetable oil:

Vegetable oil	Kinematic viscosity at 38°C (cSt)	Cetane No.	Heating value (MJ/kg)	Cloud point (°C)	Pour point (°C)	Flash point (°C)	Density (kg/l)
Diesel	3.06	50	43.8	–	–16	76	0.855
Corn	34.9	37.6	39.5	- 1.1	- 40.0	277	0.9095
Cottonseed	33.5	41.8	39.5	1.7	-15.0	234	0.9148
Crambe	53.6	44.6	40.5	10.0	- 12.2	274	0.9048
Linseed	27.2	34.6	39.3	1.7	-15.0	241	0.9236
Peanut	39.6	41.8	39.8	12.8	-6.7	271	0.9026
Rapeseed	37.0	37.6	39.7	-3.9	-31.7	246	0.9115
Safflower	31.3	41.3	39.5	18.3	-6.7	260	0.9144
Sesame	35.5	40.2	39.3	-3.9	-9.4	260	0.9133
Soya bean	32.6	37.9	39.6	-3.9	-12.2	254	0.9138
Sunflower	33.9	37.1	39.6	7.2	-15.0	274	0.9161
Palm	39.6	42.0	–	31.0	–	267	0.9180

Current and future emission regulations are, and will become, more stringent and as a consequence, the transport sector is undergoing rapid transformation in order to comply with these regulations. In addition, fossil fuel demand is continuously increasing globally, the result of which is the rapid depletion of fossil fuel deposits [10]. Such problems are compelling countries to now focus on developing or finding alternative fuels [11]. The major alternative fuels being used in automotive transport are ethanol, hydrogen and biodiesel. Ethanol technology is successfully established and commercialised in both developing and developed countries. However, ethanol use is limited only to spark ignition engines. Furthermore, ethanol use is also limited to maximum blend strengths of up to 15% only because higher blend strengths result in fuel injection system problems [11].

Hydrogen-based fuel cells could become a viable alternative to fossil fuels, however, to make its use commercially viable, many technical challenges need to be addressed, for example, complexity in hydrogen production, requirements of special infrastructure for its storage, and high fuel cell production costs. In spite of research advances on hydrogen-powered fuel cells, diesel engines are expected to remain in use for high-power applications, such as rail road locomotives, ships and over land transport trucks [12]. carried out a thorough review of publications on the characteristics of emissions of engines using biodiesel and its blends and their conclusions are summarized in Table 2.

Table 2. Estimated share of literature (in % number of publications) on effect of pure biodiesel on engine performance and emission in comparison with diesel [21,13].

Parameters	Increasing trend number of papers (%)		Similar trend number of papers (%)		Decreasing trend number of papers (%)	
	Lapuerta *et al.*	Xue *et al.*	Lapuerta *et al.*	Xue *et al.*	Lapuerta *et al.*	Xue *et al.*
NO_x emission	85	65.2	10	5.8	5	29.0
PM emission	3	9.6	2	2.7	95	87.7
THC emission	1	NR*	3	NR	95	NR
HC emission	NR	5.3	NR	5.3	NR	89.5
CO emissions	2	10.6	7	3.0	90	84.4
CO_2	NR	46.2	NR	15.4	NR	38.5
Aromatic compounds	NR	0	NR	15.4	NR	84.6
Carbonyl compounds	NR	80.0	NR	0	NR	20.0

NR: not reported

Most of the literature reviewed showed that the use of biodiesel fuels caused increases in NOx emissions [15-18]. As presented in Table 1, Lapuerta et al. [14] and Xue et al. [15] carried out a thorough review of publications on the NOx emission of engines using biodiesel and its blends. The effects of multiple feedstocks on NOx emissions [26-29] and CO2 emissions [13,30,31] have been compared by a few researchers using the same engine and testing protocol, using chassis or dyno testing. Recently Pala-En [21] compared emissions from 20% blends of biodiesel made from four feedstocks (soybean oil, canola oil, waste cooking oil, and animal fat) with emissions from ultra-low sulfur diesel (ULSD) for both real world driving as well as dynamometer tests.

They reported that the dynamometer test results showed statistically significant lower emissions of HC, CO, and PM from all B20 blends compared to ULSD. For CO2, both on-road testing and dynamometer testing showed no statistically significant difference in emissions among the B20 blends and ULSD. Their NOx dynamometer testing showed only B20 from soybean oil to have statistically significant higher emissions.As the aforementioned review highlights, the studies in emission characteristics of a CI engine running on multiple feedstock and full range of biodiesel blends are fairly inconclusive for NOx and CO2. More investigations are required in order to understand the emission characteristics of engines running with biodiesel blends.

Based on the review, in this paper two research problems are identified for investigation, which are the effects of biodiesel types on the CI engine emission characteristics and the effects of biodiesel blends on the CI engine emission characteristics.Therefore, the objective of this study is to investigate the emission characteristics of a CI engine running with biodiesel blend by varying biodiesel types and blends for heavy duty engine. To investigate the phenomena, experimental investigations were carried out using a heavy duty CI engine (four-cylinder, four-stroke, turbo-charged, water-cooled and direct-injection). In the following section the experimental facilities and test procedures are explained.

2.Experimental Facilities and Test Procedures:

In this study the combustion characteristics and performance of a CI engine running with biodiesel was investigated using a four-cylinder, four-stroke, turbo-charged, water-cooled and direct-injection CI engine. This particular engine was selected due to its wide application for heavy duty vehicles in Europe. A picture of the engine test and the schematic of the experimental facilities are shown in Figures 3 and 4, respectively.

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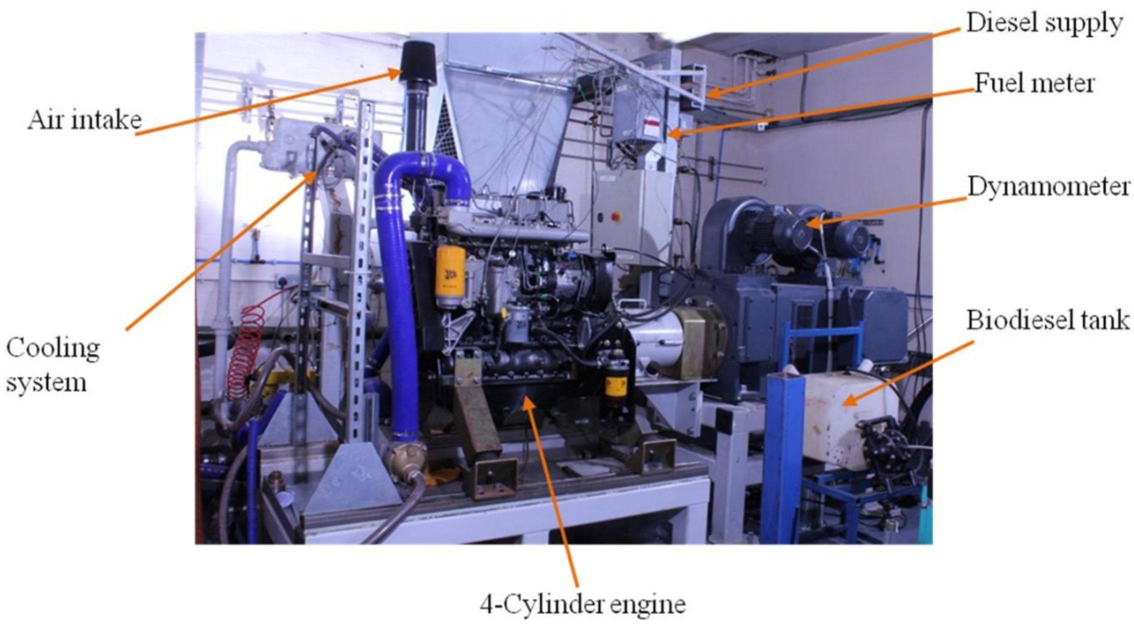

Figure 3. Experimental engine facilities.

The details of the engine are presented in Table 3. The engine was loaded by a 200 kW AC dynamometer 4-Quadrant regenerative drive with motoring and absorbing capability for both steady and transient conditions. The measurements of gaseous emissions were carried out using a HORIBA gas test bench. The measuring range and the analyser types are presented in Table 4. The sample line of the equipment is connected directly to the exhaust pipe and it is heated to maintain a wall temperature of around 191 °C and avoid the condensation of hydrocarbons into the line. The insulated line is extended from the exhaust pipe to the equipment's units where the analysers are located.All emission analysers were set on one bench. However, each emission analyser uses different principles to measure the emission. Oxides of nitrogen are measured on a dry basis, by means of heated chemiluminescent detector (HCLD) with a NO2/NO converter.

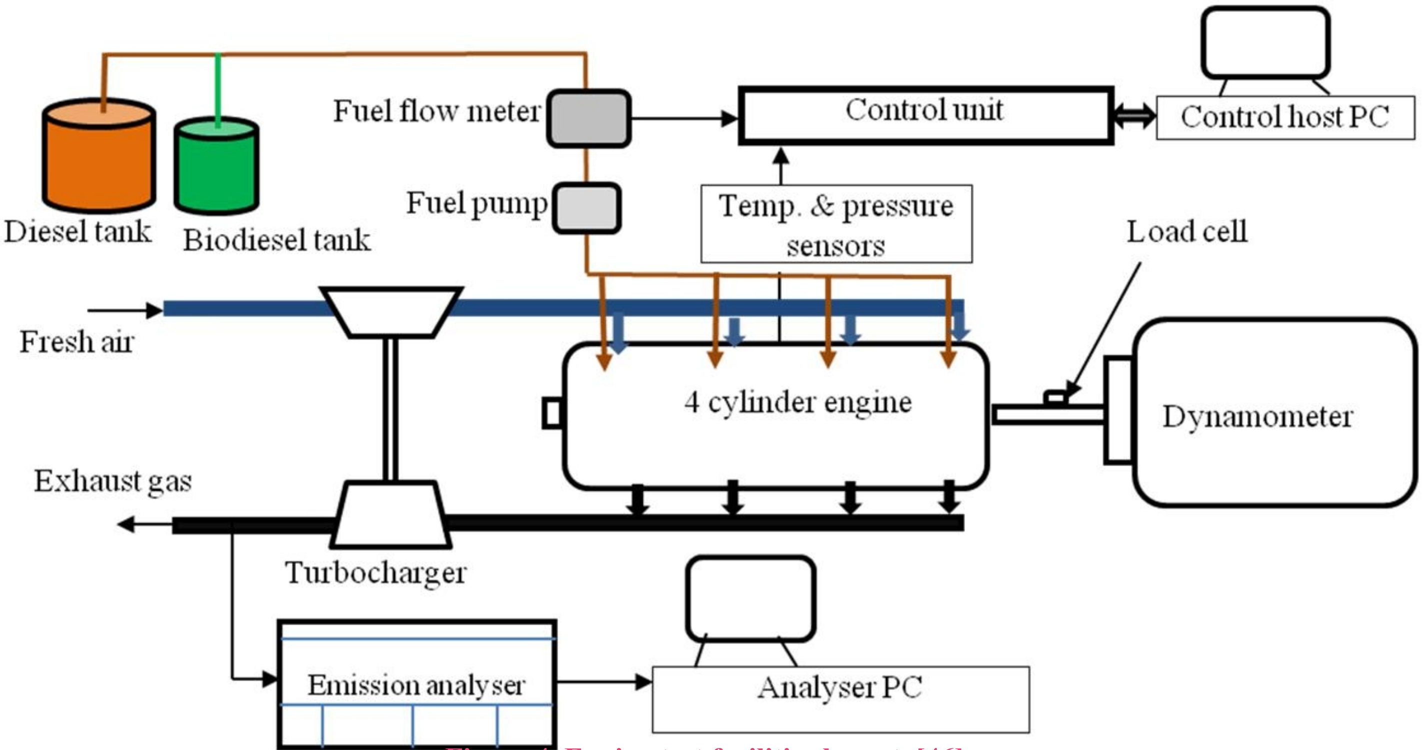

Figure 4. Engine test facilities layout [46].

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Technical parameters	Technical data
Engine type	Turbo charged diesel engine
Number of cylinders	4
Bore	103 mm
Stroke	132 mm
Compression ratio	18.3:1
Number of valves	16
Injection system	Direct injection
Displacement	4.399 litre
Cooling system	Water
Nominal idling speed	800 rpm
Maximum rating gross intermittent	74.2 @ 2200 rpm
Maximum torque	425 Nm @ 1300 rpm

Table 3. Characteristics of the engine.

Emission	Emission analyser type	Measuring range	Accuracy
CO	non-dispersive infrared (NDIR)	0–2000 ppm	±2%
CO_2	non-dispersive infrared (NDIR)	0%–100%	±2%
NO_x	heated chemiluminescent detector (HCLD)	0–5000 ppm	±2%
THC	heated flame ionisation detector (HFID)	0–100 ppm	±1%
O_2	paramagnetic detector	0%–25%	±1%

Table 3. Characteristics of the engine.

The carbon monoxide and carbon dioxide were measured with an analyser of the non-dispersive infrared (NDIR) absorption type, whereas a paramagnetic detector was employed for the measurement of O2 concentration in the exhaust flow. The hydrocarbon was measured using the heated flame ionisation detector (HFID).On the day prior to the actual test day and also when fuel was changed, a preconditioning procedure at high speed and high load was implemented to purge any of the remaining effects from previous tests in the engine fuel system and also to remove the deposited hydrocarbon on the sample line. During the testing process the engine was run for 10 min to enable it to come to a steady state before any measurements were carried out. The maximum rated speed and maximum torque of the test engine is specified to be 2200 rpm and 425 Nm respectively. The tests were carried out for a range of engine speeds (from 1000 to 1800 rpm with 200 rpm increments) and at near the maximum engine load (420 Nm). The biodiesel samples were obtained from a local company. Three common types of commercially available biodiesels (corn oil biodiesel (COB), rapeseed oil biodiesel (ROB), and waste oil biodiesel (WOB)) have been used for analysis.

The corn oil biodiesel and rapeseed oil biodiesel were produced from “virgin” oil by the transesterfication process using methanol. The waste oil biodiesel was produced by the same process, although the raw feed was from cooking oil waste. Normal diesel fuel was obtained from a local fuel supplier. The rapeseed was selected for further blend effects investigation due to its wide EU application. Waste oil biodiesel was selected to investigate how the variation of its sources affects the final emission characteristics. Crop oil biodiesel has been considered in this study to characterize the emissions from food source crop oil.To analyze the dependence of fuel type on the emissions of engines, three neat biodiesels (ROB, COB, WOB) and diesel were used. However, to establish blending and physical properties effects, the blended fuels were prepared by mixing ROB and diesel in different proportions using an in-tank blending method. Blended fuel has a percentage volumetric fraction of 0%, 10%, 20%, 50%, 75% and 100% of Biodiesel and named B0, B10, B20, B50, B75 and B100 respectively. The blend ratios were set to cover the full possible range of biodiesel application in emission reduction. However, the major car manufacturers have endorsed the application of biodiesel B5 and B20.

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The main physical properties such as composition, density, lower heating value (LHV) and viscosity of the rapeseed oil biodiesel were measured according to the official test standards in EU [32]. The blends properties are presented in Table 5.

Property		Accuracy	Diesel (B0)	B10	B20	B50	B75	B100
	C	-	87	86	85	82	79.5	77
Composition (%)	H	-	13	12.9	12.8	12.5	12.25	12
	O	-	0	1.1	2.2	5.5	8.25	11
Density (kg/m^3)		±0.05 kg/m^3	853.36	859.00	865.00	871.76	872.50	879.30
LHV (MJ/kg)		±0.01 MJ/kg	42.67	42.26	41.84	40.58	39.54	38.50
Viscosity (mm^2/s)		±0.02 mm^2/s	3.55	3.91	4.28	4.68	4.74	5.13

Table 5. Physical and chemical properties of rapeseed biodiesel and its blends [32].

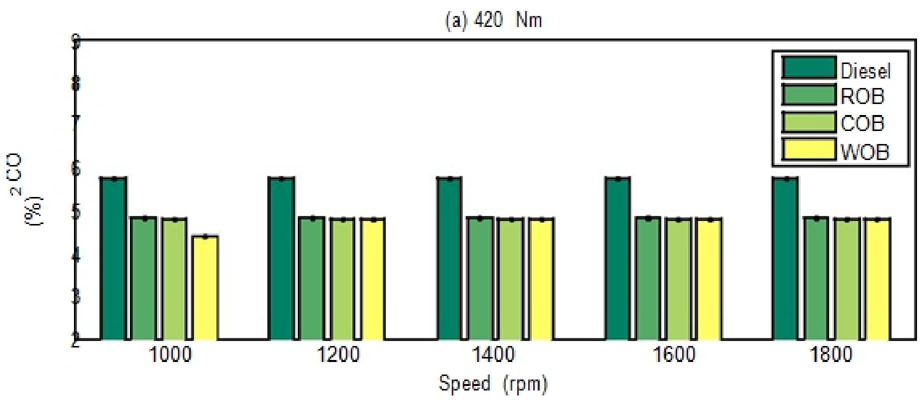
3. Results and Discussion:

One of the benefits of using biodiesel as an alternative fuel is its capability of reducing the pollutant emissions to the environment. In this section the emission characteristics of the test CI engine running with diesel, ROB, COB and WOB have been investigated. In addition, the effects of biodiesel content on the emission characteristics have been investigated and reported. The main exhaust emissions analysed in the present investigation are CO2, CO, NOx and THC.

3.1. Effects of Biodiesel Content on Engine Emissions Parameters:

The CO2 emission values of the CI engine running on ROB, COB, WOB and diesel fuel at a 420 Nm load and at a range of engine speeds are shown in Figure 3. The ROB, COB, WOB and diesel resulted in maximum CO2 emissions of 4.85%, 4.74%, 4.80% and 6%, respectively. As seen in Figure 3b, the CI engine running on biodiesel emitted lower CO2 than when running on diesel by an average of 17%. It is noticed that the engine running with the WOB resulted in inconsistent emission at lower engine speed.

Comparing the three biodiesels ROB, COB and WOB, it can be seen that each fuel emitted almost equal amounts of CO2. Similar results have been reported earlier [15,24]. However, some authors have reported that the engine fuelled by biodiesel fuels emit higher CO2 [24,26,35]. Some investigations in the past have also reported that CO2 emissions remain unchanged on changing fuel from diesel to biodiesel [22,36].



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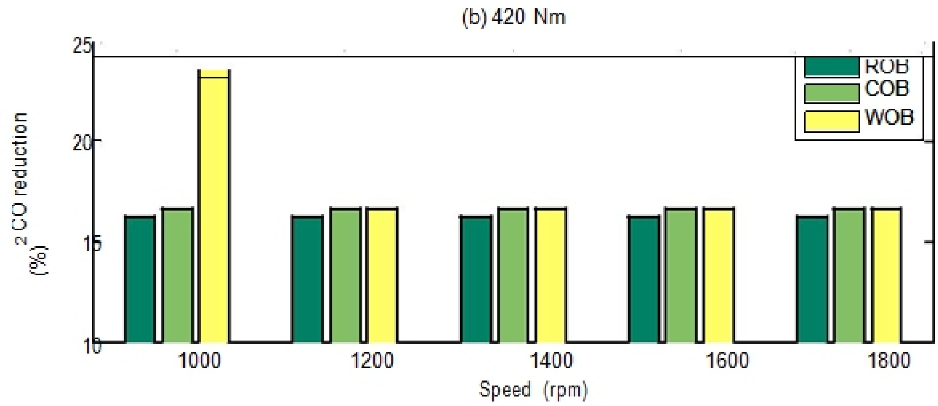
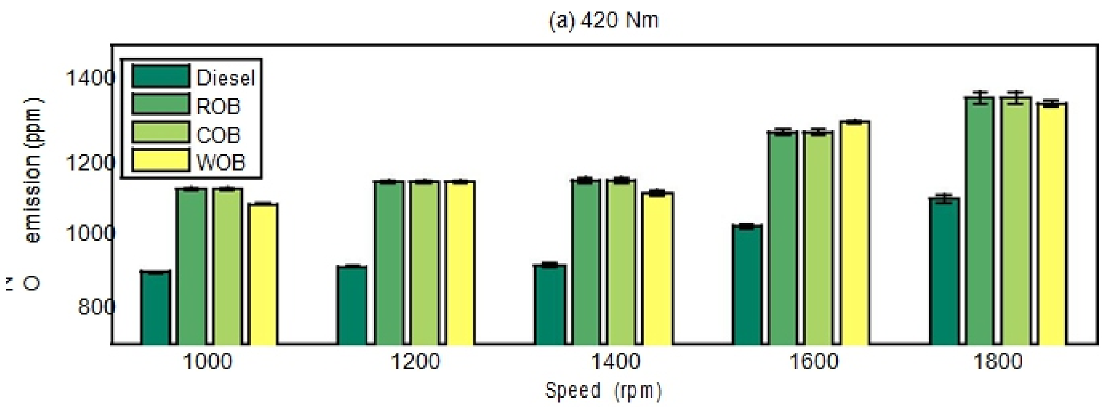


Figure 4a depicts the NOx emissions of the test CI engine running on the ROB, COB, WOB and diesel. The corresponding maximum engine emission values were observed to be 1350 ppm, 1355 ppm, 1340 ppm and 1040 ppm, respectively, at a load of 420 Nm over the engine speed range of 1000–1800 rpm. From Figure 4, it is apparent that the NOx emissions increased with the increase in the engine speed. This can be primarily due to an increase in volumetric efficiency and gas flow motion within the engine cylinder under higher engine speeds and higher load operating conditions, which led to a faster mixing between fuel and air and hence shorter ignition delay [13,42]. The ROB, COB andWOB resulted in higher NOx emissions than the normal diesel by up to 27%, as shown in Figure 4b.

This phenomenon is due to the resulting advanced injection because of the influence of the physical properties of biodiesel, such as viscosity, density, compressibility and sound velocity [15,19,20]. Some researchers argue that the main cause of NOx increase with biodiesel use is the increased cetane number [20,38] which leads to an advanced combustion by shortening the ignition delay and the higher availability of oxygen [14,15,38] which in turn promotes NOx formation. However, when comparing the NOx emissions of ROB, COB and WOB, no significant differences in the NOx emissions are apparent. The standard deviations values have been indicated with the mean value of the NOx emission for each condition, as it shown in Figure 4a. The maximum standard deviation was computed to be 15 ppm at 1800 rpm.



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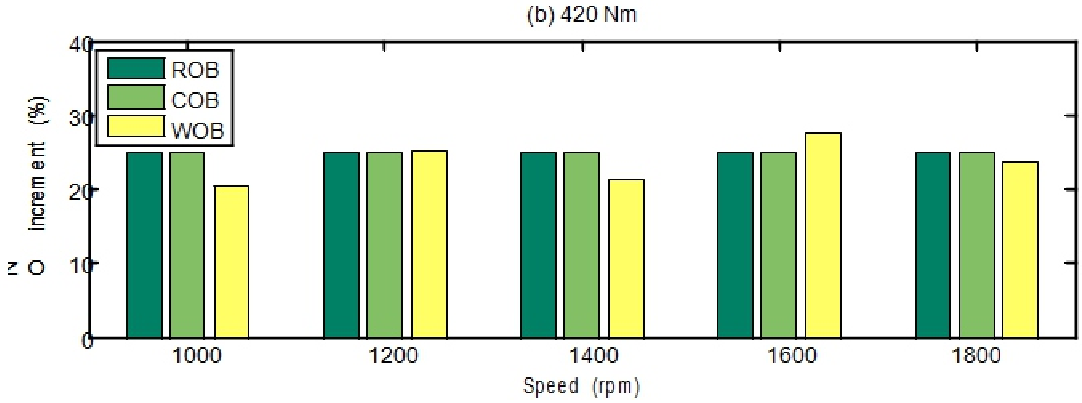

Figure 4. (a) Variation of NOx emission of CI engine running with ROB, COB, WOB and diesel at a load of 420 Nm; (b) NOx emission reductions in percentage comparing biodiesel (ROB, COB, WOB) with diesel at 420 Nm.

The graph shown in Figure 5a depicts the THC emissions of the CI engine running with ROB, COB, WOB and diesel at a load of 420 Nm over a speed range of 1000–1800 rpm. From the figure, it can be seen that the THC emission decreases with an increase in engine speed. This may be due to better air-fuel mixing process and/or the increased fuel/air ratio at higher engine speeds [19,39,40].The two "virgin" biodiesels i.e., ROB and COB did not show any significant differences in THC emission values. However, the engine running on these two biodiesels has a reduced THC emission value by 28%, as compared to the neat diesel, as shown in Figure 5b. The WOB use also reduces the THC; however the reduction was only about 5% as compared to diesel. The standard deviations of the measurements are indicated along with the mean value of the THC emission for each condition in the figure. The maximum standard deviation has been computed to be 2 ppm at 1800 rpm.

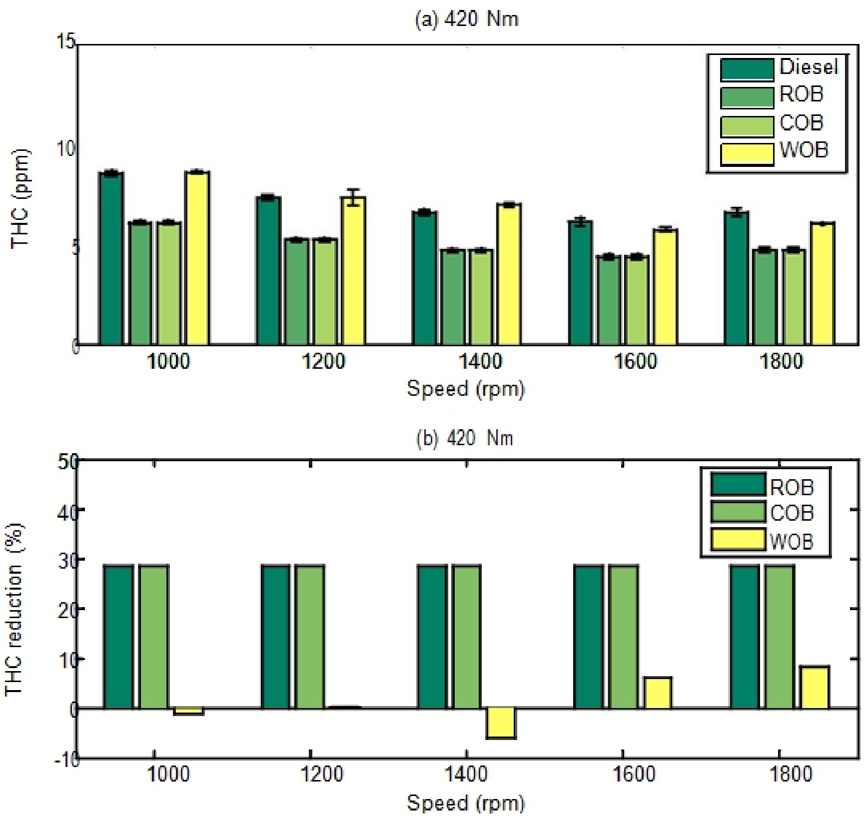

Figure 5. (a) Variation of THC emission of CI engine running with ROB, COB, WOB and diesel at a load of 420 Nm; (b) THC emission reductions in percentage comparing biodiesel (ROB, COB, WOB) with diesel at 420 Nm.

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Figure 6a presents the CO emissions for the engine running with ROB, COB, WOB and diesel at a load of 420 Nm over an engine speed range of 1000–1800 rpm. In Figure 6, a clear trend can be seen that CO emissions decrease with increasing engine speeds. This is because when the engine speed increases, the air-fuel mixing process may become more intensive and a higher fuel/air equivalence may have resulted in enhancing the conversion of CO to CO2 [19,22,41]. The CO emission of the neat biodiesel was lower than that of the diesel by 28%, as indicated in Figure 6b. However, comparing ROB, COB and WOB, the three neat biodiesels did not show any significant differences in CO emission.

The standard deviations of the measurements are indicated with the mean value of the CO emission for each condition, having a maximum standard deviation of 3.5 ppm. The above results have clearly indicated that the biodiesel sources do not affect the engine emissions and as long as physical properties are similar we can expect same emissions characteristics from the engine. The next section is therefore focused on investigation with one of the biodiesel used (ROB) for detailed analysis and in this investigation the fuel properties have been varied by blending diesel with biodiesel in different proportions.

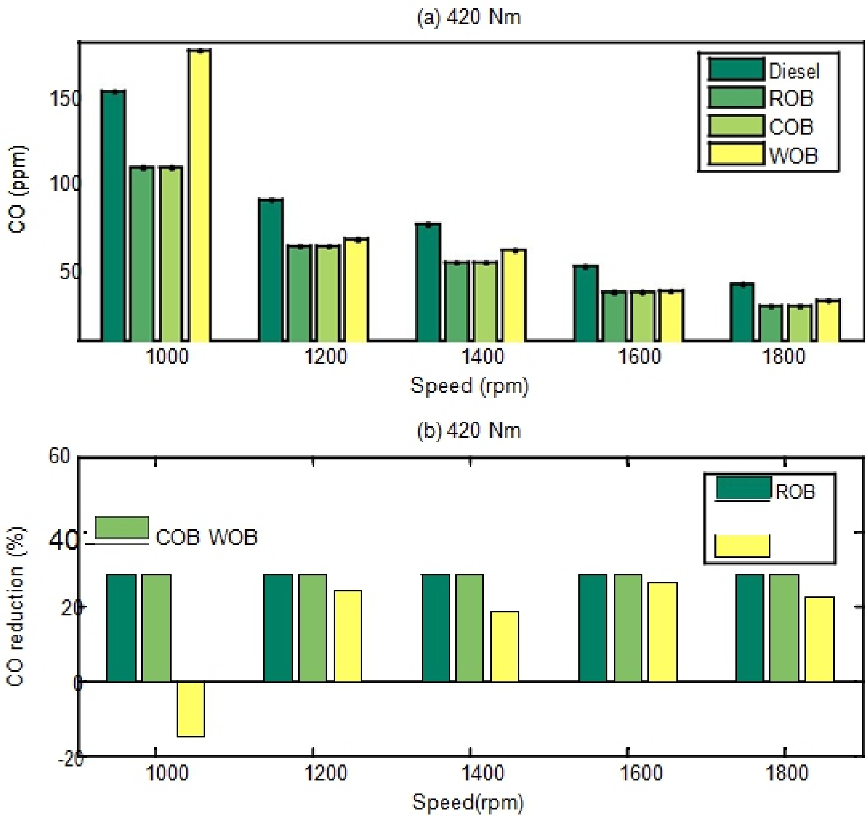

Figure 6. (a) Variation of CO emission of CI engine running with ROB, COB, WOB and diesel at a load of 420 Nm; (b) CO emission reductions in percentage comparing biodiesel (ROB, COB, WOB) with diesel at 420 Nm.

3.2. Effects of Biodiesel Blend Fraction on Engine Emissions Parameters:

Experimental emission results obtained from the tests on a CI engine fuelled with rapeseed biodiesel blends running at a range of engine speeds and at 420 Nm load, are shown in Figure 7 to Figure 10. The higher load was selected for emissions investigation due to its sensitivity for emissions.

Both the real values of the emissions and the percentage change of the emission over a wide range of conditions are reported. Figure 7a provides the CO2 emissions of CI engines over a range of engine speeds. It can be seen that the CO2 emissions reduce significantly with increases in the engine speeds. The CI engine's CO2 emissions corresponding to neat diesel and various biodiesel blends (B10, B20, B50 and B100) have been compared and resulted in a reduction change in CO2 emission as shown in Figure 7b.

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It shows that the CI engine's CO_2 emission reduced by 7%, 27%, 40% and 30% corresponding to B10, B20, B50 and B100 as compared to diesel value respectively. The CO_2 emission by B50 shows the lowest reduction. This is not the normal trend in most of the previous report. It needs a further investigation.The engine fuelled with B50 resulted in the maximum reduction of CO_2 emission among the different blends used, which is different from that which previous researchers recommended with optimum biodiesel blends of 20%. The engine fuelled with biodiesel emitted lower CO_2 emissions than diesel due to the lower carbon to hydrogen ratio [15,37]. The carbon content of biodiesel was 77%, whilst for diesel it was 87%, as can be seen in Table 5.

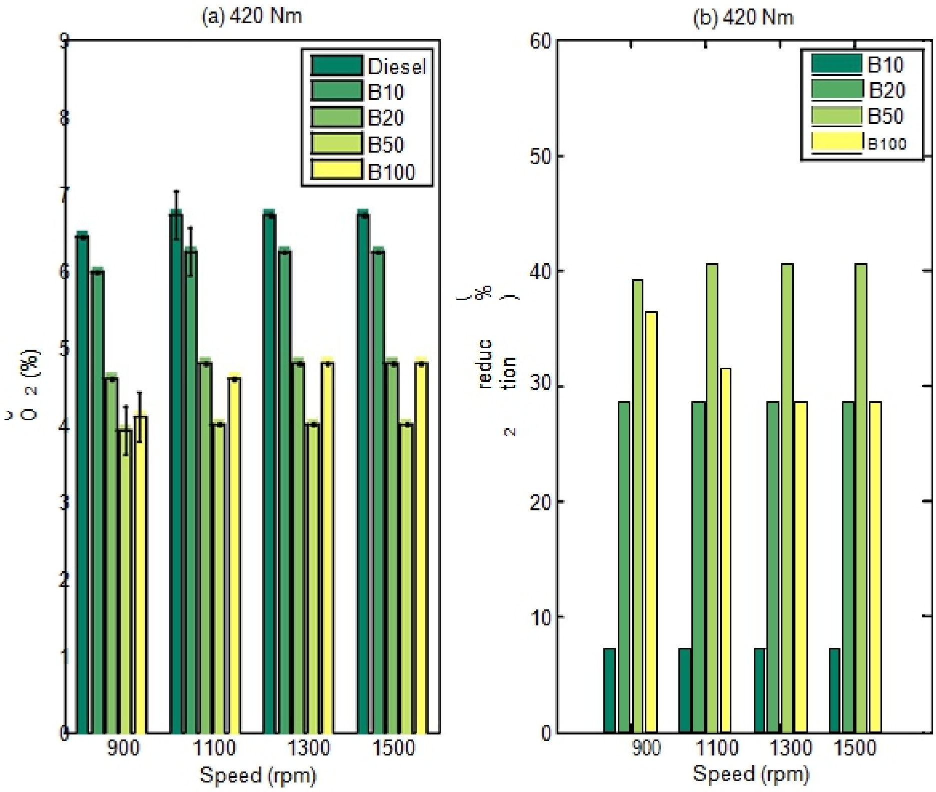

Figure 7. (a) Variation of CO2 emissions with engine speed for CI engine running with biodiesel blends at a load of 420Nm; (b) CO2 emission reductions due to biodiesel blends (B10, B20, B50, B100) comparing with diesel at 420 Nm.

Figure 8a compares the NOx emissions from the test CI engine fuelled with diesel, B10, B20, B50 and B100, at a load of 420 Nm over a wide range of engine speeds. It can be seen that the NOx emission increases with an increase in engine speed as discussed in Section 3.1. It can further be seen that a higher percentage of biodiesel blend emits higher values of NOx emissions, as shown in Figure 8b.The use of biodiesel blend B10 increased the NOx emissions by 10%, whilst the neat biodiesel increased the emission value by up to 37% at 1100 rpm, both as compared to the emission resulting from the use of diesel. Other researchers have also reported that NOx emissions increased in a similar range [42,43] if biodiesel is used as fuel as compared to diesel.

The main reasons for higher NOx emissions with an increase in biodiesel content could be due to the advance injection and advance combustion, as a result of its higher viscosity [14,13,19,18], higher oxygen content which enhances NOx formation [14,15,39] and a higher cetane number which shortens ignition delay and advances the combustion [20]. The THC emissions of the test CI engine running on diesel and biodiesel blends at various engine speeds and at 420 Nm load are depicted in Figure 9a. It can be noticed that the biodiesel blends emitted lower THC emissions as compared to diesel. However, a trend discrepancy is seen at an engine speed of 1100 rpm. The THC reduction reached 45% at 1300 rpm engine speed for B100. Previous researchers have also reported that the

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engine fuelled with biodiesel could reduce the THC up to 67% [23,25,26]. The reduction of the THC in CI engines running on biodiesel can be explained on the basis of a lower content of carbon to hydrogen ratio than the normal diesel and presence of up to 11% oxygen in its molecular structure.

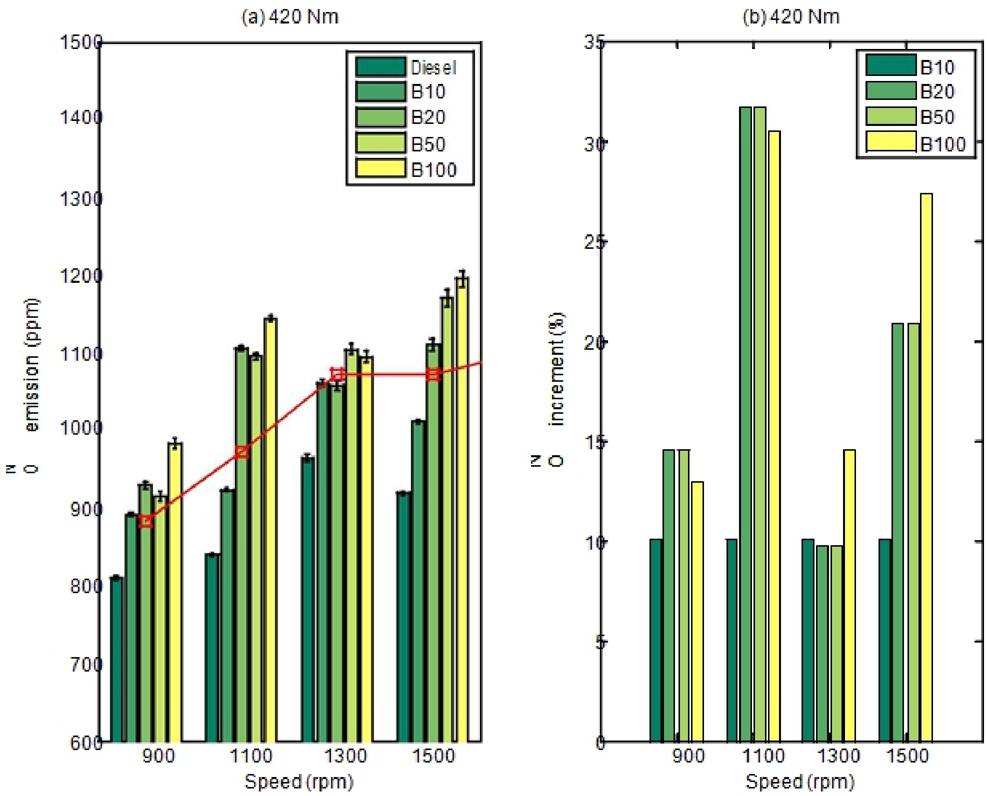

Figure 8. (a) Variation of NOx emissions with engine speed for CI engine running with biodiesel blends at a load of 420 Nm; (b) NOx emission reductions due to biodiesel blends (B10, B20, B50, B100) comparing with diesel at 420 Nm.

The CO emission characteristics of the CI engine fuelled by the diesel and rapeseed biodiesel blends at the maximum engine load and at various speed conditions are shown in Figure 10. All the fuels used produced a higher amount of CO emissions at lower speeds and emitted less CO at higher engine speeds. The effect of engine speed on CO emission is discussed in Section 3.1. It can be also seen when the biodiesel content increases, the CO emission is decreasing by an average of up to 25%.

Krahl et al. [25] and Raheman and Phadatre [43] reported that the engine running on biodiesel reduced the CO emission by 50% and 73%–94%, respectively. The main reason for reduction of CO emissions is the availability of oxygen in the biodiesel for better combustion. The extra oxygen in the biodiesel promotes complete combustion of fuel and thus results in the reduction of CO emissions [20,23,25].

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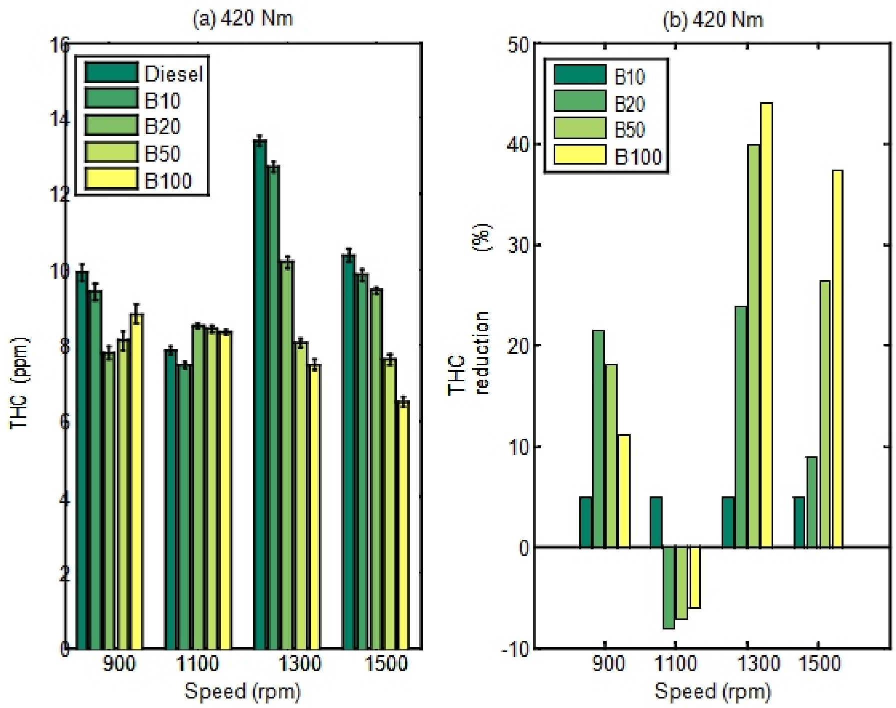

Figure 9.(a) Variation of THC emissions with engine speed for CI engine running with biodiesel blends at a load of 420 Nm; (b) THC emission reductions due to biodiesel blends (B10, B20, B50, B100) comparing with diesel at 420 Nm.

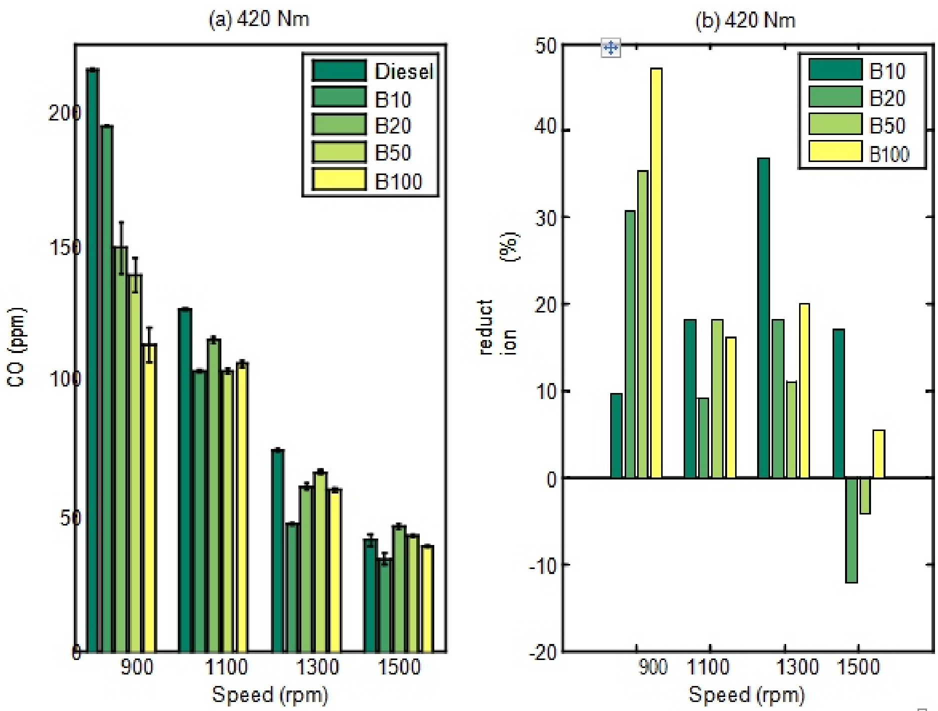

Figure 10. (a) Variation of CO emissions with engine speed for CI engine running with biodiesel blends at a load of 420 Nm; (b) CO emission reductions due to biodiesel blends (B10, B20, B50, B100) comparing with diesel at 420 Nm.

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4. Conclusions:

The effects of biodiesel types and blend fraction values on the CI engine's emissions (CO2, CO, NOx and THC) characteristics were investigated in detail for steady state operation conditions. The following conclusions are drawn for this specific fuel and engine configuration:

1.For all biodiesel contents the NOx emission increases for all operating conditions of the CI engine. This increase may be explained by the higher oxygen content present in biodiesel and the advanced injection characteristics.

2.The emission analyses of the CI engine running with biodiesel highlights a significant reduction in CO2, CO and THC emission under working engine operation conditions. It is also found that when the biodiesel content increases a further reduction in emissions is observed, except for CO, where B20 and B50 produced lower results. This emission reduction is most likely a result of the oxygen content in biodiesel and the low carbon hydrogen ratio.

3.The source of biodiesel does not show a significant effect on the CI engine's emissions (CO2, CO, NOx and THC) as long as the fuel physical (density, viscosity and lower heating value) and chemical (molecular composition) properties remain same.

References:

1.Statistical Review of World Energy, 2008, "Oil Reserves," British Petroleum, 08 Jan. 2009,

2.Nabi, M.N.; Hustad, J.E. Influence of biodiesel addition to Fischer-Tropsch fuel on diesel engine performance and exhaust emissions. Energy Fuels 2010, 24, 2868–2874.

3.Ramadhas AS, Jayaraj S, Muraleedharan C, Use of vegetable oils as I.C. Engine fuel- A review, Renewable Energy 29 (2004) 727-742.

4.Bari S, Yu CW, Lim TH, Performance deterioration and durability issues while running a diesel engine with crude palm oil, Proc. Instn. Mech. Engrs Part-D, J. Automobile Engineering 216 (2002) 785-792.

5.Kaufman KR, Ziejewski M, Sunflower methyl esters for direct injected diesel engines, Trans. ASAE 27 (1984) 1626-1633.

6.Kalam MA, Masjuki HH, Biodiesel from palm oil-an analysis of its properties and potential, Biomass and Bioenergy 23 (2002) 471–479.

7.Raheman H, Phadatare AG, Diesel engine emissions and performance from blends of karanja methyl ester and diesel, Biomass and Bioenergy 27 (2004) 393–397

8.Barnwal BK, Sharma MP, Prospects of bio diesel production from vegetable oils in India, Renew Sust Energy Rev 9 (2005) 363–378.

9.Wang YD, AZ-Shemmeri T, Eames P, McMullan J, Hewitt N, Huang Y, Rezvani S, An experimental investigation of the performance and gaseous exhaust emission of a diesel engine using blends of a vegetable oil, Appl Therm Eng 26 (2006) 1684–1691.

10.Tauzia, X.; Maiboom, A.; Shah, S.R. Experimental study of inlet manifold water injection on combustion and emissions of an automotive direct injection diesel engine. Energy 2010, 35, 3628–3639.

11.Bayraktar, H. Experimental and theoretical investigation of using gasoline–ethanol blends in spark-ignition engines. Renew. Energy 2005, 30, 1733–1747.

12.MacKenzie, J.J. Oil as a finite resource. Nonrenew. Resour. 1998, 7, 97–100.

13.Utlu, Z.; Kocak, M.S. The effect of biodiesel fuel obtained from waste frying oil on direct injection diesel engine performance and exhaust emissions. Renew. Energy 2008, 33, 1936–1941.

14.Lapuerta, M.; Armas, O.; Rodríguez-Fernández, J. Effect of biodiesel fuels on diesel engine emissions. Prog. Energy Combust. Sci. 2008, 34, 198–223.

15.Bhale, P.V.; Deshpande, N.V.; Thombre, S.B. Improving the low temperature properties of biodiesel fuel. Renew. Energy 2009, 34, 794–800.

16.Krisnangkura, K. Estimation of heat of combustion of triglycerides and fatty acid methyl esters. J. Am. Oil Chem. Soc. 1991, 68, 56–58.

17.Carraretto, C.; Macor, A.; Mirandola, A.; Stoppato, A.; Tonon, S. Biodiesel as alternative fuel:

Experimental analysis and energetic evaluations. Energy 2004, 29, 2195–2211.

18.Murillo, S.; Míguez, J.L.; Porteiro, J., Granada, E.; Morán, J.C. Performance and exhaust emissions in the use of biodiesel in outboard diesel engines. Fuel 2007, 86, 1765–1771.

19.Yamane, K.; Ueta, A.; Shimamoto, Y. Influence of physical and chemical properties of biodiesel fuels on injection, combustin and exhaust emission characteristics in a direct injection compression ignition engine. Int. J. Engine Res. 2001, 2, 249–261.

20.Monyem, A.; Van Gerpen, J.H. The effect of biodiesel oxidation on engine performance and emissions. Biomass Bioenergy 2001, 20, 317–325.

21.Pala-En, N.; Sattler, M.; Dennis, B.H.; Chen Victoria, C.P.; Muncrief, R.L. On-road measurement of N O x and CO2 emissions from biodiesel produced from different feedstocks.J. Environ. Prot. 2013, 4, 74–82.

22.Usta, N.; Öztürk, E.; Can, Ö.; Conkur, E.S.; Nas, S.; Çon, A.H.; Can, A.Ç.; Topcu, M. Combustion of biodiesel fuel produced from hazelnut soapstock/waste sunflower oil mixture in a diesel engine. Energy Convers. Manag. 2005, 46, 741–755

23.Puhan, S.; Vedaraman, N.; Sankaranarayanan, G.; Ram, B.V.B. Performance and emission study of Mahua oil (madhuca indica oil) ethyl ester in a 4-stroke natural aspirated direct injection diesel engine. Renew. Energy 2005, 30, 1269–1278.

24.Canakci, M. Combustion characteristics of a turbocharged DI compression ignition engine fueled with petroleum diesel fuels and biodiesel. Bioresour. Technol. 2007, 98, 1167–1175.

25.Nabi, M.N.; Akhter, M.S.; Zaglul Shahadat, M.M. Improvement of engine emissions with conventional diesel fuel and diesel-biodiesel blends. Bioresour. Technol. 2006, 97, 372–378.

26.Karavalakis, G.; Stournas, S.; Bakeas, E. Light vehicle regulated and unregulated emissions from different biodiesels. Sci. Total Environ. 2009, 407, 3338–3346.

27.Peterson, C.L.; Taberski, J.S.; Thompson, J.C.; Chase, C.L. The effect of biodiesel feedstock on regulated emissions in chassis dynamometer tests of a pickup truck. Trans. Am. Soc. Agric. Eng. 2000, 43, 1371–1381.

28.Rakopoulous, C.D.; Antonopoulos, K.A.; Rakopoulos, D.C.; Hountalas, D.T.; Giakoumis, E.G. Comparative performance and emissions study of a direct injection diesel engine using blends of diesel fuel with vegetable oils or bio-diesels of various origins. Energy Convers. Manag. 2006, 47, 3272–3287.

29.Muncrief, R.L.; Rooks, C.W.; Cruz, M.; Michael, P.H. Combining biodiesel and exhaust gas recirculation for reduction in NOx and particulate emissions. Energy Fuels 2008, 22, 1285–1296.

30.Fontaras, G.; Karavalakis, G.; Kousoulidou, M.; Tzamkiozis, T.; Ntziachristos, L.; Bakeas, E.; Stournas, S.; Samaras, Z. Effects of biodiesel on passenger car fuel consumption, regulated and non-regulated pollutant emissions over legislated and real-world driving cycles. Fuel 2009, 88, 1608–1617.

31.Lin, Y.; Wu, Y.G.; Chang, C. Combustion characteristics of waste-oil produced biodiesel/diesel fuel blends. Fuel 2007, 86, 2810–2816.

32.Tesfa, B.; Mishra, R.; Zhang, C.; Gu, F.; Ball, A.D. Combustion and performance characteristics of CI (compression ignition) engine running with biodiesel. Energy 2013, 51, 101–115.

33.Tesfa, B.; Mishra, R.; Gu, F.; Powles, N. Prediction models for density and viscosity of biodiesel and their effects on fuel supply system in CI engines. Renew. Energy 2010, 35, 2752–2760.

34.Lin, B.F.; Huang, J.H.; Huang, D.Y. Experimental study of the effects of vegetable oil methyl ester on DI diesel engine performance characteristics and pollutant emissions. Fuel 2009, 88, 1779–1785.

35.Ulusoy, Y.; Tekin, Y.; Cetinkaya, M.; Karaosmanoglu, F. The engine tests of biodiesel from used frying oil. Energy Sources 2004, 26, 927–932.

36.Song, J.T.; Zhang, C.H. An experimental study on the performance and exhaust emissions of a diesel engine fuelled with soybean oil methyl ester. Proc. Inst. Mech. Eng. Part D J. Automob. Eng. 2008, 222, 2487–2496.

37Lin, C.Y.; Lin, H.A. Diesel engine performance and emission characteristics of biodiesel produced by the peroxidation process. Fuel 2006, 85, 298–305.

38.Labeckas, G.; Slavinskas, S. The effect of rapeseed oil methyl ester on direct injection Diesel engine performance and exhaust emissions. Energy Convers. Manag. 2006, 47, 1954–1967.

39.Srivastava, A.; Prasad, R. Triglycerides-based diesel fuels. Renew. Sustain. Energy Rev. 2000, 4, 111–133.

40.Lin, C.Y.; Chen, L.-W. Engine performance and emission characteristics of three-phase diesel emulsions prepared by an ultrasonic emulsification method. Fuel 2006, 85, 593–600.

41.Bazari, Z. Diesel Exhaust Emissions Prediction under Transient Operating Conditions. In Proceedings of the SAE International Congress and Exposition, 28 February–3 March 1994, Detroit, MI, USA; doi:10.4271/940666

42.Raveendran, K.; Ganesh, A. Heating value of iomass and biomass pyrolysis products. Fuel 1996, 75, 1715–1720.

43.Raheman, H.; Phadatare, A.G. Diesel engine emissions and performance from blends of karanja methyl ester and diesel. Biomass Bioenergy 2004, 27, 393–397.