Experimental investigation of performance and emission characteristics of a diesel engine fuelled with simarouba oil and its blend

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Abstract. The ecosphere is attaining restructure and technologically advanced day by day. As an outcome of increasing automobiles and machines the energy sources used in these machines are limited progressively. It makes to search for a standby fuel for diesel engine is biodiesel. The main objectives are, to match performance and emission characteristics of biodiesel derived from simarouba oil in a diesel engine with base line results of diesel fuel. The performance factors evaluated are: Brake Thermal Efficiency (BTE), BSFC (brake specific fuel consumption). The emission parameters such as carbon monoxide (CO), carbon dioxide (CO_2), un-burnt hydrocarbon (HC) with the different proportion of mixtures were also measured and related with base line results. The BTE of simarouba oil and its mixtures with diesel are lower than diesel and brake specific energy consumption was found to be greater. However, HC, CO and CO_2 are found to be lower with simarouba biodiesel oil. The results suggested that, biodiesel from simarouba oil could be a good standby to diesel fuel in diesel engine and could be used without any modifications in the future as far as decentralized energy production is concerned.

Key words: Biodiesel, Simarouba oil, Performance and emission factors, Diesel and Energy consumption

1. Introduction

Biodiesel is a liquid biofuel attained by chemical methods from vegetable oils and an alcohol that can be used in diesel engines, alone or mixed with diesel oil. Standby for a diesel fuel can be made from a range of oils, which is curiosity to farmers for a number of motives: It can deliver an surplus market for vegetable oils, it can allow farmers to grow the fuel they want for plantation equipment and it can decline overseas dependency on imported oil since fuel feed stocks can be grown nationally [1]. Biodiesel is a renewable source of energy that can support in reduction of greenhouse gas and minimize the “carbon footmark” of farming. It contributes less to global warming because the carbon in the fuel was removed from the air by the plant feedstock. In addition, biodiesel produces less air pollution (exhaust emissions) than diesel made from fossil fuels [2]. The figure 1 shows process of standard biodiesel cycle [3]

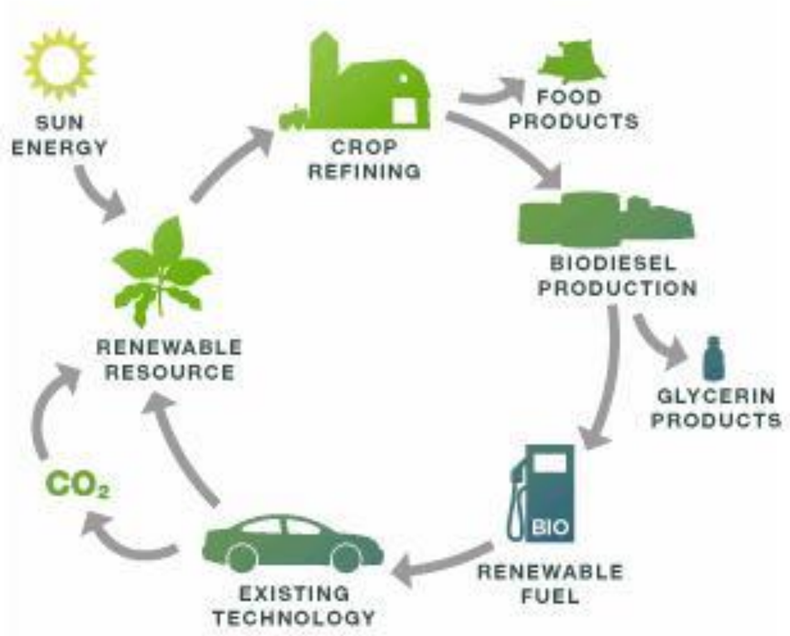

Figure 1. Standard Biodiesel cycle

Advantages of renewable fuel - obtained from vegetable oils [4].

1. Low harmfulness, in comparison with diesel.
2. Degrades more quickly than diesel, decreasing the eco-friendly concerns of biofuel tumbles.
3. Lesser emissions of noxious waste: carbon monoxide, particulate matter, polycyclic
4. Aromatic hydrocarbons, aldehydes.
5. Inferior health risk, due to reduced emissions of carcinogenic substances.
6. No sulphur dioxide (SO2) emissions.
7. Higher flash point (100 ºC minimum).

The main objectives in study are, to evaluate the different blends of Simarouba biodiesel through experiments.

- Preparation of Biodiesel blend (Simarouba Oil + Diesel)
  - B60 + 5%M
  - B80 + 5%M
- Installing the mixture in to a diesel engine and examining the performance and emission characteristics at several loads
- Plotting the readings in to graph and evaluate the performance and emission characteristics.

1.1 Basic details of Simarouba Oil

Figure 2. Typical Simarouba leaf, seed and extracted Oil

Simarouba is a flowering tree that is native to South America. The common names are paradise tree, dysentery-bark, and bitter wood. The figure 2 shows the typical simarouba leaf, seed and extracted oil. It's seeds yield an edible oil. It can be spread from seeds, grafting and tissue culture technology. The fruits are collected in the month of April and May, when they are suitable and then dehydrated in sun for about a week. The skin is detached and seeds are grown-up in plastic bags to produce sprouts.

1.2. Physical properties of Simarouba oil

1.2.1. Viscosity comparison for Simarouba oil with Diesel with respect to temperature

The figure 3 depicts that, the viscosity trend of Simarouba oil and Diesel. There is no any significant change observed in the viscosity of Diesel and Simarouba oil.

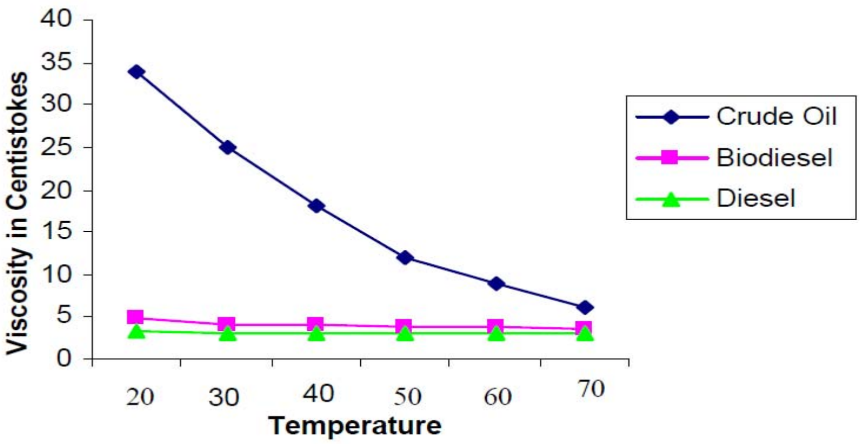

Figure 3. Viscosity trend - Simarouba oil Vs Diesel

1.2.2. Density comparison for Simarouba oil with Diesel

The figure 4 illustrates that, the density of Simarouba oil compared with diesel, where we not found a substantial difference.

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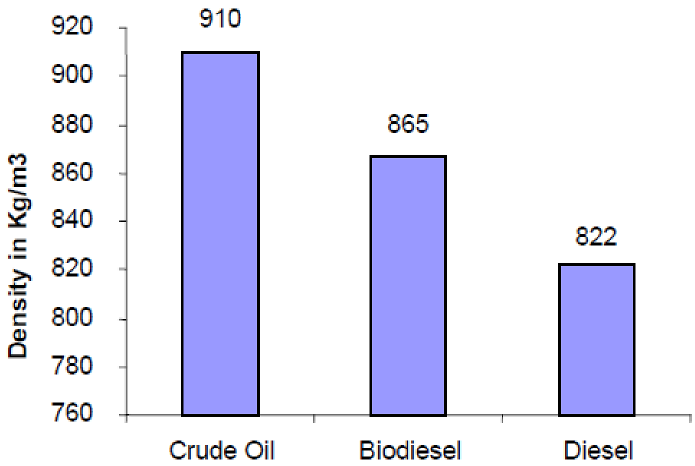

Figure 4. Density - Simarouba oil Vs Diesel

It is an important property of bio fuel. The density is equal to the mass per unit volume. The density measurement was carried out using a 25 ml specific gravity bottle at a temperature of 312K. In this method, first calculate the empty bottle weight by using the weighing machine and similarly by filling the bottle with Simarouba oil and their blends. Then take the difference of two values to get the mass of the oil and divide the mass by volume (i.e. 25ml) to get the density [5].

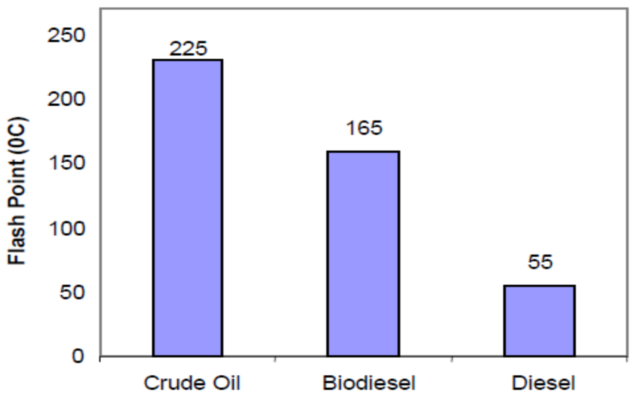

Figure 5. Flash point comparison

It is the minimum temperature at which the fuel will ignite by ignition source. It is required for proper safety and handling of fuel. The figure 5 reveals that, the flash point of Simarouba oil compared with Diesel, where we found a substantial difference. Hence the density and Flash point is higher than the diesel, the different blends were made by dilution with diesel fuel. The two blends made are B60 and B80.

1.2.3. Cetane Number

It is the indication of the combustion speed of the diesel fuel. Measurement is carried out by using the Ignition Quality Test.

1.2.4. Calorific Value

It is the measurement of the heat content in the fuel. For bio fuel, it determines the suitability of the fuel. The calorific value is found by using the bomb calorimeter. It is a constant volume calorimeter and heat content is measured by the change in the internal energy which is equivalent to the change in temperature.

1.2.5. Fire Point

The minimum temperature used at which a fuel sustains burning for 5 seconds. Note: For finding the flash point and fire point, clevel and open cup test is used. It is the simple method consists of coil heater and test cup made up of brass [6].

2. Methodology

2.1 Blend preparation – Biodiesel (B60 and B80)

The main problem with vegetable oil is high viscosity. So, there are many methods used for decreasing the kinematic viscosity like transesterification, mixing with diesel, micro emulsion etc. In this experiment, simple mixing with diesel is done. The mixtures (Blends) with diesel fuel are sign posted as “Bx”, where “x” is the proportion of biodiesel in the mixture. For illustration: “B10” indicates a mixture with 10% biodiesel and 90% diesel. In significance, B100 specifies pure biodiesel [2].

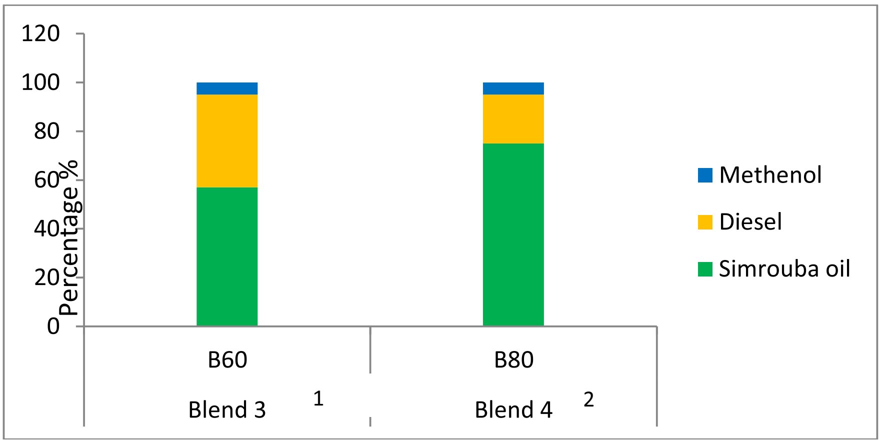

Figure 6. Biodiesel Blends

The figure 6, 7 shows the blend prepared for the experiments. The diesel, Simarouba oil and Methanol are used for making the blends. In this report, B60+5% and B80+5% blends are used in performance test and emission test. [7]

Figure 7. Bio diesel blends – B60+5M and B80+5M

Methanol's properties make it an attractive biofuel:

a) Comparatively high energy density, 98% of that of gasoline.
b) Does not freely engage water from air, avoiding the deterioration of engines and pipelines.
c) Can be mixed at any percentage with diesel.
d) It is lowest toxic of the butanol group [8].

2.2 Engine testing with Biodiesel blends (B60 and B80)

The inducting blends in to a diesel engine and analysing the performance and emission characteristics at various loads. The figure 8 shows engine test bed layout and figure 9 illustrates the single cylinder diesel test engine. The readings taken for the study were given below,

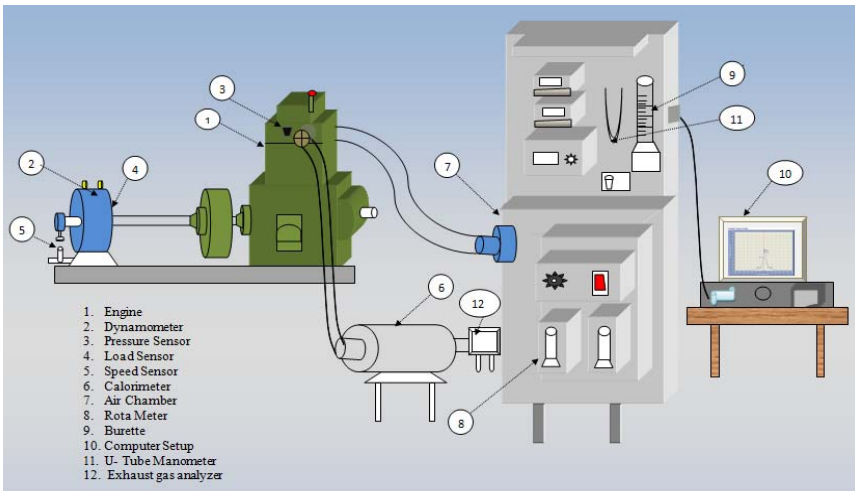

Figure 8. Engine test bed layout

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Figure 9. Actual Engine test bed

3. Results and discussion

3.1. Formulae and tabulation

3.1.1 Brake Thermal Efficiency (BTE %)

BTE=BP × 100 / (TFC × CV)

$TFC = 10 \times 10^{-6} \times density / t$ (kg/ s)

TFC= Total Fuel Consumption in kg/s

CV= Calorific Value of fuel

BP= Brake Power in kW

3.1.2. Specific fuel consumption (kg/kWh)

SFC= TFC /BP (kg / m)

TFC= Total Fuel Consumption in kg/h

BP= Brake Power in kW

3.2. Performance Table

The following tables and figures show performance characteristics.

Table 1. Brake Thermal Efficiency

Brake Thermal Efficiency (BTE)				
LOAD	BP	B60+5	B80+5	DIESEL
0	0.00	0.00	0.00	0.00
4	1.14	15.01	14.64	17.53
8	2.28	22.49	21.96	25.41
12	3.42	25.90	25.60	31.83
16	4.56	26.58	26.05	33.26

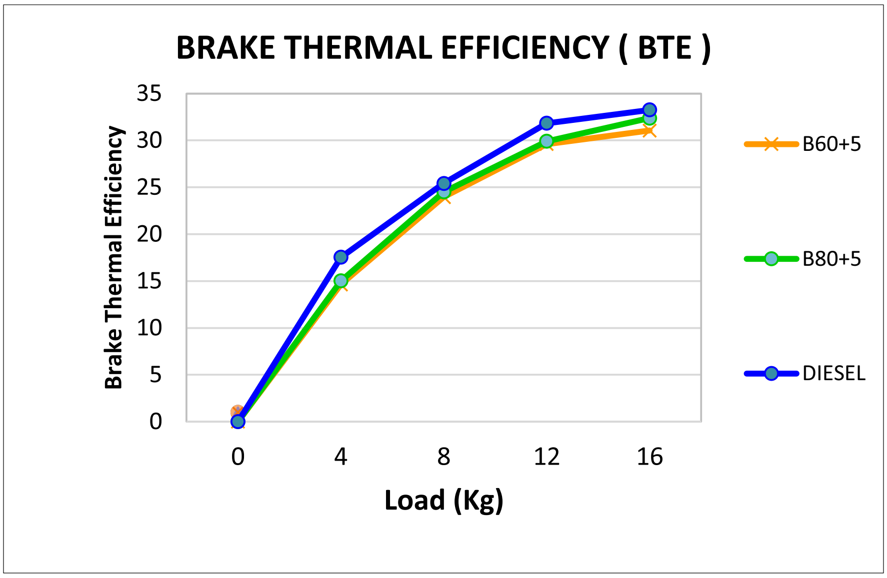

Figure 10. Brake Thermal Efficiency v/s Load

The table 1 and figure 8 shows the plot between the brake thermal efficiency and load in kg for a constant speed. According to the BTE formula, the efficiency is inversely proportional to the CV. It revealed that as the value of the load increases, the BTE increases. Thus, the BTE of the blend B10 is lowest and B20 + 10% are highest in all and have maximum deviation on the positive side.

Table 2. Specific Fuel Consumption (SFC)

Specific Fuel Consumption (SFC)				
LOAD	BP	B60+5M	B80+5M	DIESEL
0	0	0.000	0.000	0.00
4	1	0.627	0.657	0.58
8	2	0.418	0.438	0.40
12	3	0.363	0.376	0.34
16	5	0.354	0.369	0.33

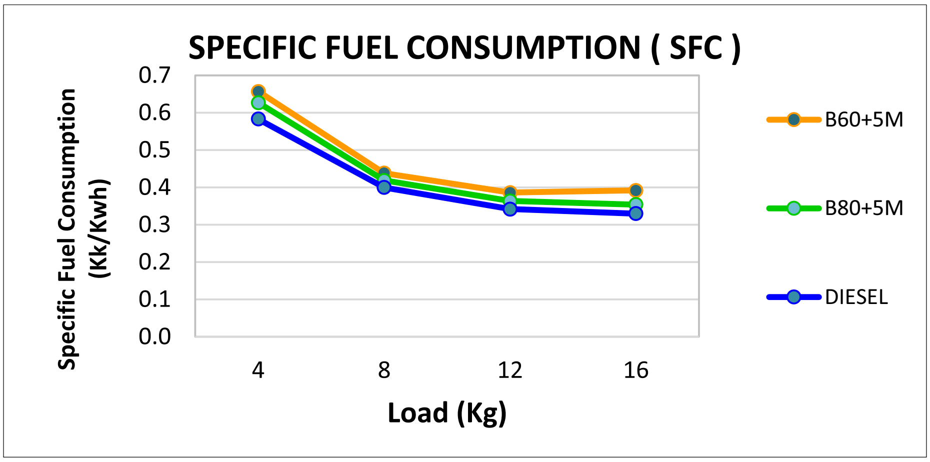

Figure 11. Specific Fuel Consumption v/s load

The table 2 and figure 11 is plotted between specific fuel consumption v/s loads. It experimental that as the load increase the value of S.F.C decreases which show the inverse trend of the BTE v/s Load graph. And also observed that, increase the amount of simarouba oil in the blends the S. F.C decreases. This trend is also observed in the addition of the Methanol, in this case in both the blends i.e. B10 and B20 shows the reflection in the graph which due to the lower calorific value of the additive. This point is already seen evidently in the corresponding BTE graph which possesses an inverse relation to the calorific value. The graph has the highest SFC for B10 blend which states that the fuel has been consumed more for the same amount of power output. The lowest value is for the blend B20+10% which increases the BTE of the system and can be seen that it is less as compared to diesel.

3.3 Emission Tables and graphs

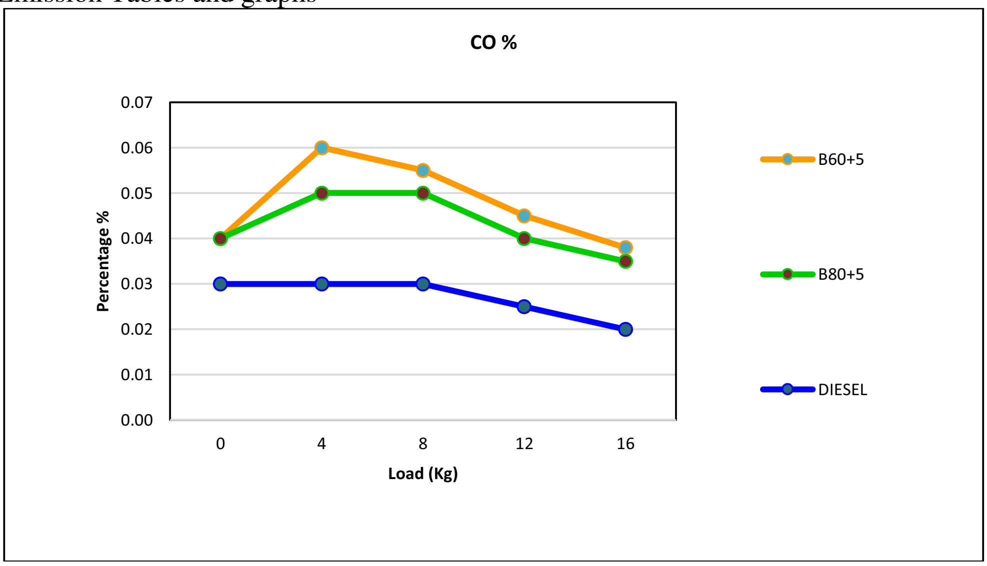

Figure 12. % volume Carbon mono oxide v/s Load

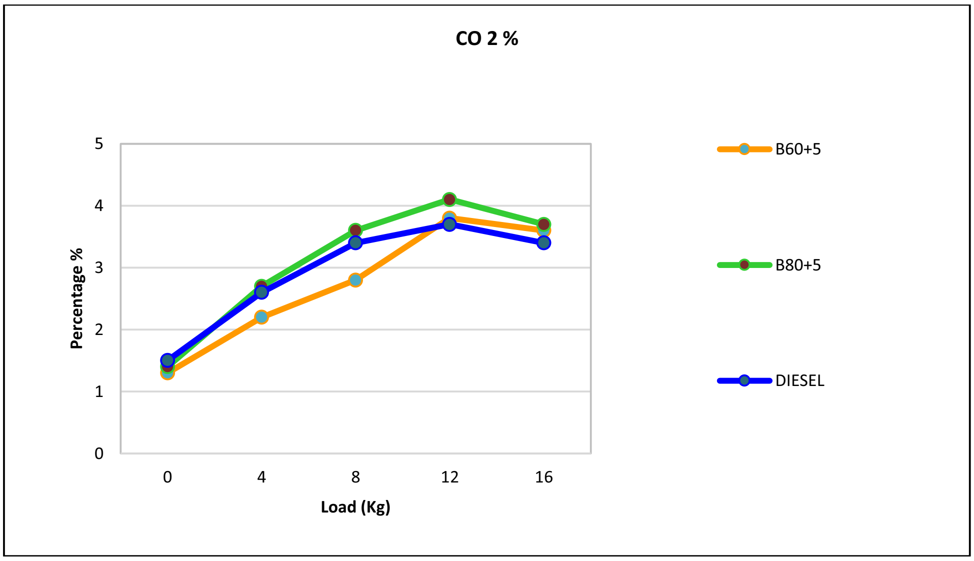

Figure 13. % volume Carbon-di-oxide (CO_2) vs Load

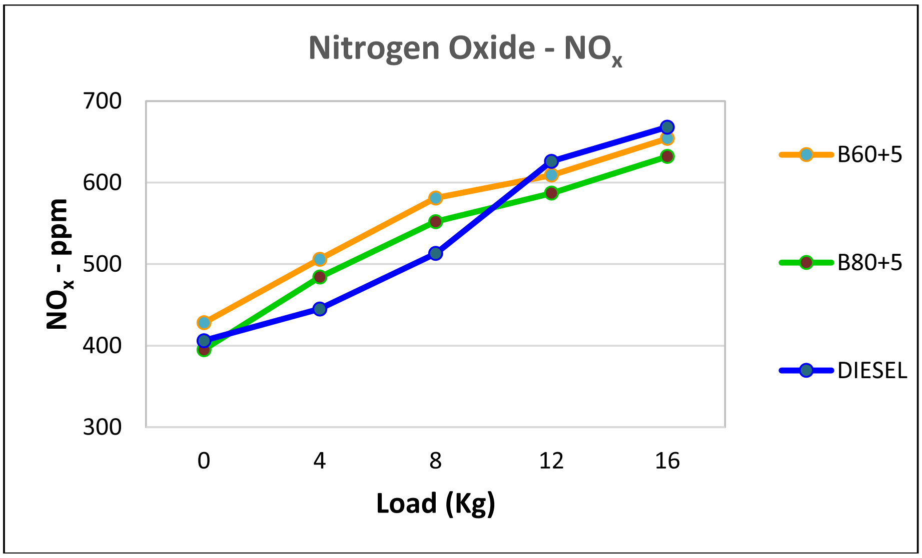

Figure 14. ppm NO_X v/s Load

The figure 13 shows that the effect of addition of the SIMAROUBA and Methanol has different effect on the formation of CO_2 at different loads. But looking at the graph we can conclude the effects on the basis of average values which shows that the amount of CO_2 reduces as the amount of simarouba oil increases in the blend which is also reciprocated in the case of addition of Methanol, thereby reducing the amount of CO_2 in the exhaust. Also, CO_2 formation is dependent on carbon to hydrogen ratio of the fuels. The more contents of carbon in the blends cause more amount of CO_2 emissions in the exhaust gases.

The curve has a normal characteristics flow as it decreases with increasing load and gets to a lowest in the cruising range and then increases. The main reason for CO formation is the improper combustion of the fuel which is a result of low peak temp at lower loads and lower air fuel ratios at higher loads. The value of the CO in the exhaust goes on decreasing as the value of Simarouba increases in the blends. This is an attribute to the higher oxygen content of the fuel which goes on increasing as we increase the amount of Simarouba in the blend. The more the CO the bad it is as it indicates that the combustion is not taking place properly that is incomplete combustion.

The figure 14 shows the perfect characteristics of the typical NO_X curve which is increasing with load and thus the temp in the cylinder increases this produces more NO_X. But the value of NO_X reduces at higher loads.As seen in the graph above, the highest value for NOx emission is B60+5%M and lowest is for B80+5%M for higher loads. B80+5%M is a less polluting blend as compared to other blends with respect to NOx emission

The tests were carried on the experimental setup for the given speed of 1500 RPM and under varying load condition for the blends of Simarouba oil and Methanol with diesel prepared on the volume basis and given names of B60+5%, B80+5%. The addition of Simarouba in diesel increases its density viscosity and oxygen content but reduces its calorific value. The brake thermal efficiency of the fuel goes on increasing as the amount of Simarouba oil increases in the blend and at the same time reduces its specific fuel consumption with a decrease in the exhaust gas temperature. The emissions were also likely affected as the values for the CO, CO_2, NO_X reduced with the addition of the Simarouba oil in the blend due to various factors and mechanism affecting the reasons for the obtained variations, there is an increase in the value of HC which is undesirable but mainly due to its high viscosity.

4. Conclusion

The test results revealed that, Simarouba oil can be used as fuel additive and the blend perform better as both the blending material increase in the blends thus stating that B80+5%m blend is the most suitable blend which can be used in place of pure diesel without making any changes in the engine system. The findings also suggested that, biodiesel from simarouba oil could be a good standby to diesel fuel in diesel engine and could be used without any modifications in the future as far as decentralized energy production is concerned.

5. Acknowledgement

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6. References

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