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Characterization of Cottonseed and Crude Palm Methyl Esters as Biodiesel Compound and their study on Performance and Emission of CI Engine

Pradeep Kumar D. S
Scholar,
Department of Mechanical engineering,
Maharaja Institute of Technology,
Mysuru

Dr. Y. T. Krishne Gowda
Professor,
Department of Mechanical engineering,
Maharaja Institute of Technology,
Mysuru

Abstract: **The goal of this work includes preparation of cottonseed and crude palm biodiesel and to characterize the performance parameters and exhaust emission of a single cylinder four stroke compression ignition diesel engines fuelled with cottonseed and crude palm biodiesel. The cottonseed and crude palm biodiesel are obtained through transesterification process and parameters of transesterification were optimized. Performance parameters and exhaust emissions with standard parameters like injection nozzle opening pressure of 200 bar, injection timing at 21 degree and compression ratio of 17.5 for different cottonseed and crude palm biodiesel blends such as CS05, CS10, CS15, CS20,CS25 and CP05, CP10, CP15, CP20, CP25 (volume basis mixing) is evaluated with varying loads. The brake thermal efficiency of the engine decreased for all blends when comparing to petroleum diesel and the brake specific fuel consumption of the engine increased for all blends when compared to petroleum diesel. Emissions levels of CO are slightly less, HC emissions were also observed to and NOx emissions increased for both blends of cottonseed and crude palm biodiesel when compared with diesel. The engine performance improved for cottonseed with standard parameters with significant reduction in carbon monoxide and unburnt hydrocarbon emissions as compared to standard injection timing.**

Keywords: Cottonseed, Crude Palm, Transesterification, Performance, Emissions.

INTRODUCTION

Biodiesel is getting an immense demand due to its ecofriendly and less emissions when compared to diesel from the past few decades. For country like India, critical input for economic development is the energy. The goal of the country on energy strategy is to provide efficient and environmental friendly and to achieve an optimum mix of resources in energy generation. In the next few decades fossil fuels plays a significant part in the energy scenario of our country. Cottonseed belongs to the family of Malvaceae and commonly called as “Gossypium” and it is widely cultivate in tropical and sub-tropical regions. Textile industries make use of the fiber which grows around the seeds. Palm oil is extracted from the palm fruit and it is in reddish, high amount of beta carotene involves itself. It belongs to the family of “Arecaceae”. -leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow. R. Anand, G. R. Kannan1, K. Rajasekhar Reddy and S. Velmathi have concluded the results for methyl esters of cottonseed oil with blends of 5%, 10%, 15% and 20% conducting the tests in VCR diesel engine with 1500 rpm of constant speed, for 5% blends they obtained highest brake thermal efficiency also observed lowest specific fuel consumption when CR between 15 to 17 and 20% blends for CR 19. Compression ratio of 17 with blend 20% shows the maximum emission of nitric oxide of 205 ppm when compared to diesel it is 155 ppm. Emissions levels like CO and smoke will be reduced in full range of CR and loads were observed. Finally characteristic of heat release is improved for the blends. [3]

Basavaraj M. Shrigiri, Omprakash D. Hebbal, K. Hemachandra Reddy, in this present work, they have selected two methyl esters like cottonseed oil and neem kernel oil. These oils are get transesterified to convert as cottonseed oil methyl esters (CSOME) and neem kernel oil methyl esters (NKOME). CSOME and NKOME is used as an alternate fuel for low heat rejection engines, the combustion chamber temperature is increased by thermal barrier coating on piston face. Interpretation of results obtained like 5.91% for CSOME and 7.07% for NKOME of brake thermal efficiency is lower at peak load, 28.57% for CSOME and 10.71% for NKOME of BSFC is higher in LHR engine. Emissions levels like NOx increases in LHR engine while slight increase in CO, HC and smoke. The value of cylinder pressure for CSOME and NKOME is obtained from the combustion characteristics in LHR engine and it resembles to diesel fuel in regular engine. [11]

The investigational work from the researchers has concluded that biodiesel can be used as alternative fuel for compression ignition engines. Cottonseed, rice bran, neem kernel, canola, palm, rapeseed, waste cooking oil, Moringa oleifera are the various biodiesel that researchers have conducted the experimental work. Cottonseed biodiesel will have higher consumption and less tendency to form choke and possess good oxidation and acceptable stability, emission levels of CO, CO2 and NOX was less when compared to diesel. CO emission and smoke will be reduced in full range of CR and loads. Viscosity is the property of biodiesel which is greater than diesel and it leads to many problems in fuel injection, atomization leads to incomplete combustion, nozzle choke up, excessive deposits in engine, rings gap sticking, heavy smoke. By introducing the preheating in the fuel lines transesterification and modification of fuel injection system it

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could be solved. Compression ratio of 17 with blend 20% shows the maximum emission of nitric oxide of 205 ppm when compared to diesel it is 155 ppm. For 5% blend highest brake thermal efficiency and specific fuel consumption will be lower when CR between 15 to 17 and 20% blends for CR 19. Pre heated Cottonseed methyl esters up to 90ºC at higher loads has revealed that brake thermal efficiency increases by 2% when contrasted to diesel fuel.

Palm methyl esters of B20 have showed lowest brake specific energy consumption when pre heated at 60ºC and temperature of exhaust gas is greater compared to other blends. Increased in brake thermal efficiency and reduced in fuel consumption. Blends of 5% show moderately lower brake power and brake specific fuel consumption is higher. 13.17% of emissions levels of CO are reduced from the blends 5% and HC increases with 14.47% in blends 5% and 18.42% in blends 10%. Emissions of nitric oxide increases with 1.96% in blends 5% and 3.38% in blends 10%, CO2 increases with 5.60% in blends 5% and 11.73% in blends 10%. Diesel engines can be substituted with 20-40% of palm oil biodiesel.

EXPERIMENTATION

A single cylinder engine of air cooled direct injection stationary diesel engine is used for experimental work. An electric dynamometer is attached to the engine in which brake load is applied by using an electric panel. The circuit which is used to composition from one fuel to another fuel when engine is in operating condition is called fuel switch. With the help of burette and stop watch action the brake specific fuel consumption is calculated. The temperature of exhaust gas will be measured by a thermo couple.

Experimentation was conducted with the standard injection opening pressure of nozzle 200 bar, compression ratio 17.5 and injection timing 21º, cottonseed blends of percentage of 5, 10, 15, 20 and 25 and crude palm blends of percentage of 5, 10, 15, 20 and 25 with varying loads of 6.5, 13, 19.5 and 26 N-m at engine speed 1500 rpm.

Table 1: Specifications of engine test rig.

Sl No.	Engine Parameters	Specification
1	Machine Supplier	INLAB Equipment's, Bangalore
2	Engine Type	TV1 (Kirloskar, four stroke)
3	Number of Cylinders	Single Cylinder
4	Rated Power	5.2 kW(7HP) @ 1500 rpm
5	Bore	87.5 mm
6	Stroke	110 mm
7	Cubic Capacity	661cc
8	Compression Ratio	17.5:1
9	Rated Speed	1500 rpm
10	Dynamometer	Eddy Current dynamometer
11	Type of Cooling	Water cooling
12	Fuel Injection pressure	200 bar
13	Fuel	Diesel

Table 2: Properties of cottonseed and crude palm biodiesel

Properties	Units	Diesel	Biodiesel	
			CS100	CP100
Viscosity	cSt	3.02	5.94	4.54
Density	Kg/m^3	816	885	860
Specific Gravity	---	0.88	0.885	0.86
Flash point	^oC	52	170	150
Calorific value	KJ/Kg	43796	39860	40957.1

RESULTS AND DISCUSSION:

The performance characteristics of cottonseed and crude palm oil biodiesel is evaluated for standard engine opening pressure of nozzle, injection timing and constant compression ratio for different blends and results are as discussed below.

Brake Thermal Efficiency (BTE):

Figure 1 and 2 reveals the level of brake thermal efficiency(BTE) with reference to brake power for standard injection timing of 21º, standard injection opening pressure of nozzle 200 bar and standard compression ratio 17.5 for cottonseed and crude palm biodiesel blends (5%, 10%, 15%, 20%, 25% in volume basis) and petroleum diesel.

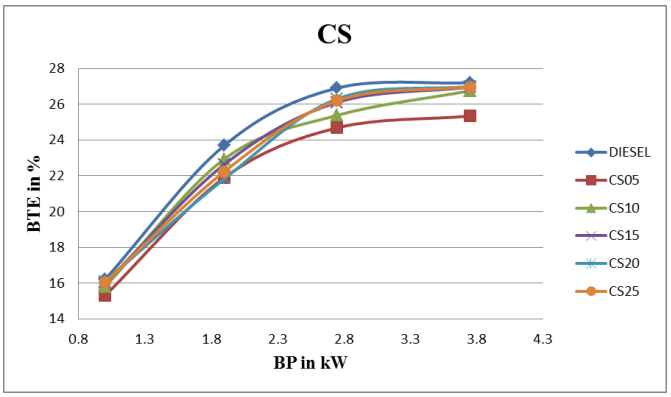

Fig 1: Brake thermal efficiency v/s Brake power

BTE of blend CS20 shows 26.99% maximum and further blend CS 25 shows in decrease in efficiency of 26.97% and the emission levels are much lower when compared to other blends. Biodiesel being higher in oxygen content and self-lubricity resulted with better performance. This factor was dominated by lower calorific value of biodiesel at higher concentration blends thus leading to drop in performance.

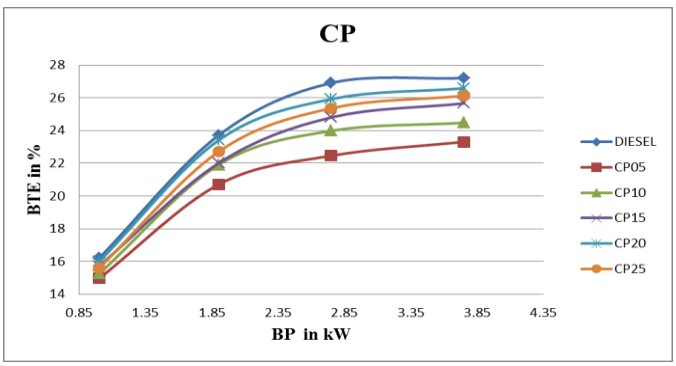

Fig 2: Brake thermal efficiency v/s Brake power

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For full loading condition at blend 20% brake thermal efficiency blend CP20 shows 26.58% maximum with further increase in blend CP25 shows 26.12% which is lower than CP20 but the emission levels of CP25 is observed lower when compared to other blends. BTE for blends of cottonseed biodiesel is higher when compared to crude palm biodiesel can be observed.

Brake Specific Fuel Consumption (BSFC):

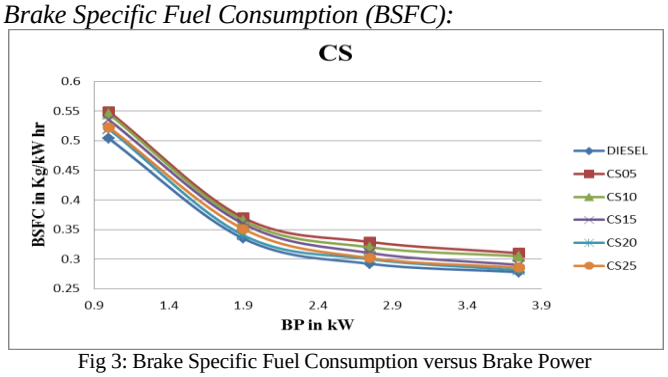

Fig 3: Brake Specific Fuel Consumption versus Brake Power

From the figure 3 it is perceived that blend CS20 shows 0.2812 Kg/kW hr and blend CS25 shows 0.2856 Kg/kW hr, it shows increase in blend percentage increase the consumption of fuel. Also it is noted that fuel consumption is higher in biodiesel due to lower calorific value.

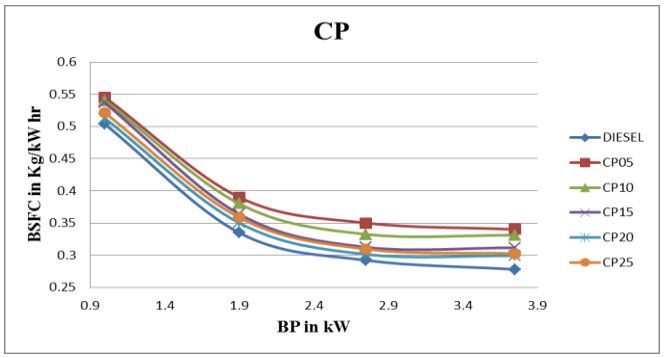

Fig 4: Brake Specific Fuel Consumption versus Brake Power

From the figure 4 it is perceived that blend CP20 shows 0.299 Kg/kW hr and blend CP25 shows 0.3025 Kg/kW hr, it shows increase in blend percentage increase the consumption of fuel. Increase in brake power leads to decrease in BSFC for blends of 5%, 10%, 15%, 20%, and 25% with reference to petroleum diesel. BSFC shows higher values under the case of petroleum diesel when measured with biodiesel. At full load condition blend CS20 obtain 0.2812 Kg/kW hr and CP20 obtain 0.299 Kg/kW hr, which will be similar to petroleum diesel. The main cause for lower BSFC in biodiesel is lower calorific values than petroleum diesel.

Carbon Monoxide Emission (CO):

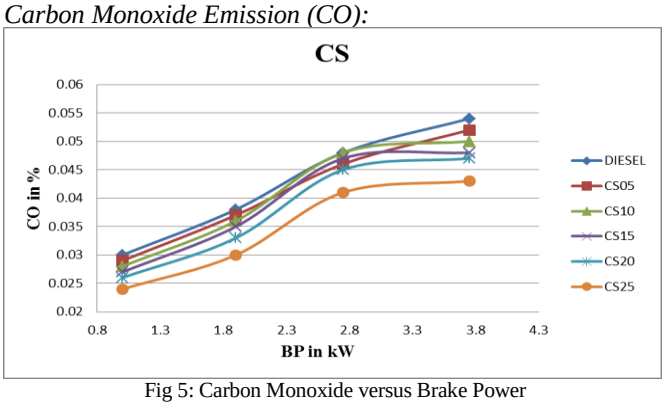

Fig 5: Carbon Monoxide versus Brake Power

From the figure 5 it is perceived that blends of CS25 shows minimum emission level when compared to other blends. At full loading condition CS25 obtains 0.043% which will be very less than petroleum diesel. Blend CS20 obtains 0.047% as the blends percentage increase the level of emission will be less due to complete combustion.

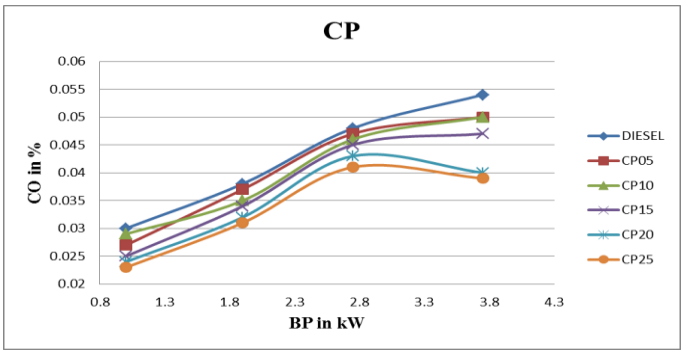

Fig 6: Carbon Monoxide versus Brake Power

From the figure 6 it is perceived that blends of CP25 shows minimum emission level when compared to other blends. At full loading condition CP25 obtains 0.039% which will be very less than petroleum diesel. Blend CP20 obtains 0.04% as the blends percentage increase the level of emission will be less due to complete combustion.

At full load condition CS25 and CP25 obtained 0.043% and 0.039% which will lower than other blends. Containment of oxygen within the biodiesel is sufficient, this is the main cause for decrease in CO emission also it will stimulate for complete combustion. Greater the ratio of fuel air CO emission increases.

Carbon Dioxide Emission (CO_2):

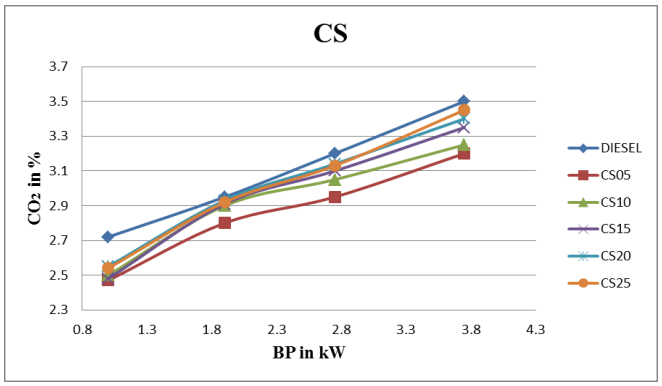

Fig 7: Carbon Dioxide versus Brake Power

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From the figure 7 it is perceived at full loading condition CS25 obtains 3.45% which will be very less than petroleum diesel. Blend CS20 obtains 3.4% as the blends percentage increase the level of emission of CO_2 which will indicate the good combustion process, also the level of emission will be balanced by the atmosphere.

From the figure 8 it is perceived at full loading condition CP25 obtains 3.48% which will be very less than petroleum diesel. Blend CS20 obtains 3.45% as the blends percentage increase the level of emission of CO2.

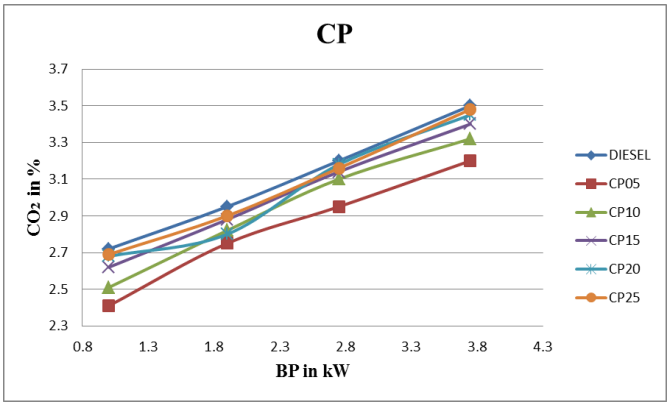

Fig 8: Carbon Dioxide versus Brake Power

CO_2 emissions are lower when compared to petroleum diesel also complete combustion is caused. Emissions of CO_2 increases proportionally as the engine speed increases. Emission of CO_2 is balanced in atmosphere absorbing by plantation. Both the blends of cottonseed and crude palm biodiesel have less significant in CO_2 emission

Hydro Carbon Emission (HC):

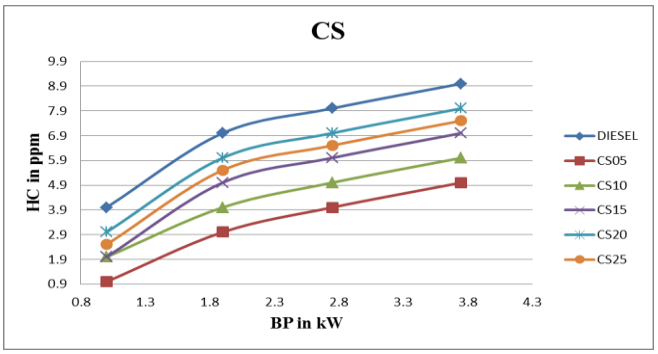

Fig 9: Hydro Carbon versus Brake Power

From the figure 9 it is perceived at full loading condition CS20 obtains 8 ppm with further increase in blend CS25 the emission level will reduce to 7.5 ppm which will lower than blend CS20.

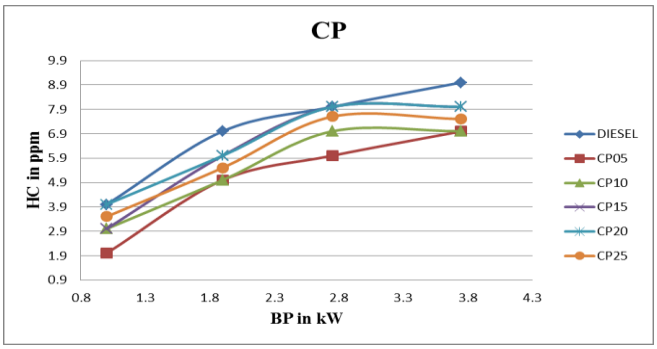

Fig 10: Hydro Carbon versus Brake Power

From the figure 10 it is perceived at full loading condition CP20 obtains 8 ppm with further increase in blend CS25 the emission level will reduce to 7.5 ppm which will lower than blend CS20.

Emissions of hydrocarbon increases with reference to brake power increase for blends of biodiesel when compared to petroleum diesel also absolute combustion is caused. As blends of cottonseed biodiesel increases the percentage of emission decreases. Overview of reduction in HC emission is caused by rich oxygen and less in carbon and hydrogen content in biodiesel than in petroleum diesel. Investigation reveals that HC emission decreased with increasing in engine load.

Nitrogen Oxide Emission (NO_X):

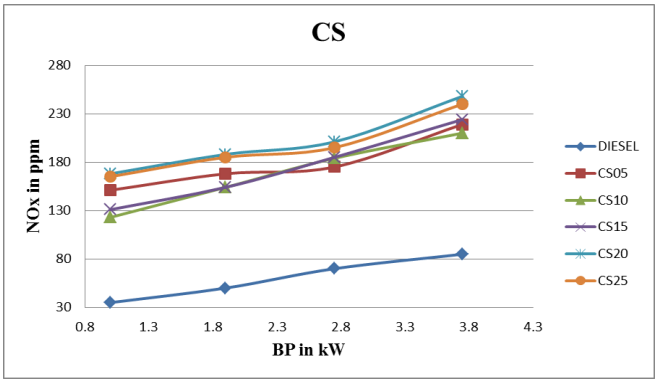

Fig 11: Nitrogen Oxide versus Brake Power

From the figure 11 it is perceived at full loading condition CS20 obtains 248 ppm with further increase in blend CS25 the emission level will reduce to 240 ppm which will lower than blend CS20 and very much higher than petroleum diesel.

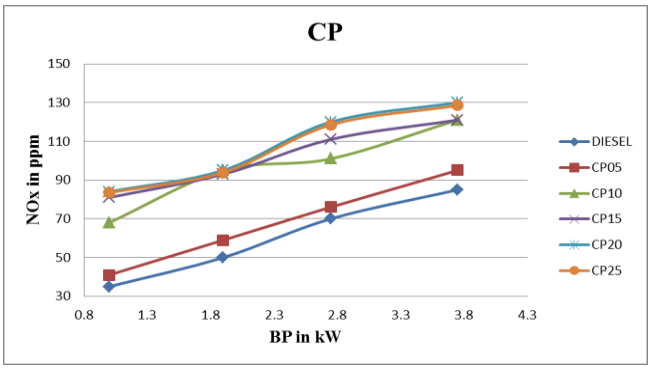

Fig 12: Nitrogen Oxide versus Brake Power

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From the figure 12 it is perceived at full loading condition CP20 obtains 130 ppm with further increase in blend CP25 the emission level will reduce to 128.5 ppm which will lower than blend CP20 and very much higher than petroleum diesel.

Emissions of NOx increases with reference to brake power increase for biodiesel blends when compared to petroleum diesel. Due to high temperature in engine combustion chamber emissions of NOx increases. It is very much temperature determined parameter. For the blend CS20 and CP20 shows maximum level of NOx further increase in blend percentage shows reduction in NOx emission level.

CONCLUSION

Investigation of the experimental work evaluates the characteristics of performance and emission of cottonseed and crude palm biodiesel blends with the petroleum diesel conducted on a computerized four stroke diesel engine of rated power 5.2 KW at 1500 rpm speed under standard injection opening pressure of nozzle 200 bar, injection timing 21 degree and compression ratio 17.5:1.

- With the increase in brake power it is perceived that thermal efficiency increased. The efficiency of petroleum diesel is observed to be higher, when compared to blends of both cottonseed and crude palm biodiesel under investigation.

- With the increase in biodiesel blends percentage increases, the brake thermal efficiency increases at full loading conditions for blend CS20 it is perceived that brake thermal efficiency is 26.99 % and for blend CP20 it is 26.58%, lower than petroleum diesel, biodiesel contains greater viscosity and density due to this cause brake thermal efficiency of biodiesel blends is perceived to lower than petroleum diesel.

- The brake specific fuel consumption is observed to be decreased in petroleum diesel with increase in brake power and it is observed that blend CS20 0.2812 Kg/kW hr and for blend CP20 it is 0.299 Kg/kW hr to be slightly increased for biodiesel than the petroleum diesel.

- Carbon monoxide (CO) is observed to be increased with the increase in the brake power. At full loading condition blends CS25 shows 0.043% and CP25 shows 0.039% which is lesser than petroleum diesel emissions. Carbon di oxide (CO2) is observed to be increased as the brake power increases simultaneously.

- Emission of hydrocarbon (HC) is observed to be increased when brake power increases proportionally. At full loading condition blends of CS25 and CP25 shows the percentage of 7.5 %. For petroleum diesel this emission is higher, as contrasted to all other blends of biodiesel under the investigation.

- Nitrogen oxide (NOx) emission is observed to be increased with increase in brake power. At full loading conditions blends of CS20 and CP20 shows the highest percentage of 65.72% and 34.61% emission level. For petroleum diesel these emissions is lower, as compared to other blends under the investigation.

- Cottonseed biodiesel is observed to be better biodiesel when comparing with crude palm biodiesel. Brake thermal efficiency will be found higher when compared to crude palm. Emission levels will be observed least with the blends 25% .Cottonseed biodiesel operates slightly near the values of diesel and it reduces the emission levels and also efficiencies are better. Cottonseed oil arrives in non-edible category; hence fuel versus food conflict will not be the issue.

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