



Studies on Performance and Emission Characteristics of Waste Cooking Oil and Jatropha Biodiesels in a DI Diesel Engine Test Rig for Varying Injection Pressures

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Abstract:- In this study the performance and emission characteristics of biodiesels of Jatropha and Waste Cooking Oil (WCO) are tested on a single cylinder 4 stroke DI diesel engine. The study is carried out at different injection pressures of 190, 200 and 210 bars. Jatropha oil is non edible and toxic in nature. It grows in all types of soil. Its seeds consist of about 32-40% [5] of oil. It can grow in waste land and does not require fertile agricultural lands. Hence it is a promising source of biodiesel. The second oil in this study is the Waste Cooking Oil. It is cooking oil used once for frying which should not be used for frying again. It is also called abused frying oil. Large quantities of such used oil from different hotels and restaurants like KFC, Mc Donald etc., is thrown out and wasted. Instead, we can Transesterify and produce biodiesel from this WCO [7]. From this we can produce hundreds of litres of biodiesel. The work carried out shows that both Jatropha and WCO biodiesels show good performance characteristics and can be used as fuels for diesel engine. The emission proportions of their blends are less compared to diesel.

Key Words: Biodiesel, Jatropha, Waste Cooking Oil, Injection Pressure, Performance parameters & emission characteristics

I. INTRODUCTION:

Biofuels have proven that they emit lesser percentage of pollutants when compared to conventional diesel and another advantage is that plants like Jatropha [3], Honge, Simrouba, Neem can be found abundantly in our country.

Among all the sources, WCO has a great potential as a source of biofuel. WCO is nothing but used edible oil. Cooking oils should be used only once and are not recommended for secondary usage. Usually they are disposed off after using once. However this used oil can be transesterified to produce biodiesel instead of being disposed as waste oil. Daily hundreds of litres of WCO are disposed off by big restaurant chains like KFC, Mc Donald's, star hotels etc., This WCO from the restaurants can be processed to produce biodiesel[9].

Jatropha is another source of biofuel. It is found in most parts of our country and its seeds are non-edible. Its seed contains about 32%-40% of oil content [5]. It can be grown in low quality soil and requires less water to grow.

WCO and Jatropha oils form promising sources of biodiesel because of the following reasons:

- Both Jatropha and WCO are easily and abundantly available.
- The cost of Jatropha crude oil and WCO [10] is very low.
- Biodiesel produced in large scale from these two oils cost less than conventional diesel.
- Both Jatropha and WCO biodiesel emits less pollutants than conventional diesel fuel.
- The engine requires no modifications when these biodiesels are used as fuels.

Emission and Performance Test

1. DI 4-S Diesel Engine
2. Eddy Current Dynamometer
3. Air Box
4. Fuel Tank
5. Decoder
6. Computer
7. Exhaust gas analyser

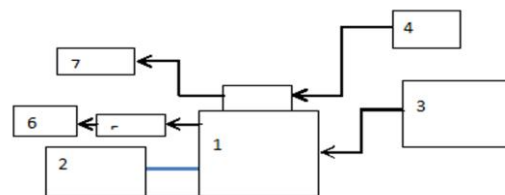


Fig 1: Block Diagram of Diesel Engine Test Rig

The procedures for performance tests:

- Fill the tank and check the lubricating system.
- Ensure that no load is applied on the engine.
- Start the engine by cranking.
- Allow the engine to attain the speed.
- Allow the cooling water to circulate through engine.
- Switch on the Laptop and open the “Mixed Fuel Diesel Engine Analysis” software.
- Apply torque with the help of the torque set up.
- Log the Data in software.
- During this time the decoder shown in fig 1 processes the data from the engine and sends the information to the computer and output readings are displayed.
- Again the torque is changed and new results are obtained following the same steps.

Table 1 Engine and Dynamometer specifications

Sl. No.	Parameters	Specification
1.	Type	AV 1 (Kirloskar make)
2.	Horse Power	3.67Kw (5 hp)
3.	Software used	Mixed Fuel Diesel Engine analysis
4.	Nozzle Opening Pressure	200 to 225 bar
5.	Governor Type	Mechanical Centrifugal Type
6.	No of Cylinders	One
7.	No. of Strokes	Four
8.	Standard Fuel	Diesel
9.	Compression Ratio	16.5:1
10.	Cylinder Bore	80 mm
11.	Stroke Length	110 mm
12.	Speed	1400-1500 rpm
Electrical Dynamometer		
13.	Type	Foot Mounted, Continuous rating
14.	Alternator Rating	3 KVA
15.	Speed	2800-3000 rpm
16.	Voltage	AC

Table 2: Properties of Biodiesel and diesel [6]

Property	Unit	Jatropha Biodiesel	WCO Biodiesel	Diesel	ASTM
Density at 15°C	Kg/m ³	893	878	850	875-900
Viscosity at 40°C	mm ² /s	4.84	3.95	2.60	1.9-6.0
Flash Point	°C	162	150	70	>130
Pour Point	°C	-6	-9	-20	-15 to 10
Acid Value	mgKOH/g	0.24	0.44	0.35	<0.8

Iodine Value	-----	104	88	-----	140
Calorific Value	MJ/Kg	35.7	39.34	42.7	-----
Cetane Number	-----	51.6	55	46	-----

II. RESULTS AND DISCUSSION

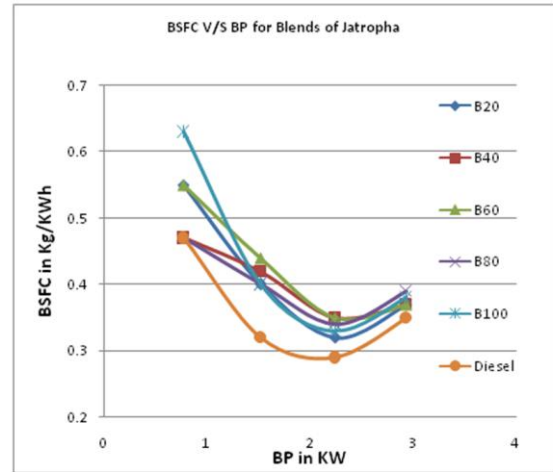


Fig 2: BSFC V/S BP Plot for Jatropha Biodiesel and Diesel at 200 bar Injection Pressure.

From the above plot it is clear that among all the blends the BSFC is low for B20 blend [1 & 2]. Lesser the BSFC higher is the fuel efficiency of the engine. This means compared to all the blends B20 blend of Jatropha gives higher fuel efficiency. Hence B20 blend of Jatropha is considered the optimum blend and hence the performance tests for different injection pressures are carried out for this blend.

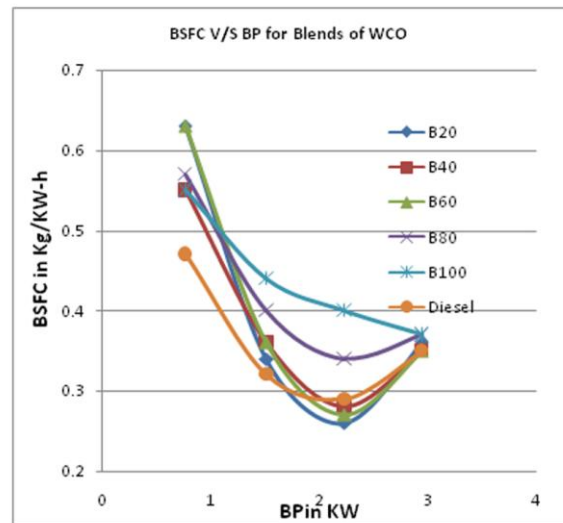


Fig 3: BSFC V/S BP Plot for WCO Biodiesel and Diesel at 200 bar Injection Pressure.

From the above plot it is clear that among all the blends the BSFC is low for B20 blend. Lesser the BSFC higher is the fuel efficiency of the engine. This means

compared to all the blends B20 blend of WCO gives higher fuel efficiency. Hence B20 blend of WCO is considered the optimum blend [7] and hence the performance tests for different injection pressures are carried out for this blend.

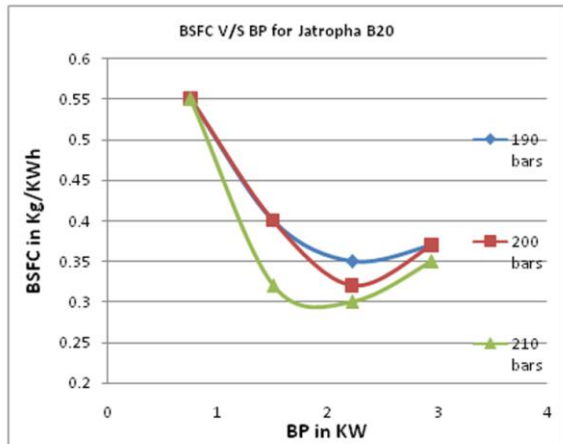


Fig 4: BSFC V/S BP for Jatropa B20 at Different Injection Pressures.

From the graph it is clear that BSFC decreases for higher injection pressures. BSFC is less for B20 blend at 210 bars and maximum for 190 bars pressure. At higher injection pressure the atomisation of fuel is good and results in better combustion and hence results in lesser BSFC. Hence from the above plot it is clear that the fuel efficiency of the engine increases with increase in fuel injection pressure.

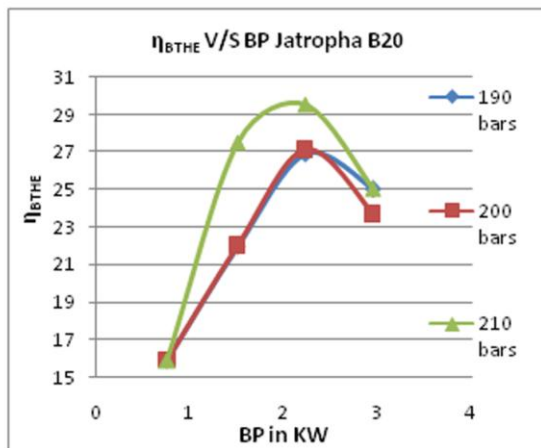


Fig 5: Brake Thermal Efficiency V/S BP for Jatropa B20 at Varying Injection Pressure.

From the above Graph it is clear that the brake thermal efficiency is higher at higher injection pressure. At 210 bars injection pressure the brake thermal efficiency is maximum. Higher injection pressure results in better combustion and better power output and hence the Brake Thermal Efficiency of the engine is increased at higher injection pressure.

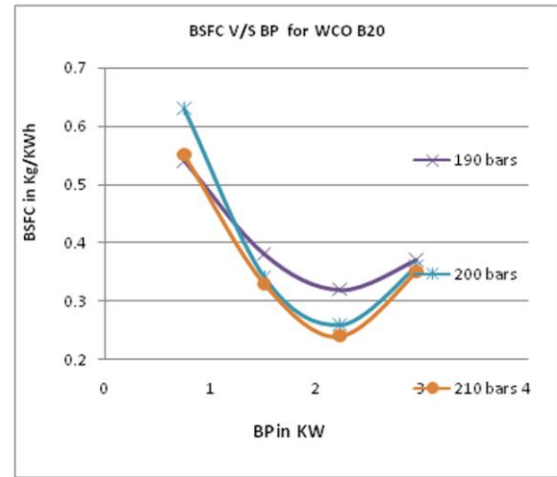


Fig 6: BSFC V/S BP for WCO B20 at Varying Injection Pressure.

From fig 4 it is clear that BSFC decreases for higher injection pressures. BSFC is less for B20 blend at 210 bars and maximum for 190 bar pressure. At higher injection pressure the atomisation of fuel is good and results in better combustion and hence results in lesser BSFC. Hence from the above plot it is clear that the fuel efficiency of the engine increases with increase in fuel injection pressure.

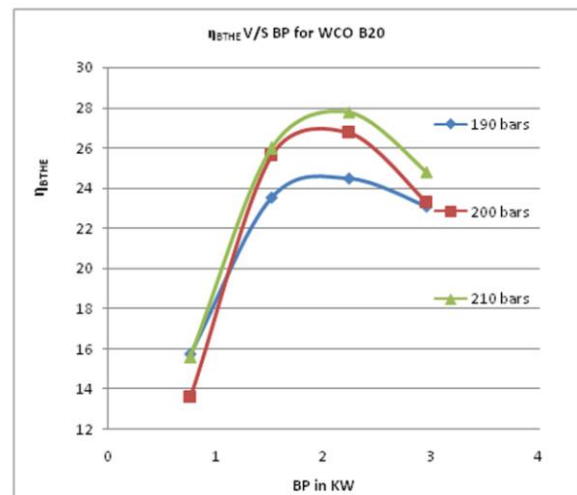


Fig 7: Brake Thermal Efficiency V/S BP for WCO B20 at Varying Injection Pressure.

From the above Graph it is clear that the Brake Thermal Efficiency is higher at higher injection pressure. At 210 bar injection pressure the brake thermal efficiency is maximum. Higher injection pressure results in better combustion and better power output and hence the Brake Thermal Efficiency of the engine is increased at higher injection pressure.

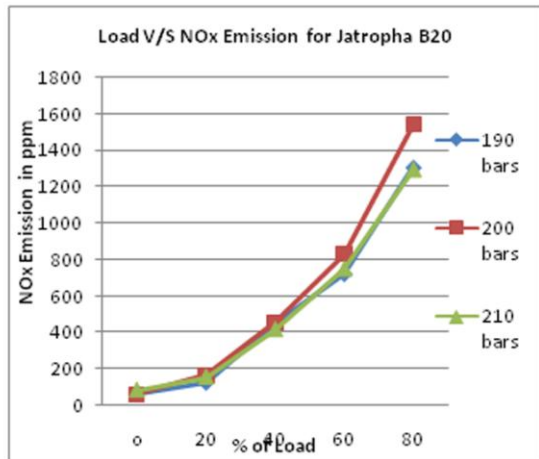


Fig: 8 NOx emissions V/S Torque for Jatropa B20 at Varying Injection Pressure.

The NOx emission is higher for 200 bar injection pressure and lower for 190 bar injection pressure. High temperature in the combustion chamber supports the formation of NOx. This means at 200 bar injection pressure at maximum load the combustion chamber might have reached high temperature and hence we can see maximum NOx formation at 200 bar injection pressure.

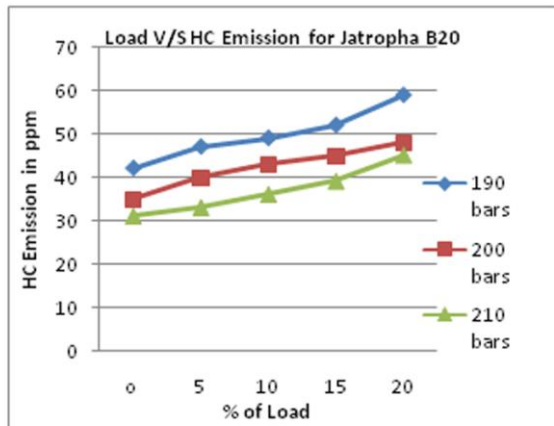


Fig 9: HC emission V/S Torque for Jatropa B20 at Varying Injection Pressure.

The HC emission is minimum at 210 bar injection pressure. From the plot it is clear that at 190 bar injection pressure the HC emission is maximum. Higher the injection pressure better will be the atomisation of the fuel and better will be the combustion hence lesser amount of HC is found in the exhaust.

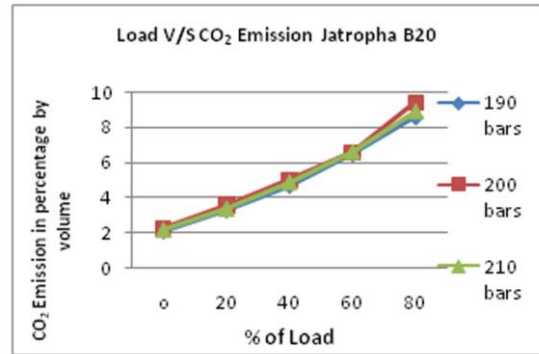


Fig 10: CO₂ emission V/S Torque for Jatropa B20 at varying Injection Pressure.

CO₂ emission is high at 200 bar injection pressure and lower at 190 bar injection pressure. However the amount of CO₂ emitted does not change significantly with change in injection pressure.

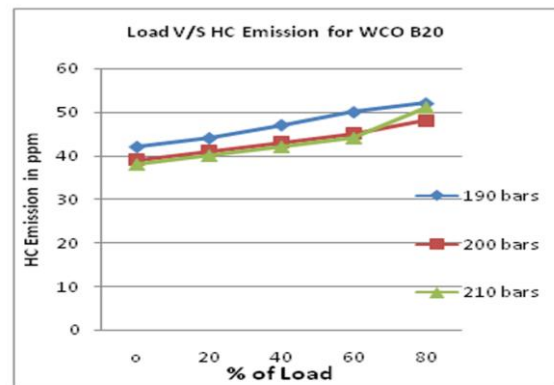


Fig 11: HC emission V/S Torque for WCO B20 at Different Injection Pressure.

The HC emission is minimum at 210 bar injection pressure. From the plot it is clear that at 190 bars injection pressure the HC emission is maximum. Higher the injection pressure better will be the atomisation of the fuel and better will be the combustion hence lesser amount of HC is found in the exhaust.

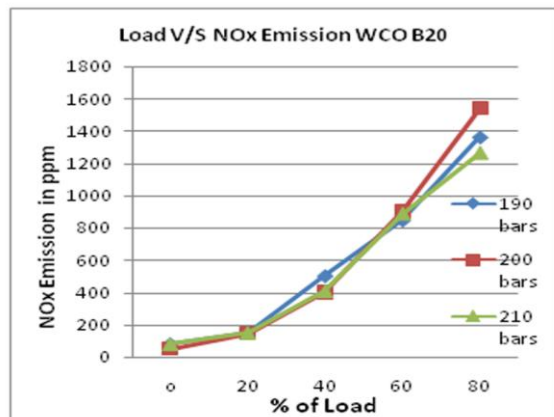


Fig 12: NOx emission V/S Torque for WCO B20 at Varying Injection Pressure.

As we can observe from the graph NO_x emission is higher at 200 bars injection pressure. The main cause for NO_x formation is high temperature in the combustion chamber.

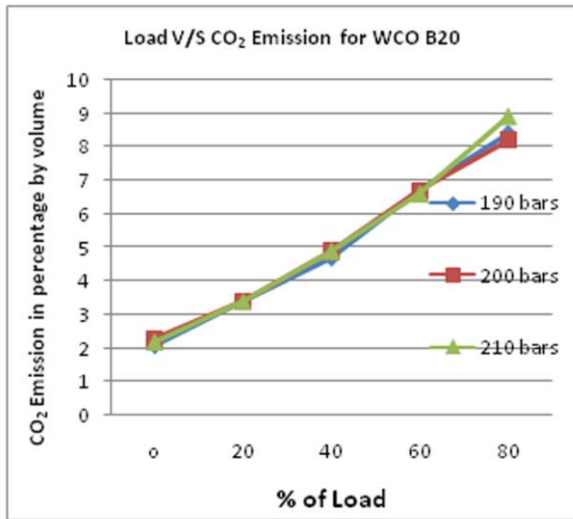


Fig 13: CO₂ emission V/S load for WCO B20 at Varying Injection Pressure.

It can be seen from the graph that the CO₂ emission is almost same at all the pressures. However at maximum load CO₂ emission is more for 210 bar injection pressure and minimum for 200 bars injection pressure.

III. CONCLUSION

In this study the performance and emission characteristics of Jatropha biodiesel and WCO biodiesel were evaluated in a computerised 4stroke, single cylinder, direct injection water cooled CI engine at different injection pressures (190 bar, 200 bar and 210 bar). The test was carried out first at 200 bar for all the blends i.e. B20, B40, B60, B80, B100. In case of both Jatropha and WCO biodiesel B20 blend was considered optimum since the performance characteristics of B20 blend was better compared to all the blends. Later experimentation was done at 190 bar followed by 210 bar for optimum blend (B20) of WCO and Jatropha biodiesel only.

It was observed that with the increase in injection pressure the performance of the engine also increases for both WCO and Jatropha biodiesel blends. No major changes were observed in emission of CO, CO₂ and O₂ for different injection pressures. However in NO_x and HC levels noticeable changes were seen with increase in injection pressure. From the study, it is clear that both Jatropha [4] and WCO biodiesel can be used as an alternate fuel for CI engine. During this study following observations were made:

- The BSFC of WCO B20 Blend at 210 bar injection pressure is 8.7 percent less compared to same blend

at 190 bar and it is less by 7.5 percent when compared with BSFC for same blend at 200 bar. This shows that at higher injection pressure the fuel efficiency of the engine has increased since there is a decrease in BSFC.

- The BSFC of Jatropha B20 Blend at 210 bar injection pressure is 8.9 percent less compared to same blend at 190 bar and it is less by 7.3 percent when compared with BSFC for same blend at 200 bar.
- The Brake Thermal Efficiency of WCO B20 blend at 210 bar injection pressure is 8.4 percent higher compared to Brake Thermal Efficiency for same blend at 190 bar and it is 5.4 percent high compared to the same blend at 200 bar injection pressure.
- The Brake Thermal Efficiency of Jatropha B20 blend at 210 bar injection pressure is 8.7 percent higher compared to Brake Thermal Efficiency for same blend at 190 bar and it is 10.36 percent high compared to the same blend at 200 bar injection pressure.
- This shows that at higher injection pressure the fuel efficiency of the engine has increased since there is a decrease in BSFC.
- With the increase in injection pressure an increase in brake thermal efficiency is observed. Hence at higher injection pressure the ratio of brake power output to input has increased. So power output of the engine will be high at higher injection pressure.
- The HC emission decreases with increase in injection pressure for both WCO and Jatropha biodiesel. This is due to good atomisation of the fuel at higher injection pressure which results in better combustion.
- The HC emission ranges between 31 to 59 ppm for B20 blend of Jatropha biodiesel and 38 to 51 ppm for B20 blend of WCO biodiesel. So at higher loads, Jatropha biodiesel emits more HC compared to WCO biodiesel.
- The NO_x emission is more at 200 bar injection pressure for both Jatropha and WCO B20 blend and NO_x emission is minimum at 190 bar injection pressure for both. NO_x emission ranges between 50-1500 ppm for both the B20 blends.
- At higher injection pressure the CO₂ emitted in is less compared to lower injection pressure for both B20 Jatropha and B20 WCO blend. The value of CO₂ emission ranges between 2 to 9 percent by volume. However at maximum load the WCO B20

emits 5.2 percent lesser CO₂ compared to Jatropha B20.

From the study it is clear that the WCO biodiesel shows good performance than Jatropha biodiesel and also WCO biodiesel emits less amount of pollutants compared to Jatropha biodiesel. WCO is easily available and cheaper in cost compared to Jatropha biodiesel. WCO has got higher calorific value than Jatropha biodiesel. Hence from this study WCO biodiesel is better fuel for CI engine than Jatropha biodiesel.

REFERENCES

- [1] Performance of Jatropha biodiesel production and its environmental and socio-economic impacts, a case study in Southern India, Lisa Alexson and Maria Franzen.
- [2] Potential of waste cooking oils as biodiesel feed stock, Sudhir C V, Sharma N Y and Mohanan P, EJER, 2007.
- [3] Combustion analysis of Jatropha, Karanja and Polanga based biodiesel as fuel in a diesel engine, Sahoo P K, Das L M, Elsevier, 2008.
- [4] Biodiesel production from waste sunflower cooking oil as an environmental recycling process and renewable energy, Hossain A B M S and Boyce Bulgarian A N, Journal of Agricultural Science, 2009.
- [5] Analysis of Waste Cooking Oil as Raw Material for Biofuel Production, K. Khalisanni K, Khalizani, M.S. Rohani and Khalid P O, IDOSI 2008.
- [6] Characterisation of Jatropha oil for the preparation of biodiesel, R K Singh, Saroj K Padhi, Natural Product Radiance, Vol 8(2), 2009.
- [7] Evaluation of biodiesel blending, engine performance and emissions characteristics of Jatropha curcas methyl ester, Mofijur M, Masjuki HH, Kalam M A, Atabani A E, Elsevier, 2013.
- [8] Experimental Analysis of Jatropha Curcas Bio-Diesel for Optimum Blend Characteristics, Manikanda Prabu N, Nallusamy S and Thirumalai Rasu K, Bonfring IJIEM Vol. 3, No. 2, June 2013.
- [9] Biodiesel Production and Investigations on the Performance of Diesel Engine Using Jatropha Oil, 1M. Bassyouni, F. H. Akhtar, Hussain A. and A. Umer, ATE, Vol-2, Issue-3.
- [10] Effect of used cooking oil methyl ester on compression ignition engine, Shahid E M, Jamal Y, 2012.

