Performance and Emission Testing of VCR Engine by using Blends of Simarouba Biodiesel with Turmeric Leaf Oil at Various Compression Ratios

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Abstract— In modern times, biodiesel is derived, or has been reported to be producible from many different sources, including vegetable oils, animal fats, used frying oils, etc. In the present work, Simarouba Glauca oil biodiesel blends with turmeric leaf oil and diesel were used as a fuel. Simarouba Glauca oil is made from the seeds of a Simarouba plant commonly known as Paradise tree. Dry seeds of Simarouba Glauca contains 60% to 75% oil. In turmeric plant leaves are the waste product, we can use it for extraction of oil. So the oil extracted from these waste leaves is used for the production of biodiesel. The blends are prepared with pure diesel as B12, B24 and B36 which includes 5% of turmeric leaf oil as an additive in each blend. Turmeric leaf oil improves stability of blends. The B12 contains 12% of Simarouba oil and 5% of turmeric leaf oil and remaining is pure diesel. Likewise the contents of remaining blends are varied. The test has been taken on VCR engine with compression ratios of 14, 16 and 18 by using biodiesel blends at maximum loading. Further the parameters such as brake power, brake specific fuel consumption (BSFC), brake thermal efficiency were compared with the pure diesel test on engine. Also, the effects of biodiesel blends on emissions has been studied under the present research.

Key words: VCR Engine, Blends of Simarouba Biodiesel, Turmeric Leaf Oil

I. Introduction

Consumption of fossil fuels has highly increased and the use of these energy resources has major environmental impact as well. The consumption of petroleum diesel is increasing day by day. The combustion of fossil fuels is main reason in increasing the global warming and depletion of conventional sources are also causes of concern and have prompted research world-wide into alternative energy sources for internal combustion engines. Bio fuels appear to be a potential alternative “greener” energy substitute for fossil fuels.

There is increasing need to find out the new alternatives to the fossil fuels lead to the development of bio fuels. Diesel and petrol engines are the major sources of power generation & transportation hence both are being used extensively but due to gradual impact of environmental pollution there is an urgent need for suitable alternate fuels for use in SI and CI engines without any modification. Also there is number of alternatives to fossil fuels under development such as use of electric energy or solar energy for the transportation. But as the electricity generation is majorly depends upon the coal reserves, it is again our prime concern to reduce the use of coal to avoid it from depletion.

Combustion of fuel results in the emission of carbon dioxide (CO_2) and other harmful pollutants. This results in increasing the global CO_2 level and global warming. The harmful pollutants not only affect the environment but also on human being. These emission CO generally caused by insufficient oxygen and causes breathing problem, headache. The emission HC is raw fuel escaping to the atmosphere causes irritation in respiratory system. No_x irritates the eyes, nose and throat, & it causes headache and damage to lungs. Therefore there is a need to search alternative fuels argent in India to meet the demand for transportation, agricultural sector.

The biodiesel is the best alternative for the petroleum diesel to decrease the emission caused by the combustion of diesel. Bio-diesel which can be used as an alternative diesel fuel is made from renewable biological sources such as vegetable oils and animal fats. It is bio-degradable; non-toxic and possesses low emission profiles. Also, the use of bio-fuels is environment friendly. This research lead to the study of Simarouba Glauca and turmeric leaf oil biodiesel blends with the petroleum diesel fuel to control the emissions and increase the performance of diesel engine.

Simarouba glauca belongs to family simarubaceae, commonly known as “The Paradise Tree” or “King Oil Seed Tree”, is a versatile multipurpose evergreen tree having a height of 7-15 m. It is mainly found in coastal hammocks throughout South Florida. In India, it is mainly observed in Andhra Pradesh, Karnataka and Tamil Nadu etc. It can adapt a wide range of temperature, has the potentiality to produce 2000-2500 kg seed/ha/year; can grow well in marginal lands/wastelands with degraded soils and therefore considered as a major forest tree. The seeds are economically very important as they contain 60-75% oil, which can be used in the manufacture of biodiesel.

Turmeric is cultivated in India, China, Myanmar, Nigeria and Bangladesh. However, authentic figures about area and production are not available. Major production area is in India which constitutes 82% followed by China (8%), Myanmar (4%), Nigeria (3%) and Bangladesh (3%).The main turmeric producing states in India are Andhra Pradesh, Tamil Nadu, Orissa, Karnataka, West Bengal, Gujarat and Kerala. The biological name of turmeric is Curcuma Longa. The leaves of C. Longa have been observed to be a waste product which has traditionally been used for culinary preparation which are aromatic and contain oil. The local experiences show that turmeric leaves are readily explosive, which proves it to have higher calorific content.

Simarouba oil contains free fatty acids. To decrease the amount of free fatty acids esterification of oil is done. For production of biodiesel from esterified Simarouba oil transesterification process is required. It consists of removal of glycerin in the oil with help of catalyst sodium methoxide ($NaOCH_3$).

II. EXPERIMENTAL SETUP

The experimental test rig consists of a variable compression ratio engine, eddy current dynamometer as loading system, fuel supply system for both Diesel oil and biodiesel supply, water cooling system, lubrication system and various sensors and instruments integrated with computerized data acquisition system for online measurement of load, air and fuel flow rate, exhaust emissions and smoke opacity.

Fig. 1 gives the information about experimental test rig. Specially designed tilting cylinder block arrangement. The injection point and spark point can be changed for research tests. Rotameters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement. The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Lab view based Engine Performance Analysis software package "Enginesoft" is provided for on line performance evaluation. The test engine setup is manufactured by Apex Innovations, Sangli

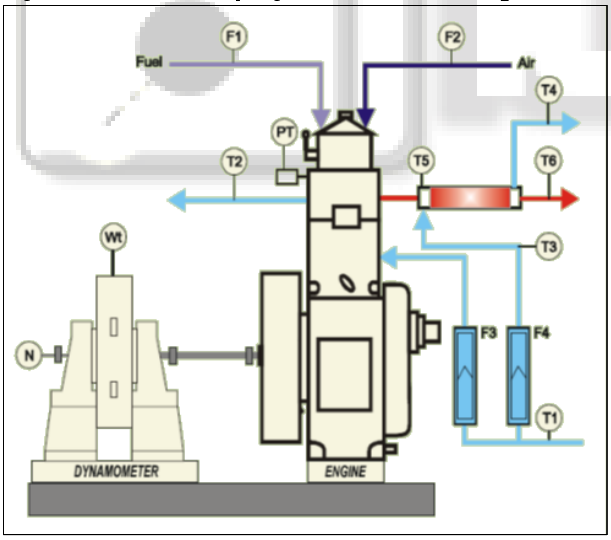

Fig. 1: Experimental Set up

Where, T_1= Temperature of jacket water IN
F_1= Flow rate of fuel
T_2= Temperature of jacket water OUT
F_2= Flow rate of air
T_3= Temperature of water Calorimeter IN
F_3= Flow rate of engine cooling water
T_4= Temperature of water Calorimeter OUT
F_4= Flow rate of calorimeter cooling water
T_5= Temperature of Exhaust Gas, before calorimeter
T_6= Temperature of Exhaust Gas, after calorimeter
Wt= Load cell reading
N= Engine speed Tachometer reading

Product	Research Engine test setup 1 cylinder, 4 stroke, Multifuel, VCR
Engine	Single cylinder, 4 stroke, water cooled, stroke 110 mm, bore 87.5 mm, 661 cc. Diesel mode: 3.5 KW, 1500 rpm, CR range 12-18. Injection variation:0- 250 BTDC Petrol mode: 4.5 KW@ 1800 rpm, Speed range 1200-1800 rpm, CR range 6-10
Dynamometer	Type eddy current, water cooled, with loading unit
Air Box	MS fabricated with orifice meter and manometer
Fuel Tank	Capacity 15 lit, Type: Duel compartment, with fuel metering pipe of glass
Calorimeter Type	Pipe in pipe
ECU	PE3 Series ECU, Model PE3-8400P, full build, potted enclosure. Includes peMonitor & peViewer software
Piezo sensor	Combustion: Range 350Bar, Diesel line: Range 350 Bar, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Temperature sensor type	RTD, PT100 and Thermocouple, Type K
Temperature transmitter Type	Two wire, Input RTD PT100, Range 0–100 Deg C, Output 4–20 mA and Type two wire, Input Thermocouple
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel Flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC
Software	"Enginesoft" Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Pump Type	Monoblock
Overall dimensions	W2000 x D2500 x H1500 mm

Table 1: Engine Specification

III. RESULTS AND DISCUSSION

In this work the performance and emission characteristics are studied and experiment is carried out by testing single cylinder, 4 stroke, VCR engine fuelled with Diesel (B00) and Simarouba diesel blends namely B12, B24 and B36. These blends contains 5% of turmeric leaf oil. The test were made at different compression ratios of 14, 16 and 18. The experiment was conducted at maximum load of 12 kg. The corresponding BP, BSFC, BTE and emissions HC, CO and NO_x were recorded.

A. Performance Parameters

The performance parameters are examined for Diesel and Simarouba blends for compression ratios of 14:1, 16:1 and 18:1 at constant load of 12 kg.

1) Brake Power:

The variation of brake power (BP) with maximum load at CR 14, 16 and 18 is illustrated in Fig. 2. It is seen that engine brake power increased, as the compression ratio was increased. This is due to the increase in brake torque at high compression ratios. Increase in compression ratio induces greater turning effect on the cylinder crank. This means that the engine is giving more push on the piston, and more torque is generated. From figure it was observed that B36 blend has greater brake power at compression ratio 18:1.

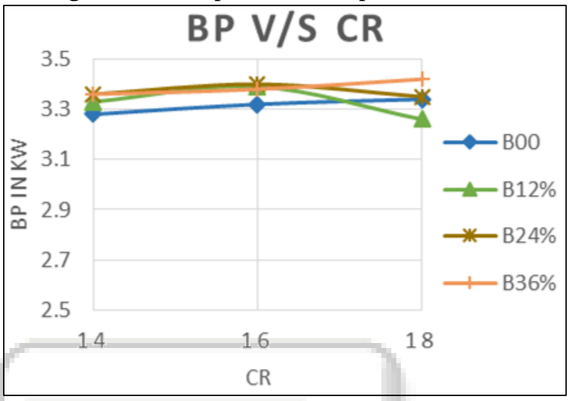

Fig. 2: B.P. V/s C.R

2) Brake Specific Fuel Consumption (BSFC):

The variation of BSFC with maximum load for different biodiesel blends is presented in fig. 3. The BSFC of all biodiesel blends was found to be higher than diesel fuel. As the proportion of biodiesel blend increased, the BSFC was observed to be increased. The BSFC of B36 was higher than all other fuels. This is due to the higher density of Simarouba oil biodiesel. As the percentage of blend increases the density also increases. The higher densities of biodiesel blends caused higher mass injection for the same volume. Due to high density of biodiesel the fuel consumption is more. The brake specific fuel consumption (BSFC) decreases with the increase in compression ratio, as expected. This is because of at higher compression ratio power generated is more, with respect to fuel consumption rate.

The BSFC of B24 blend is almost equal to the diesel fuel.

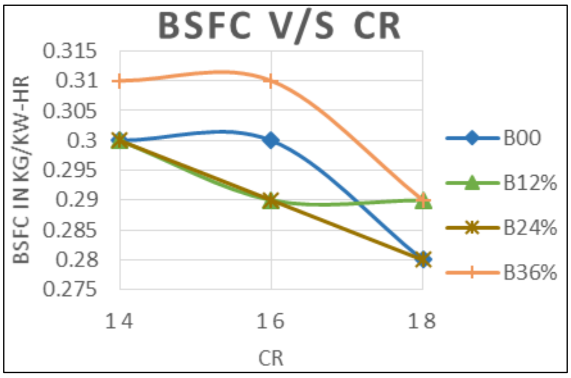

Fig. 3: BSFC V/s C.R

3) Brake Thermal Efficiency (BTE):

Brake thermal efficiency is found to be decrease with the increase in blend content as shown in fig. 4. This is due to the higher viscosity of blends which led to the poorer atomization and poor combustion. The another reason for the decrease in brake thermal efficiency with the blend content is due to the increase in fuel consumption which is mainly due to higher density of blends. Also, it was observed from figure that with the increase in compression ratio the brake thermal efficiency was found to be increased. The trend is observed because at higher compression ratio, the air temperature is high which results in better combustion of fuel. The variation of brake thermal efficiency with maximum load and various compression ratio for B24 blend is equal to the diesel fuel.

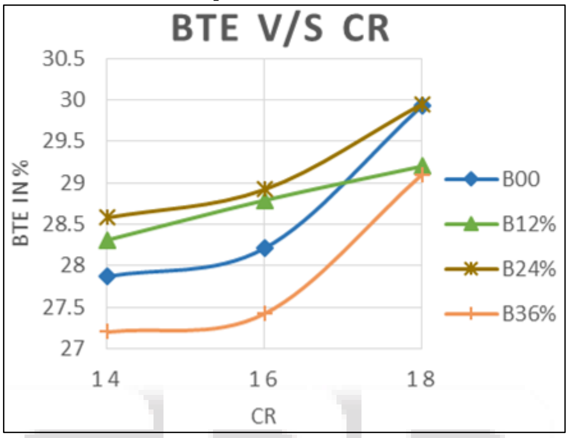

Fig. 4: BTE V/s C.R

B. Emission Characteristics

The emission parameters namely HC, CO and NO_X for diesel and Simarouba blends at different compression ratios of 14:1, 16:1 and 18:1 at maximum load.

1) Unburned Hydrocarbon Emission (HC):

The variation of hydrocarbon emissions for diesel, B12, B24, B36 are compared at compression ratios of 14, 16 and 18. It can be observed from the fig. 5 that HC emissions decrease with increase in CR for all the fuels tested. The trend observed may be due to complete combustion of fuel which may be due to high heat of compressed air at higher CR. It was observed that HC emissions for diesel fuel were highest and for B12 blend it was lowest.

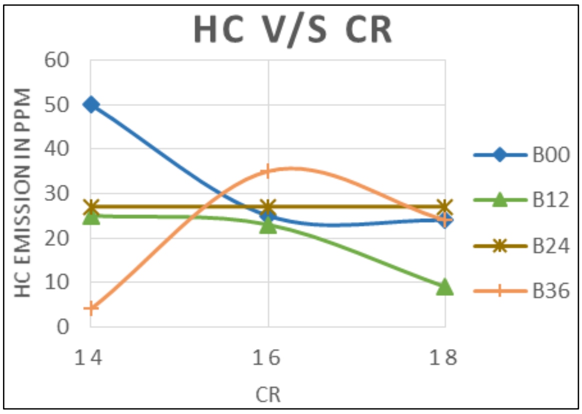

Fig. 5: HC Emission V/s C.R

2) CO Emissions:

The variation of CO emissions for diesel, B12, B24, B36 are compared at compression ratios of 14, 16 and 18 as shown in fig. 6. It can be observed that CO emission decreases with increase in CR. The trend may be due to better combustion of fuel at higher CR which in turn is due to high air temperature inside the cylinder. The higher CO emissions for the blends at low CR may be due to higher viscosity of biodiesel which leads to poor atomization and incomplete combustion. It was observed from the graph that CO emissions are lower for B12 blend.

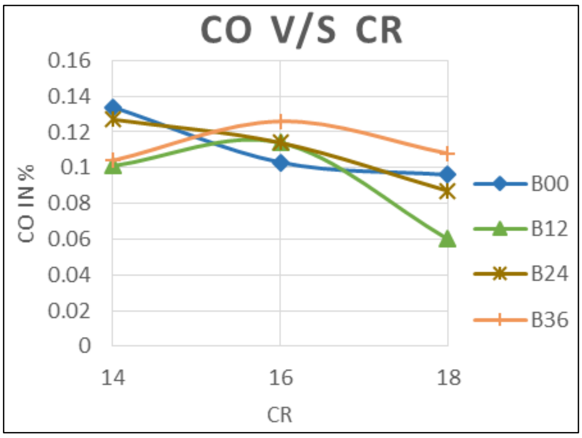

Fig. 6: CO Emission V/s C.R

3) NO_X Emissions:

NOx emissions of diesel, B12, B24, B36 at compression ratios of 14, 16, 18 were compared for maximum load. The graph of NO_X vs CR is shown in fig. 7. NOx emissions are temperature dependent. It was observed that NO_X emissions increase with increase in compression ratio. This is because of increase in temperature inside combustion chamber at high compression ratio. NOx emissions were observed to be increased with increase in blend content. This is because of high oxygen content in the biodiesel fuel. During combustion process of blends, more oxygen is available from fuel and nitrogen from air readily gets combined with oxygen at higher cylinder temperatures and forms compounds like nitrogen dioxide (NO_2) and nitric oxide (NO) which constitute NO.

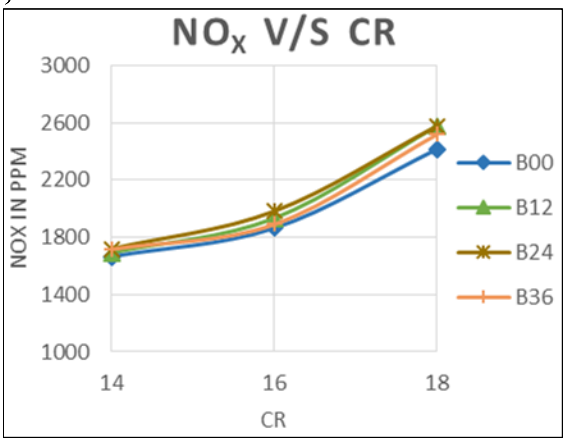

Fig. 7: NO_X Emission V/s C.R

IV. Conclusion

Experimental investigations are carried out on a single cylinder VCR diesel engine to examine the suitability of Simarouba biodiesel with Turmeric leaf oil. The performance and emission characteristics of blends are evaluated and compared with diesel and optimum blend is determined as an alternative fuel. From the above study, the following conclusions are drawn:

– The performance parameters such as BP, brake thermal efficiency with B12 were observed to be nearly similar to diesel fuel at all loads.B12 have better performance parameters than other blends. At higher compression ratio the performance of VCR engine was better. The BSFC of B12 blend was lowest among the blends and nearly to the B36 blend at higher CR.
– The brake thermal efficiency of B24 blend is highest and almost equal to the diesel at higher CR of 18:1.
– The emissions parameters of B12 blend such as HC, CO were lowest than diesel fuel. With increase in blend content these emissions were observed to be decreased. Among all blends, these emissions from B12 blend were observed to be lowest.
– The NO_X emissions are greater for biodiesel blends than diesel fuel. The NO_X emissions for B36 blend were observed to be lowest among all the blends. The CO and HC emissions were lowered at higher compression ratio while NO_X emission were higher at high compression ratio.

From the above observation, it has been found that the blend B24 shows better performance and emission characteristics than other blends and diesel at compression ratio 18:1 and full load condition.

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