

Study of Performance and Emission Characteristics of Maize oil (B30) with Diesel using Variable Compression Ratio Diesel Engine

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ABSTRACT:In recent years' biodiesel become more attractive due to continuously increasing the awareness of the depletion of resources of fossil fuels and related environmental issues. Production of biodiesel is an important and promising field of research as it gains its relevance from increasing the price of petroleum products and their environmental benefits. Several research workers have been making systematic efforts in order to use various vegetable oils as fuel engines. The aim of this present paper is to find out the performance and emission characteristics of biodiesel using maize oil on a variable compression ratio engine. No paper has been presented that, detail procedure of how to measure the performance of biodiesel on VCR engine. For that maize oil blend (30%) have taken as an example. First the performance parameter such as fuel consumption, brake thermal efficiency, mechanical efficiency and volumetric efficiency analysis were calculated and then emission characteristics such as Hydrocarbon, Nitrogen oxide at various compression ratios have been carried out. After experimentation, it is concluded that, volumetric efficiency, brake thermal efficiency maize oil as compared to diesel is same at a higher compression ratio, but vary when the compression ratio decreases. Also at lower compression ratio maize oil blend creates more noise than diesel. Fuel consumption when it is diesel is less as compared to maize oil because of variation in fuel viscosity. As the load increases, Nitrogen Oxide emission of engine increases, whereas hydrocarbon emission of engine decreases.

KEYWORDS:Biodiesel, B30, Compression Ratio, Maize Oil, VCR Engine.

I. INTRODUCTION

The demand for petroleum products is continuously increasing due to the large increase in the number of automobiles. As day by day fossil fuel reserves are getting depleted, serious attention should be given to search alternative fuel sources such as renewable fuel products like ethanol, natural gas, Biodiesel etc. But among these sources biodiesel is the most suitable as an alternative fuel for conventional fuels specially for diesel. It can be produced from animal oils, waste cooking oils, vegetable oils using transesterification process. [1] Savale Bhushan Gajanan et.al has investigated experimental performance and emission characteristics measurement of esterified cotton seed and maize oil blends with diesel by using variable compression ratio diesel engine. It was found that brake thermal efficiency of cottonseed oil and maize oil is higher than diesel. Nitrogen Oxide (NO) emission of an engine increases with increase in compression

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ratio. Nitrogen Oxide (NO) emission of esterified cottonseed and maize oil is more than diesel. Hydrocarbon (HC) emission of the engine decreases with increase in compression ratio. There is not much variation in the emission of Hydrocarbon for diesel, Cottonseed oil and maize oil. [2] Ravichandran N et.al have studied performance and emission characteristics of cotton seed oil methyl ester using the VCR diesel engine. They reported that Oxides of nitrogen emission are more for the biodiesel in all compression ratios compared to diesel but decrease with increase in compression ratio. Cotton seed oil biodiesel is a renewable alternate source. Hence it can be an alternate source of fuel in the future. [3] Vishwanath Shavi et.al have proposed the study of characteristic performance of VCR engine for different fuels. It was noted that if the compression ratio increases until certain limits increases brake thermal efficiency decreases brake specific fuel consumption & CO emissions. Injection pressure and injection timings also. [4] P. Manimaran et.al experimental investigation of the orange peel oil and cotton seed oil blend with petrol as an alternate fuel for petrol engines. It was concluded that the Brake thermal efficiency is increased by 5.69% with the blends when compared to petrol. The reduction of hydrocarbons and CO emissions will be noted for proportions of orange peel oil blends with cottonseed oil. [5]K. Satyanarayana et.al has investigated variable compression ratio diesel engine performance analysis. They concluded that the optimum compression ratio is 19 as an operation for the given engine. Better fuel economy is obtained as the compression ratio 19. Fuel consumption is higher at compression ratio 16.5. Smoke density is less in compression ratio 19.0. Exhaust gas temperatures are moderate at compression ratio 16.5. For more power at high loads the engine should operate at compression ratio 19 due to less specific fuel consumption. For lower power output at light loads the engine should operate at compression ratio 16.5 due to less fuel consumption. [6] Hemanandh Janarthanam et.al have studied experimental investigations of performance and emission analysis of direct ignition diesel engine fuelled with refined vegetable oils. It was found that for a blend of diesel by 30% PM, at 240 bars and full load, the CO, HC, CO₂, decreased by 31.25%, 55.26%, 15.85%, and a marginal decrease in NO.BSFC increases with a 30 % blend at a higher injection pressure by 28.57% due to the lower energy content and higher density. The Break power is increased by 15.28%.

II. FUEL MODIFICATION AND METHODOLOGY

Corn oil (maize oil) is extracted from the germ of corn. Maize oil is generally less expensive than other types of vegetable oils. The problems with substituting triglycerides for diesel fuels are mostly associated with high viscosity. So before mixing maize oil with diesel transesterification process is carried out to reduce viscosity. Transesterification: The major components of vegetable oils and animal fats are Triglycerides. To obtain biodiesel, the vegetable oil or animal fat is subjected to a chemical reaction termed as transesterification.



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Fig.1. Transesterification setup



Fig.2. Pure biodiesel (Settling process)

A reactor or heater is used in transesterification process. The first esterification process is carried out in the reactor as shown in fig.1. Due to this process quantity of fatty acids in non-edible oil is reduced by using H_2SO_4 . The duration of this process is 1 hour. After this transesterification process is carried out in the same reactor. The prepared mixture is heated at $64^\circ C$ by using KOH catalyst for 1 hour, then settling process is carried out in reducing area bowl as shown in fig.2. After some hour's biodiesel is at the upper side and glycerine is at lower side which is productively used for soap making process. Then upper biodiesel is washed with hot water because the spray of hot water makes pH value neutral. Thus the problems of acidic value, rust formation is minimized and it is safe for engine parts.

III. EXPERIMENTAL WORK

The experimental test rig consists of single cylinder, four stroke VCR (Variable Compression Ratio) Diesel engine having power 3.5kW @ 1500 RPM with cylinder bore 87.50 mm, stroke length 110mm, connecting rod length 234 mm, compression ratio ranges 12 to 18. It is connected to eddy current type dynamometer for loading. Specially designed tilting cylinder block arrangement is used by which compression ratio can be changed without altering the combustion chamber geometry and without stopping the engine. For combustion pressure and crank-angle measurements necessary instruments are provided during setup. Also for interfacing airflow, fuel flow, temperatures and load measurement provision is made during setup.

The setup has a panel box which is consisting of air box, manometer, fuel measuring unit and fuel flow measurements, two fuel tanks for dual fuel test, process and engine indicator. For cooling water and calorimeter water flow measurement Rota meters are provided. This setup is useful to study of the performance of VCR engine for brake power, indicated power, frictional power, BMEP, IMEP, Indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, heat balance and A/F ratio. Analysis software package "Engine soft LV" is provided for evaluation of online performance of VCR engine.

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Fig.3. VCR Diesel Engine



Fig.4. Gas Analyser

Test Procedure:

1. Initially, the required Blend of biodiesel is filled in the fuel tank.
2. Ensure cools water circulating for eddy current dynamometer and engine.
3. Adjust the required compression ratio.
4. Start the set up and run the engine at no load for 4-5 minutes.
5. Note down the observations for no load condition.
6. Note down the fuel consumption per minute.
7. Gradually increase the load on the engine by rotating dynamometer loading unit.
8. Wait for steady state (four @ 3 minutes) and collect the reading at respected loads.
9. Gradually decrease the load to zero.

This procedure is followed for various compression Ratios.

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IV. RESULTS AND DISCUSSIONS

In this study experimental performance is carried out on maize oil (B30) blend using a variable compression ratio engine. For studying procedure of performance and emission characteristics measurement of biodiesel observations have collected for constant variation of load 0,3,6, 9 and 12 kg. The sample calculation has shown for maximum load (12kg) and compression ratio 16.

Table 1: Observations Table 2: Theoretical Constants

Calorific value	4436 KJ/Kg
Density	840 Kg/m ³
Engine Flow	280 lph
Calorimeter Flow	150 lph
Air Flow Head	0.076 m
Volume	10 ml
Ambient temperature	25°C

Dynamometer Arm Length	0.185 m
Orifice diameter	0.02 m
Orifice C _d	0.6
Cylinder bore	0.0875 m
Connecting rod length	0.234 m
Stroke length	0.110 m

Table 3: Observations for **B30 CR16**

SR.NO.	LOAD (Kg)	T1 °C	T2 °C	T3 °C	T4 °C	T5 °C	T6 °C	SPEED (RPM)	TIME (Sec)
1	0	24	30.75	24	30.5	150	114	1507	54
2	3	24	30.75	24	29.75	153	117	1495	44
3	6	24	31.75	24	30.5	174	129	1484	36
4	9	24	33.25	24	32.25	201	144	1467	31
5	12	24	35	24	33.75	240	162	1453	25

Calculations for load – 12 Kg:

$$1. \text{ Air flow} = C_d \times A \times \sqrt{2gh \times \frac{\rho_w}{\rho_a}} \times \rho_a \times 3600 \quad (\text{Kg/hr})$$

$$= 0.6 \times \frac{\pi}{4} \times 0.02 \times \sqrt{2 \times 9.81 \times 0.076 \times \frac{1000}{1.17}} \times 1.17 \times 3600$$

$$= 28.343 \text{ Kg/hr.}$$

Where,

ρ_w – Density of water in 'Kg/m³,

ρ_a – Density of air in 'Kg/m³,

h -- Manometer difference in 'm'

A -- Orifice area in 'm²,

$$2. \text{ Fuel Consumption} = \frac{\text{Volume} \times \text{Density} \times 3600}{\text{Time}} = \frac{1 \times 840 \times 10^{-3} \times 3600}{2500}$$

$$= 1.21 \text{ Kg/hr}$$

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$$3. \text{ Indicated Power} = \frac{P_m \times L \times A \times N}{60 \times 1000} = \frac{7 \times 0.110 \times \frac{\pi}{4} \times 0.0875 \times 1453}{60 \times 1000}$$

$$= 5.84 \text{ KW}$$

Where,

P_m - Mean effective pressure in bar.

L - Stroke length in 'm'.

A - Area of piston in 'm²'.

N - Speed in RPM.

$$4. \text{ Brake Power} = \frac{2\pi NT}{60 \times 1000} = \frac{2\pi \times 1453 \times 21.77}{60 \times 1000}$$

$$= 3.32 \text{ kW}$$

Where,

Torque (T) = load in Kg \times gravitational acceleration in 'm²/s' \times Arm length in 'm'

$$= 12 \times 9.81 \times 0.185$$

$$= 21.77 \text{ Nm}$$

N - Speed in RPM.

$$5. \text{ Frictional Power} = \text{Indicated Power} - \text{Brake Power} = 5.84 - 3.32$$

$$= 2.52 \text{ kW}$$

$$6. \text{ Brake Specific Fuel consumption} = \frac{\text{Mass of fuel (Kg/hr)}}{\text{BP (KW)}} = \frac{1.21}{3.32}$$

$$= 0.364 \text{ Kg/kW hr}$$

$$7. \text{ Brake Thermal Efficiency} = \frac{\text{Brake Power (Kw)} \times 100}{\text{Mass of fuel (Kg/s)} \times \text{Calorific Value (KJ/Kg)}}$$

$$= \frac{3.32}{0.000336 \times 43200}$$

$$= 22.27 \%$$

$$8. \text{ Mechanical Efficiency} = \frac{\text{Brake Power} \times 100}{\text{Indicated Power}} = \frac{3.32}{5.84} \times 100$$

$$= 56.81\%$$

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Table 4: Results for B30CR16

LOAD	Mf	BP	IP	$\eta_{vol.}$	$\eta_{bth.}$	$\eta_{mech.}$	$\eta_{ith.}$	HC	NOx	CO
Kg	Kg/hr	KW	KW	%	%	%	%			
0	0.56	0	2.74	81.05	0	0	39.7	10	6	0.06
3	0.69	0.85	3.54	81.7	10.08	24.11	41.82	6	25	0.03
6	0.84	1.7	4.33	82.31	16.38	39.12	41.86	2	39	0.01
9	0.98	2.51	5.09	83.26	20.91	49.37	42.36	3	59	0.01
12	1.21	3.32	5.84	84.06	22.27	56.81	39.21	3	82	0.01

The graphs of maize oil blend (B30) have shown the performance and emission parameter with Brake power is as below. The performance characteristics of maize oil are as shown in Fig.5,6,7,8 and emission characteristics are as shown in Fig.9,10.

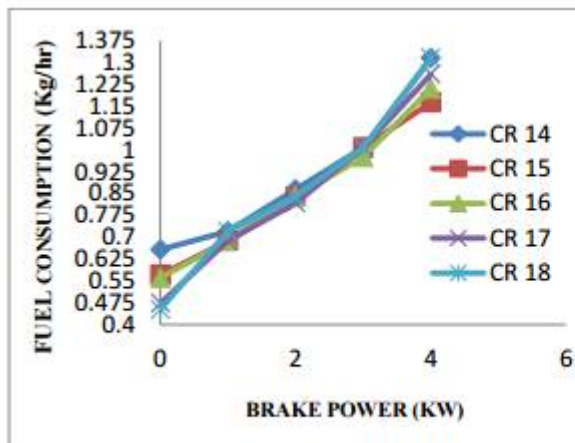


Fig.5. Variation of Fuel Consumption with BP

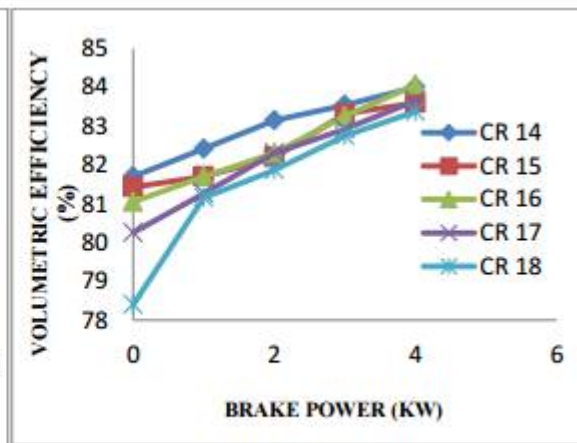


Fig.6. Variation Of Volumetric Efficiency with BP

If brake power increases fuel consumption increases at various compression ratio. The range of fuel consumption at maximum load is 1.16-1.31 Kg/hr. As shown in fig.6 at a lower compression ratio volumetric efficiency is more (CR 14) than higher compression ratio (CR 18). The range of volumetric efficiency is 83-84% at maximum load (12Kg).

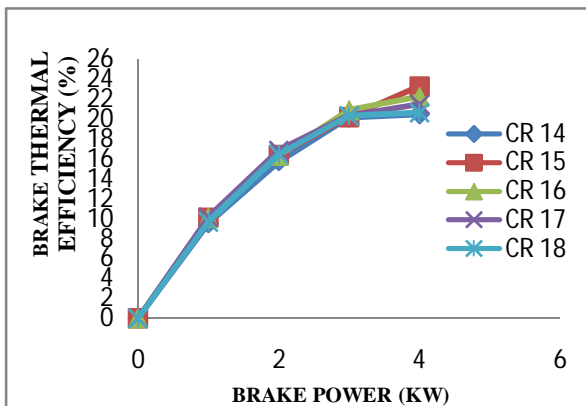


Fig.7. Variation Of Brake Thermal Efficiency With BP

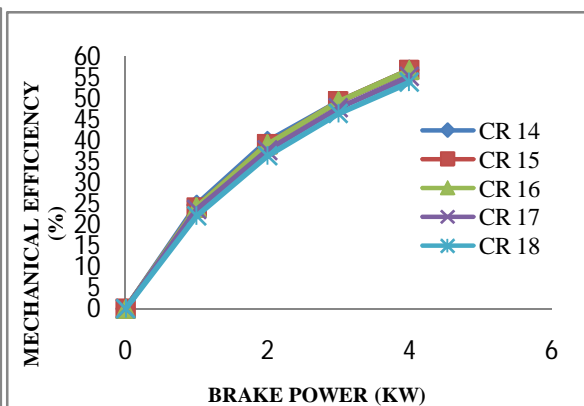


Fig.8. Variation Of Mechanical Efficiency With BP

It has been studied that volumetric, brake thermal, mechanical efficiency increases with BP. But when considering compression ratio result indicates that not much variation in mechanical and brake thermal efficiency. From fig.7,8 it is found that the range of brake thermal efficiency is 20-24 % and for mechanical efficiency is 53-56% at maximum load condition.

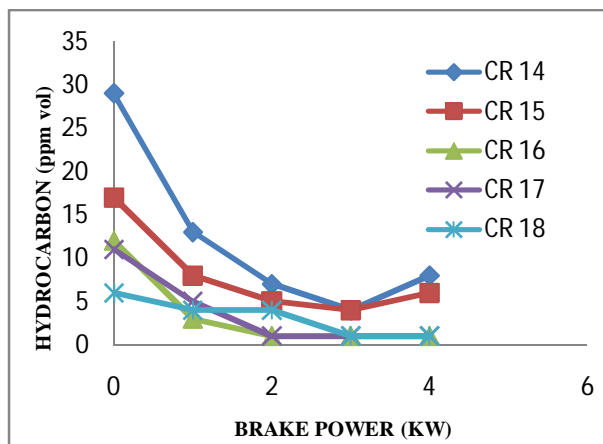


Fig.9. Variation of Hydrocarbon with BP

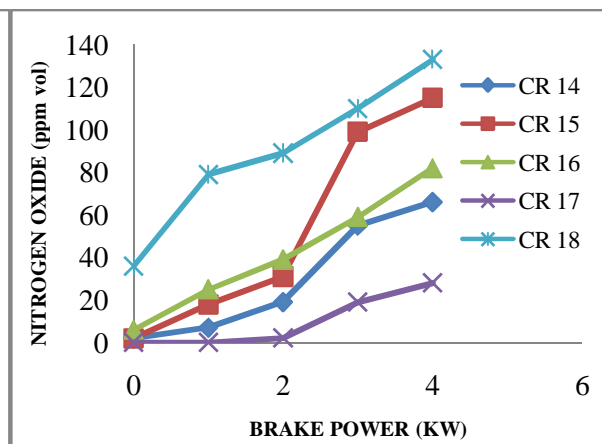


Fig.10. Variation of Nitrogen Oxide with BP

As shown in fig.10, Nitrogen Oxide emission is more for higher compression ratio than lower compression ratio and it increases with BP. The reason for higher NO_x emission is pressure and temperature is comparatively high at higher compression ratio. Hydrocarbon emission is less for less compression ratio and it decreases with BP. Due to the incomplete combustion of fuel at lower compression ratio unburned hydrocarbon produces more.

V. CONCLUSIONS

In this study suitability of using biodiesel as an alternative fuel in Variable Compression Ratio (VCR) engine is evaluated. At higher loads and at higher compression ratios, brake thermal efficiency of VCR engine increases. Fuel consumption of the engine is more and it increases with increase in load at a lower compression ratio. At a lower compression ratio volumetric efficiency is high and it decreases with increase in compression ratio. The specific fuel consumption of the engine increases with increases in load. Nitrogen Oxide (NO) emission of an engine increases with increase in compression ratio. Hydrocarbon (HC) emission of the engine decreases with increase in compression ratio. From this result it is possible to predict if maize oil mix with diesel 30% by volume then at what load and which compression ratio gives better result.

REFERENCES

- [1] Savale Bhushan Gajanan, D.S.Robinson Smart, Savale Amit Siddhappa, Kulkarni Bramhanand R, Dabhole Onkar S, "Experimental Performance And Emission Characteristics Measurement of Esterified Cotton Seed and Maize Oil Blends with Diesel by Using Variable Compression Ratio Diesel Engine", Proceedings of 67 IRF International Conference, 8 January, 978-93-86291-94-3,2017.
- [2] Ravichandran N, Kannan C, Senthil R, Gopinathan R L, "Performance and Emission Characteristics of Cotton Seed Oil Methyl Ester Using VCR Diesel Engine", JCHPS Special Issue 7: 0974-2115,2015.
- [3] Vishwanath Shavi, Adiveppa Ramapuri, Chetan Mirje, Manjunath Mathapati, R V Nyamagoud, "Study of Characteristics Performance of VCR Engine for Different Fuels", IJECS, Vol. 4, Issue 6 June,2319-7242,2015.
- [4] P. Manimaran, E.Muthurajakumar, S.Musakansiva and R.Vinoth " Experimental investigation of the orange peel oil and cotton seed oil blend with petrol as an alternate fuel for petrol engines", IJIRSET, Volume 3, Special Issue 3, 2319-8753,2014.
- [5] K.Satyanarayana, Vinodh Kumar Padala, T.V.Hanumantha Rao, S.V.Umamaheswararao, "Variable Compression Ratio Diesel Engine Performance Analysis". International Journal of Engineering Trends and Technology, 28,2015.
- [6] Hemanandh Janarthanam, Narayanan K V, "Experimental Investigations of Performance and Emission Analysis of Direct Ignition Diesel Engine Fueled with Refined vegetable oils", American Journal of Engineering Research, 02, 2320-0847, 2013.