Experimental Study on Performance Characteristics of VCR Diesel Engine using Ziziphus jujuba Oil

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***Abstract*— Due to the depleting sources of fossil fuels, it pushes the researchers to find alternate fuel for the future. Recent research work shows that biofuel has the potential to be used as a fuel in compression ignition engine. For a single cylinder, four stroke, variable compression ratio diesel engine, a biofuel derived from Ziziphus jujuba (Indian jujube) which is edible in nature was used as a fuel to run the engine. In our work an experimental investigation was made on the biofuel derived from ziziphus jujuba, which is blended with diesel in the ratio of 20%(B20), 40%(B40) and 60%(B60) for the compression ratio from 15:1 to 18:1 and their results were compared with diesel. Performance parameters like Exhaust gas temperature, Specific fuel consumption, Brake thermal efficiency are presented for varying compression ratio and blending.**

Keywords—Biofuel, Ziziphus jujuba, Blending, Variable compression ratio (VCR) engine.

I. INTRODUCTION

Fossil fules are running out due to over exploitation than production. India and many other developing countries, are severely affected by the price hike of petroleum products due to their demand. Hence these problems can be solved by replacing alternate fules for conventional fossil fuels.

The properties which determine the combustion capability are viscosity, fire point and flash point. Oil extracted from dry seeds of vegetables posses low combustion capability. Its combustion capablity is mainly affected due to insufficient oxygen content and presence of higher percentage of fatty acid. Hence the combustion properties are retained by means of chemical process known as "Esterification."

Esterification is a chemical process which invoves the reaction of vegetable and animal fats and oils with short chain alcohols. Chemically it is the conversion of carboxyilc acids to esters using alcohols and acid.

In esterification process the unwanted fatty acids are removed which inturn reduces the viscosity. Also it improves the combustion qualities of the raw oil interms of flash point, fire point, heating value nearer to the diesel. Esterification may be done in single or two stage based on the fatty acid content of the oil. At the end of esterification, the flash point and fire point are found to be slight higher than diesel, which indicates ease of storage and transportation of fuel in safety point of view. The application of bio fuel in engine induces some changes in engine parameters like setting higher compression ratio, increase of injection timing and retard the ignition delay which improves the combustion environment suitable for bio fuel.

In our study bio fuel derived from dry seeds oil of ziziphus jujuba blended with diesel in three different proportions and compression ratios at different engine loads without altering the engine parameters and the corresponding performance characteristics is checked with diesel.

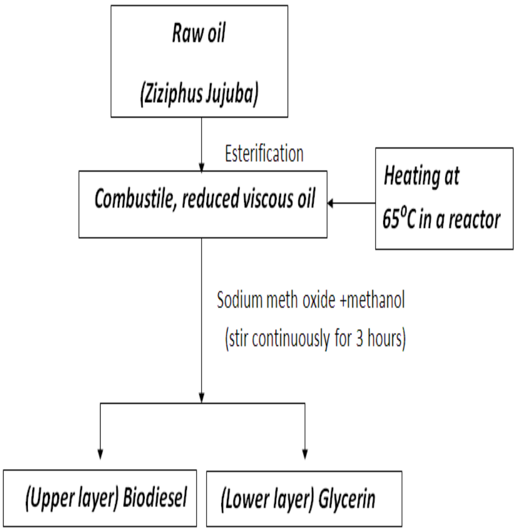
Some of the recent research has been conducted on various bio fuels derived from cotton seed oil, pinnai oil, karanj oil, rubber seed oil, etc by various research scholars and students. Their combustion,emission and performance characteristics are studied with minor modification in engine parameters

II. MATERIAL AND METHOD

A . Biofuel Preparation

First step in the bio fuel preparation was the extraction of oil from dry seed of ziziphus jujuba. Extraction was normally done by means of crushing dry seeds using crusher machines. Raw oil which was extracted posses higher viscosity and poor combustion qualities. This was due to the presence excess unwanted fatty acids and oxygen content. This can be eliminated by means of esterification.

Raw ziziphus jujuba oil was taken in a reactor for the measured quantity and it was heated slowly up to 65^{o} C. After that, the mixture of sodium methoxide(catalyst) and methanol was added in the reactor. Maintaining the temperature at 65^{o}C, the mixture was stirred continuously for three hours. During that time, a chemical reaction takes place between raw oil and methanol. Finally after the completion of reaction, the mixture was drained and transferred to the seperate funnel. Here phase separation takes place in two layers. Lower phase was glycerine and upper phase was bio diesel. Bio diesel is separated and washing was made with water to remove glycerine from the funnel.



B. Biofuel properties

The biofuel properties are compared with diesel for the successful use in diesel engine. The values are shown in table 1.

From the table we can interfere that various properties of bio fuel are almost closer to that of diesel. Hence on further blending with diesel can be used as source of fuel (bio diesel) in variable compression ratio diesel engine.

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Properties	Diesel	Ziziphus jujuba
Density at 30°C (kg/m^3)	0.8316	0.8777
Kinematic Viscosity at 40°C	3.294	4.02
Kinematic Viscosity at 100°C	1.269	2.03
Flash Point (^{0}C)	69	182
Pour Point (^{0}C)	-6	-2
Calorific Value (kJ/kg)	44000	38232

TABLE 1:PROPERTIES OF FUEL

C. Experiments:

Performance investigation of blended ZJ oil with diesel is carried out in a single cylinder, four stroke, variable compression ratio diesel engine. Initially experiment begins with 20% blending of jujube oil with diesel at CR of 18:1 under no load condition. Engine parameters such as Exhaust Gas Temperature (EGT), Brake Thermal Efficiency (BTE) and Specific Fuel Consumption (SFC) are recorded by means of computerized data logger. Here the load was applied by means of electrical dynamometer. Now the load is raised to 25%and parameters were recorded. Again the engine was loaded with 50%, 75%, 100% of loads and their corresponding readings are recorded. The CR was set to 17:1 by adjusting the clearance volume of the combustion chamber and corresponding engine parameters are recorded for different loads. The clearance volume was adjusted by means of tilting the cylinder head. The experiment was repeated for other bio fuels of various blending percentage (B40%, B60%) and CR (16:1, 15:1) with the engine load was recorded.

D. Experimental Setup

Figure 1 shows the schematic diagram of the VCR engine experimental setup.

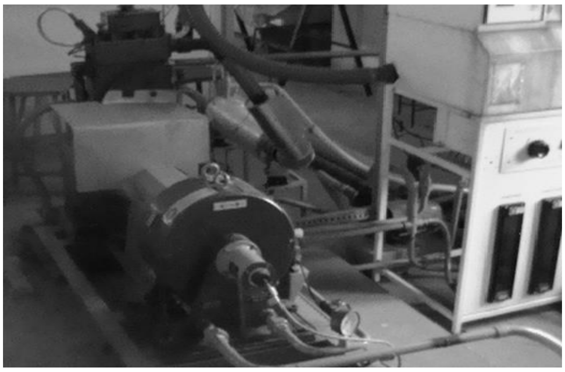

Fig 1: Experimental setup of VCR engine

Performance analysis in engine was done by using software package called "Engine Soft"- an online performance analyzer. The experimental setup involves a single cylinder, four stroke, VCR engine which was connected to the Eddy current dynamometer for loading. The cylinder head in cylinder was made specially for tilting purpose in order to adjust the clearance volume. Combustion pressure and crank angle measurement instruments are provided in the setup. These data are interfaced to computer for pressure-angle diagram. Various parametric indicators like manometers, fuel measuring unit, transmitters for air-fuel flow measurements, process and engine indicators are made on the stand alone box setup. Also calorimeter was provided for water flow measurements and rotameter for cooling purpose.The specifications of the VCR engine was shown in Table 2.

III. RESULTS AND DISCUSSIONS

S. No	Engine part	Specification
1	Make	Kirloskar
2	Model	PS234
3	Number of cylinder	Single
4	Ignition system	Compression ignition
5	Cylinder Bore	87.5 mm
6	Stroke length	110 mm
7	Power rated	3500 W at 1500 rpm
8	Cooling medium	Water cooled
9	Combustion chamber	Open chamber (DI)
10	Compression ratio	12:1 to 18:1

Initially engine was started at no load condition and made to run for few minutes to reach steady running condition. Once the engine attains the steady condition, fuel supplied to engine is changed from fuel tank to burette measuring setup using knob provided in the setup. Measurements such as Brake thermal efficiency, Specific fuel consumption and Exhaust temperature were simultaneously noted by using software through the data logger connected with the engine setup. Then the fuel supply is switch backed to its origin condition. Now the load is applied from 0 to 100% of full load with increasing 25% of full load. For each load condition, the data were collected and stored using software. Brake thermal efficiency for each load condition is calculated from the values obtained from the software. The above procedure is repeated for each compression ratio and variations of parameters such as BTE, SFC and EGT are shown with respect to load for compression ratio of 15,16,17,18 with three different blending proportions.

A. Specific fuel consumption:

From the graphs it clearly shows that SFC was decreased with increase in load for compression ratios of 15,16,17,18 as shown in Figs.2 to 5. The obtained results were same as to the results reported by many other researchers. Lower fuel consumption at higher load was the reason for higher brake power developed in the engine. Here, SFC tends to increase with increase in blend percentage of fuel from 20% to 60%. by interpreting our graph.

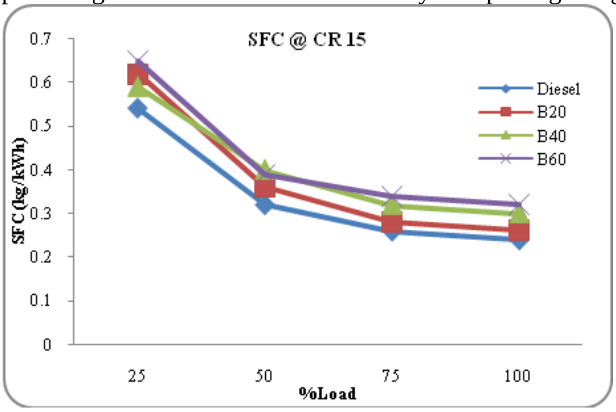

Fig 5: Specific fuel consumption variation at CR15

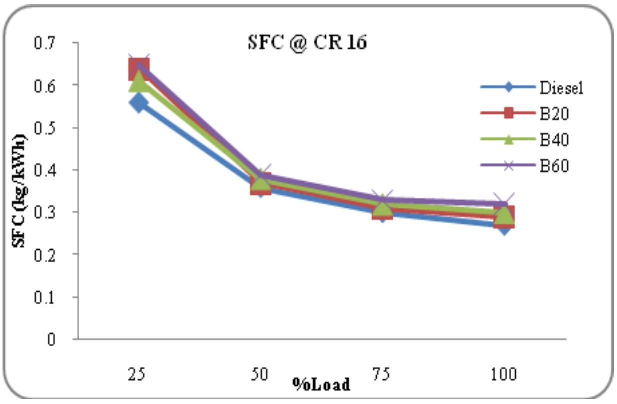

Fig 2: Specific fuel consumption variation at CR16

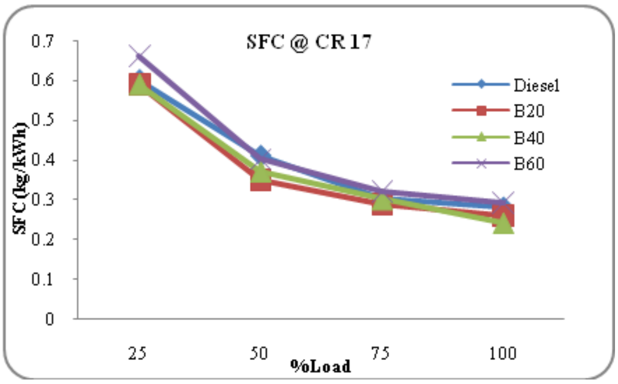

Fig 3: Specific fuel consumption variation at CR17

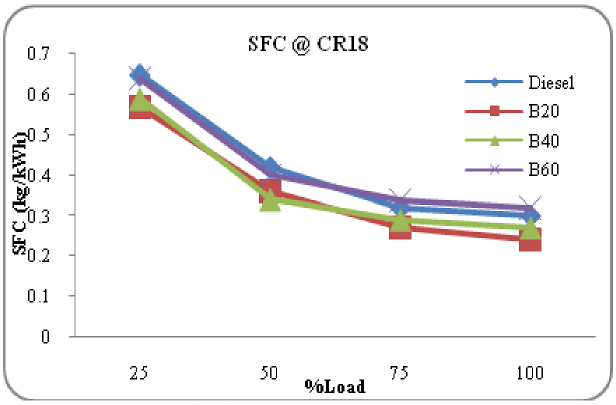

Fig 4: Specific fuel consumption variation at CR18

At high load condition, B20 consumes lesser fuel when compared with other blending except the compression ratio of 17:1. B60 marks the higher fuel consumption for the entire compression ratio. This is due to the effect of higher density and lower calorific value. Since the density of the ZJ oil is high leads to higher mass injection of fuel at the same volume at same injection pressure and the lower calorific value leads to higher fuel consumption for the same power development. Since it has different chemical structure, it has poor combustion quality which increases the fuel consumption. SFC decreased with increase in compression ratio, consequently produces higher temperature at the end of compression.

B. Brake thermal efficiency:

The capacity of mechanical energy conversion by engine from heat released by the explosion of fuel inside the cylinder volume is known as Brake Thermal Efficiency (BTE). BTE is directly proportional to brake power developed whereas mass of fuel injection and calorific values are inversely proportional it. Experimental results show that for the compression ratio selected from 15:1 to 18:1 BTE increases with increase in load as shown in Figs. Increase in load on engine increases the brake power output. Results show that brake thermal efficiency was reduced for the entire compression ratios when the percentage of blending increased.

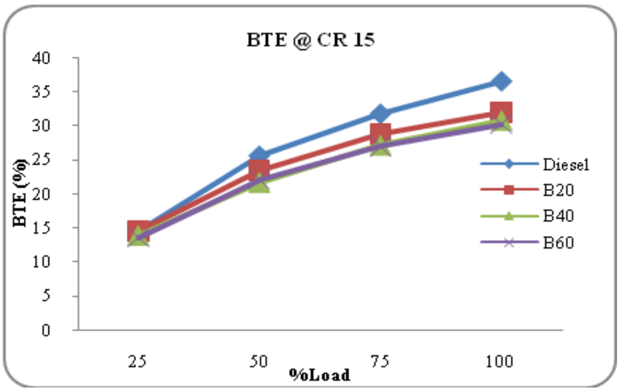

Fig 6: Brake thermal efficiency variation at CR15

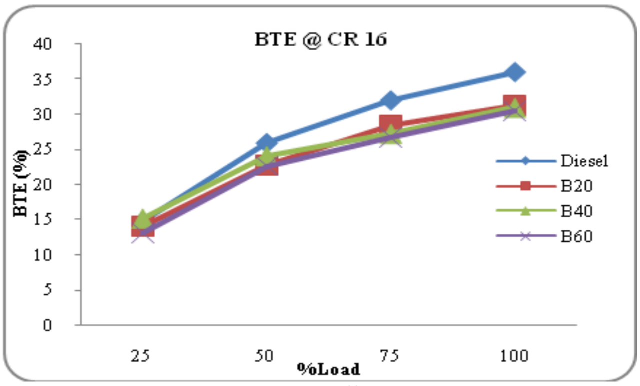

Fig 7: Brake thermal efficiency variation at CR16

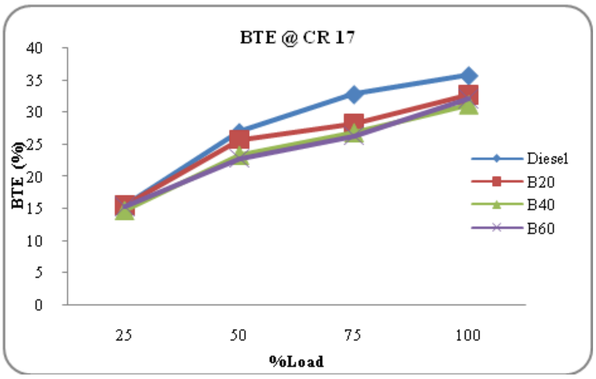

Fig 8: Brake thermal efficiency variation at CR17

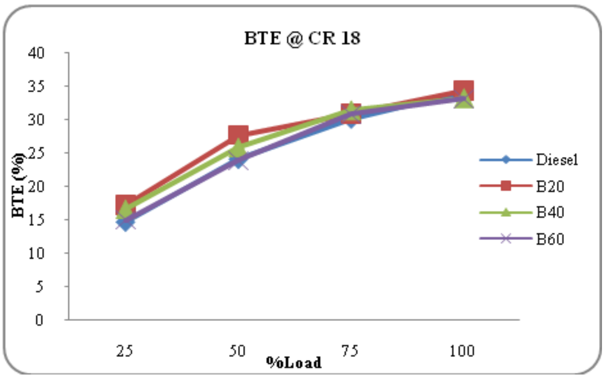

Fig 9: Brake thermal efficiency variation at CR18

This is due to increase of blending percentage from 20 to 60 increases the density and viscosity. Higher the density of blending increased the mass of fuel injected for same power output. At high load condition B20 attained higher BTE among the three different blending for all the compression ratios except the CR17. At the same time, the flash point and fire point of the fuel increases with the percentage blending of ZJ oil increased. At CR18, engine fueled with 20% blending of ZJ oil gives the same result of diesels BTE. High peak pressure and high temperature are produced at the end of compression due to the increase of compression ratio of the engine. Even with higher viscosity, increased peak temperature helps to achieve good combustion quality.

C. Exhaust gas temperature:

Exhaust gas temperature (EGT) indicates the emission and combustion characteristics of the engine. Generally, higher the exhaust gas temperature higher will be the amount of NO_x present. Exhaust Gas Temperature of the engine for the corresponding variation in compression ratio from 15:1 to 18:1 and load for 25%. 50%, 75%, 100% are shown in Figs 10 to 13. EGT were increased due to higher heat loss from the combustion with increase in engine load and decreased with increase in blending percentage. Among B20, B40 and B60 at full load conditions, B20 shows the highest EGT. Among three different blending and diesel, the lowest EGT was registered by B60. This is due to high viscosity and lower calorific value.

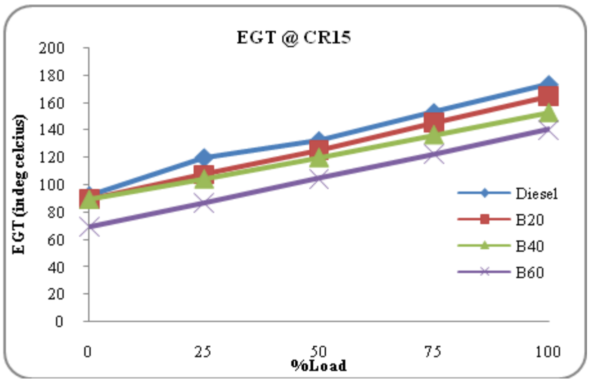

Fig 10: Exhaust gas temperature variation at CR15

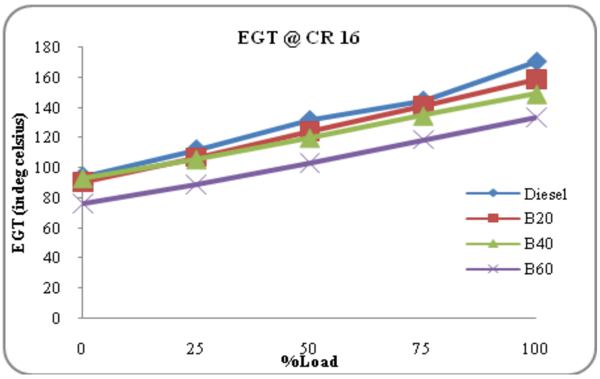

Fig 11: Exhaust gas temperature variation at CR16

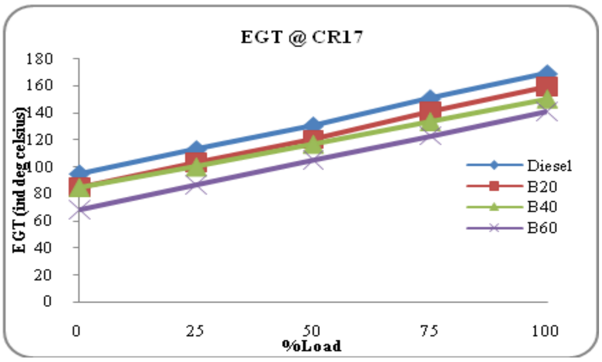

Fig 12: Exhaust gas temperature variation at CR17

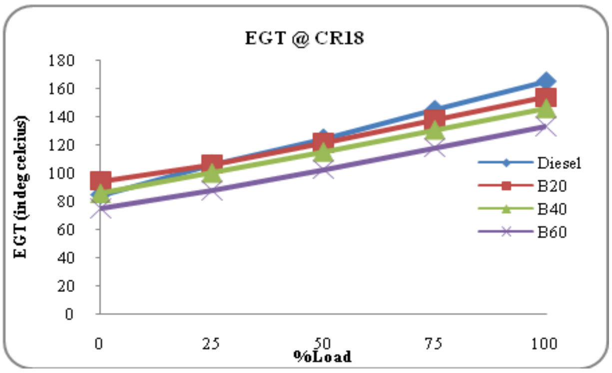

Fig 13: Exhaust gas temperature variation at CR18

Higher viscosity causes poor atomization rate and lower calorific value causes poor combustion. With increase in compression ratio, the combustion quality increases. The positive effect in EGT is obtained by raising the compression ratio and blending of ZJ.

IV.CONCLUSION

Thus the performance parameters of single cylinder, four stroke, variable compression ratio (VCR) engine with Diesel blended fuel Ziziphus jujuba oil have been investigated. The results of the experiment showed that the SFC, BTE & EGT varied with respect to blending and compression ratios. The results of the experiments are as follows

- For the compression ratio from 15:1 to 18:1 SFC decreases with increasing load and increases with increasing percentage blending of biofuel. When comparing with B40 & B60 , B20 has lower specific fuel consumption
- Increasing the compression ratio and blending percentage EGT decreases. B60 register lower EGT At all compression ratio comparing with B20 & B40 as well as Diesel B60 shows the lower
- For all the compression ratio (18:1 to 15:1) ,BTE and EGT increases with increasing the load and all the blending (B20, B40 & B60). When compared to B40 & B60 except the compression ratio of 17:1 , B20 register higher BTE .

NOMENCLATURE

ZJ Zizipus Jujuba

B20 80% Diesel + 20% ZJ oil

B40 60% Diesel + 40% ZJ oil

B60 40% Diesel + 60% ZJ oil

SFC Specific Fuel Consumption

EGT Exhaust Gas Temperaure

CR Compression Ratio

BTE Brake Thermal Efficiency

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