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EXPERIMENTAL ANALYSIS OF EMISSION AND PERFORMANCE ON VCR ENGINE USING PALM OIL BIODIESEL

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Abstract

The growth of any developing country will depend upon the use of petroleum fuels, in various areas as like industry, aviation, transportation, power production etc. The demand of energy has increased with growing of world population.Consumption of energy is proportional to the progress of the mankind. Till date primary source of energy is fossil fuel which is main fuels for thermal power, however the finiteness of fossil fuel reserve and large scale environmental degradation caused by their extensive use, air pollution, acid rain, global warming also there is a fear that they will get exhausted from the earth. Therefore other systems based on nonconventional and renewable sources are being tried by many countries based on solar, wind, and biomass, tidal, geothermal and hydro.Among the various alternative fuels being developed, the biodiesel has received special attention because itis easy to produce from available and renewable sources (vegetable oils and animal fats), safe to handle and use, eco-friendly, and miscible with petroleum diesel in all proportional for use in existing diesel engines without modification.

1. Introduction

India is fourth largest economy of world and has to extensively use energy to sustain its growth. Since India does not have huge reserves of petroleum products, it is heavily dependent upon the import of petroleum products to supply to its need for automobiles and other applications in spite of larger initiatives by government and exploration of new sources. Growing prices, insufficient supply and limited reserves of petroleum have imposed an enormous burden on country’s foreign exchange. In year 2006-07 the indigenous production of crude oil was 33.99 million tones whereas consumption was 144.88 million tones forcing to import 110.89 million tones. The country is spending Rs.2199.91 billion worth valuable foreign exchange towards import of crude petroleum which could otherwise be utilized for various other development works that might ultimately prove to be more beneficial to Indian people. To improve the present energy crisis, future energy conversion in India should be sustainable which include increase share of renewable fuel, increase efficiency of fuel conversion, reduce environmental impacts, and increase knowledge.

2. Objective of the Research Work

The following objectives were associated with the present research work

- Determination of various physic-chemical properties of palm oil.
- To analysis the performance and emission nature of palm oil and compare with base line data of diesel.
- Development of dual fuel mode experimental diesel engine test rig.
- Analysis of results.

The desired level of fuel inlet temperature of palm oil can be obtained by controlling the amount of exhaust gases passing through the heat exchanger with the bypass arrangement.

3. EXPERIMENTAL SET-UP AND PROCEDURE

3.1. Diesel engine

Diesel engines are amongst the most efficient prime movers and with the view of protecting global environment and concerns for long-term energy security, it has becomes necessary to develop alternative fuels with properties comparable to petroleum based diesel fuels. For the developing countries, fuels of bio-origin provide a feasible solution to the above twin crisis. Bio-fuels are getting a renewed attention because of global stress on reduction of green house gases (GHGs) and clean development mechanism (CDM). The fuels of bio-origin may be alcohol, vegetable oils, biomass, and biogas. Vegetable oils have comparable Physico-chemical properties with mineral diesel and they are biodegradable, non-toxic, and have a potential to significantly reduce pollution.

The qualities of this fuel, environmentally as well as technically, have pushed this fuel close to the last stages of commercialization in many countries. Each country can proceed in the production of particular oil, depending upon the climate and economy. Different countries have taken initiatives in this field and re-forestation has a key role to play in meeting the challenge of Climate Change. Several initiatives have been taken in recent years in different parts of the country to promote large scale cultivation of oilseed bearing plants. Amongst the various plant species, oil extracted from seeds of Palm (palm kernel) has been found very suitable as a substitute to diesel fuel [Srinivaskommana et.al. (2016)].

3.2. Engine Selection

There is no difference of opinion that India is going to face a severe fuel crisis in future because fuel consumption has increased in all the vital sectors specially transportation and agricultural sector. As diesel engines plays an indispensable role in transportation and agriculture sector and as such diesel consumption will increase multifold in time to come. The diesel engine continues to dominate the agriculture sector in our country in comparison to spark ignition engine and have always been preferred widely because of power developed, specific fuel consumption and durability. A through description of combustion mechanism in diesel engine is beyond the scope of this study. However, it would be worthwhile to inform that the fuel is burnt in diesel engine by self-ignition at higher temperature and pressure conditions of the order of 600°C and 40 bar, respectively. Diesel as a fuel is injected into the combustion chamber after compression stroke and after certain ignition delay; it burns to give the motive power. In India, almost all irrigation pump sets, tractors, mechanized farm machinery and heavy transportation vehicle are powered by direct injection diesel engines. Keeping the specific features of diesel engine in mind, a typical engine system, which is actually used widely in the Indian agricultural sector, has been selected for the present experimental investigations.

3.3. Experimental Setup

The setup consists of four stroke,single cylinder, Variable Compression Ratio Diesel engine. A Kirloskar TV1 having power 3.50 KW @ 1500 rpm which consists of single Cylinder, Four stroke , Constant rpm Water cooled Variable compression ratio (VCR) Diesel Engine is used for the experiments.

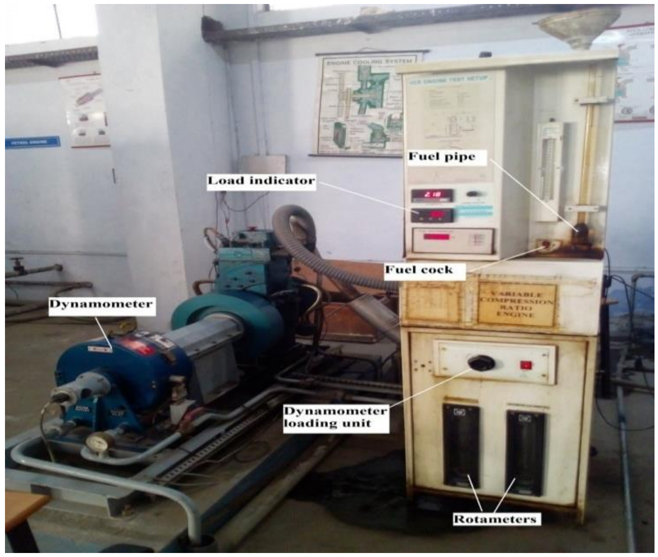

Fig.3.1 Variable Compression Ratio Diesel Engine, [KIET Ghaziabad].

Table 4.1: Technical specification of the engine [KIET Ghaziabad]

Parameters	**Specifications**
Manufacturer	Kirloskar
Swept vol.(cc)	661.45
Clearance vol.(cc) At CR 18	38.9
Model	TV1
No of cylinders	1
No. of stroke	4
Bore (mm)	87.5
Stroke (mm)	110
Compression Ratio	12 to 18:1
Speed (RPM)	1500
Rated output	3.5 KW
Orifice diameter (mm)	20
Dynamometer	Eddy current dynamometer
Dynamometer arm length (mm)	185

For conducting the desired set of experiments and together required data from the engine, it is essential to get the various instruments mounted at the appropriate location on the experimental setup. Apart from this, a dual fuel system has been developed for diesel and palm oil.

3.4. Consideration of Parameters

The section of parameters is very important for the engine calculations, and parameters were selected very carefully. The important parameters desired from the engine are listed below**.**

1. Power produced by engines
2. Temperature
3. Fuel consumption

With a view to calculate the parameters mentioned above, it was essential to pick up the following signals from the test bench.

1. RPM of the engine which is fixed (1500 rpm).
2. Exhaust gas temperature at inlet and outlet of heat exchanger.
3. Palm fuel inlet and outlet temperature across heat exchanger.
4. Fuel consumption rate.
5. AVL smoke meter.
6. AVL Di Gas analyzer.

Once the parameters were selected, the necessary instruments required for sensing these parameters were installed at the proper points in the experimental set-up.

3.5. Measurement Method

Required components of the experimental setup are two fuel tanks (Diesel and Palm oil), Heat Exchanger, bypass line,Fuel consumption measuring unit, Electrical loading arrangement, voltmeter, ammeter, RPM meter, Temperature indicator and emissions measurement equipment’s. The engine is started with diesel for at least 25 to 35 minutes and once the engine warms up, it is switched over to palm oil.

For changing the engine from diesel to palm oil, a two way valve is provided on the control panel. Both the fuels from the two tanks can be feed to the engine through this valve separately. One end of the valve is connected to palm oil and the other end is connected to diesel. The fuel from the valve enters into the engine through this fuel measuring unit with the help of this fuel measuring unit, the volumetric flow of the fuel can be easily measured. The fuel from the fuel measuring unit than enter in to the fuel, filters before entering to the engine. In case of heat exchanger, the palm oil flows into the heat exchanger where it gets heated to the desired fuel inlet temperature before entering into the fuel pump and injectors to minimize their resistance to flow and for good atomization

3.6. Fuel Flow Measuring Arrangement

The fuel consumption of engine is measured by determining the time required for consumption of a given volume of fuel. The mass of fuel consumed can be determined by multiplication of the volumetric fuel consumption to its density. In the present set up volumetric fuel consumption was measured using a glass burette. The time taken by the engine to consume a fixed volume was measured using a stopwatch. The volume divided by the time taken for fuel consumption gives the volumetric flow rate.

Fig.3.2. Fuel Flow Measuring System [KIET Ghaziabad].

The fuel measuring was done only after the initial run. After stable operating conditions were experimentally achieved, the engine was subjected to similar loading conditions. Starting from no load to peak load.

3.7. Adjuster

This consists of an in-built valve mechanism to change the compression ratio of the engine by adjusting it to the desire mark with the help of a spanner.

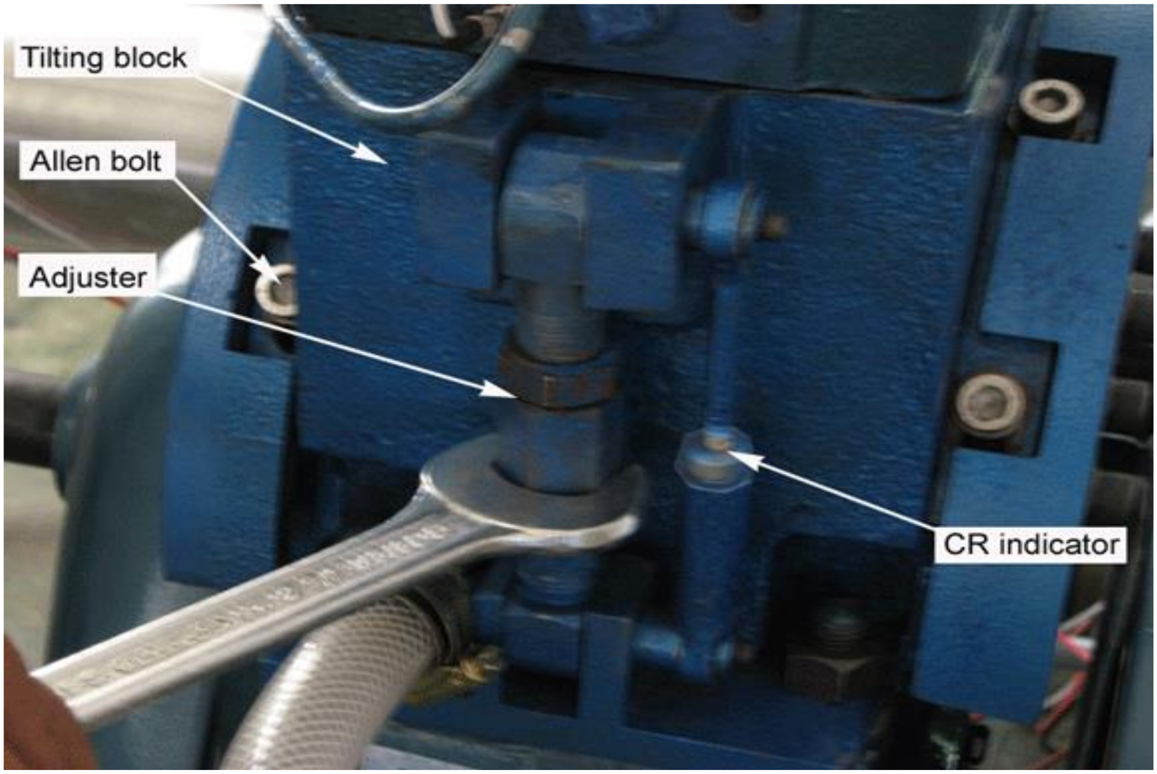

Fig.3.3 Adjuster (Change the Compression Ratio) [KIET Ghaziabad].

Hydrocarbons: The value of HC indicates unburned fuel and is measured in the ppm. Modern Vehicles in good running condition shows 10ppm or less.

Carbon Dioxide: The amount of CO_2 is a product of combustion and represent the amount of completely burned fuel. The higher value of CO_2 indicates a higher engines efficiency. Many fuel injection engines will show about 14 % CO_2.

Carbon monoxide: Incompletely burned fuel results in CO. High CO level indicate a fuel mixture. A perfect fuel mixture meters in precisely enough fuel to consume total O_2 entering the engines. A fuel mixture that holds excess fuel is referred to as a rich condition. A lean condition cites to an excess of O_2.

NO_X: NO_X refers to NO and NO_2 (nitric oxide and nitrogen dioxide). This measurement in ppm and indicates the combustion product of burning nitrogen. This occurs at the higher engine temperature associated with a lean fuel mixture. Output of a typical engine, the NO component will make up the highest proportion. The CI engine are generally associated with higher NO_X and particulate emissions.

3.8. Experimental Procedure

The engine is started by cranking. It does not possess any electric starting mechanism. It needs to be hand cranked with speed just enough to topple over the compression pressure. The engine was started at no load by pressing the exhaust valve with decompression lever, it was released suddenly at that enough speed. After adjusting the feed control to enable the engine to achieve the rated speed of 1,498 rpm, it was allowed to run (about 30 min) until the steady state condition was reached. With the fuel measuring unit and stop watch, the time elapsed for the consumption of 50 cc of fuel was measured. Exhaust gas temperature inlet and outlet to calorimeter, water temperature inlet and outlet to calorimeter, cooling water temperature inlet and outlet to engine and rpm of the engine was measured. Along with this exhaust gas analysis was also done using an exhaust gas analyzer. With the fuel measuring unit and stop watch, the time elapsed for the consumption of 10, 20 and 30cc of fuel was measured and average of them was taken. Fuel Consumption, RPM, exhaust temperature, smoke density, CO, NO_x, HC , $CO_2$and power output were also measured. Fuel leakages from the injector were measured with small measuring cylinder. The engine was loaded gradually keeping the speed with in the permissible range and the observations of different parameters were evaluated. Initially performance tests were carried out on the engine with diesel to generate the base line data and with the help of a funnel prepared blend is poured in to other tank. After 5-6 minute the valve which allows the diesel to flow in to the engine is closed and other valve allowing palm oil to the cylinder is opened. The performance and emission characteristics of neat palm oil were evaluated and compared with diesel fuel. The engine was always started with diesel as a fuel and it was run for 20-25 minutes, it was switches over to palm oil. Before turning the engine off, the palm oil is replaced with diesel oil to avoid the starting problem during next start and it is run on diesel oil till all palm oil in fuel filter and pipe line is consumed. An I.C ENGINE software 9 is used to measure the data obtained and all the data's are measured at three CR 16,17,&18.

4. RESULTS AND DISCUSSION

Experiments are carried out on an unmodified diesel engine which was converted to run on a dual mode operation. The main of this work is to fuel the diesel engine with palm oil biodiesel and emission and performance characteristics of the different blends are compared with base line data obtained from diesel.

4.4. Comparison of physic-chemical properties between diesel & POME

4.4.1. Kinematic Viscosity

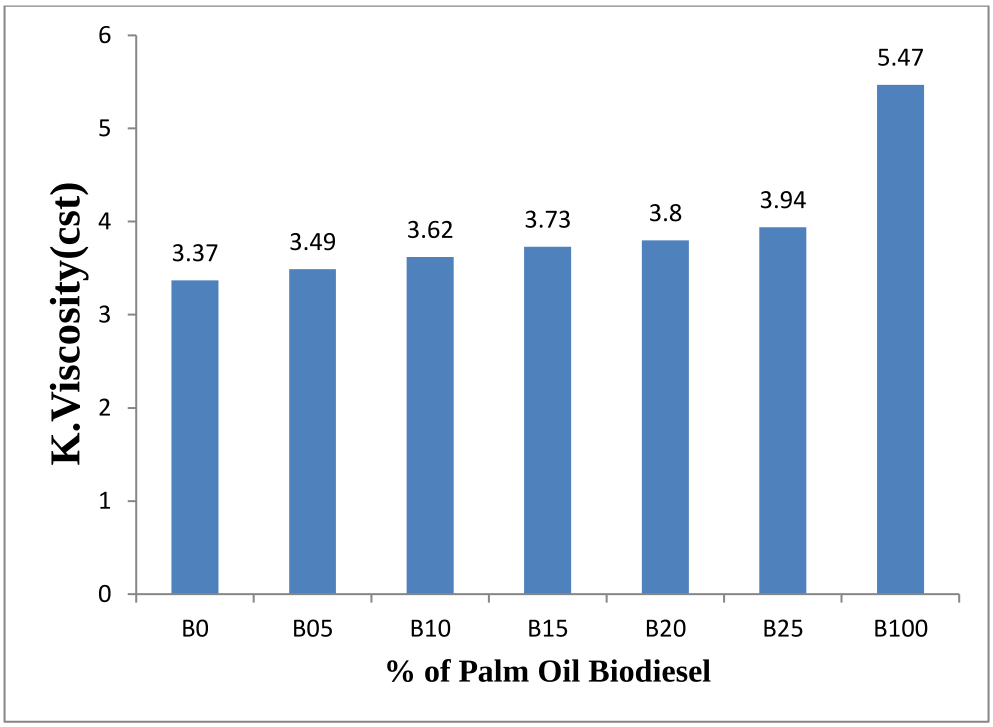

Fig 4.1 Kinematic Viscosity Vs. % of POME

Kinematic viscosity increases with increase in the percentage of palm oil biodiesel in the blends. The viscosity of B100 is maximum whereas the viscosity of pure diesel is minimum.

4.5. Density

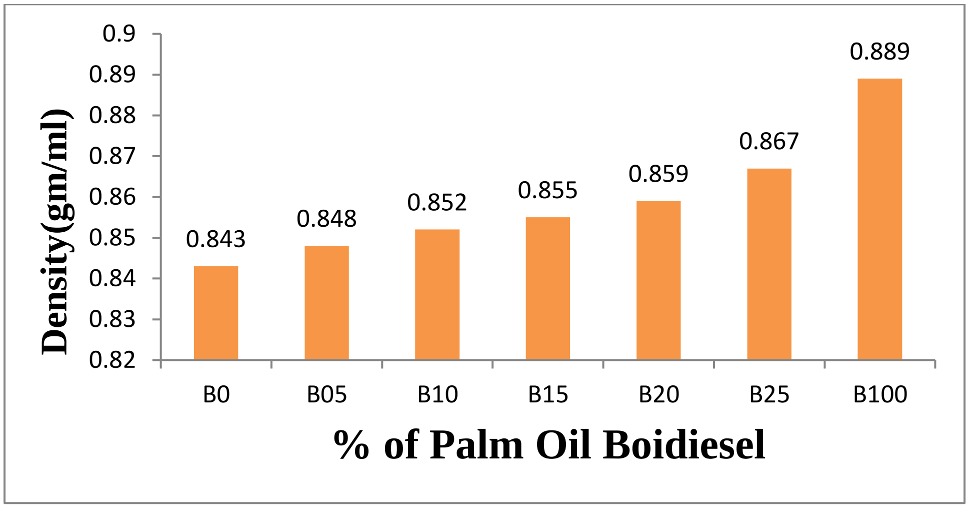

Fig. 4.2 Density Vs. % of POME

Density increases with increase in the percentage of palm oil biodiesel in the diesel blends. The density of B100 is maximumwhereasthe density of pure diesel is minimum.

4.6. Calorific value

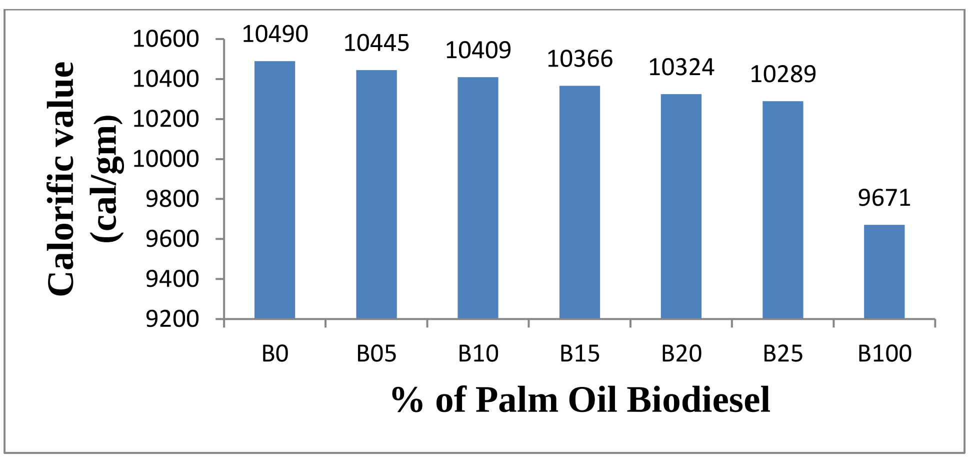

Fig.4.3 Calorific value Vs. % of POME

Calorific value is decreases with decrease in the percentage of palm oil biodiesel in the mixture as the diesel is having higher calorific value than palm oil biodiesel. The calorific value of B100 is minimum whereas maximum for pure diesel.

4.7. Performance Characteristics

4.7.1. Brake Thermal Efficiency

It is defined as ratio of brake power to the heat supply.

$$\eta_{BT} = \frac{BP}{\dot{m}_f \times CV}$$

BP = BWD/s = $F_b \times 2\pi r_b \times N/60$

η_{BT}= brake thermal efficiency

CV= Calorific value of fuel (kJ/kg)

F_b= Load on engine (kg)

BP= brake power (kW), BWD= brake work done (kJ)

r_b= brake radius (m), $\dot{m}_f$- mass of fuel per second (kg/s)

The fluctuation of Brake Thermal efficiency of engine with POME and it's blends is shown in figure and it is than compared with the diesel base line data obtained from it. As POME percentage increases then brake thermal efficiency decreases because of it's calorific value decreases and density, viscosity increases that affect the combustion of fuel.

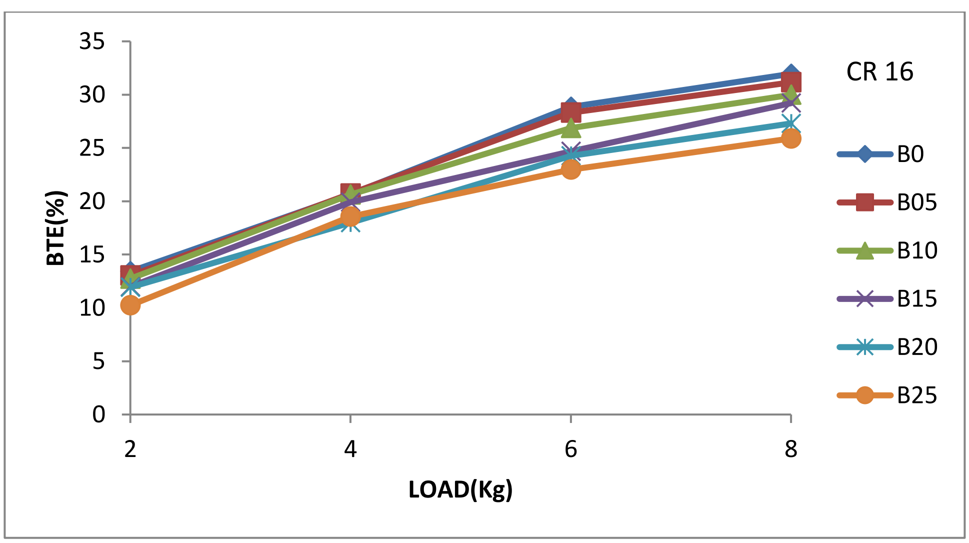

Fig. 5.4 BTE Vs. Load at CR 16

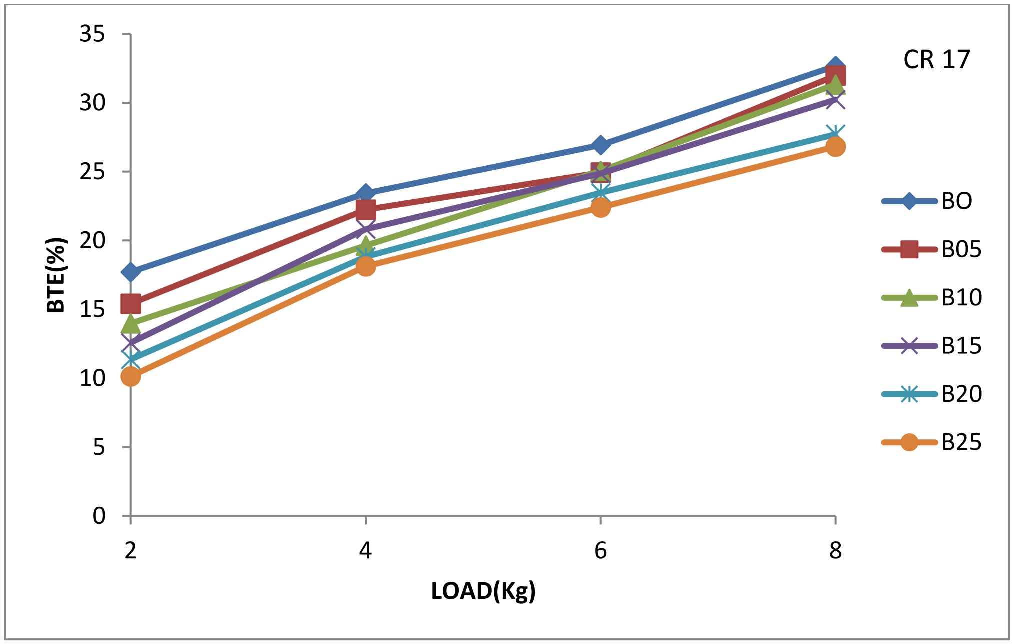

Fig.5.5 BTE Vs Load at CR 17

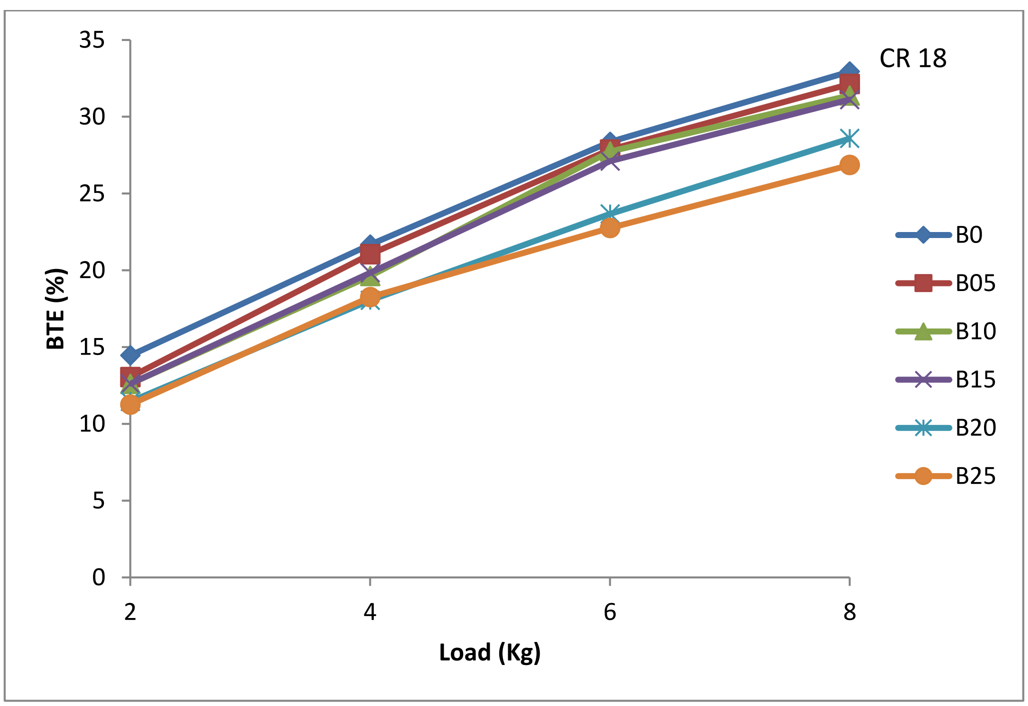

Fig.5.6 BTE Vs. Load at CR 18

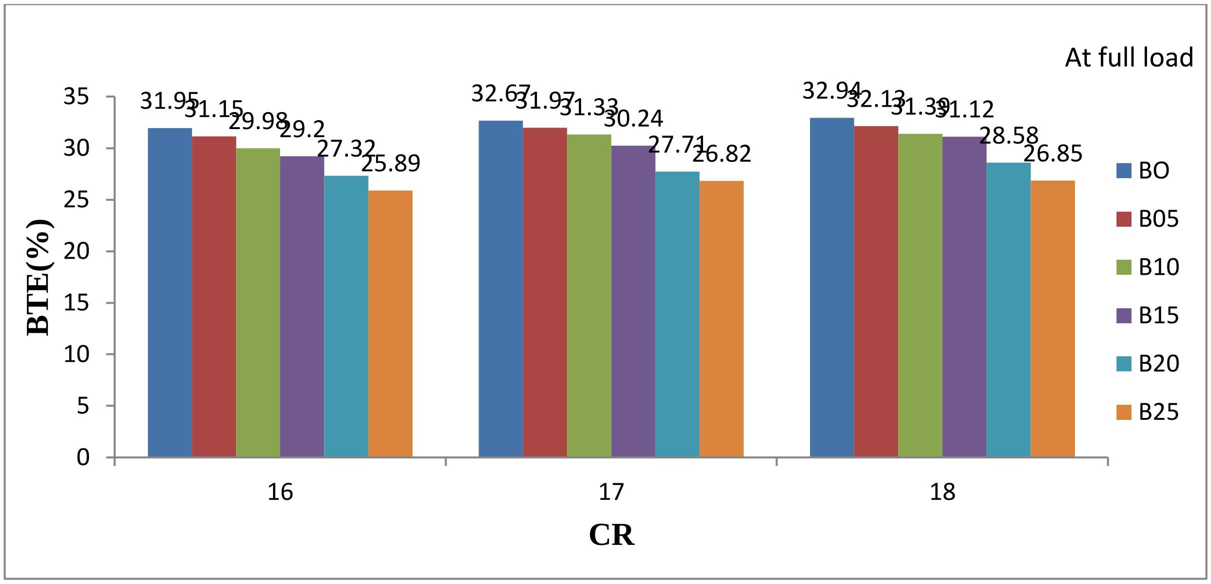

Fig.5.7 Variation of BTE with CR

When CR is increased from 16 to 18 a slight increase in BTE is observed for all the blends. The reason behind that the proper atomization of fuel at higher compression ratio and as CR increases load increases that increase the brake power whereas the BTE of all blends and at all CR and loads was observed lower than pure diesel because of lower calorific value and higher density of POME blends.

4.8. Brake specific fuel consumption (BSFC)

BSFC is defined as the mass of fuel required per hour for per kg of brake power produced.

BSFC = Mass of fuel per hour / brake power.

$$= (V \times \rho \times 3600) / (BP \times t)$$

Where, BSFC = Brake specific fuel consumption, (g/kW-h)

V = Volume of fuel consumed, (cc)

ρ= Density of fuel, (g/cc)

BP= brake power, kW

t=Time taken to consume, cc of fuel, (sec).

The variation in BSFC with respect to load for all blends of POME and for diesel as shown in fig.

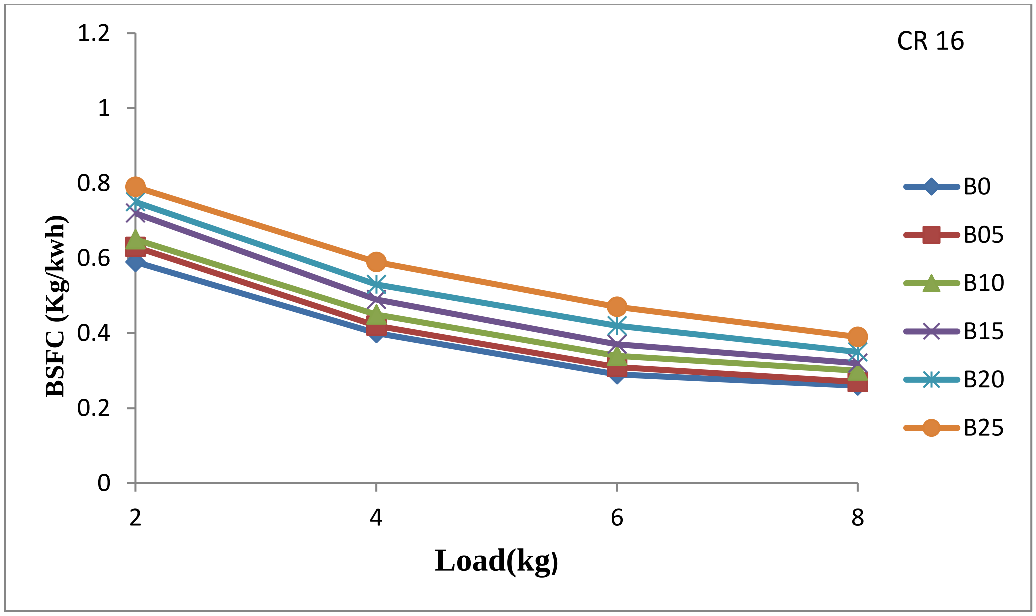

Fig.5.8 BSFC Vs Load at CR at 16

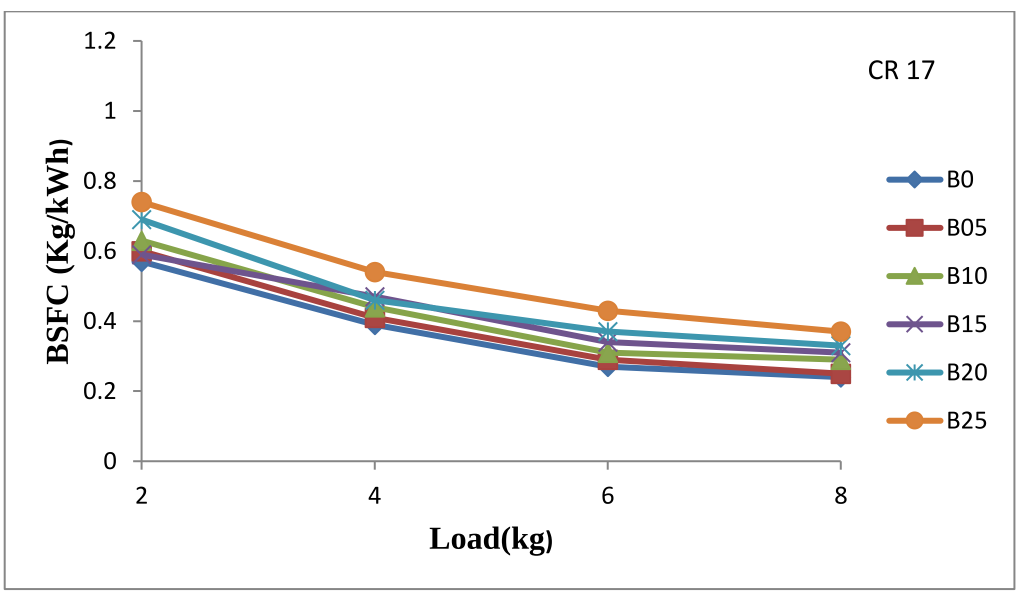

Fig. 5.9 BSFC Vs Load at CR 17

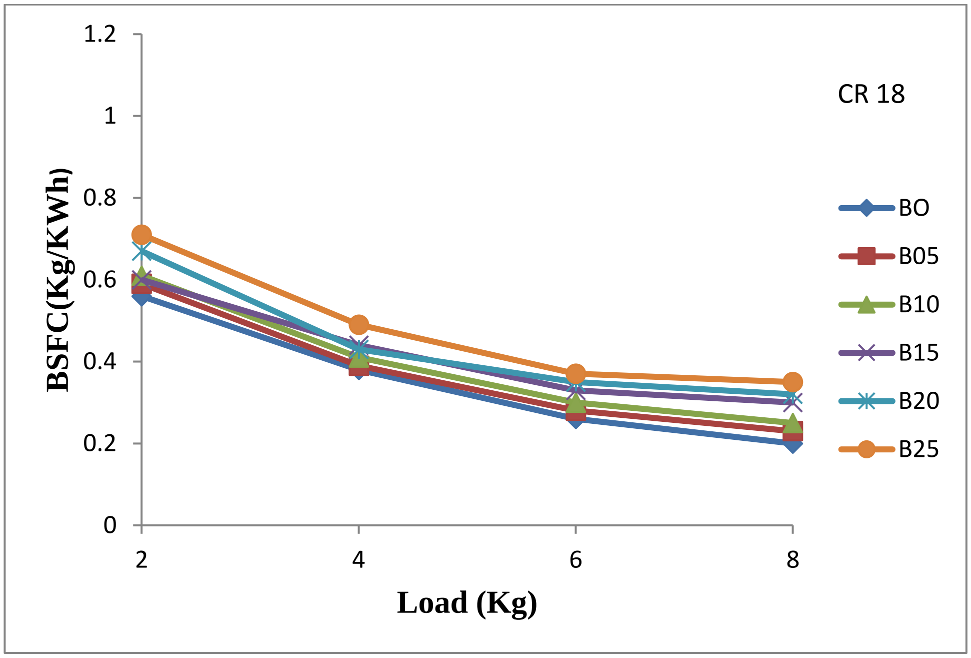

Fig. 5.10 BSFC Vs Load at CR 18

It is clear from the graph the BSFC is decreasing with increase in load and increases with as blend percentage increases as the calorific value for POME is less than that of diesel. So that the BSFC is slightly higher than that of diesel fuel.

At low load condition the BSFC is higher for all the blends as load increases BSFC start to decreasing because at higher load inside temperature of cylinder. This increase in temperature results decrease in viscosity of POME blends which causes in proper atomization of fuel.

At higher load BP is increases which result in decrease in BSFC. It can be seen from the graph the maximum BSFC is for the blend B25 for all CR and all loads and minimum for pure diesel.

CONCLUSION

A single cylinder VCR engine of rated power 10 BHP and constant speed RPM 1500 was operated successfully using biodiesel produced from palm oil and its blends as fuel. The following conclusions are made based upon the observations:

B05 blend indicate very close thermal efficiency as compared to diesel. Additional oxygen present in the fuel improves combustion process and this can be one of the reasons. However increase in blending with blending percentages above 5 % results in reduced efficiency compared to diesel. This is due to increased density and lower calorific value of mixture due to higher density and lower calorific value of Biodiesel oil.

CO_2 emissions are reduced with increase in biodiesel percentage in diesel and biodiesel blend. This is due to additional oxygen present in fuel. The excess oxygen results in oxidation of CO formed into CO_2.

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