Performance & Characterization of Hybrid Methyl Ester on Single Cylinder Diesel Engine

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ABSTRACT

World is suffering with continuous crises of energy demand, hike in its price, and depletion of fossil fuels. Largely used one of the fossil fuel is diesel is used for transportation, for locomotives, and all types of CI engines, but all countries aren't fulfill with diesel fuel and they import their fuel from other countries like UAE, East Asia and some European countries. India is one of the country which consumes 3.7 mb/day of crude oil out of which 70 % of crude oil was import by other countries, it directly affects the growth of economy of India. The alternative for diesel fuel was comes out is an Biodiesel (Methyl Ester) which is defined as per ASTM standards is, long chain of mono alkyl ester obtained by fatty acids which prepared from renewable resources. Biodiesel has obtained from vegetable oils by 'Transesterification Process' that have been considered as a promising alternate fuel. The researches regarding blend of diesel and single biodiesel have been done already. But very few researches are done with combination of two biodiesels, so it shows lots of scope for research in this area.

In this research work we took combination of two biodiesels prepared from thumba and waste fried oil. Firstly we prepared biodiesel from waste fried oil which is easily available in the hotels and restaurants at very cheap cost so that we can easily overcome cost issue. The second biodiesel was prepared from thumba which is non edible vegetable oil plant, mainly grows in rain fed parts of Rajasthan and Gujarat. We firstly mix the both biodiesels and then prepare blends of them with pure diesel in the various ratios of B09, B18, B27, and B36. Testing of hybrid methyl ester is taken on single cylinder VCR CI without any modification in hardware of engine with two compression ratios of 16 and 18. By putting biofuel in engine works without any disturbance in working of the single cylinder engine and results are as below.

Keywords: - *Biodiesel, Thumba, Waste Fried Oil, Hybrid Biodiesel, Alternate Fuel, etc.*

1. INTRODUCTION

The countries developing or developed are developing day by day. Also, the population of world is increasing. Due to these, consumption of fossil fuels increased. Due to increased consumption and hundreds of years required for generation of fuels, the primary energy sources i.e. fossil fuels like coal, natural gas, oil, etc. are depleting. Primary fuels are the main source of energy and that we have to be secure for coming generations. Also the use of primary energy sources produces the gases such as Hydrocarbons, Carbon Dioxide, Carbon Monoxide, Sulphur, etc. are dangerous to nature and human and animal health. All these develops the need of alternative source to primary energy sources. Biodiesel is a fuel used as alternative for widely used Diesel fuel Biodiesel can be blended with diesel and used in diesel engines and generators in industries and vehicles. This reduces the use of diesel. Excessive use of the fossil fuels has led to global environmental degradation and health hazards. The increasing concern of environmental protection and more stringent regulation on exhaust emissions, reduction in engine emissions becomes a major task in engine development. In addition to this lots of efforts are needed to reduce dependence on the petroleum fuels as it is obtained from limited reserves. These concerns led research on alternative renewable. Among the proposed alternative fuels biodiesel and ethanol have received much attention in recent years for diesel engines.

The direct use of vegetable oil is unfavorable to the engine. The major problems occurred after a long operation include chocking and trumpet formation on the injectors, carbon deposits, oil ring sticking and thickening and gelling of the lubricant. The problems associated with the use of pure vegetable oils with high viscosities in CI engines can be solved by directly mixing crude vegetable oils with diesel fuel. Another proven solution is by preheating the vegetable oil which will decrease the viscosity and improve the atomization and mixing process, which results in better combustion. Different feedstock to be used in conventional diesel engines without modifications, biodiesel must undergo certain processes and procedures to convert it into biodiesel. There are several processes and procedures to produce a better quality of biodiesel such as direct use and blending, micro-emulsions, pyrolysis of vegetable oil and transesterification.

2. PREPARATION OF BIODIESEL

The most advanced and promising technology of biodiesel production is transesterification of oils (triglycerides) with alcohol which gives biodiesel (fatty acid alkyl esters, FAAE) as main product and glycerin as by product. The transesterification reaction of triglycerides is shown in Fig. 1. Transesterification, also called alcoholysis, is exchanging of alcohol from an ester by another alcohol in a process similar to hydrolysis, except that an alcohol is used instead of water. Generally, in order for the reaction to be completed in a shorter reaction time, a catalyst is used to enhance and improve there action rate. Reaction temperature, reaction time, reaction pressure, ratio of alcohol to oil, concentration and type of catalyst, mixing intensity and kind of feedstock are among the most relevant operating variables affecting the transesterification process.

Steps used for preparation of biodiesel-

1] Feedstock preparation: Removal of solid particles from raw oil by ‘filteration processes.
Pre-Treatment: Removal of water vapours from raw oil by heating.

2] Mixing of Alcohol and Catalyst – Reaction I – Esterification Reaction.
Reaction II- Transesterification Reaction.

3] Separation of Glycerin and Biodiesel – Once the reaction is complete, two major products exists, glycerin and Biodiesel. Each has the substantial amount of excess methanol that was used in the reaction. Time required for layer separation is appx. 18 Hrs. The entire mixture is settles and glycerol is left on bottom and methyl ester (Biodiesel) is left on top.

4] Alcohol Removal – Once the glycerin and biodiesel phases separated, the excess alcohol in each phase is removed with the flash evaporation process or by distillation.

3. EXPERIMENTATION

Actual Experiment is done on single cylinder four stroke diesel engine at the mechanical department of K.K.Wagh College of Engineering, Amrutdham, Nashik. The setup consists of single cylinder, four stroke, Multi-fuel, research engine connected to eddy current type dynamometer for loading. The operation mode of the engine can be changed from diesel to ECU Petrol or from ECU Petrol to Diesel mode.

Engine Specification: Single cylinder, 4 stroke, water cooled, stroke 110 mm, bore 87.5 mm. Capacity 661 cc, Diesel mode, Power 3.5 KW, Speed 1500 rpm, CR range 12-18, ECU Petrol mode: Power 3.5 KW @ 1500 rpm, Speed range 1200-1800 rpm.

Eddy current type dynamometer is used with loading unit & water cooling. Software used is “Enginesoft” for Engine performance analysis software.

Various blends used for test are as following:

B00 (Pure Diesel), B09, B18, B27 and B36 at two CR 16 & 18.

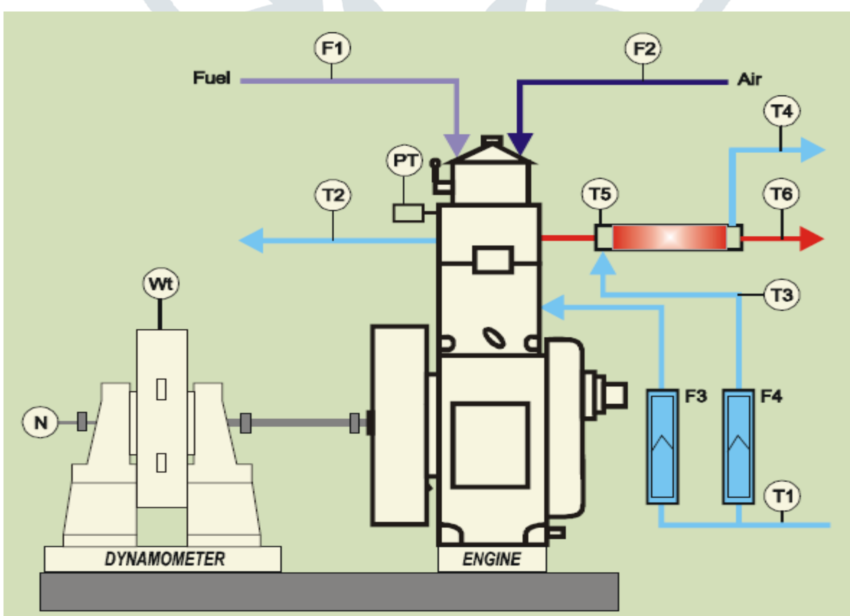

Fig- 1: Experimental Set-Up Schematic.

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.
W_t=Load cell reading.
T_6= Temperature of Exhaust Gas, after calorimeter.
N=Engine speed Tachometer reading.

Fig 2: Experimental Set-Up (Actual).

4. COMPRESSION RATIO ADJUSTMENT

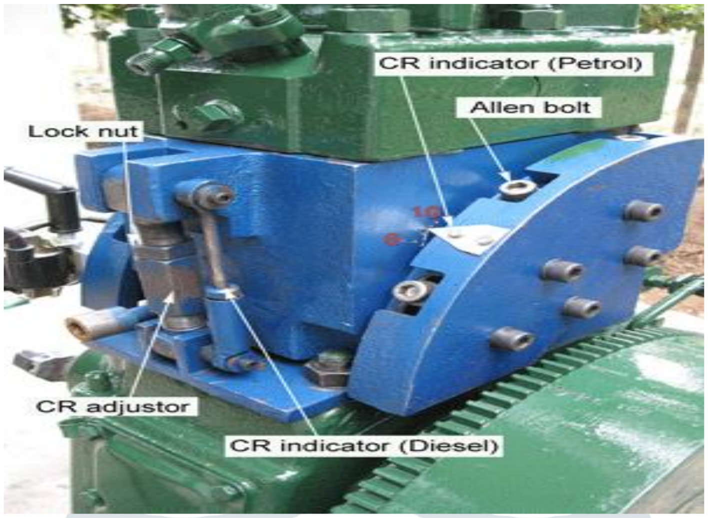

Fig 3 Variable Compression Ratio Adjustment.

The standard available engine (with fixed compression ratio) can be modified to VCR by providing additional variable combustion space. There are different arrangements by which this can be achieved. Tilting cylinder block method is one of the arrangements where the compression ratio can be changed without changing the combustion geometry. With this method the compression ratio can be changed within designed range without stopping the engine. The clearance volume of the combustion chamber is changed by tilting the cylinder block. As the clearance volume is changed and swept volume is constant the CR changes. The diagram explains the principle. At different CR the engine power shall change marginally. However, it is recommended to load the TV_1 engine up to 12 kg (i.e. 3.5 KW at all CRs).

5. RESULTS AND DISCUSSION

5.1 Brake power (BP): It indicates the available power at the output of engine to do work.Fig.4 shows variation of brake power with load for blends B00, B09, B18, B27 and B36 at CR 16 and it is observed that brake power increases as the load on the engine increases, also as percentage of biofuel in diesel increases the break power increases. For the lower loads, the break power for blend B27 is increased by 7.95%. After the blend B27 for particular loads the break power decreases with increase in percentage of biodiesel. And for the higher loads break power either increases or decreases with increase in percentage of biodiesel.

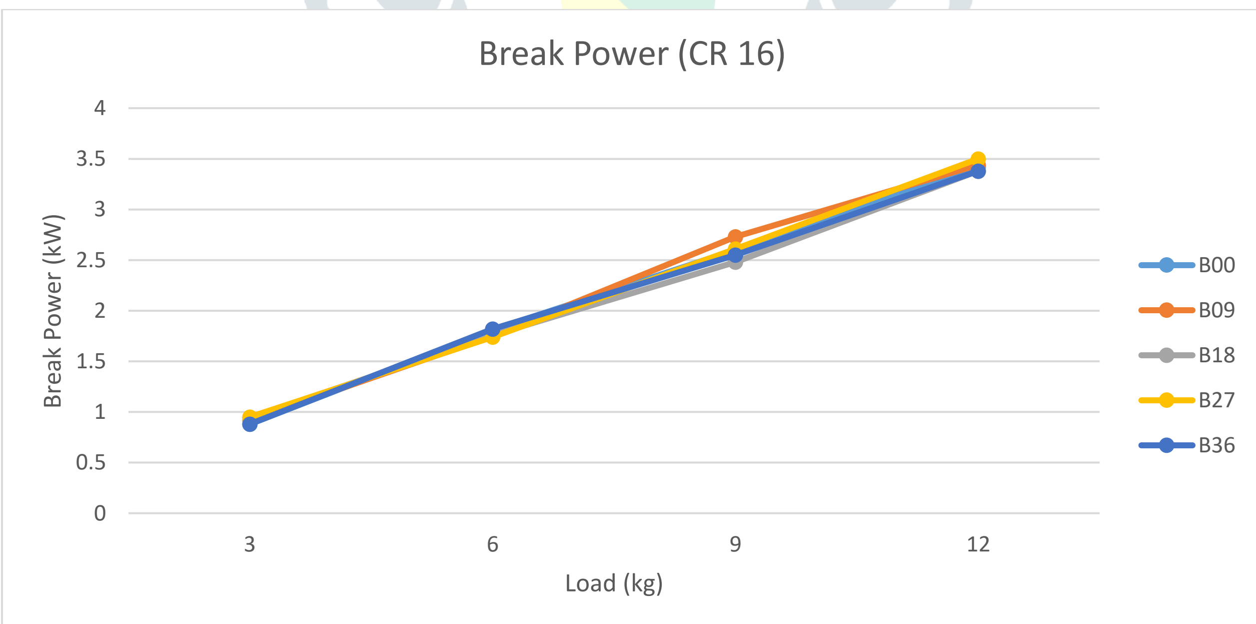

Fig 4: Break Power for CR 16.

Fig.5 shows variation of brake power with loads for blends B00, B09, B18, B27, and B36 at CR 18 with increase in load break power increases. But with increase in biofuel the variation of break power is not constant. Break power of biodiesel either increase or decrease as compared to diesel.

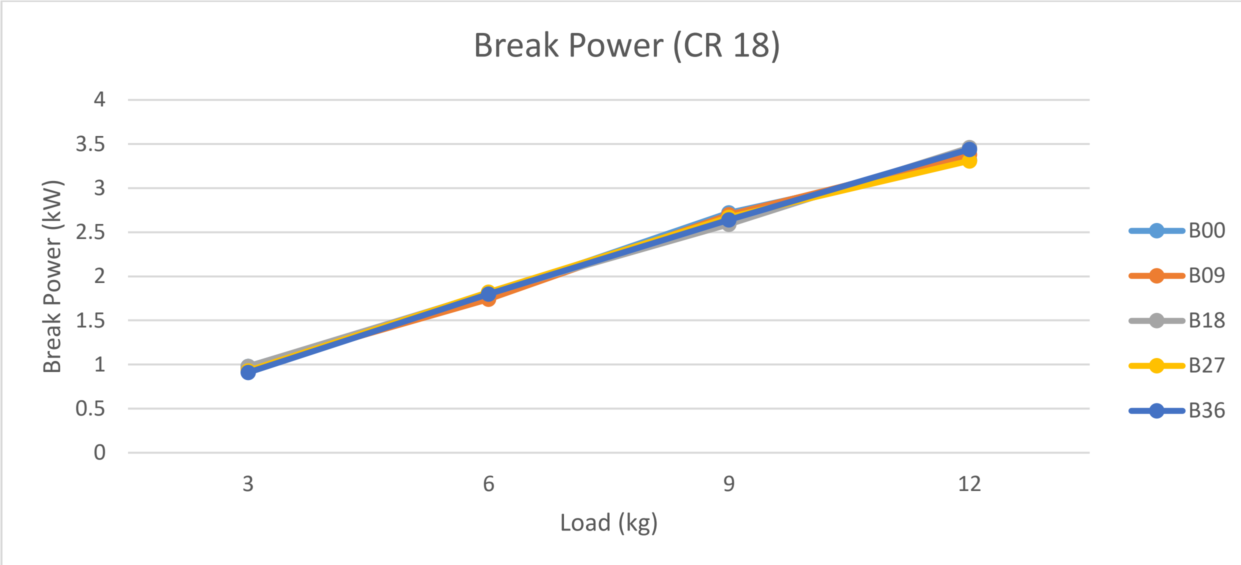

Fig 5: Break Power for CR 18.

5.2 Brake specific Fuel Consumption (BSFC):

Brake specific fuel consumption (BSFC) is defined amount of fuel required to develop 1 kW power per hour (kg/kWh). The Figure 6 shows the variation of BSFC with load. It is observed that at lower biodiesel blends the specific fuel consumption is decreased. Also for higher blends and lower loads specific fuel consumption is decreased. But for higher blends and higher loads specific fuel consumption is increased.

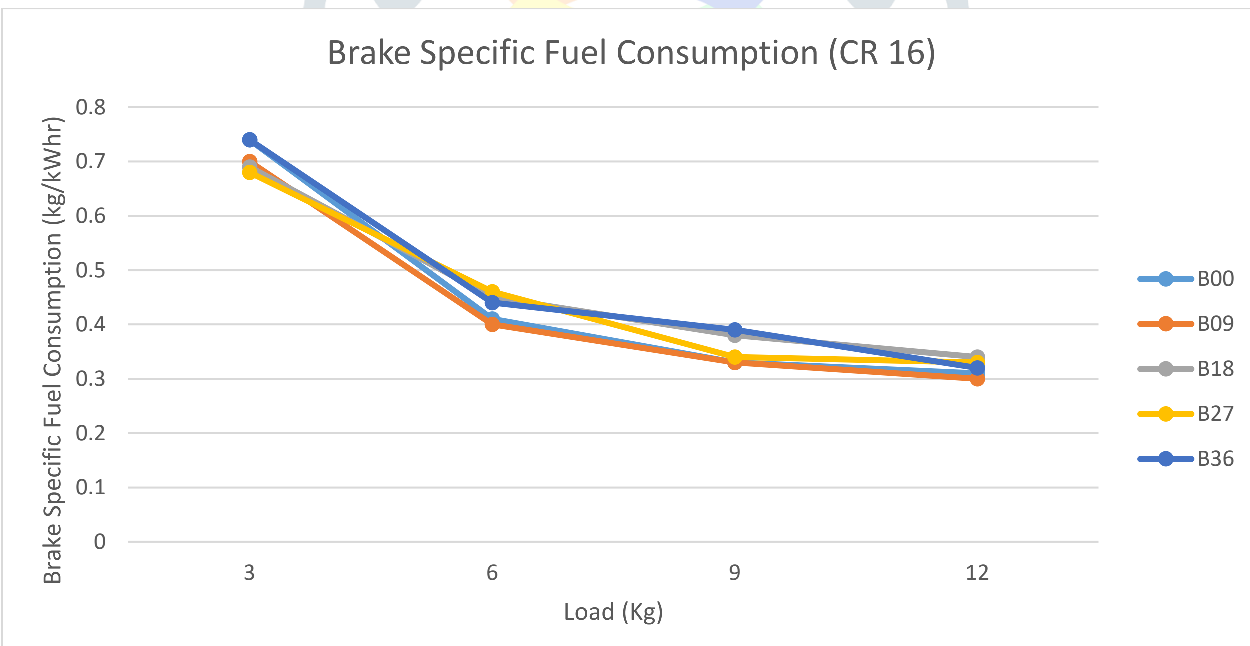

Fig 6: BSFC for CR 16.

Fig. 7 shows the variation of specific fuel consumption with load at compression ratio 18. For any blend at any load specific fuel consumption is increased or remained constant. At lower load and blend B36 specific fuel consumption increased by 16.39%. And that for B18 specific fuel consumption remained constant.

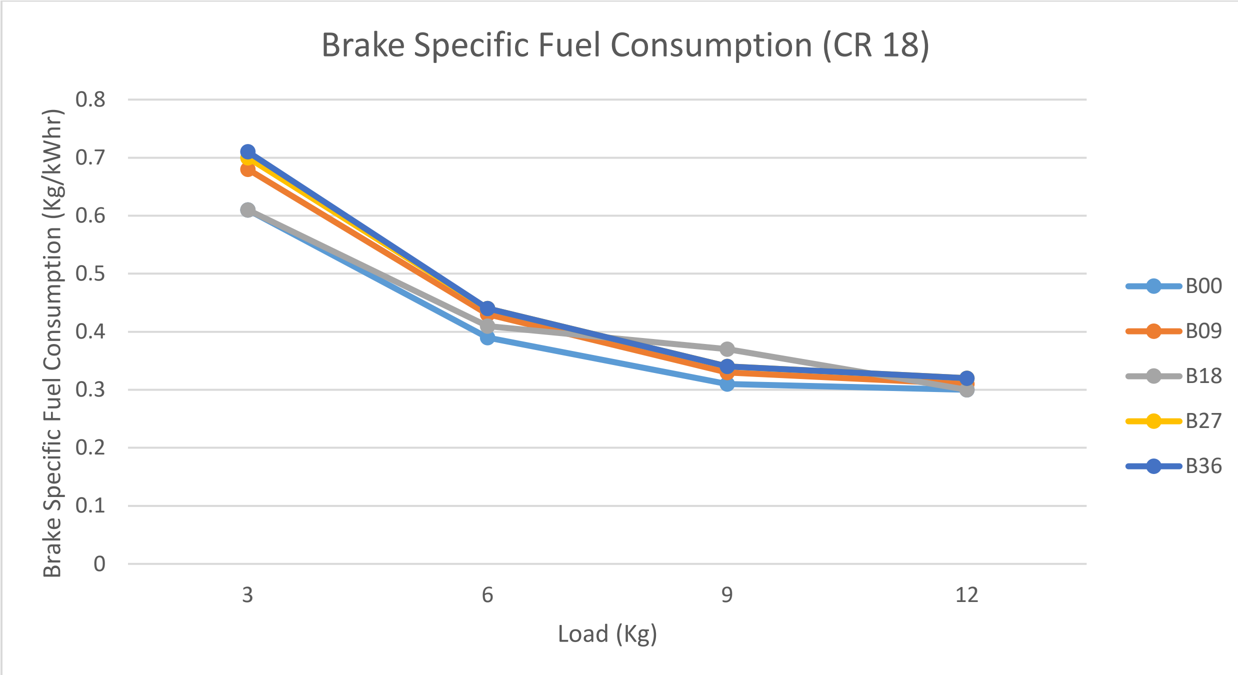

Fig 7: BSFC for CR 18.

5.3 Volumetric efficiency ($\eta_{Volumetric}$):

It is explained as the ratio of actual volume of air fuel mixture drawn into the cylinder at atmospheric pressure to the volume of cylinder. It indicates the breathing capacity of engine. Figure 8 & 9, shows the variation of volumetric efficiency with load for CR 16 and 18 respectively. It is observed that volumetric efficiency at compression ratio 16 either increases or decreases with increase in load and blend ratio.

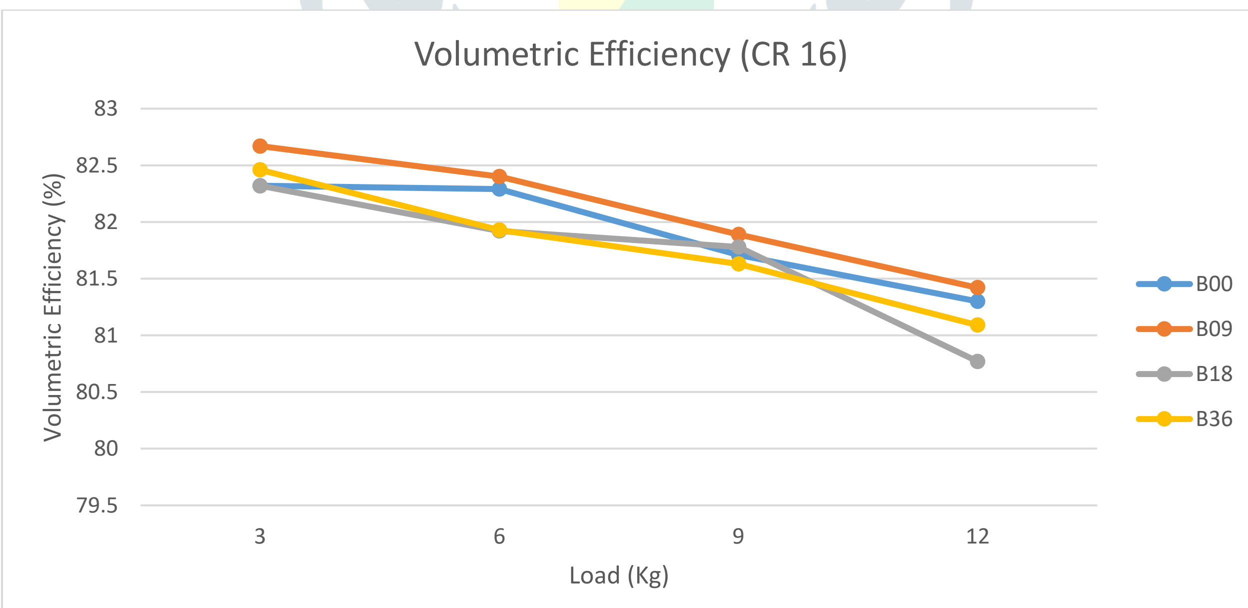

Fig 7: Volumetric Efficiency for CR 16.

Fig 9 Variation of volumetric efficiency with load for CR 18. It is observed that for blends B09 and B27 volumetric efficiency is increased with increase in load. The maximum variation of volumetric efficiency is at lower load and is for blend B27. Volumetric efficiency for blend B36 is lower for every load. For B18 Volumetric efficiency is higher excepting at load 9kg.

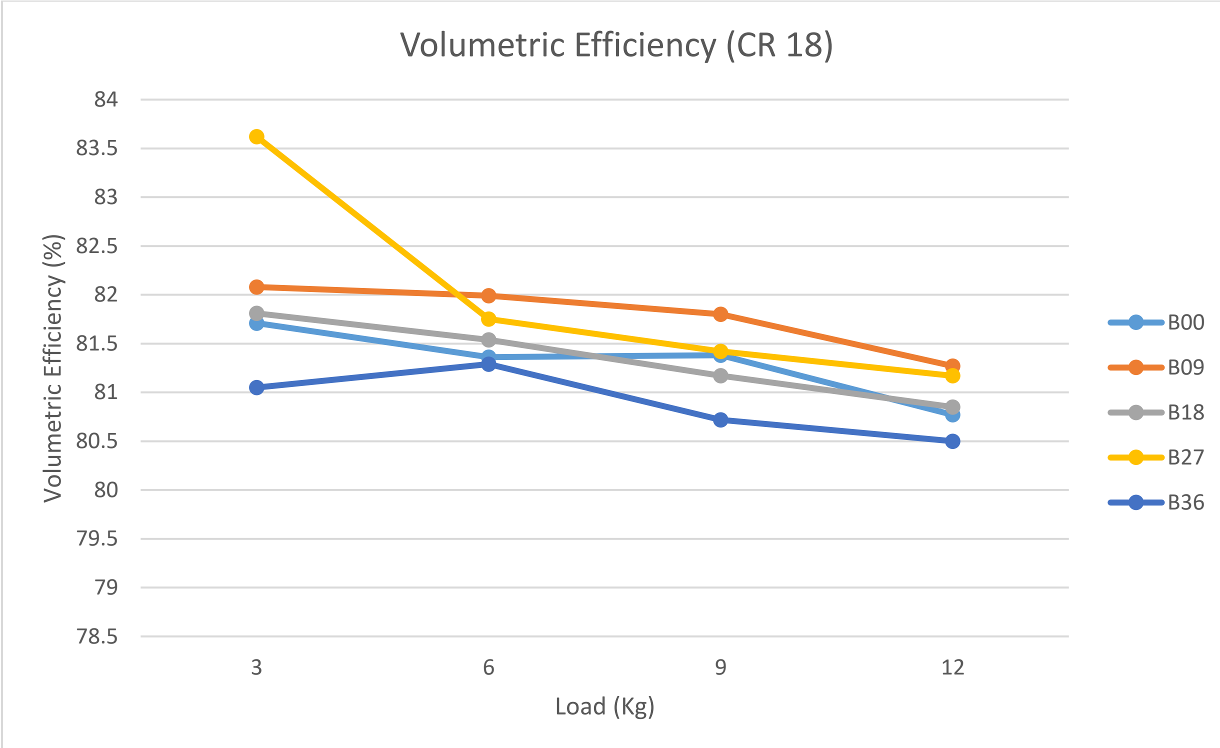

Fig 8: Volumetric Efficiency for CR 18.

5.4 Brake thermal efficiency (BTE):

It is the ratio of output i.e. BP to that of the chemical energy of fuel supplied. Figure 10 & 11, shows variation of BTE with load for CR, 16 and 18. From the figures, it is observed that in comparison with diesel fuel, the BTE of every blend get lowered except B09.

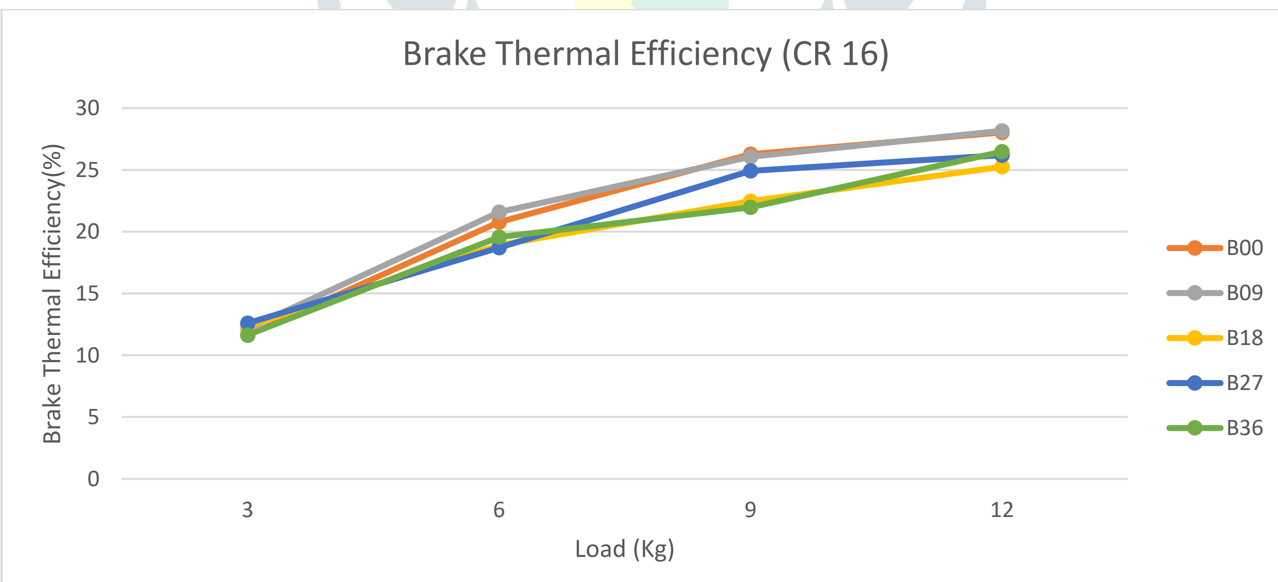

Fig 9: Brake Thermal Efficiency for CR 16.

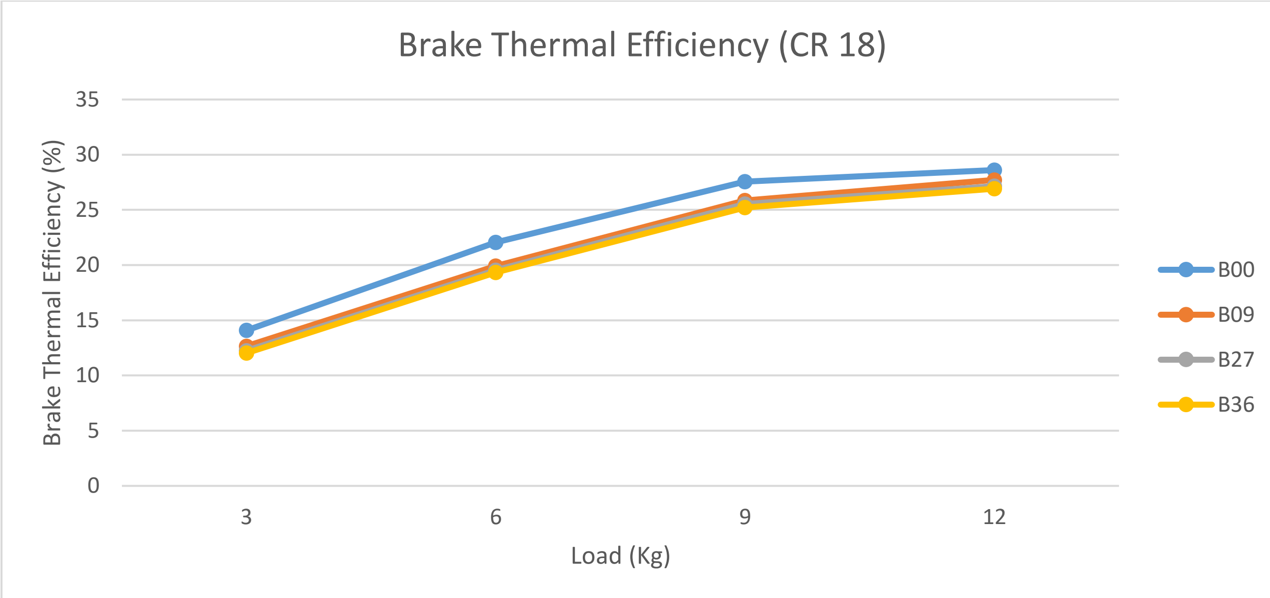

Fig 10: Brake Thermal Efficiency for CR 18.

6. CONCLUSION

The experiment was done on single cylinder four strokes diesel engine using Hybrid biodiesel blends (Mixture of two biodiesel i.e. made from raw oil of thumba and waste fried oil) and compared with pure diesel fuel gives conclusions as follows,

1] The Engine was easily started without any problem as well as Hybrid biodiesel blends perform well with diesel engine, without any change in setup. We conclude that BP increases as the load on the engine increases, also as percentage of biofuel in diesel increases. For the lower loads, the break power for blend B27 is increased by 7.95%. After the blend B27 the BP decreases with increase in percentage of biodiesel. And for the higher loads BP either increases or decreases with increase in percentage of biodiesel.at CR 18 with increase in biofuel the variation of BP is not constant.

2] For BSFC at CR 16 it is observed that, at lower biodiesel blends the BSFC is decreased. Also for higher blends and lower loads BSFC is decreased. But for higher blends and higher loads specific fuel consumption is increased. For CR 18, . For any blend at any load specific fuel consumption is increased or remained constant. At lower load and blend B36 specific fuel consumption increased by 16.39%. And that for B18 specific fuel consumption remained constant.

3]For Volumetric efficiency($\eta_{\text{Volumetric}}$), It is observed that volumetric efficiency at CR 16 either increases or decreases with increase in load and blend ratio and for CR 18 at blends B09 and B27 volumetric efficiency is increased with increase in load. The maximum variation of volumetric efficiency is at lower load and is for blend B27. Volumetric efficiency for blend B36 is lower for every load. For B18 Volumetric efficiency is higher excepting at load 9kg.

4] For Brake Thermal Efficiency (BTE), it is concluded that, In comparison with diesel fuel, the BTE of every blend get lowered except B09.

7. ACKNOWLEDGMENT

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