PERFORMANCE ANALYSIS OF CI ENGINE BY USING TWO OILS JATROPHA OIL & METHANOL BLENDED WITH DIESEL AS ALTERNATIVE FUEL

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Abstract : The world is facing a huge problem of high fuel prices, air pollution and a lot of climatic changes. Alternate Fuels play an essential role in the present scenario in Internal Combustion Engines as the mineral fuels are depleting. Alternative fuels generally have lower vehicle emissions that contribute to smog, air pollution and global warming.

Most alternative fuels don't come from finite fossil-fuel resources and are sustainable. To reduce reliance on petroleum-based fuels, Alternate fuels are best solution for the tomorrow IC engines. "Alternative fuel'' is used in motor vehicles to deliver direct propulsion, less damaging to the environment than conventional fuels.

Bio-diesel can be used as an alternate and non-conventional fuel to run all type of C.I. engine. Fast depletion of the fossil fuels and sometimes shortage during crisis period directs us to search for some alternative fuel which can reduce our dependence on fossil fuels. Thus, further increase requirement of this depleting fuel source. Many alternative fuels like biogas, methanol, ethanol and vegetable oils have been evaluated as a partial or complete substitute to diesel fuel.

The vegetable oil can be used directly in diesel engine as a fuel, because their calorific value is almost 90-95 percent of the diesel. The oil is extracted from the seeds and converted into methyl esters by the trans-esterification process. The methyl ester obtained from this process is known as bio diesel. Bio diesel is renewable source of energy which can be produced locally by our farmers by growing oil seed producing plants on their waste lands, barren land which is eco-friendly also. In order to propagate and promote the use of bio-diesel as an alternate source of energy in rural sector, the bio-diesel is produced from non-edible oils by using bio-diesel processor and the diesel engine performance for water lifting are tested on bio-diesel and bio-diesel blended with diesel. In addition, biodiesel is better than diesel fuel in terms of very low sulfur content and it is also having higher flash and fire point temperatures than in diesel fuel. Biodiesel and its blends with diesel were employed as a fuel for diesel engine without any modifications in the existing engine. We are mixing two oils blended with diesel & measure the Performance analysis of CI engine.

IndexTerms **-** *blended* 1, *flash and fire point* 2, *trans-esterification process* 3, etc

I. Introduction

The blends of varying proportions of jatropha oil and methanol blended with diesel were prepared, analyzed and compared with diesel fuel. The effect of temperature on the viscosity of biodiesel and jatropha oil was also studied. The performance of the engine using blends and jatropha oil was evaluated in a single cylinder C.I. engine and compared with the performance obtained with diesel. The use of biodiesel has slightly reduced the engine performances while notably increased Specific Fuel Consumption (SFC). The performance of the engine using blends and jatropha oil was evaluated in a single cylinder C.I. engine and compared with the performance obtained with diesel. Significant improvement in engine performance was observed compared to vegetable oil alone. The specific fuel consumption and the exhaust gas temperature were reduced due to decrease in viscosity of the vegetable oil. Acceptable thermal efficiencies of the engine were obtained with blends containing up to 50% volume of jatropha oil. From the properties and engine test results it has been established that 40–50% of jatropha oil can be substituted for diesel without any engine modification and preheating of the blends

1.1 Production process of Biodiesel

1) *Heating of Oil:* 1 litre of Vegetable Oil is heated up to a temperature of 55-60°C and maintained at this temperature.
2) *Mixing of catalyst and methanol:* 4 grams NaOH is mixed with 250 ml of methanol and stirred properly for 20 min. Sodium Methoxide is formed. This mixture of catalyst and methanol is poured into the oil.
3) *Transesterification:* The reaction process is called transesterification. The solution is stirred for 1 hour.
4) *Settling:* After shaking the solution is kept for 16 hours to settle the biodiesel and sediment layers clearly. Two distinct layers of glycerin and biodiesel are formed.
5) *Separation of biodiesel:* The biodiesel is separated from sedimentation by flask separator carefully.
6) *Washing:* Biodiesel is washed and rewashed by water until the water appears clean. This is necessary to remove the methanol and NaOH traces from the biodiesel. Avoid agitating the biodiesel while adding water as this agitation may cause emulsification of water and methyl ester. Each time the mixture takes 12-16 hours to settle properly.
7) *Drying:* Biodiesel is dried by keeping it under a running fan for 12 hours.

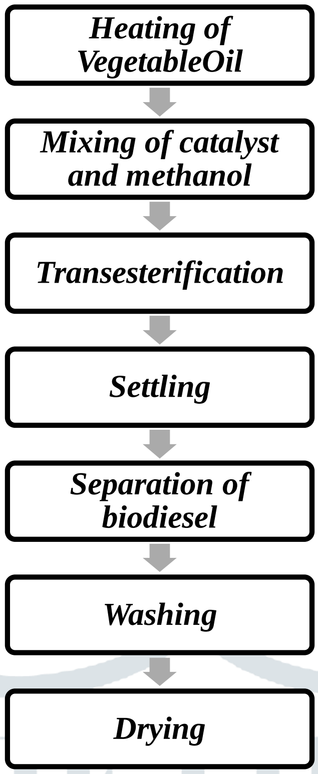


Fig 1. Production of biodiesel

1.2 Properties of Biodiesel used in this project:

Property	Diesel	Jatropha	Methanol
Calorific value (kJ/kgK)	42000	36000	41300
Kinematic Viscosity at 40^0C (cSt)	2.87	9 to 10	4.5
Specific Density (kg/m^3)	840	860 to 890	855
Flash Point (^{0}C)	75 to 78	180 to 190	174
Cloud Point (^{0}C)	6 to 8	10 to 12	16
Cetane Number	40 to 50	50 to 60	65

Table1: Shows Properties of Jatropha & Methanol used in this paper

II. PERFORMANCE OF I.C. ENGINES

A. Performance parameters of C.I. Engines

1) **Indicated thermal efficiency (η_t):** Indicated thermal efficiency is the ratio of energy in the indicated power to the fuel energy.
2) **Brake thermal efficiency (η_{bth}):** A measure of overall efficiency of the engine is given by the brake thermal efficiency. Brake thermal efficiency is the ratio of energy in the brake power to the fuel energy.
3) **Mechanical efficiency (η_m):** Mechanical efficiency is the ratio of brake horse power (delivered power) to the indicated horsepower (power provided to the piston).
   η =*Brake Power / Indicated Power*

4) **Specific fuel consumption (SFC):** Brake specific fuel consumption and indicated specific fuel consumption, abbreviated BSFC and ISFC, are the fuel consumptions on the basis of Brake power and Indicated power respectively.

5) **Fuel-air (F/A) or air-fuel (A/F) ratio:** The relative proportions of the fuel and air in the engine are very important for combustion and efficiency of the engine. This is expressed either as the ratio of the mass of the fuel to that of the air or vice versa

6) **Calorific value or Heating value or Heat of combustion:** It is the energy released per unit quantity of the fuel, when the combustible is burned and the products of combustion are cooled back to the initial temperature of combustible mixture. The heating value so obtained is called the higher or gross calorific value of the fuel. The lower or net calorific value is the heat released when water in the products of combustion is not condensed and remains in the vapour form.

7) **Power and Mechanical efficiency:** Power is defined as rate of doing work and equal to the product of force and linear velocity or the product of torque and angular velocity. Thus, the measurement of power involves the measurement of force (or torque) as well as speed.

8) **Mean effective pressure and torque:** Mean effective pressure is defined as a hypothetical pressure, which is thought to be acting on the piston throughout the power stroke.
Power in kW = (Pm LAN/n 100)/60 in bar
n = 2 (for four stroke engine)

Thus we can see that for a given engine the power output can be measured in terms of mean effective pressure. If the mean effective pressure is based on brake power it is called brake mean effective pressure (BMEP) and if based on indicated power it is called indicated mean effective pressure (IMEP)

9) **Volumetric efficiency (η_v):** The engine output is limited by the maximum amount of air that can be taken in during the suction stroke, because only a certain amount of fuel can be burned effectively with a given quantity of air.
Volumetric efficiency is an indication of the 'breathing' ability of the engine and is defined as the ratio of the air actually induced at ambient conditions to the swept volume of the engine.

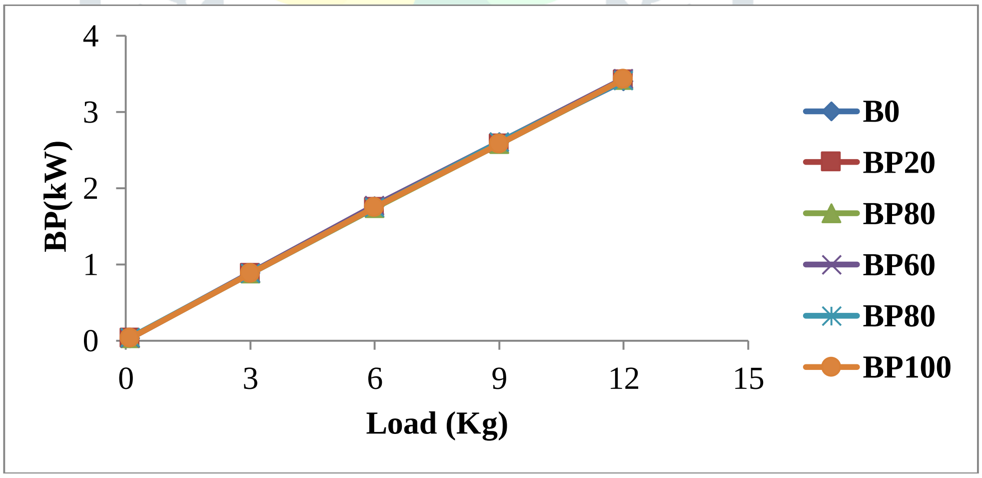
2.2 Basic measurement parameters in CI Engine:

The basic measurements, which usually should be undertaken to evaluate the performance of an engine in the test, are the following:

1) **Measurement of speed**
Following different speed measuring devices are used for speed measurement.
   i) Photoelectric/Inductive proximity pickup with speed indicator
   ii) Rotary encoder
2) **Measurement of fuel consumption**
   i) Volumetric method: The fuel consumed by an engine is measured by determining the volume flow of the fuel in a given time interval and multiplying it by the specific gravity of fuel. Generally a glass burette having graduations in mm is used for volume flow measurement. Time taken by the engine to consume this volume is measured by stopwatch.
   ii) Gravimetric method: In this method the time to consume a given weight of the fuel is measured. Differential pressure transmitters working on hydrostatic head principles can be used for fuel consumption measurement.
3) **Measurement of brake power**
Measurement of BP involves determination of the torque and angular speed of the engine output shaft. This torque-measuring device is called a dynamometer.
4) **Measurement of indicated power**
Indicator diagram: A dynamic pressure sensor (piezo sensor) is fitted in the cylinder head to sense combustion pressure. A rotary encoder is fitted on the engine shaft for crank angle signal. Both signals are simultaneously scanned by an engine indicator (electronic unit) and communicated to computer. The software in the computer draws pressure crank-angle and pressure volume plots and computes indicated power of the engine.

2.3 Performance analysis graphs

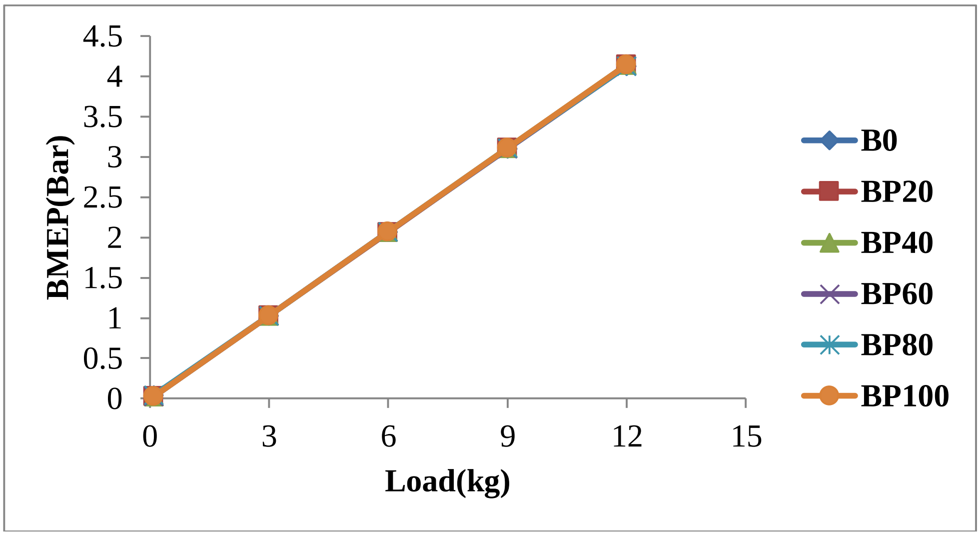
(i) Brake Power vs. Load



Graph i) **Brake Power vs. Load**

The brake power developed by engine on different load conditions starting from no load to 12 kg is presented in graph. As the load increases, the BP developed by engine increases for all blends of mixture of Jatropha oil & methanol. At maximum load i.e. 12 kg, we got maximum efficiency for all blends.

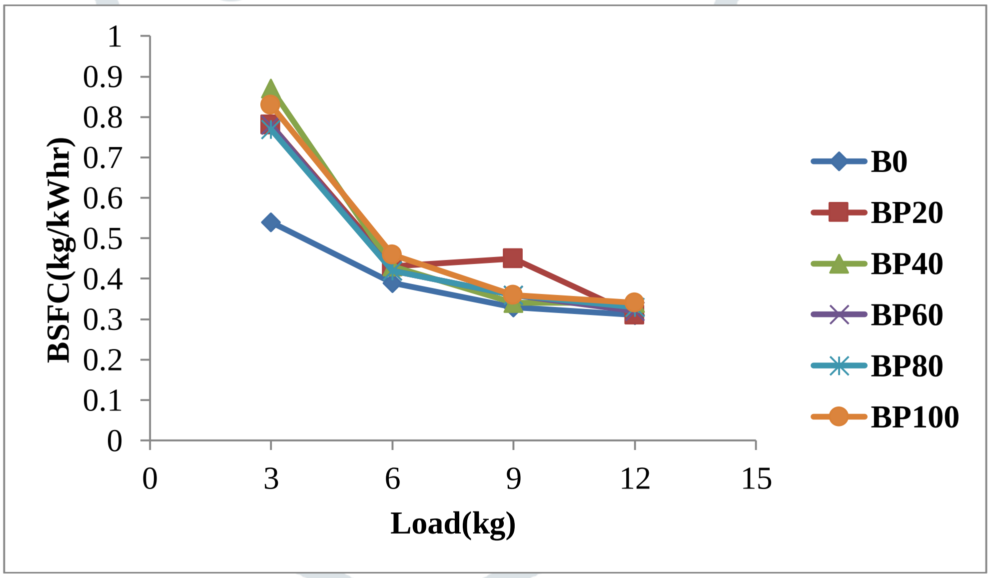
(ii) Brake Mean Effective Pressure vs. Load



Graph ii) **Brake Mean Effective Pressure vs. Load**

The brake mean effective pressure developed by engine on different load conditions starting from no load to 12 kg is presented in fig. As the load increases, the BMEP developed by engine increases for all blends of mixture of Jatropha oil & methanol. At maximum load i.e. 12 kg, we got maximum BMEP for all blends.

(iii) Brake Specific Fuel Consumption vs. Load

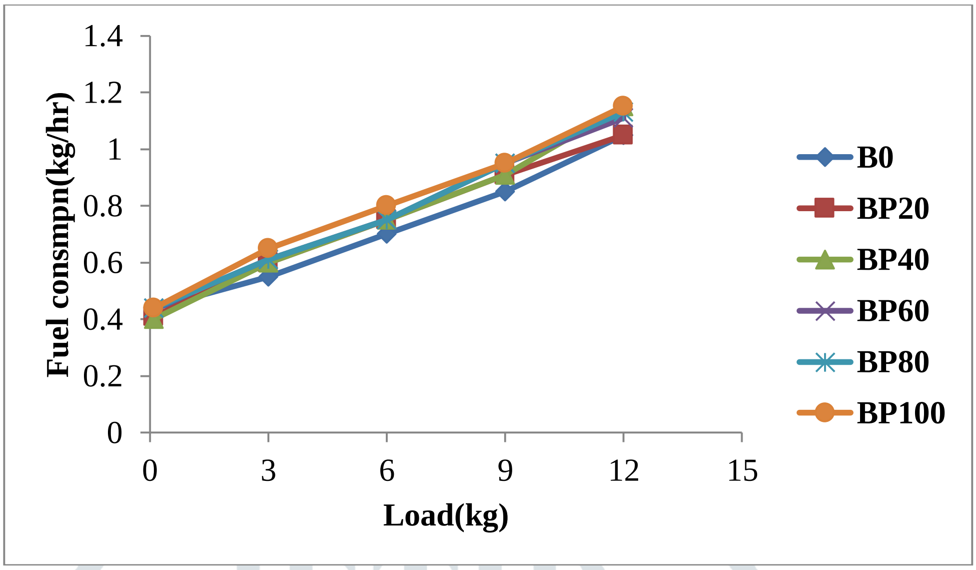


Graph iii) Brake Specific Fuel Consumption vs. Load

The BSFC is defined as ratio of mass fuel consumption to the brake power. Graph shows the variation of brake specific fuel consumption with load. For all blends tested brake specific fuel consumption is found to decrease with increase in load. This is due to higher percentage increase in brake power with load as compared to the increase in fuel consumption. But at lower load condition, the developed brake power is less and BSFC is more on that load for all blends. At lower percentage of mixture of Jatropha oil & methanol the brake specific fuel consumption is lower than that of all other blends. With increase in mixture of Jatropha oil & methanol percentage in the blends, the calorific value of fuel decreases, hence brake specific fuel consumption of higher percentage of mixture of Jatropha oil & methanol in blends increases as compared to diesel (B0).

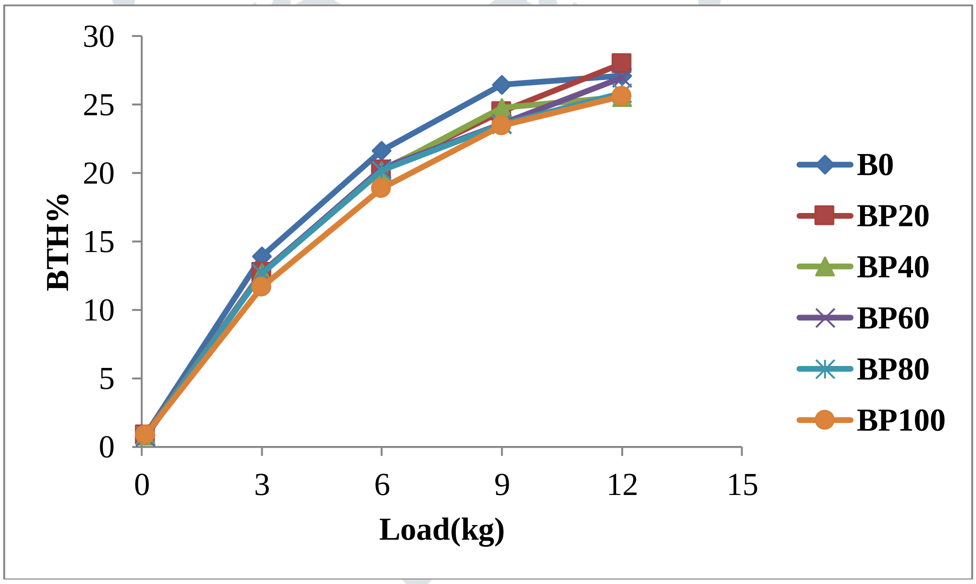
(iv) Fuel Consumption vs. Load

Graph above illustrates the relation between applied load & the fuel consumption (Kg/hr). As the load increases, fuel consumption also increases.



Graph iv) Fuel Consumption vs. Load

(v) Brake Thermal Efficiency vs. Load

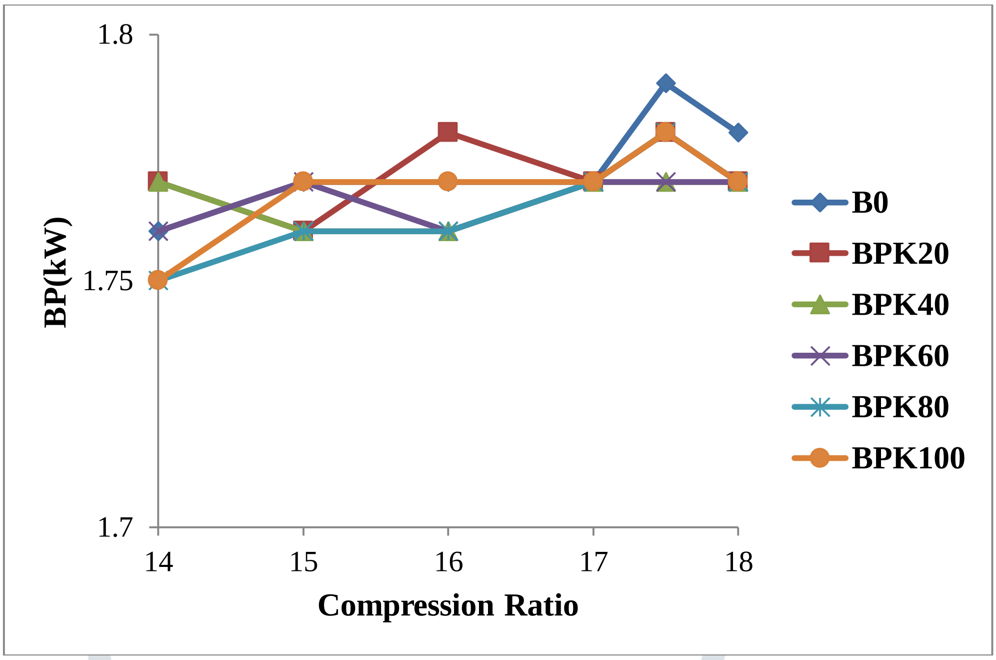


Graph v) **Brake Thermal Efficiency vs. Load**

Fig below shows the variation of brake thermal efficiency with respect to load for different loads. In all cases brake thermal efficiency was having tendency to increase with increase in applied load. This was due to reduction in heat loss and increase in power developed with increase in load.

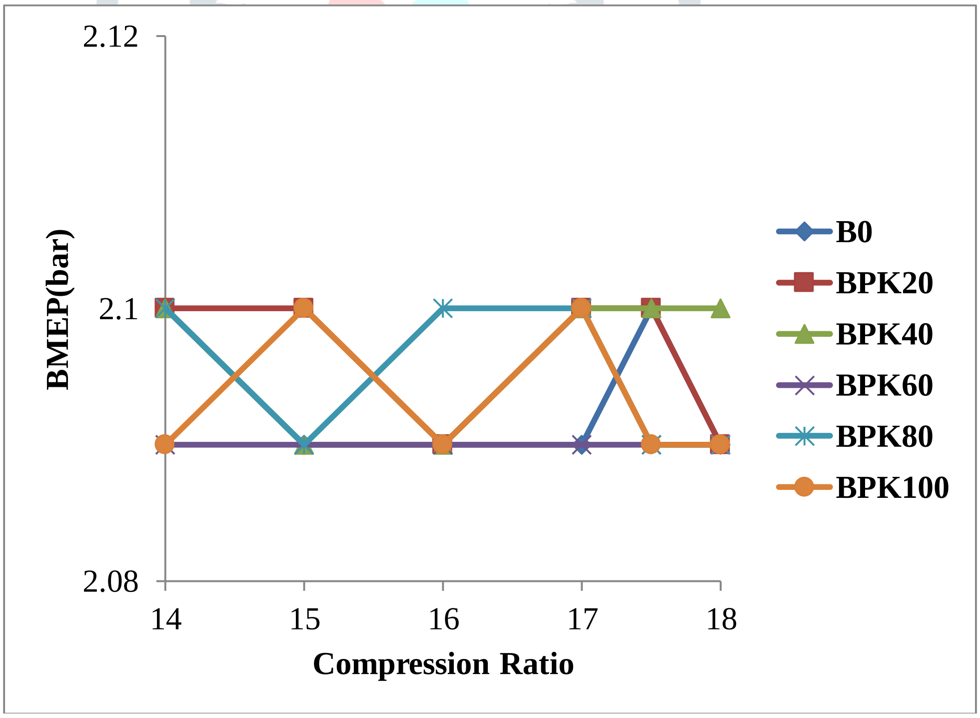
(vi) Brake Power vs. Compression Ratio

The brake power developed by engine on different compression ratio starting from 14 to 18 is presented in fig. As the compression ratio increases, the BP developed by engine increases all blends of mixture of Palm and Karanja oil. Maximum BP is obtained at BPK80 blend at 17.5 compression ratio.



Graph vi). Brake Power vs. Compression Ratio

(vii) Brake Mean Effective Pressure vs. Compression Ratio

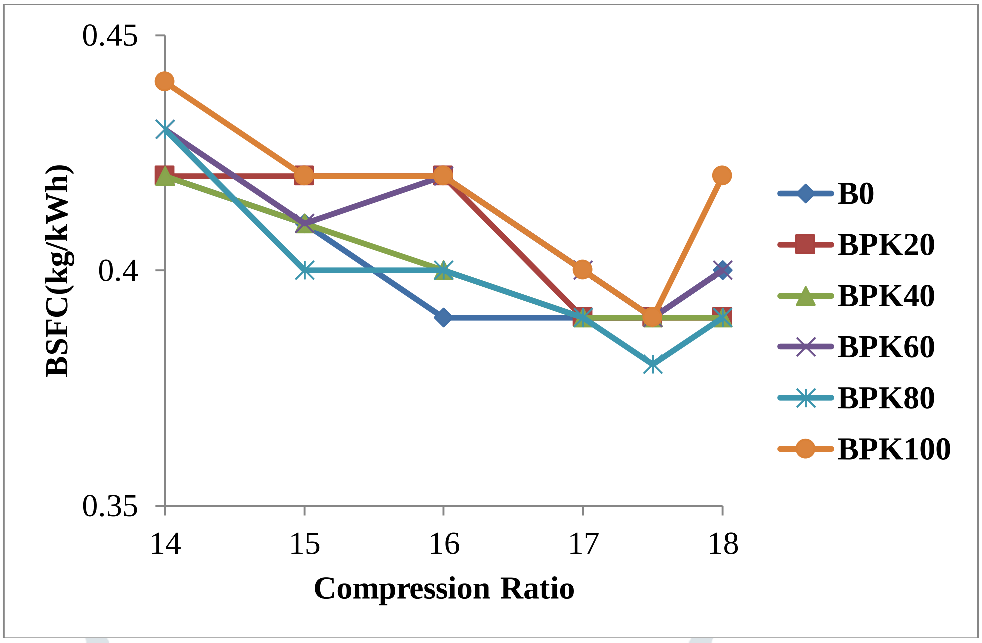


Graph vii) Brake Mean Effective Pressure vs. Compression Ratio

The brake mean effective pressure developed by engine on different compression ratio starting from 14 to 18 is presented in fig. As the compression ratio increases, the BMEP developed by engine varies for all blends of biodiesel mixture. At maximum compression ratio, BPK60 blend develops maximum BMEP as compared to other tested blends.

(viii) Brake Specific Fuel Consumption vs. Compression Ratio

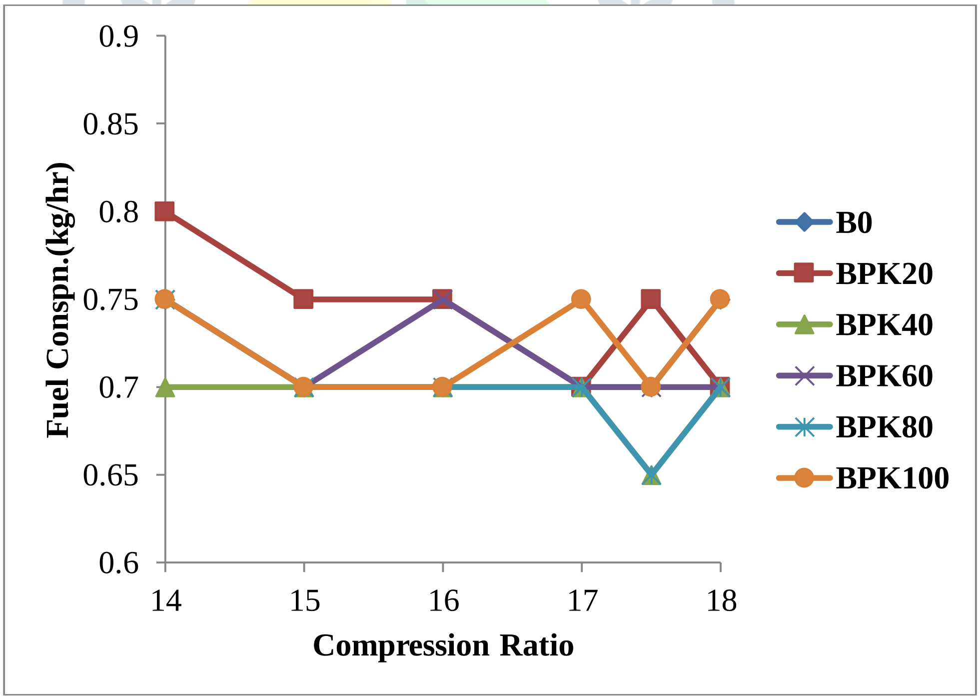
Fig shows the variation of brake specific fuel consumption with compression ratio. For all blends tested brake specific fuel consumption is found to decrease with increase in compression ratio. At lower percentage of biodiesel mixture the brake specific fuel consumption is less than that of all higher blends.



Graph viii) Brake Specific Fuel Consumption vs. Compression Ratio

(ix) Fuel Consumption vs. Compression Ratio

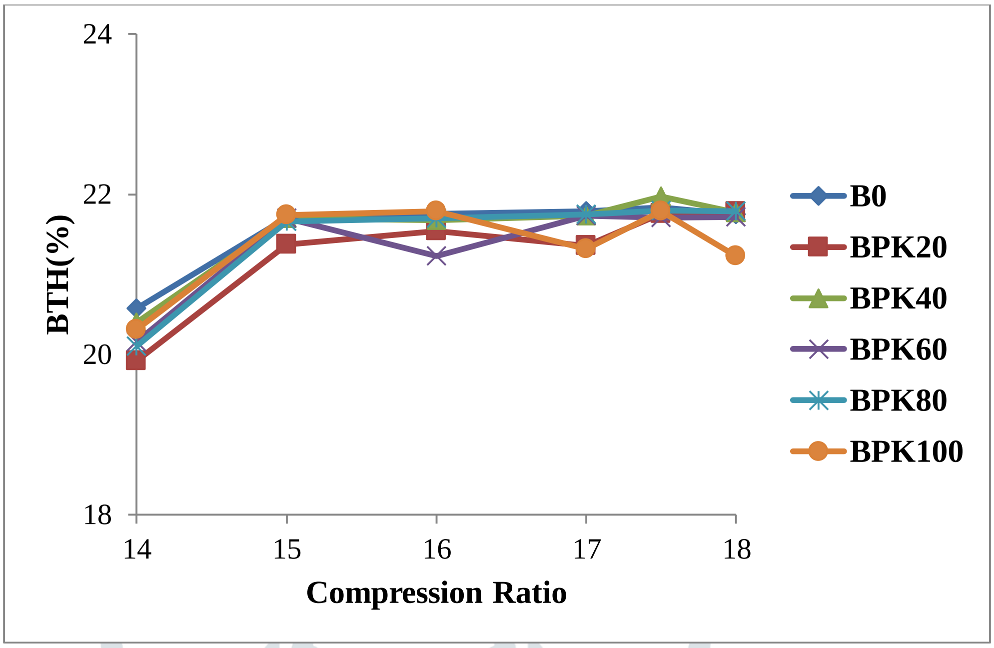
Fig illustrates the relation between applied compression ratio & the fuel consumption (Kg/hr). As the compression ratio increases, fuel consumption decreases. But during study, fuel consumption was found lesser at lower compression ratio for all blends but it is greater than diesel. BPK40 gives the minimum fuel consumption at 17.5 compression ratio.



Graph (ix) Fuel Consumption vs. Compression Ratio

(x) Brake Thermal Efficiency vs. Compression ratio

Fig shows the variation of brake thermal efficiency with compression ratio. For all blends tested BTH is found to increase with increase in compression ratio. At lower blends of biodiesel the BTH is less than that at higher blends.
In diesel engines, crude plant oils can be used as well as blended with the diesel. However, for better performance biodiesels must be used.



Graph (x) Brake Thermal Efficiency vs. Compression ratio

Most of the researchers are of the opinion that biodiesel blends can be used in diesel engines without any engine modifications. Literature indicate that there is loss in power and increased fuel consumption due to employment of biodiesel but for blends up to B40 there is no significant loss in power nor there is any increased fuel consumption. Thus, blends up to B40 are appropriate to use.
The important parameters for measuring engine performance are brake power, specific fuel consumption, mean effective brake pressure, brake thermal efficiency and mechanical efficiency. The common engine emissions are carbon monoxide, oxides of nitrogen and particulate matter. The biodiesel can be produced by oil sources viz. plant, animal, and microbial sources by tranesterification.
Performance analysis is done using a single cylinder, 4 stroke Diesel, water cooled, 3.5 kW power at 1500 rpm, computer interfaced engine. Eddy current dynamometer is used for measurement of brake power. Piezo sensor with quartz material is used for dynamic measurements of pressures. Rota meter is used for flow measurement and a mono block pump is used for pumping. Exhaust emission analysis is done by using a Fuel Efficiency Monitor manufactured by Technovation Analytical Instruments Pvt. Ltd. The electrochemical sensor used in the instrument converts the concentration of the gas encountered around it into an electrical signal, which is sensed by the instrument and displayed in terms of percentage or ppm. Biodiesel can be made by transesterification of plant oil such as karanja using monoalkyl alcohol and NaOH as catalyst, and washing it further. The obtained biodiesel is more viscous than petroleum diesel and its flash point, cloud point and pour point are higher. Its calorific value is lower than that of diesel.
From the obtained results and generated graphs it can be observed that the brake power, specific fuel consumption and mechanical efficiency at varying loads are similar for diesel and biodiesel. The brake thermal efficiency of biodiesel is higher.

III. CONCLUSIONS

Considering the results obtained from the tests on engine,
it can be concluded that:

1) The brake power, BSFC and mechanical efficiency for biodiesel at varying loads are almost similar to that of diesel. Hence, there is no significant loss in power.
2) The brake thermal efficiency is observed to be more for biodiesel compared to diesel.
3) Thus, it suggests that there is no degradation in performance of the C.I. engines running on biodiesel.

IV. ACKNOWLEDGEMENT

It is a matter of great me pleasure for me to present my project work on *"Performance Analysis of CI Engine by using Two Oils (Jatropha oil & Methanol) blended with Diesel as Alternative Fuel"*. First and foremost, I am highly thankful to my project guide *Prof. S. S. Kale, Department of Mechanical Engg., NKOCET, Solapur* for his expert guidance and continuous encouragement during all stages of dissertation. His help in the form of valuable information and research thoughts at proper time has brought life in this paper. I feel lucky to get an opportunity to work with him.

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