Experimental Study & Analysis of Diesel-Jatropha-Biodiesel Blend on VCR Engine

Sneha Jagtap
Matoshree College Of Engineering, Nashik

Abstract- *Today the important challenge is to reduced energy crises and pollution problems , since the use of fossil fuel is continuously increasing due to growth in industrialization. For economic development of country and living standards. Hence there is need to find and alternative fuels to decrease the consumption of fossil fuel and reduce the emission emitted from fossil fuel which produces hazardas effect on human health and environment. Biodiesel and ethanol are most suitable alternative for petroleum fuels since they are produced from renewable feedstock's and are biodegradable. A number of research work was carried on biodiesel and ethanol blends with diesel fuel to study the performance and emission characteristics at constant compression ratio. In this paper the research work is carried to study performance and emission analysis of diesel- jatropha-biodiesel blends on Variable compression ratio engine at different loads and CR and result obtained will be validated with pure diesel (D100)at same load and compression ratio.*

Keywords- Bio diesel blends, alternative fuel, Jatropha Oil,, Transesterification, Cetane Number, Performance and emission analysis

I. INTRODUCTION

Energy is one of the most important building blocks in human development, and as such, acts as a key factor in determining the economic development of all the countries. World's energy consumption has increased continuously since decade, because the world population is increasing and the economies of developing countries are expanding rapidly. Also, the source and supply of primary energy sources like coal, oil and natural gas seem to decrease to a critical point. The petroleum fuels are one of the major sources of energy are currently the dominant global source of CO2 emissions, greenhouse gases and global warming. The rise in petroleum prices and increase in environmental pollution jointly have necessitated finding renewable alternatives to conventional petroleum fuels. Also, depletion of fossil fuels, vehicular population, increasing industrialization, growing energy demand, explosion of population, environmental pollution, emission norms etc emphasize on the need for alternative fuels. The possible renewable energies are solar power, hydrogen, bioalcohol such as methanol, ethanol, butanol, propane, non-fossil methanol, non-fossil natural gas, emulsified fuels, biofuels mostly from non- edible seed oils, biodiesels. The use of renewable resources of energy is rapidly increasing worldwide.

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. Fossil fuel emissions from vehicles damage the environment and contribute to air pollution. Several major environmental problems are caused by the use of fossil fuels like Global warming, Oil Spills, Acid rains, Air Pollution. 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.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

Liaquat A.M. et al. [1] investigated the engine performance parameters and emissions characteristics for direct injection diesel engine using coconut biodiesel blends without any engine modifications. Three fuel samples such as DF (100% diesel fuel), CB5 (5% coconut biodiesel and 95% DF), and CB15 (15% CB and 85% DF) were used and Engine performance test was carried out at 100% load keeping throttle 100% wide open with variable speeds of 1500 to 2400 rpm at an interval of 100 rpm. Also engine emission tests were carried out at 2200 rpm at 100% and 80% throttle position. After the investigation it was observed that the performance parameter like torque and brake power were decreased while specific fuel consumption were increased for biodiesel blended fuels over the entire speed range compared to net diesel fuel. While emissions like HC, CO were found to be lower but it was observed that CO2 and NOx emissions were increased for biodiesel blended fuels compared to diesel fuel. Also sound level decreased for both biodiesel blended fuels compared to diesel fuel.

Atabani A.E.et al. [4] did a comprehensive review on biodiesel as an alternative energy resource to study various aspects such as biodiesel feedstocks, extraction and production methods, properties and qualities of biodiesel, problems and potential solutions of using vegetable oil, advantages and disadvantages of biodiesel, the economical viability and finally the future of biodiesel. The study was done to search beneficial biodiesel sources. It was observed that these feed stocks include non-edible oils such as Jatropha curcas and Calophyllum inophyllum, and more recently microalgae and genetically engineered plants such as poplar and switch grass for biodiesel production. It has been also observed that feedstock alone represents more than 75% of the overall biodiesel production cost.

Alan C. Hansen, Qin Zhang and Peter W.L. Lyne [8] carried a review on Ethanol–diesel fuel blends. It was observed that with ethanol percentages of 10% or less, there was no noticeable differences in performance compared to running on diesel fuel. But the ethanol-diesel blend had flashpoints below 37.8 °C, therefore it was suggested that for maintaining vehicle safety with Ethanol–diesel blends may need to fuel tank modifications.

Tate R. E. et al. [22] studied the viscosities of three biodiesel fuels at temperatures up to 300 ^{0}C.To obtain the kinematic viscosities of biodiesel fuels at temperatures up to 300 ^{0}C, a modified Saybolt viscometer was designed. The viscometer was used to measure the efflux times for 60 ml of methyl esters of canola and soy, and ethyl esters of fish-oil. The Modified Saybolt Viscometer was calibrated using a standard oil and can be used to measure the kinematic viscosity to within0.056 mm^2 /s with 2% repeatability. Using the measured densities over the same temperature range, the dynamic viscosities were obtained

Yilmaz Nadir et al. [25] studied performance of CI engine emissions in biodiesel–ethanol–diesel blends as a function of ethanol concentration. Ethanol was mixed with biodiesel–diesel blends and the effect of ethanol concentration on diesel emissions was investigated. Both low and high concentrations of ethanol were studied. Ethanol concentrations were varied at 3%, 5%, 15% and 25% in biodiesel–diesel–ethanol (BDE), while biodiesel and diesel concentrations were maintained equal (BDE3, BDE5, BDE15 and BDE25). Emission characteristics for biodiesel– diesel–ethanol blends were compared to baseline curves of diesel as a function of engine load.

Write Down Your Studies And Findings

Preparation of Blend

For the presented work the different blends of diesel and Jatropha biodiesel are used. They are B05, B10, B15, B20 & B40 etc. The number following B indicates percentage of volumetric amount of Jatropha biodiesel in diesel. These blends are prepared for one liters of each category. The ethanol used for blend preparation is 99.9% pure and the properties are given by the supplier in the test report provided.

Property	Diesel	Biodiesel	Ethanol
Chemical formula	$C_{12}H_{23}$	$C_{19}H_{36}O_2$	C_2H_6O
Density (kg/m3) at 15 °C	837.8	896.9	799.4
Viscosity (mm2 /s) at 40 °C	2.649	4.643	1.10
Calorific value kJ/kg	44,893	38,085	28,180
Cetane Number	54	46–55	8
Flash point (°C)	50	163–238	12

III. EXPERIMENTAL SETUP

Engine experimentations were practiced on a single cylinder, constant speed variable compression ratio engine. The experimental engine is able to operate with both gasoline and diesel fuels. 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 by following some procedural steps. In both modes the compression ratio can be varied without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. In Diesel mode fuel injection point and pressure can be manipulated for research tests. In Petrol mode fuel injection time, fuel injection angle, ignition angle can be programmed with open ECU at each operating point based on RPM and throttle position. It helps in optimizing engine performance throughout its operating range. Air temp, coolant temperature, Throttle position and trigger sensor are connected to Open ECU which control ignition coil, fuel injector, fuel pump and idle air. Set up is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The setup has stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and hardware interface. Rotameters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement. The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Labview based Engine Performance Analysis software package "Enginesoft" is provided for on line engine performance evaluation. PE3 series software package is provided for programming open ECU for petrol mode operation of the engine.

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 TV1 engine up to 12 kg (i.e. 3.5 KW at all CRs)

Procedure for Compression ratio adjustment:

- Unload the engine completely, if it is in running condition.
- Slightly loosen 6 Allen bolts provided for clamping the tilting block.
- Loosen the lock nut on the adjuster and rotate the adjuster so that the compression ratio is set to "maximum". Refer the marking on the CR indicator.
- Lock the adjuster by the lock nut.
- Tighten all the 6 Allen bolts.
- You may measure and note the centre distance between two pivot pins of the CR indicator. After changing the compression ratio the difference (Δx) can be used to know new CR.

Diesel to Petrol mode:

A. Removing Diesel Head:

- Disconnect the Battery connection positive and negative and put at safe position.
- Switch off and disconnect electric supply of engine panel
- Close the Fuel cock at the outlet of "Diesel tank".
- Keep Fuel cock on engine panel in "Tank" position. At fuel junction bracket, open the drain cock and collect the Diesel from fuel measuring unit and fuel line.
- Disconnect the low noise cable from combustion chamber Piezosensor.
- Disconnect the low noise cable from fuel line Piezosensor, mark it for identification.
- Remove Piezosensor from the engine head and keep it at secured and safe place.
- Disconnect the high pressure fuel pipe and overflow pipe connected to the injector. Connect these pipes to each other by inserting plastic pipe over high pressure metal pipe.
- Disconnect air duct pipe from engine head bend and remove CI bend.
- Remove exhaust connection from engine head
- Remove water outlet from engine head along-with water outlet temperature sensor.
- Loosen and remove 4 nuts which clamp engine head to the linear block. (Use 9/16 spanner)
- Remove push rods (2 nos.)

B. Fitting Petrol Head

- Adjust the compression ratio to 10:1 on petrol scale.
- Use new head packing. Apply thin grease layer to head packing before use.

Performance Parameter

Brake power – It indicates the available power at the output of engine to do work.Fig.6.1.1A shows variation of brake power with load for blends D100, D90E5B5, D80E10B10 and D80E15B5 at CR 16 and it is observed that brake power for the blend D80E15B5 is 0.70% more for load 15 kg compared to pure diesel (D100) due to higher percentage of ethanol which increases the oxygen contain in blend which lead to higher BP at same load and compression ratio

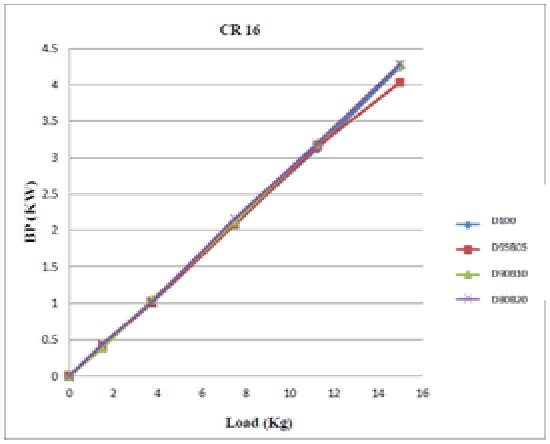


Figure 6.1.1A: Variation of BP with load at CR 16

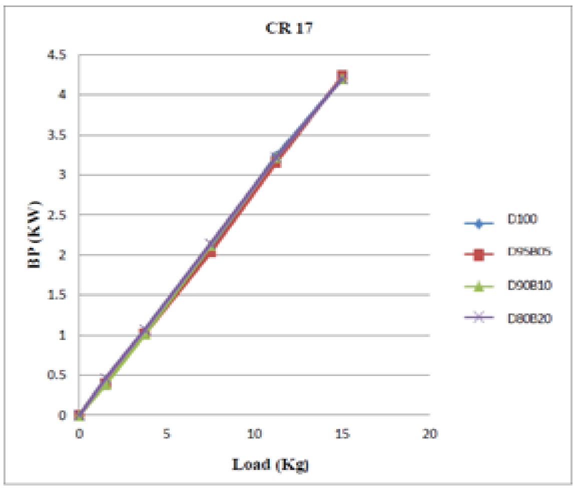


Figure 6.1.1B: Variation of BP with load at CR 16

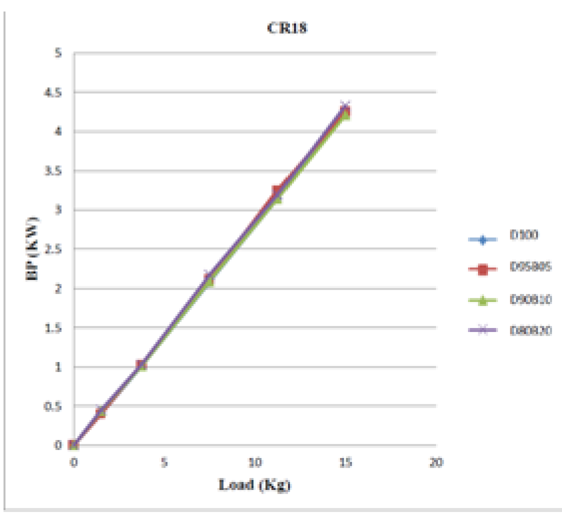


Figure 6.1.1C: Variation of BP with load at CR 16

Fig. 6.1.1B and Fig. 6.1.1C shows variation of brake power with load for blends D100, D90E5B5, D80E10B10 and D80E15B5 at CR 17 and 18 respectively. It is observed that there is no drastic change in brake power for the blends D90E5B5, D80E10B10, D80E15B5 when compared with pure diesel (D100) at same load for CR-17, But brake power is increased by 1.643% for the blend D80E15B5 when compared with pure diesel at load 15.

Brake specific Fuel Consumption –

Brake specific fuel consumption (BSEC) is defined amount of fuel required to develop 1 kW power per hour (kg/kWh). The Figure 6.1.2A shows the variation of BFSC with load. It is observed that at low load bsfc for blend D80E10B10 is 4.10% more compared to pure diesel ,but at higher load bsfc for blend D80E15B5 decreases by 14.38% compared to pure diesel at compression ratio 16.

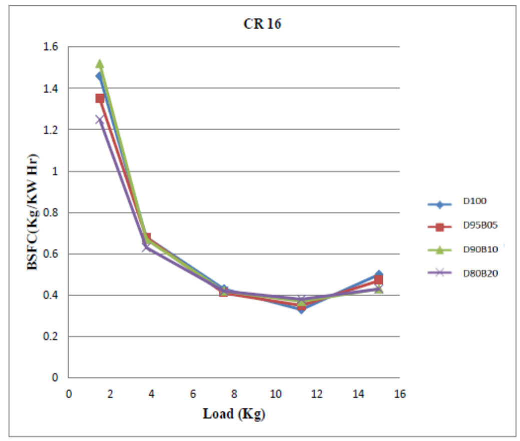
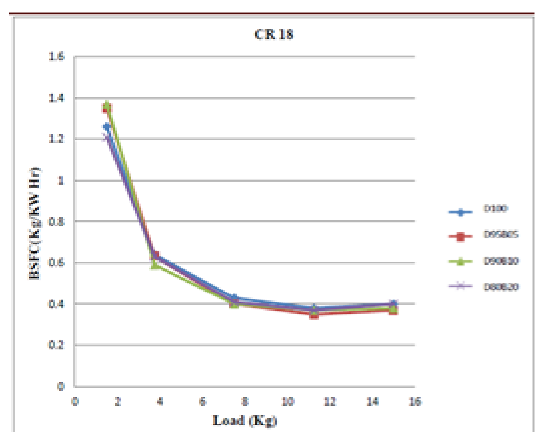
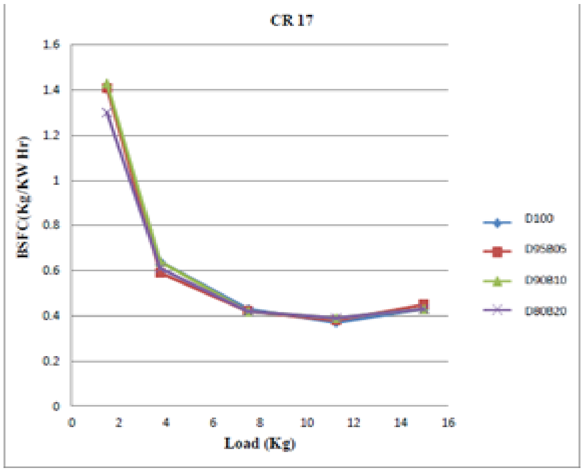


Figure 6.1.2A:Brake specific Fuel Consumption Vs load at CR-16

Fig . 6.1.2B and Fig 6.1.2C. shows varation of bsfc with load .It is observed that at low load for blend D80E15B5 the bsfc is lower than pure diesel by 16.27% for CR-17 but at CR-18 there is very less variation of bsfc for blended fuel compared to pure diesel.





IV. CONCLUSION

Part I: Performance analysis of ternary blends:

Following conclusions are made on practical study of ternary blends**.**

- Brake power for the blend D80B20 is 0.70% ,1.643% more for load 15 kg compared to pure diesel (D100) due to higher percentage of ethanol which increases the oxygen contain in blend which lead to higher BP at same load and compression ratio 16 and 18 respectively.
- BSFC for blend D80B20 decreased by 14.38%, 16.27% for compression ratio 16 and 17 compared to pure diesel at higher load.
- Volumetric Efficiency is at high at low load but as load increases the volumetric efficiency goes on decreasing for all blended fuel at CR 16, 17 and 18 respectively.
- Brake thermal efficiency of all blended fuels goes on increasing with increase in load compared to pure diesel.

Part II: Emission analysis of ternary blends:

Following conclusions are made on practical study of ternary blend.

- CO emission are decreased by 22.15%, 35.38% and 35.69% for blends of D95B5, D90B10 and D8020 respectively for CR-16. Also it is observed that for CR-17 CO emission are decreased by 2.19%, 2.63% and 13.15% for blends of D95B5, D90B10 and D8020 respectively compared to pure diesel.
- HC emission are decreased by 9.45%,9.45% and 14.86% for blends D95B5, D90B10 and D8020 respectively compared to pure diesel at CR-16.
- NOx emission decreased for CR-17 and CR-18. But for CR-16 the NOx emission increased with increase in load.
- Smoke emission are decreased by 22.44%,54.57% and 51.52% for blends D95B5, D90B10 and D8020 respectively compared to pure diesel at CR-16.
- CO2 emission decreased with increase in load by 3.44%, 9.19% and 5.74% for blends D95B5, D90B10 and D8020 respectively at CR-16. Also for CR-17 and CR-18 there is decrease in CO2 emission with increase in load.
- Biodiesel blends have more heat release rate than mineral diesel at CR18. Diesel fuel shows lowest heat release rate initially and longer duration.
- Peak pressure increases with increase in loads for all fuels and at all compression ratios. Blends have more peak pressure than neat diesel and at higher compression ratio and it decreases as the biodiesel percentage decreases.
- A practical conclusion can be drawn that all tested fuel blends can be used safely without any modification in engine. So blends of methyl esters of Jatropha oil could be used successfully.
- On the whole it is concluded that Jatropha oil can be used as fuel in diesel engine directly and by blending it with diesel fuel. Use of Jatropha oil can give better performance and reduced smoke emissions.

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