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PROPERTIES AND PERFORMANCE OF E-BIODIESEL WITH CETANE IMPROVER ON VARIABLE COMPRESSION RATIO ENGINE

Pratapsinh S. Chougule1, Dr.R.M.Warkhedkar2.
1ME Student-Heat Power Engineering, Govt. College of Engg., Karad, India
2Department of Mechanical Engineering, Govt. College of Engg., Karad, India.

Abstract

In the transport sector, a Major source of energy is from diesel engine. Karanja oils have a great potential to be alternative fuel for diesel engines. Use of non edible oil is helpful for food security. Blend of biodiesel, ethanol and diesel fuel improve some properties compared with biodiesel diesel blends and ethanol biodiesel blends. Addition of ethanol (CN-6 to 8) lowers cetane number of blend with the addition of cetane improver it can be overcome. This paper consist of investigation of properties of karanja biodiesel, karanja biodiesel with 15% ethanol and cetane improver(3ml) and karanja biodiesel with 20% ethanol and cetane improver (3ml). Also the performance of these blends investigated with the help of variable compression ratio engine taking 15,16,17,18 as a compression ratio. Addition of cetane improver (2-EHN), lower ignition delay and improve combustion quality. The effect of these blends on Brake Specific Fuel Consumption (BSFC), Brake Thermal Efficiency (BTE), Indicated Thermal Efficiency (ITE), Volumetric Efficiency, Mechanical Efficiency, Exhaust Gas Temperature (EGT) is Studied. From experimental result it is found that additional lubricity gives better output with minimum frictional loss as compared with conventional diesel. Cetane improver which gives better combustion characteristics reduces ignition delay and maximum amount of fuel burnt nearer to TDC and no fuel remain for the after combustion stage or exhaust pipe combustion. Lower heating value give less heat generation which causes lower exhaust gas temperature.

Introduction

Fossil fuel demand increases worldwide on the other hand fast depletion of the reserve of fossil fuel influences to overcome this, researcher around the world highly concentrate their attention towards biodiesel production. In the transport sector, a Major source of energy is from diesel engine. Diesel engines are predominantly used in locomotives, large trucks and for marine propulsion. Owing to their higher thermal efficiency and lower fuel consumption, they have become increasingly attractive for smaller trucks and passenger cars also. But higher NO_x (oxides of Nitrogen) emissions from diesel engine remain a major problem in the pollution aspect [7]. Vegetable oils have a great potential to be alternative fuel for diesel engines [2]. However using raw vegetable oils for diesel engine can cause numerous engine related problems. The higher viscosity and lower volatility of vegetable oil compared with diesel lead to serve engine deposits, injector choking and piston ring sticking. However these effects can be reduced or eliminated through Transesterification of vegetable oil to form an ester.

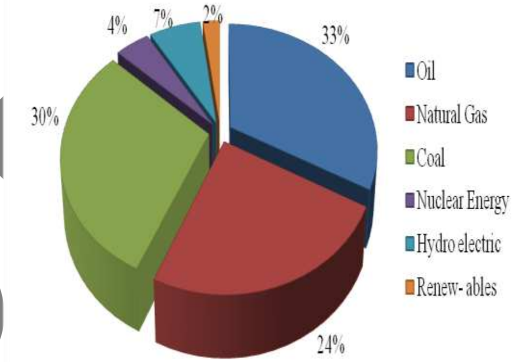

Fig.1 World primary energy production in 2014 by Source [1]

The process of transesterification moves glycerine from the triglycerides and replaces it with radicals from the alcohol used for the conversion process. The term biodiesel commonly refers to fatty acid methyl or ethyl esters made from vegetable oils or animal fats, whose properties are good enough to be used in diesel engines. Karanja biodiesel blend showed reduction in carbon monoxides (CO), Total Hydrocarbons (THC) and particulate emissions however slight increase in NO_x emissions in an unmodified transportation engine. One Prospective method to reduce NOx and smoke simultaneously in normal diesel engines is to use oxygenated fuels to provide more oxygen during combustion. Blend of biodiesel, ethanol and diesel fuel may improve some properties compared with biodiesel diesel blends and ethanol biodiesel blends [8]. The change in oxygen concentration causes change in the structure of the flame and hence changes the duration of combustion. It is suggested that flame temperature reduction is the most important factor influencing NO_x formation [6]. Ethanol having cetane number 6-8, with the addition of more concentration of ethanol results decrease in cetane number of blend. Lower cetane number increases ignition delay it results in higher Hydrocarbons (HC) and NO_x emissions [7].

Biodiesel Preparation Method:

Transesterification [2][3][5]

Although blending of oils and other solvents and micro emulsions of vegetable oils lowers the viscosity, engine performance problems such as carbon deposit and lubricating oil contamination still exist. Pyrolysis produces more biogas line than biodiesel fuel. Transesterification is by far the most common method for the production of biodiesel. As the name suggests it is the conversion of one ester into other. When the original ester is reacted with an alcohol, the transesterification process is called alcoholysis. The transesterification is an equilibrium reaction and the transformation occurs essentially by mixing the reactants. However, the presence of a catalyst (typically a strong acid or base) accelerates considerably the adjustment of the equilibrium. In order to achieve a high yield of the ester, the alcohol has to be used in excess.

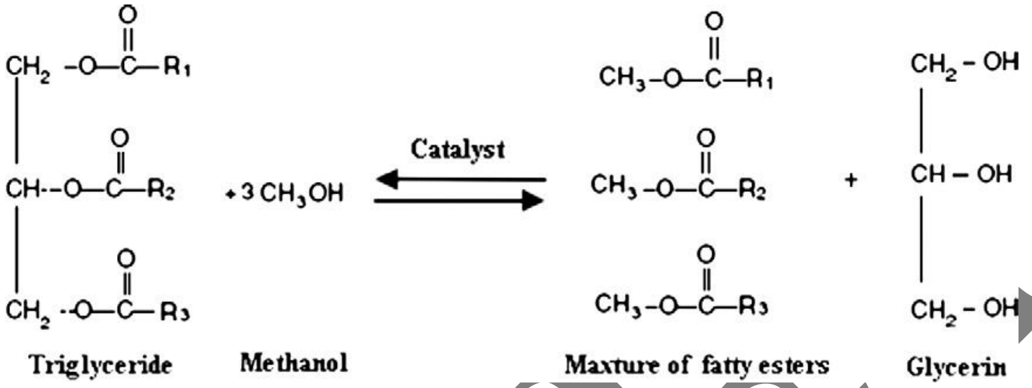

Fig. 2 The transesterification reaction

. R is a mixture of various fatty acid chains. The alcohol used for producing biodiesel is usually methanol (R′ = CH_3). **[2]**

Generally, transesterification can proceed by base or acid catalysis. However, in homogeneous catalysis, alkali catalysis (sodium or potassium hydroxide; or the corresponding alkoxides) is a much more rapid process than acid catalysis.

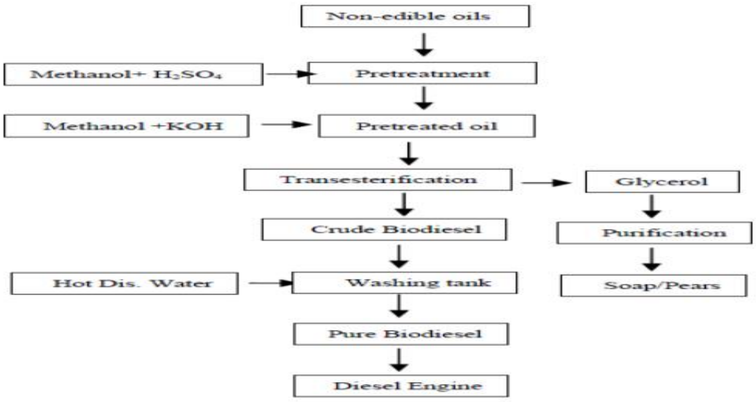

Fig.3 Flow chart of Biodiesel production from non-edible oils [35]

Fatty Acid	Molecular formula	Percentage	Structure
Palmitic acid	$C_{16}H_{32}O_2$	11.65	$CH_3(CH_2)_{14}C00H$
Stearic acid	$C_{18}H_{36}O_2$	7.5	$CH_3(CH_2)_{16}COOH$
Oleic acid	$C_{18}H_{34}O_2$	51.59	$CH_3(CH_2)_{14}(CH=CH)COOH$
Linoleic acid	$C_{18}H_{32}O_2$	16.64	$CH_3(CH_2)_{12}(CH=CH)_2COOH$
Eicosanoic acid	$C_{20}H_{40}O_2$	1.35	$CH_3(CH_2)_{18}COOH$
Dosocasnoic acid	$C_{22}H_{44}O_2$	4.45	$CH_3(CH_2)_{20}COOH$
Tetracosanoic acid	$C_{24}H_{48}O_2$	1.09	$CH_3(CH_2)_{22}COOH$
Residual		6.83	

Table.1 fatty acid composition of karanja oil [34].

Properties of biodiesel

1. Karanja Biodiesel blends with Ethanol 15% and 20%

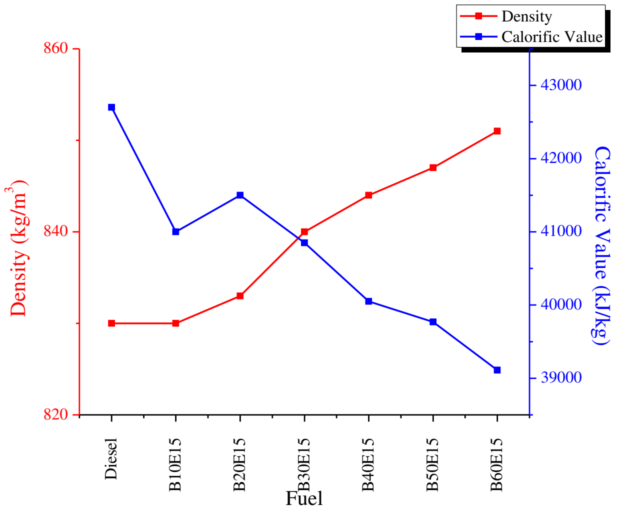

Fig.4 Variation of density and calorific value with increasing concentration of biodiesel (ethanol 15%)

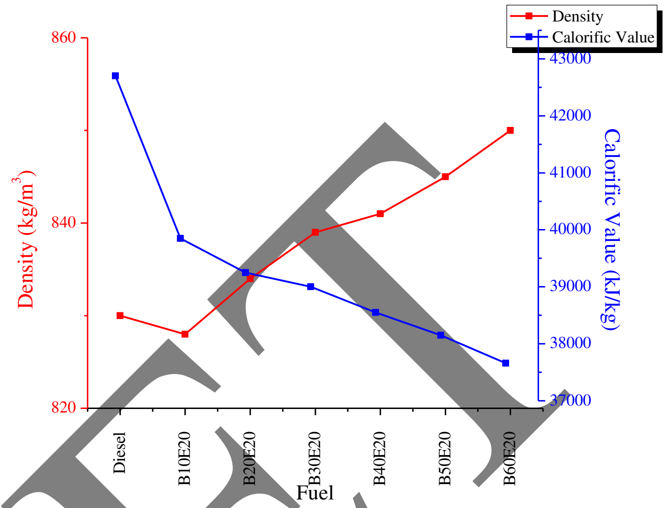

Fig.5 Variation of density and calorific value with increasing concentration of biodiesel (ethanol 20%)

2. Karanja Biodiesel Blends

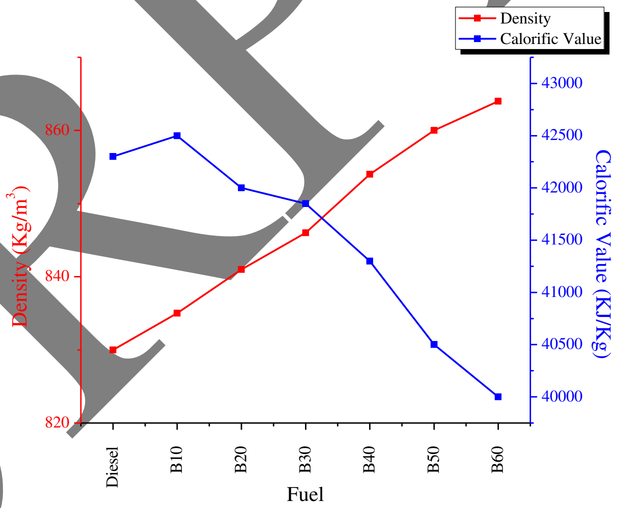

Fig.6 Variation of density and calorific value with increasing concentration of biodiesel

Experimental Methodology

The standard available engines (with fixed compression ratio) can be modified 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 change is combustion geometry. With this method the compression ratio can be changed within designed range without stopping the engine.

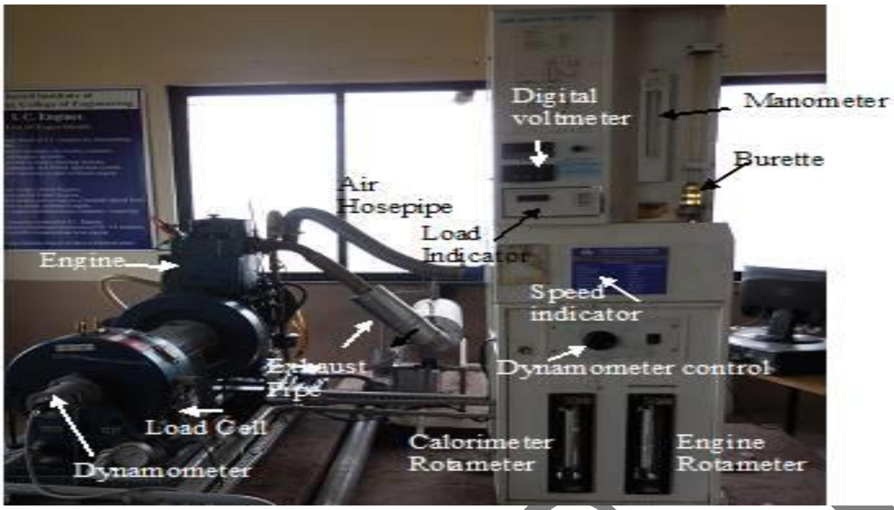

Photo:1 Experimental Setup

The tilting cylinder block arrangement consists of a tilting block with six Allen bolts, a compression ratio adjuster with lock nut and compression ratio indicator. For setting a chosen compression ratio, the Allen bolts are to be slightly loosened. Then, the lock nut on the adjuster is to be loosened and the adjuster is to be rotated to set a chosen compression ratio by referring to the compression ratio indicator and to be locked using lock nut. Finally all the Allen bolts are to be tightened gently. The compression ratios considered for conducting the experiments are 15, 16, 17, and 18.

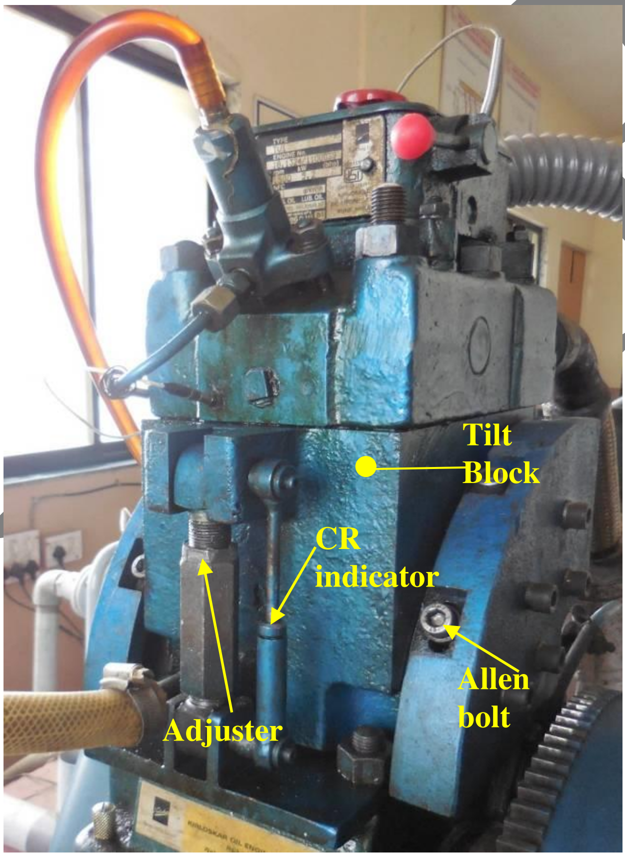

Photo 2. Arrangement for change in compression ratio.

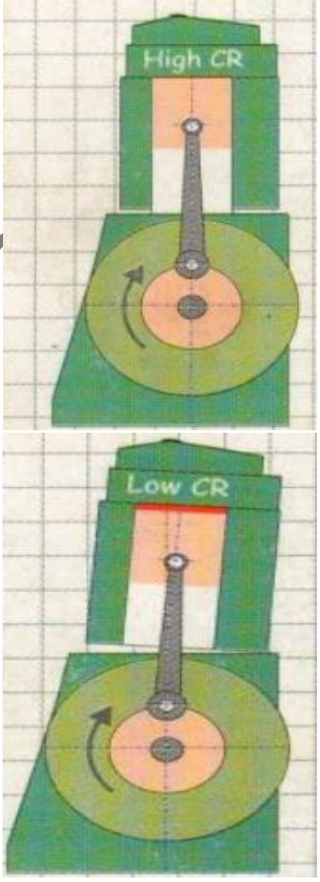

Fig.7 Principle of tilting block assembly

Result and Discussion

1. Brake Specific Fuel Consumption (BSFC)

Brake specific fuel consumption (BSFC) is the amount fuel energy consumed per unit of brake power developed per hour. It is inversely proportional to thermal efficiencies.

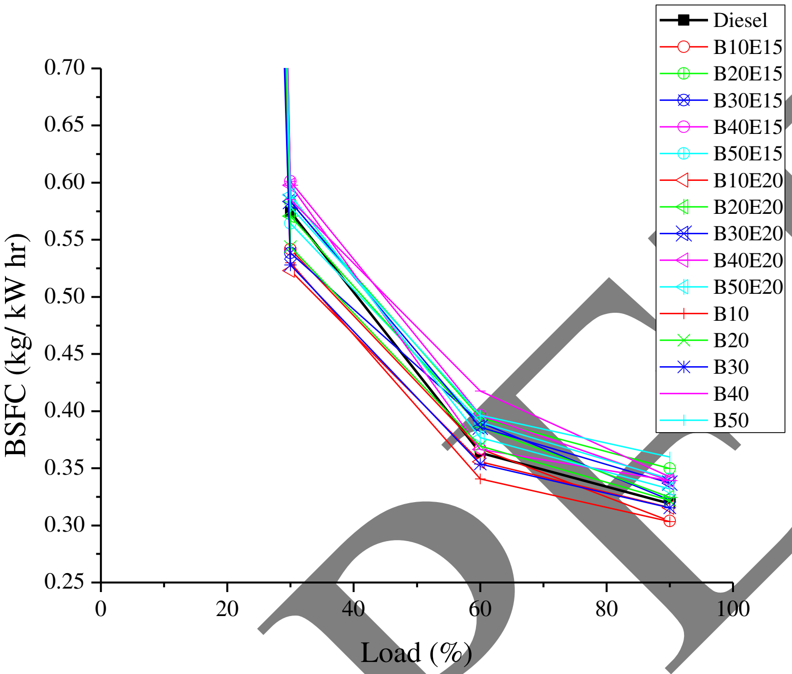

Fig.8 Graph showing BSFC Vs Load at compression ratio 18

Graph shows BSFC increases with increase in load. At lower load BSFC decreases for B10E15, B30E15, B10E20, B10, B20, B30 but form 60% above load it increases expect B10E15 with respect to Diesel. All remaining fuel shows increased BSFC at all load conditions. Maximum BSFC increase of 9% with B40E20 blend. Fig.10 and Fig.11 shows, all blends have high BSFC for all load condition at lower compression ratio. It is because of the increased clearance volume and lower pressure and temperature range.

Lower heating value of the blends is the main reason behind increased BSFC. To compensate lower heating value fuel consumption increases which gives higher BSFC. For higher compression ratio, high pressure and temperature generated inside the cylinder causes ignition advance and by which it shows some % decrease in BSFC at 60% load condition for some blends. B10E15 blend having less density than diesel it may helpful for spray formation and effective combustion, which result in decrease in BSFC at full load condition in compression ratio 18.

2. Brake Thermal Efficiency (BTE)

BTE increases with increase in load. Fig.12 shows E15% blends has higher efficiency below 50% load. B10E15 blend shows higher BTE at full load condition. Whereas all blends of biodiesel with E20 shows increase in BTE. Maximum 7.78 % and 8 % increase in BTE for E15 & E20 biodiesel blends respectively. The increased BTE because of the decrease in friction loss.

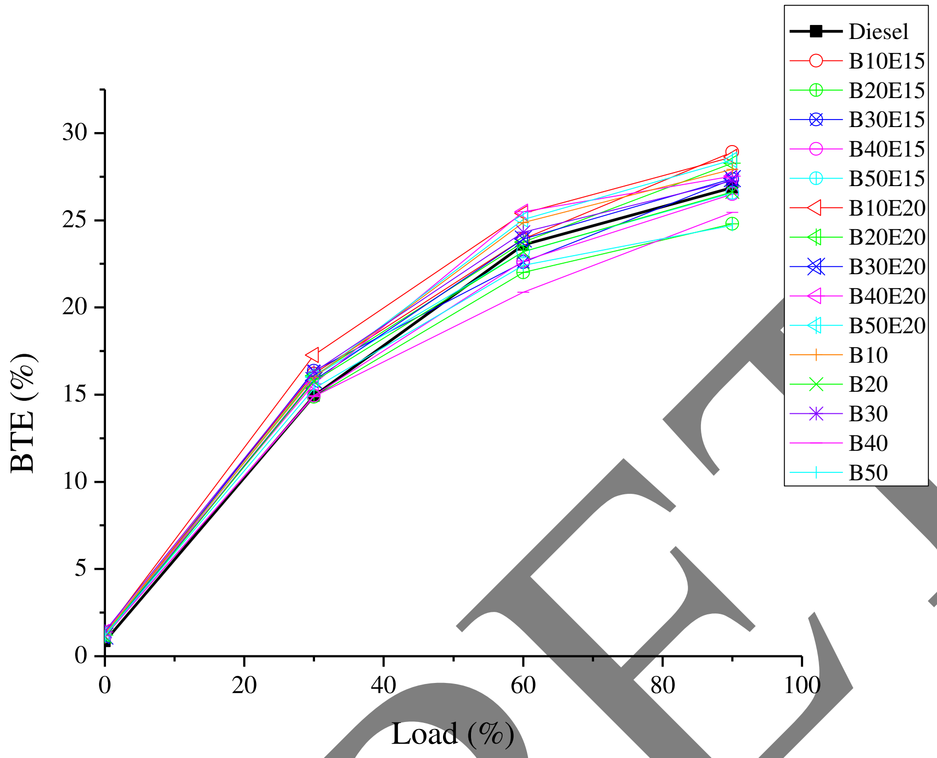

Fig.12 Graph showing BTE Vs Load at compression ratio18

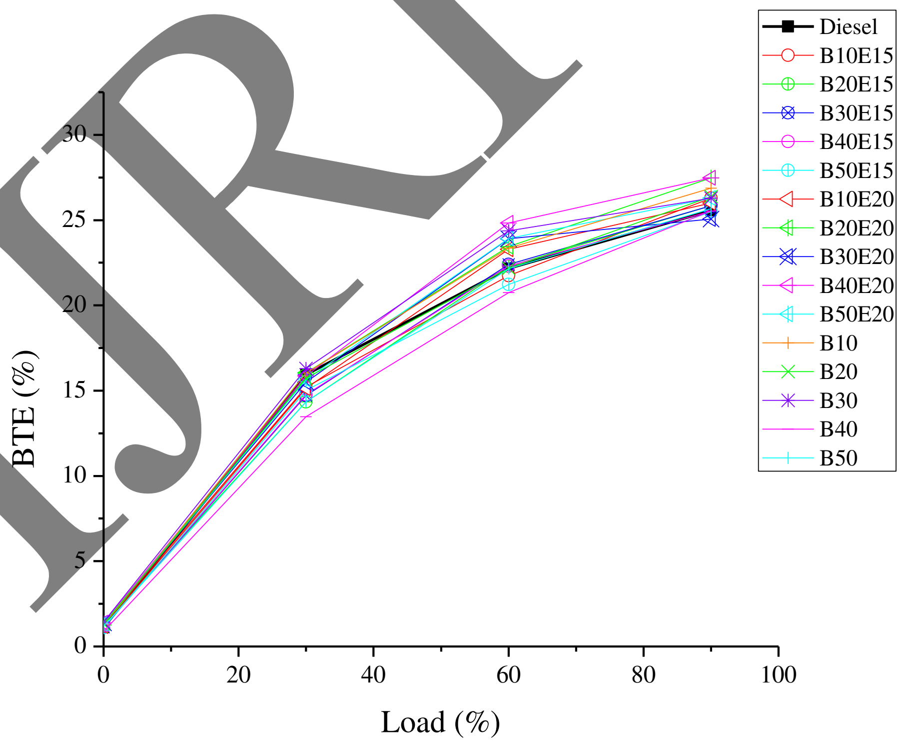

Fig.13 Graph showing BTE Vs Load at compression ratio17

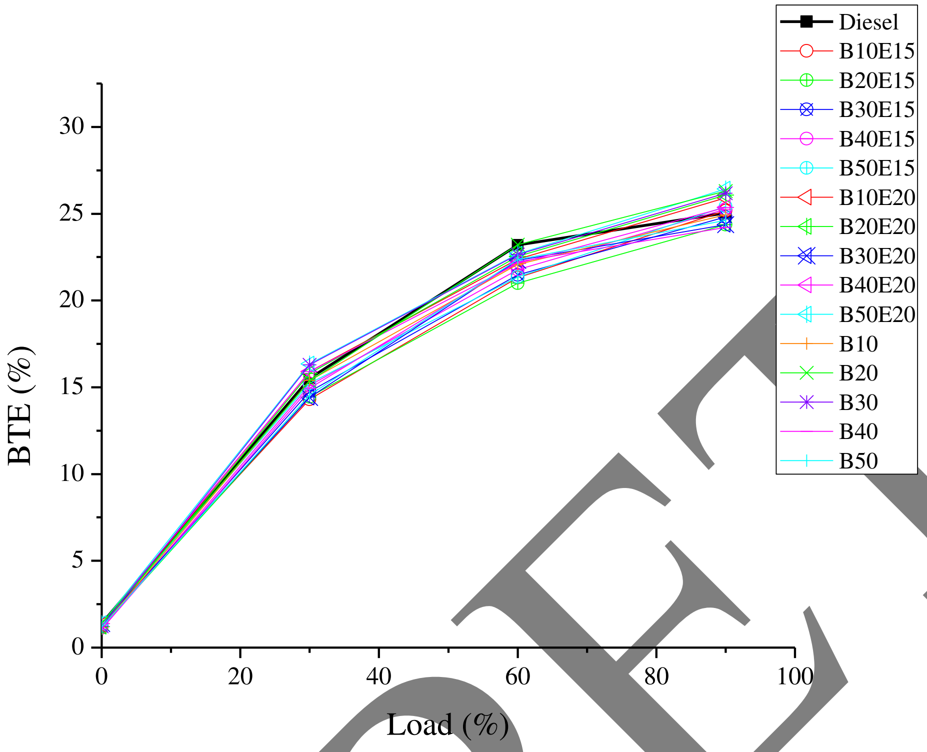

Fig.14 Graph showing BTE Vs Load at compression ratio16

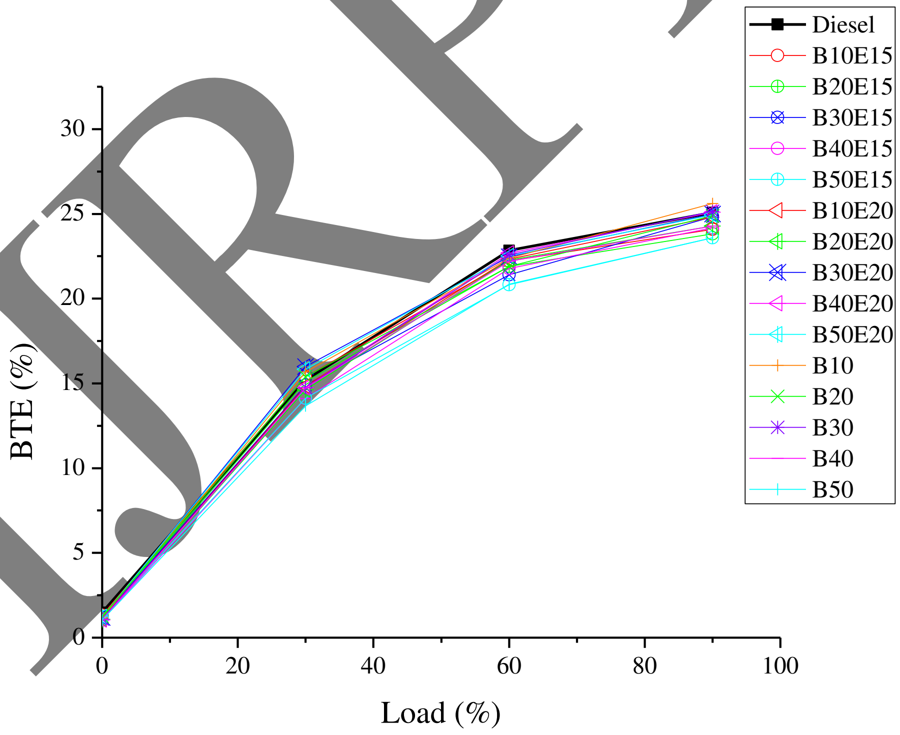

Fig.15 Graph showing BTE Vs Load at compression ratio15

Fig.13 shows E-15% blends decreased BTE at lower load and nearly same on full load condition.E-20 blends have increased BTE after 50% load. B40E20 and B20E20 blend shows higher BTE. Additional lubricity causes decrease in frictional power.

Fig.14 shows all blends have decrease in BTE at all load conditions as compared with conventional diesel fuel. Maximum decease in BTE obtained at 60% load.

Fig.15 shows deceased BTE for all blends at all load conditions. This is because of lower heating value and inferior combustion.

The reason behind increased BTE is may be because of higher lubricity and more complete combustion for E20 biodiesel blends.

3. Indicated Thermal Efficiency (ITE)

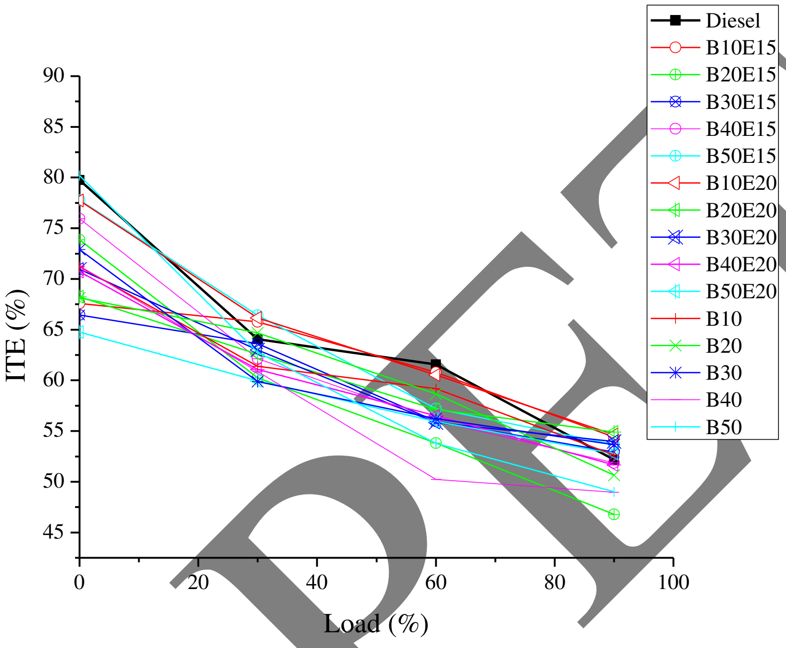

Fig.16 Graph showing ITE Vs Load at compression ratio18

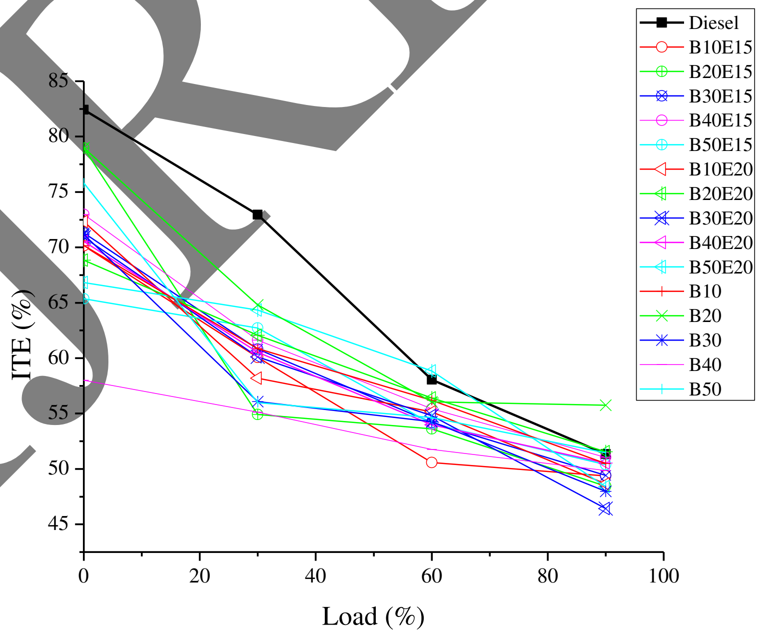

Fig.17 Graph showing ITE Vs Load at compression ratio 17

Fig.16 and 17 shows reduced indicated thermal efficiency maximum for E15 and E20 blends

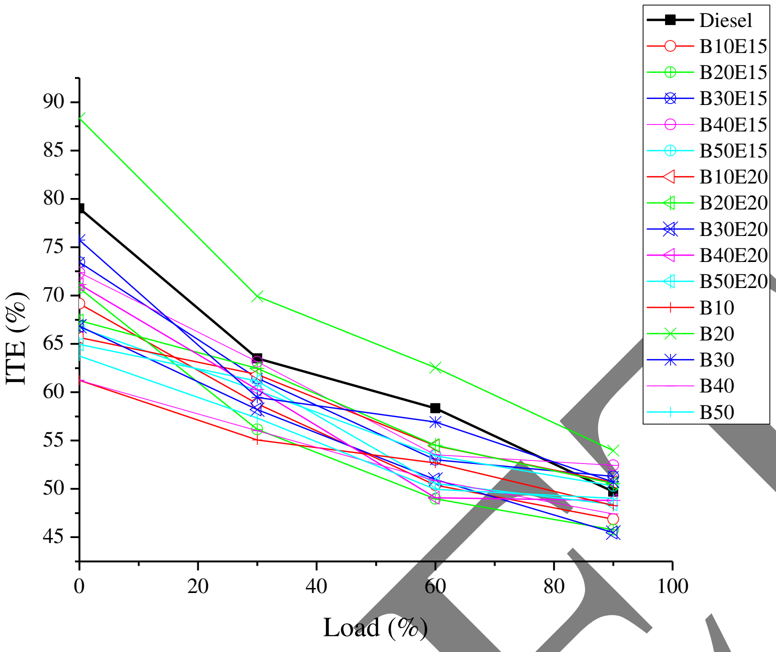

Fig.18 Graph showing ITE Vs Load at compression ratio 16

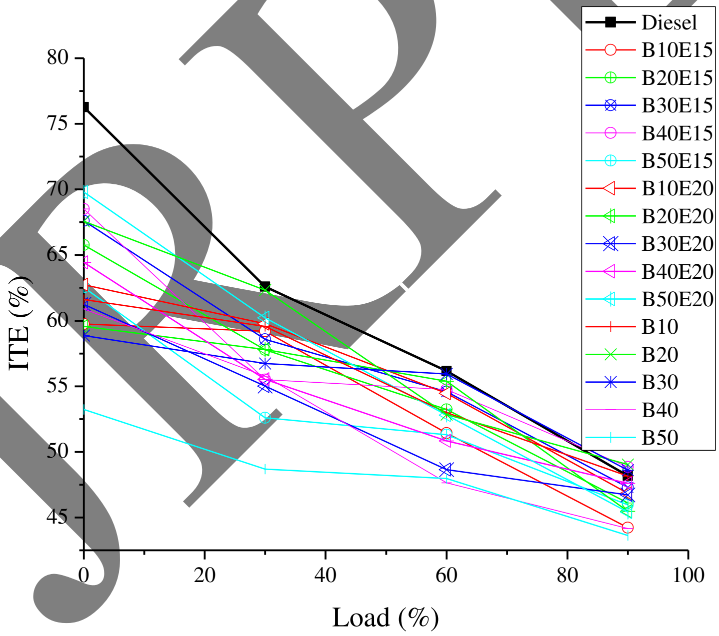

Fig.19 Graph showing ITE Vs Load at compression ratio 15

From above all graphs of ITE it is clear that ITE decrease for all biodiesel blends. Reason for that is high fuel consumption and lower heating value.

4. Volumetric Efficiency (η_{vol})

Volumetric efficiency is the breathing capacity of the engine.

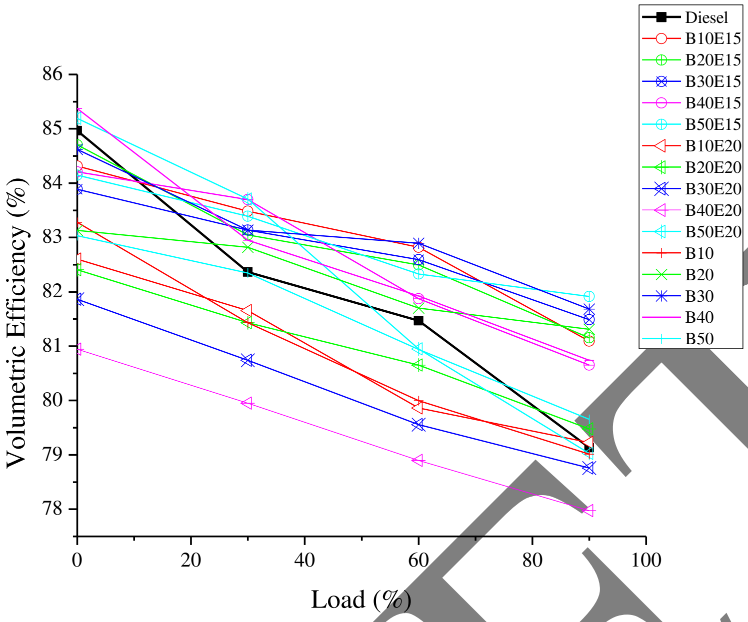

Fig.21 Graph showing Volumetric Efficiency Vs Load at compression ratio 18

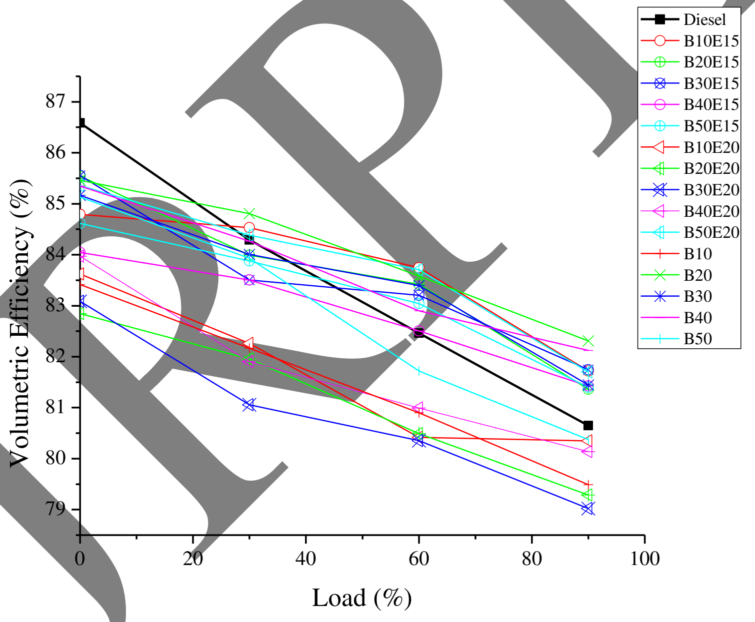

Fig.22 Graph showing Volumetric Efficiency Vs Load at compression ratio 17

Volumetric efficiency decreases with increase in load. Fig.21 and 22 shows less volumetric efficiency for all E20 biodiesel blends where as it is increased for the all other biodiesel blends.

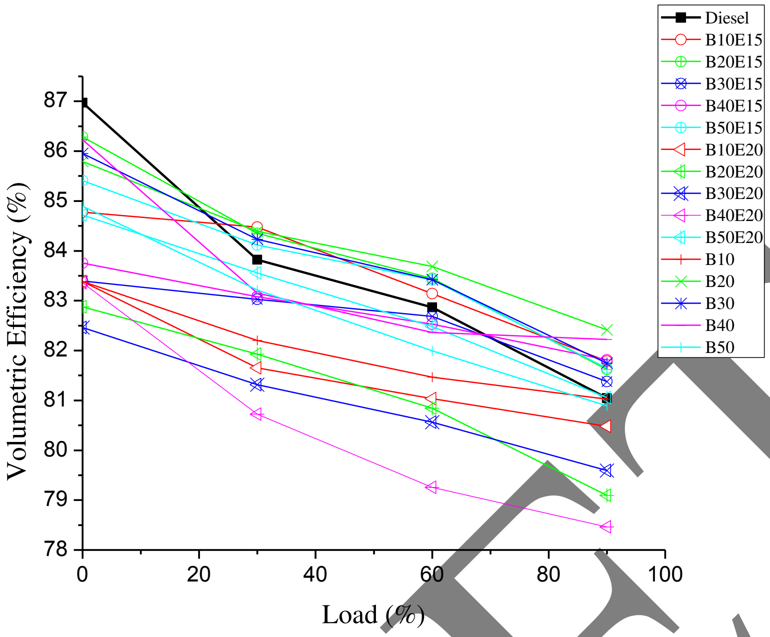

Fig.23 Graph showing Volumetric Efficiency Vs Load at compression ratio 16

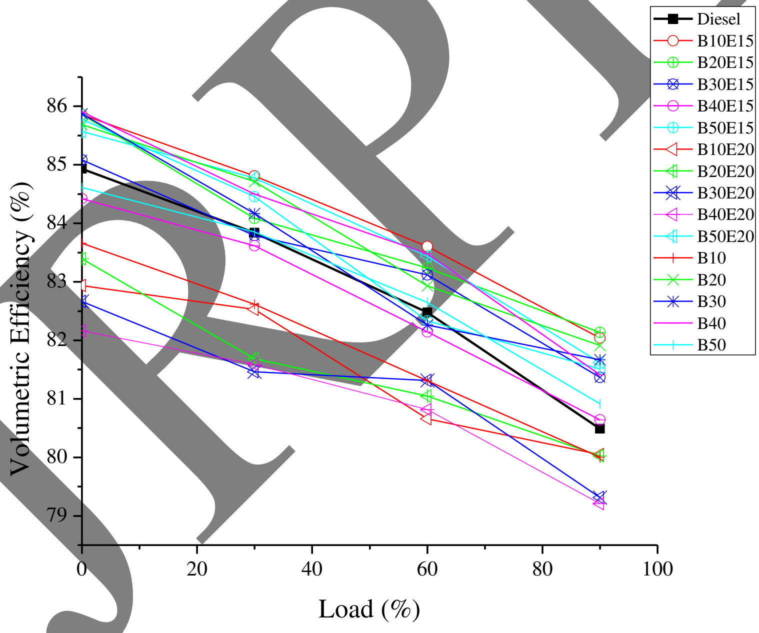

Fig.24 Graph showing Volumetric Efficiency Vs Load at compression ratio 15

All graphs of volumetric efficiency shows decreased for E20 biodiesel blends. This is mainly due to the oxygen contained in the fuel. Ethanol helps combustion process and reduces need of air from the atmosphere.

5. Mechanical Efficiency (η_{mech})

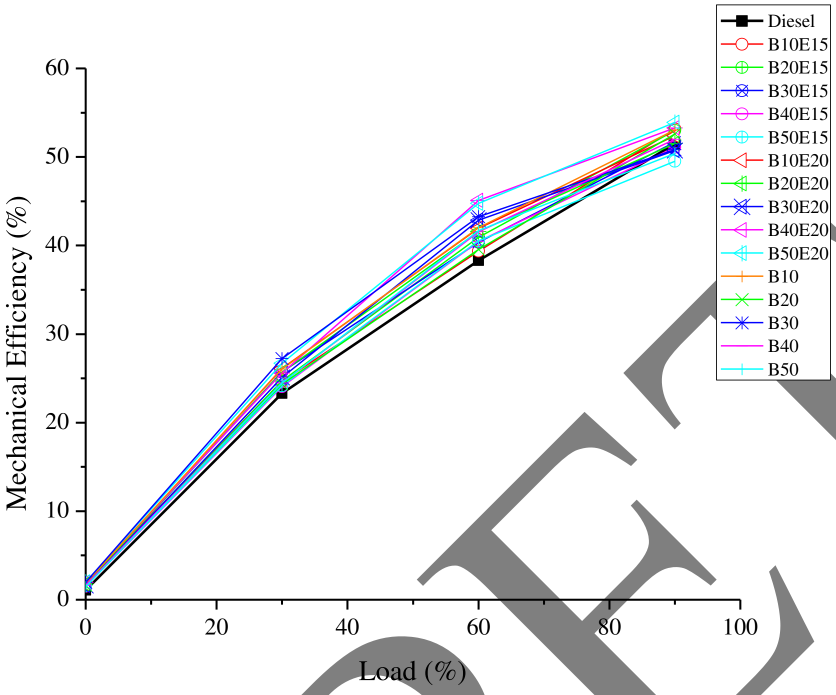

Fig.25 Graph showing Mechanical Efficiency Vs Load at compression ratio18

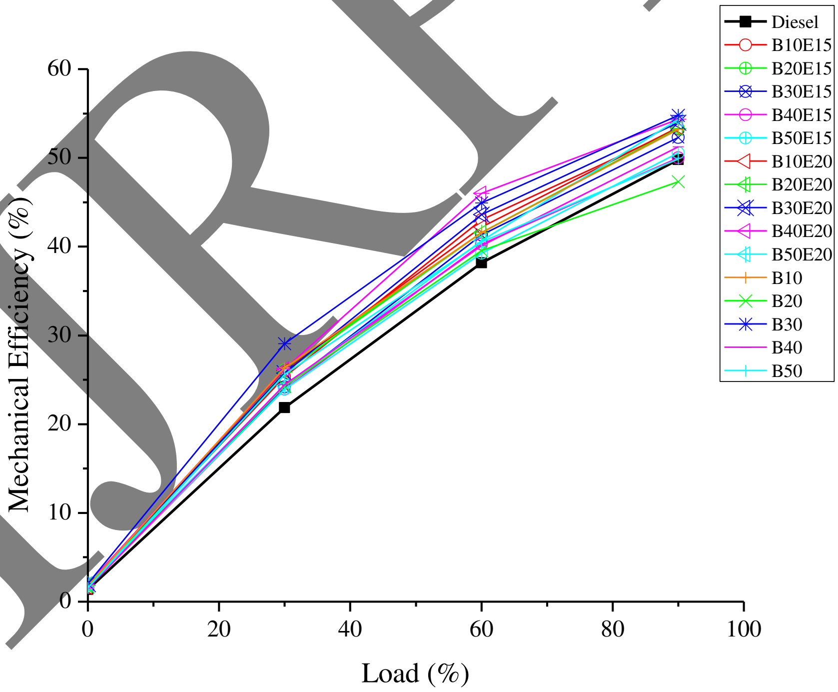

Fig.26 Graph showing Mechanical Efficiency Vs Load at compression ratio17

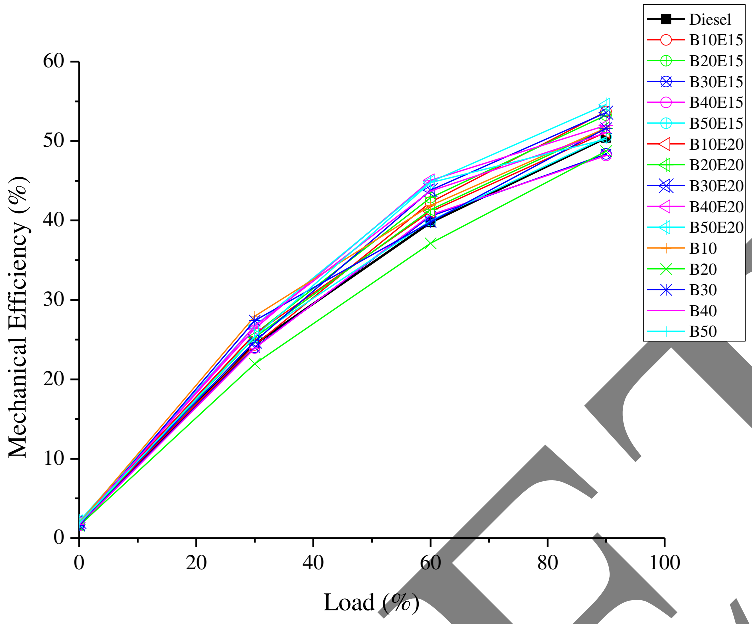

Fig.27 Graph showing Mechanical Efficiency Vs Load at compression ratio16

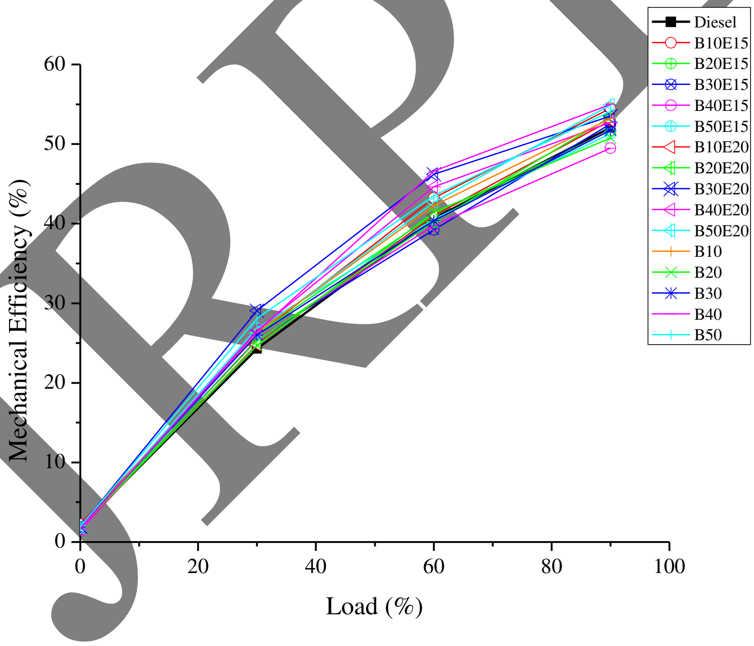

Fig.28 Graph showing Mechanical Efficiency Vs Load at compression ratio 15

All graphs of mechanical efficiency shows increase for all blends of biodiesel. This may be because of the additional lubricity which helps to reduce frictional power. Also addition of cetane improver decreases ignition delay period and improve combustion characteristics.

6. Exhaust Gas Temperature (EGT)

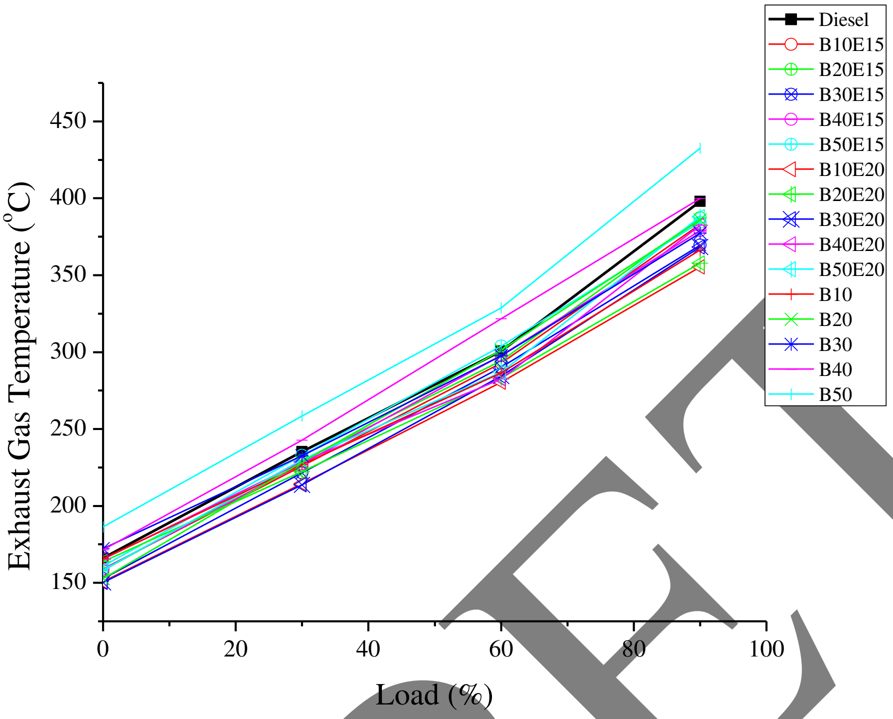

Fig.29 Graph showing EGT Vs Load at compression ratio 18

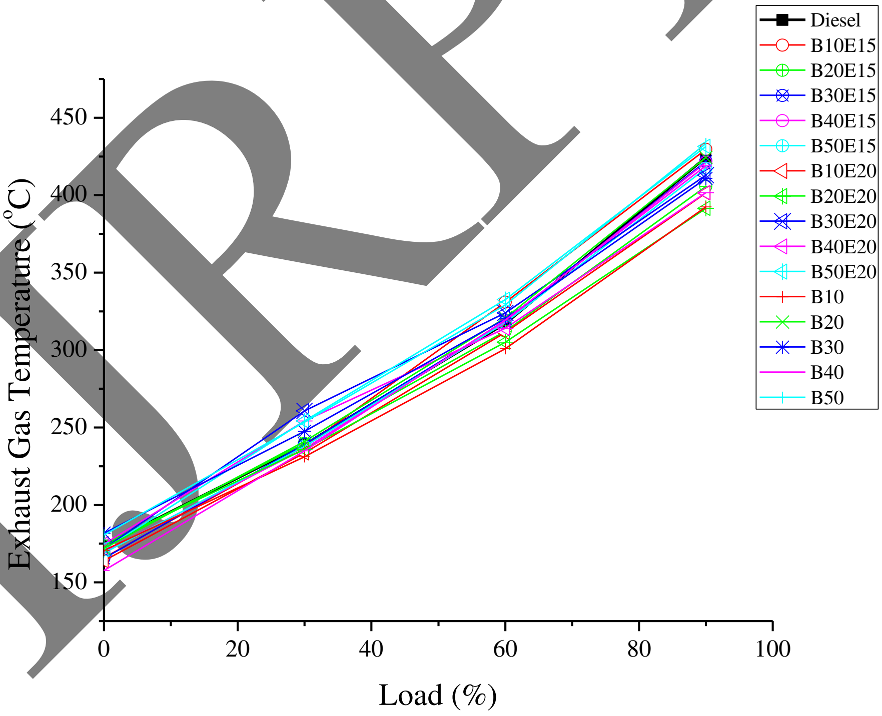

Fig.30 Graph showing EGT Vs Load at compression ratio 17

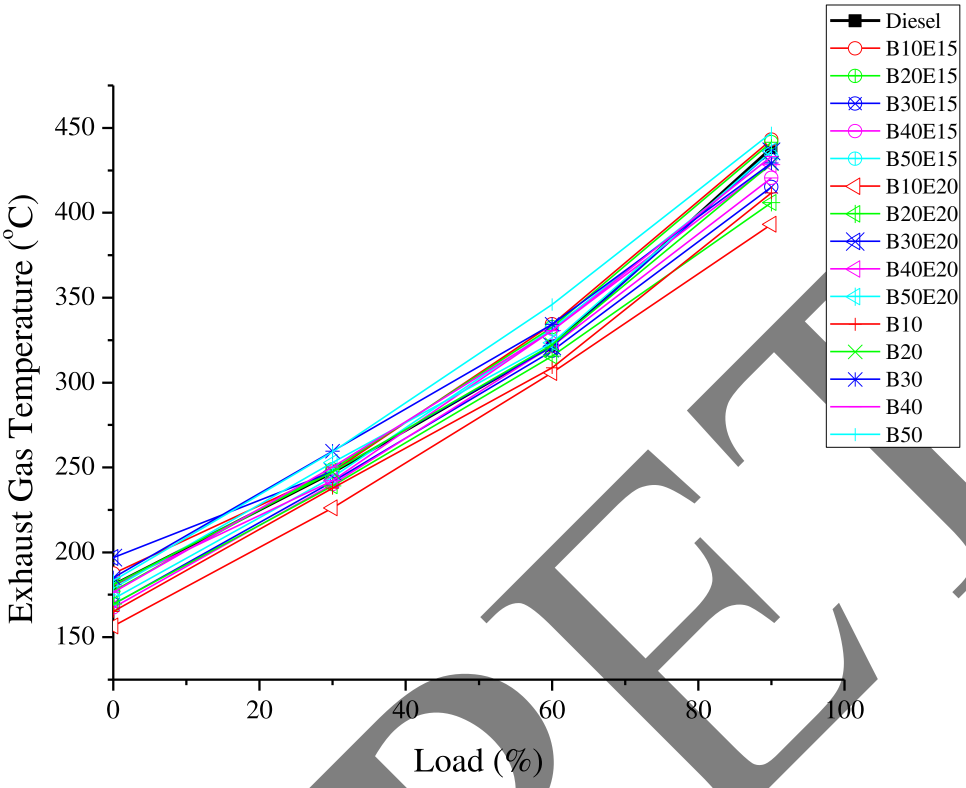

Fig.31 Graph showing EGT Vs Load at compression ratio 16

Fig.29 shows all blends of E15 and E20 biodiesel shows decrease in EGT. B30E15 blend show maximum decreased EGT compared with diesel.

Fig.30 and 31 shows almost all blends of biodiesel show nearly same EGT as compared with diesel fuel. B50E20 blend have higher EGT at compression ratio 17.

Difference in exhaust gas temperature of conventional diesel and biodiesel is about 20-30°C

The addition of 2-EHN i.e. cetane improvers reduces the ignition delay which is responsible for reduction of combustion temperatures also reduce the chance of burning extended to exhaust pipe.

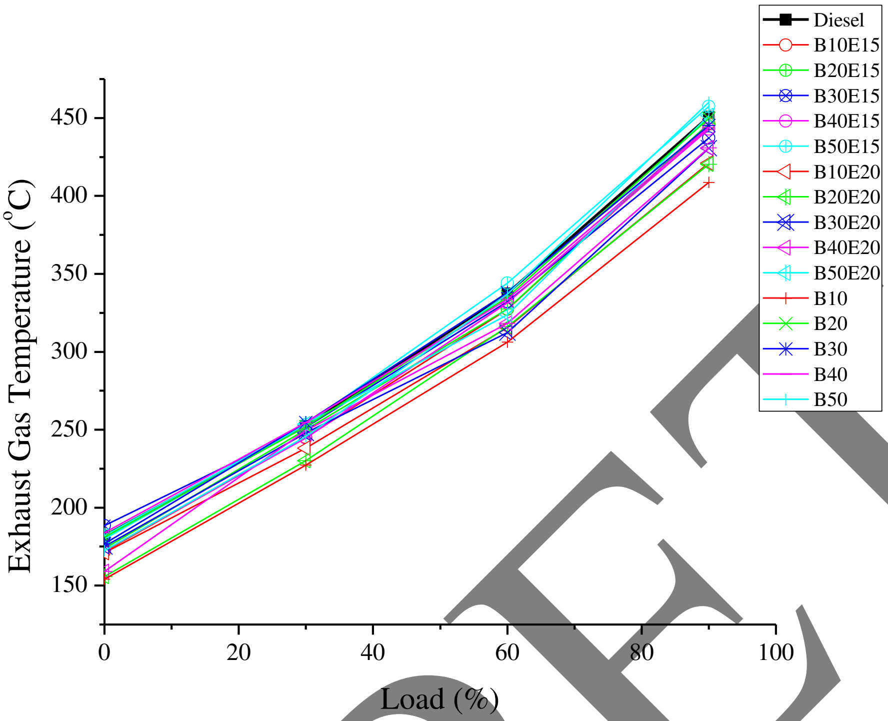

Fig.32 Graph showing EGT Vs Load at compression ratio 15

Conclusion

I. **Properties of Biodiesel Blends**-Increasing concentration of biodiesel in base diesel, increases density and on the other hand decreases heating value.

II. **Brake specific fuel consumption**- Increased fuel density causes higher brake specific fuel consumption. Higher fuel density gives poor spray formation and combustion characteristics.

III. **Brake thermal efficiency**- Additional lubricity given by the biodiesel blends decreases frictional losses, increases brake thermal efficiency up to 25%. On the other hand lower heating value and inferior combustion combinedly gives lower brake thermal efficiency for higher concentration.

IV. **Indicated thermal efficiency**- Lower heating value form less heat inside the combustion chamber gives less indicated power.

V. **Mechanical efficiency**- Addition of cetane improver sometimes called as ignition enhancer reduces ignition delay period and improve combustion quality. Also additional lubricity gives better output with minimum frictional loss as compared with conventional diesel.

VI. **Exhaust gas temperature**-Cetane improver which gives better combustion characteristics reduces ignition delay and maximum amount of fuel burnt nearer to TDC and no fuel remain for the after combustion stage or exhaust pipe combustion. Lower heating value give lower heat generation which causes lower exhaust gas emissions

VII. For CR 15- B10E15, B20E15 gives better performance with respect to BTE, η_{Mech}.

VIII. For CR 16- B20E20 and B10E15 gives better performance with respect to BTE, η_{Mech}.

IX. For CR 17- B10E15, B30E15, B10E20 gives better performance with respect to BTE, η_{Mech}.

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