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Experimental Investigation of single cylinder diesel engine operated on eucalyptus oil and cotton seed oil as biodiesel.

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Abstract

Biodiesel has obtained from vegetable oils that have been considered as gifted Non-conventional fuel. The researches regarding blend of diesel and single biodiesel have been done already. Very few works have been done with the combining of two different biodiesel blends with diesel and left a lot of scope in this area. The present study bring out an experiment of two bio-fuel from cotton seed oil and eucalyptus oil and they are blended with diesel at various mixing ratios B9%,B18%,B27%,B36%,B45%. The effect of duel biodiesel work in engine and exhaust emission were examined in a one, cylinder, 4- stroke multi fuel VCR engine at several loads with engine speed of 1500rpm. Result shows that hybrid blends of Cotton Seed Oil Methyl Ester(CSOME) and Eucalyptus Oil Methyl Ester biodiesel an its blends present significance improvement in of CO, unburned HC emission particularly at high loads with corresponding performance to those of bio-fuels, however NOx emission are marginally increases when the biodiesel compositions is improved. The word faces the disasters of energy demand, increasing petroleum prices and reduction of fossil fuel resources
Keywords— *Biodiesel, hybrid,Transterification, CSOME, EOME, performance,emission..*

1. Introduction

Constantly increasing fuel prise, constant increasing of on road vehicles, fast decreasing petroleum resources and continuing gathering greenhouse gases are the main recourses for the development of non-conventional fuels. Many non-conventional fuels are identified and tested successfully in the current engine with and without engine changes. Most of the substitute fuels identified today are bio-fuels and are having one or few objectionable fuel features which are not allowing them to replace the existing petro fuel completely. However, the various admission techniques experimented by the scholars are giving good solution to apply larger section of replacing fuel in the present engine. Biodiesel is may be a uncontaminated burning alternating fuel, made of domestic, renewable resources. It can be used in diesel Engines with little or no changes. Biodiesel is simple to use, decomposable, harmless, and basically free of sulphur and aromatics [1].
At present, India is manufacturing only 35% of the total gasoline fuels required. The residual 65% is being imported, which costs about Rs.80, 000 crores every year. It is an amazing fact that mixing of 10% bio-diesel and 20% fuel to the present diesel fuel is made available in our country, which can save about Rs.500 billion rupees every year. It is predictable that India can produce 390 metric tons of bio-fuel by the completion of 2017.The Government of India has launched a biodiesel project in 200 regions from 18 states in India. It has suggested two plant species, viz. Jatropha and Karanja for bio-diesel production. The current auto fuel strategy document states that bio-fuels are effective, sustainable and 100% natural energy unconventional to gasoline fuels [2]. Remodification technique is used to prepare biodiesel which is shows similar properties as diesel fuels [3]. Blends of Eucalyptus with diesel shows the brake thermal efficiency is improved about 6.2% for blend which has 60% of diesel and 40% of eucalyptus oil as compared to diesel fuel operations and 16.7%, 25% and 15.15% reduction of smoke, carbon Monoxide and Unburned hydrocarbons respectively as compared to Diesel fuel [4]. Kinematics viscosity of Cotton Seed Oil Methyl Ester (COME) is greater than those of diesel fuel the calorific value of COME lesser while its flash point is greater than diesel [5].C20 have closer performance to diesel. Also it is observed that CSOME gives better performance compared to Neem Oil Methyl Ester (NOME) and also the emissions for these diesel blends are fewer as relate to the pure diesel [6].The vegetable oils possesses almost the same heat values as that of diesel fuel. The power output and the fuel depletion of the vegetable oil and its mixture with diesel are almost the similar when the engine is powered with diesel [7]. Vegetable oils can be used as experimental fuel, which removes the use of petroleum diesel fuel [8]. The fuel consumption of rapeseed methyl ester was little higher than diesel fuel operation [9]. Most of the literatures suggested that cotton seed oil is a suitable substitute of diesel and a few research works have also been carried out with Eucalyptus oil. So, the Cotton seed oil and Eucalyptus oil were selected for this current study which is easily and locally available. As a first level of experimentation, the properties of above said fuels in various combinations were found out in this work. This proved that the

calorific value of the dual biodiesels and its combinations with diesel fuel is more than the single biodiesel and its blends with diesel fuel. Hence it is decided to select cotton seed oil and eucalyptus oil and diesel as the fuel for this current analysis. In the second level performance and emission features of a diesel engine with dual biodiesel and its blends and the results are compared with diesel.

2. Biodiesel preparation and its characteristics

A. Biodiesel preparation procedure

Vegetable oils are 3-glycerides of fatty acids and alcohol esters of fatty acids have been prepared by the transesterification of the glycerides, wherever in linear, monohydroxy alcohols reacts with the edible fats in the presence of catalyst to produce alcohol esters of vegetable oil. Transesterification is the process of cutting down heavier molecules into lighter ones in this process of preparing eucalyptus biodiesel ethyl ester was employed ethanol was used as alcohol in this process. In first stage pure eucalyptus oil was taken in a beaker the capacity was 500ml pure eucalyptus oil 100 ml ethanol and 5 grams of NaOH Flakes. The eucalyptus oil in the beaker was heated around 500^0C-600^0C in a burner the oil was stirred thoroughly. While the oil is heated at one side on the other hand simultaneously the NaOH flakes is made to dissolve completely and mixed with ethanol to form sodium ethoxide solution. After heating the oil for an hour the sodium ethoxide is poured into the heated oil and stirred for an another hour maintain the temperature for around 500^0C-600^0C while stirring the colour transformation took place from yellow to light red in colour after that the entire solution from the beaker is now poured into a separation flask for allowing the glycerol to separate from biodiesel it took nearly 24 hrs. for the glycerol to get separated. After separating the glycerol that observed in black colour was isolated from the biodiesel the extracted biodiesel is heated for around one hour to remove any untreated ethanol and the biodiesel was washed with 15% fermentation alcohol to eliminate impurities. The cleaned biodiesel thus obtained was the ethyl ester of Eucalyptus oil, which is known as Eucalyptus biodiesel. Same procedure followed for preparing CSOME.

2.1 Materials and methods

The various properties like viscosity, calorific value, flash point temperature and fire point Temperature of baseline fuel, raw oils and two biodiesel mixed blends were found by using ASTM methods and compared with diesel properties. The experiments were conducted on a 1- cylinder 4- stroke air cooled diesel engine with electrical loading dynamometer and the performance and emission features were matched with reference point data of diesel fuel. experiments were conducted at a constant speed and at varying loads for all dual biodiesel blends. Engine speed was retained at 1500 rpm during all experimentations. Fuel depletion and exhaust gas heats were also measured. The smoke capability of the exhaust gases was measured by the AVL make smoke meter. Gas Analyzer is used to measure exhaust gases. The experimental set up is presented in Fig.4 and the detailed engine specifications are also mention in Table 4.

Table 1 Blending of CSOME and EOME

Sr. No.	Notation	Bio-Diesel Qty (%)		Diesel Qty (%)	Fuel Qty (%)
		CSOME	EOME		
1	B9	4.5	4.5	9	100
2	B18	9.0	9.0	82	100
3	B27	13.5	13.5	73	100
4	B36	18	18	64	100
5	B45	22.5	22.5	55	100
6	B54	27	27	46	100
7	B100	50	50	----	----

3. Result and discussion

Various physical and thermal properties of dual biodiesels of Cotton seed oil and Eucalyptus oil and its blends were evaluated in the laboratory of Indian Biodiesel Corporation.

Table 2 Property of raw Cotton seed and Eucalyptus

Sr. No.	Property	Diesel ASTM	Cotton Seed	Eucalyptus
1	Viscosity Cst	2-4	55.6	1.6-2.1
2	Density Kg/m3	838	912	913
3	Heating value KJ/Kg	42,700	39,500	43,270
4	Flash Point 0C	76	205	54

Table 3 Property of Tested Blends

Sr. No.	Property	B9	B18	B27	B36	B45
1	Viscosity Cst	3.5	3.8	4.1	4.6	4.9
2	Density Kg/m3	935	839	842	844	846
3	Calorific value MJ/Kg	42.3	41.9	41.79	41.5	41.22

3.1 Calorific value of fuel.

The digital bomb calorimeter is used to find out the calorific value of fuels. ASTM D6751 procedure is followed to analyze the calorific value of different test fuels. Fig.1 shows the calorific value of different fuels. The fresh vegetable oil has lower heating value than diesel. After transesterification process, the biodiesels have slightly higher calorific value than raw oil. The EOME has higher calorific value than CSOME by blending the dual biodiesels with diesel; the calorific values of Blend B9 and Blend B18 are close to diesel which is more than single biodiesel blends. The calorific values of Blend B27, Blend B36 and Blend B45 are almost equal to the single biodiesel blends. The heating value of Blend B100 is lesser than the single biodiesel blends due to the presence of pure biodiesel blends without diesel. Hence, dual biofuel and its mixture are used to analyse the performance and emission features of biodiesel.

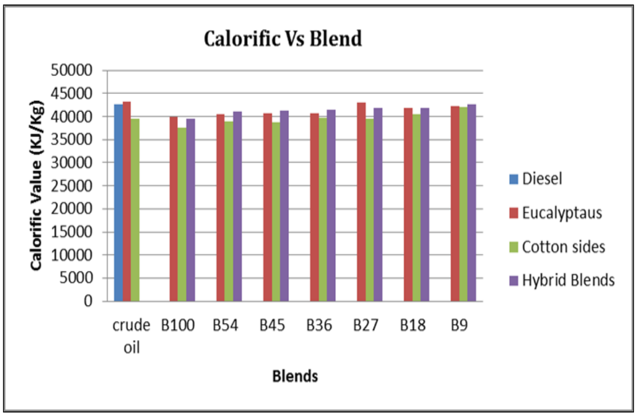

Fig. 1 Comparision of calorific value of various blends with diesel.

3.2 Viscosity of fuel.

Calibrated Redwood viscometer is used for determining the Kinematic viscosity ASTM D 0445 procedure is followed to analyze the viscosity of fuels. Fig.2shows the viscosity of different fuels. The viscosity of the blends rises with the blend ratio and the viscosities of dual biofuel blends and they are progressive than diesel fuel. As compared to diesel fuel viscosity of cotton seed oil is higher but viscosity of Eucalyptus is low compare to diesel..

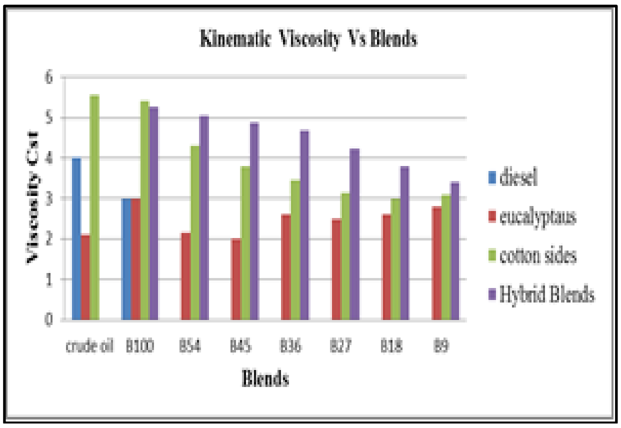

Fig. 2 Comparison of viscosity of various blends with diesel fuel.

Blends B9,B18 shows viscosity closer to diesel fuel. The viscosity of diesel is 4 Cs whereas for the Blend B9 and Blend B18 it is 3.8 Cs and 3.4 Cs respectively.

3.3 Density of fuel.

Density of different blends is measured using a Precision hydrometer. The density of dual biodiesel blends Blend B9, Blend B18 and Blend B27 is 835 Kg/m³, 839 Kg/m³and 842 Kg/m³respectively whereas for diesel it is 832Kg/m³The other blends have more deviation than diesel. Increase in the fuel density advances the dynamic injection timing by 1° Crank angle thus, the fuel density affect engine combustion and emission. PM emission generally increase with increase in fuel density.

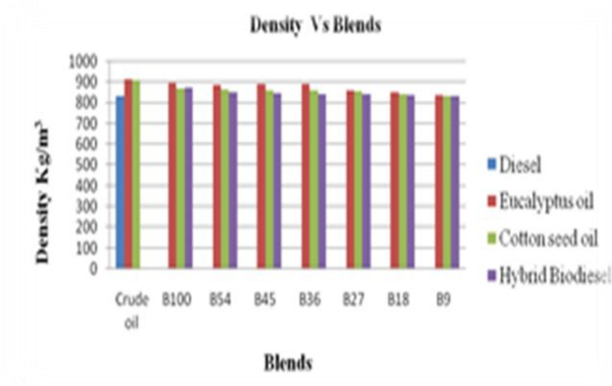

Fig. 3 Comparison of density of various blends with diesel.

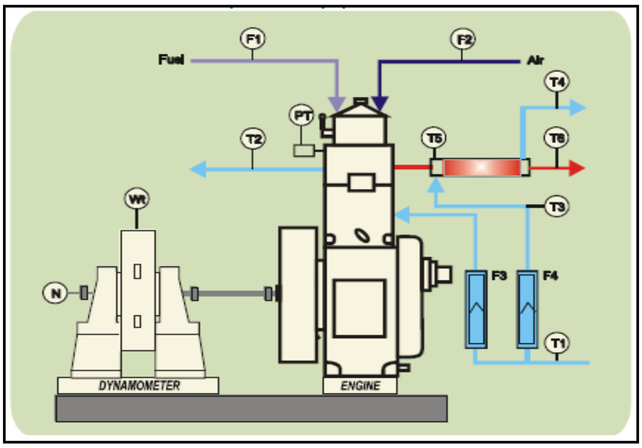

Fig. 4. Single cylinder, four stroke,Multi-fuel VCR engine.

F_1: Fuel in F_2:- Air in

P_T: Petro Diesel Tank T_1:-Temperature in ^{0}C

T_2: Temperature out ^{0}C T_3: Calorimeter water in ^{o}C

T_4: Calorimeter water out^{o}CT_5: Exhaust Temp engine ^{o}C

T_6: Exhaust temp cal. ^{o}C

Table 4 Engine Specifications

Manufacturing	Kirloskar engine Ltd. Pune, India
Engine type	Single cylinder, Four stroke, constant speed, multi-fuel VCR engine.
power	3.5Kw
Bore diameter	87.5mm
Stroke length	110mm
Capacity	661 cc
Compression	12:1-18:1
Injection variation	0-25deg BTDC

Cooling system	Water cooled
Dynamometer	water cooled, Eddy current with loading unit

3.4 Performance analysis.

- Brake Specific Fuel Consumption (BSFC)

The fuel burning characteristics of an engine are usually expressed in terms of specific fuel consumption in Kg/Kwhr. Fig.5 showsthe BSFC of the engine with CSOME-EOME (B36,B45) is higher when compared to B9, B18, B27 and diesel at given loads. Due to lower calorific value and higher density and viscosity of cotton seed oil methyl ester the BSFC's reduces from 0.46,0.44,0.42,0.39,0.38 and 0.36 Kg/Kwh for BD45,BD36,BD27,BD18,BD9 biofuels respectively. The major reason is, increase in BSFC with increase in fuel blends is the additional depletion of biodiesel fuel by the test engine in order to retain continuous power output.

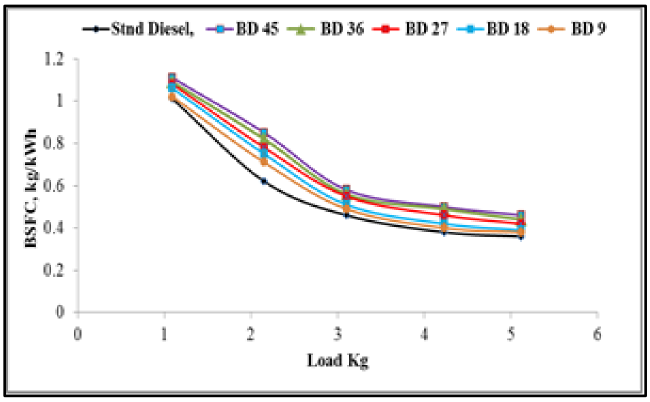

Fig.5 Variations of BSFC Vs Load

- Brake Thermal Efficiency(BTHE)

Brake Thermal Efficiency (BTHE) is the break power of a engine as a function of the heat input from the fuel. It is used to estimate how well an engine changes the heat from a fuel to mechanical energy. As shown in fig.6BTHE increases with a rising in engine load as the quantity of diesel in the blends rises. The BTHE of the B27 blend was improved than B9, B18, B36, B45 blends,which is near to diesel. Due to a faster burning of biodiesel in the blend, the BTHE enriched. The value is 24.06% as against 29.01% for diesel at 100% load.

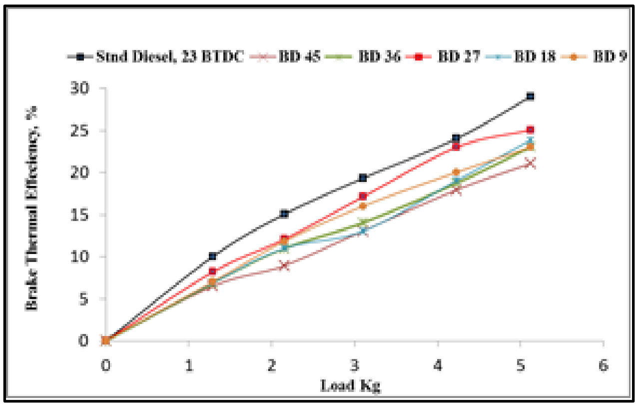

Fig .6 Variations of BTHE Vs Load

- Mechanical Efficiency

The influence of load on mechanical efficiency is revealed in Fig. 7 Indicated power and engine friction is essential for calculating the mechanical effectiveness of the I.C .engine. Efficiency is calculated as a ratio of the measured performance to the performance of an ideal engine. Mechanical efficiency measures the use fullness of an engine in changing the energy and power that is given as an input to the engine into an output force and movement. Hence, mechanical efficiency indicates how good an engine is, in converting the indicated power to useful power. Blend B36 gives the maximum mechanical efficiency of 42.3% for the maximum load, whereas the diesel gives 40.2% at the same load. For the other blends, mechanical efficiency is lower than diesel fuel.

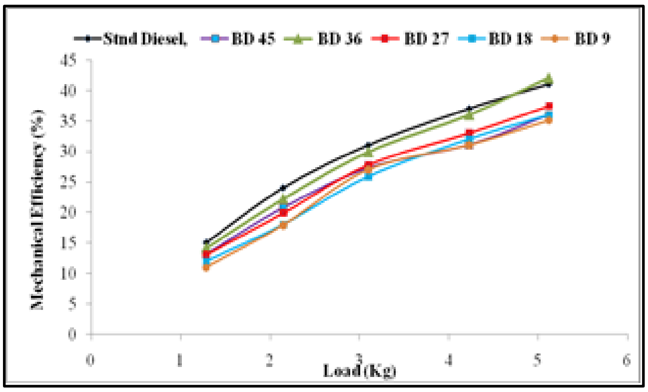

Fig.7 Mechanical efficiency Vs Load

- Effect of Exhaust gas temperature (EGT)

Fig. 8 indications that Exhaust Gas Temperature(EGT) increases with increase in load at wholly injection timing with biodiesel and diesel. It was found that, exhaust gas temperature (EGT) was higher for BD27, and BD45. This may be due poorer cetane number and greater ignition delay of the mixture As a consequence; there is increase in NOx emission with small drop. At lower and higher load exhaust temperature of B18 blend closer to diesel.

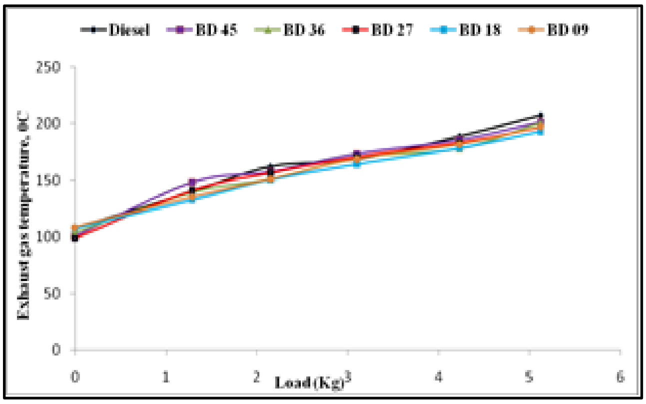

Fig 8 Variation of Exhaust Gas Temperature with Load (EGT)

3.5 Emission Characteristics of biodiesel

- Carbon Monoxides (CO) Emission.

The fig. 9 shows the variations of CO emissions with CSOME-EOME blends. Carbon monoxides not changes for small and medium loads as compare to diesel fuel fuel.CO emission increases as load on engine increases. This may be due to the improvement of O_2 in the EOME. There was a 21% decrease of Carbon Monoxides emission for the B36 blend at maximum load.

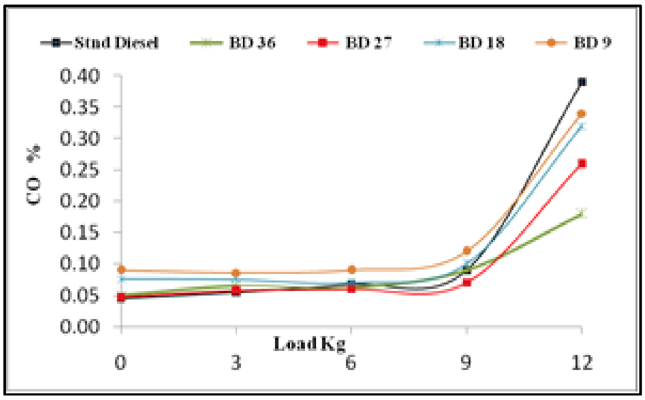

Fig 9 Variation of CO emission with Load

- Unburned Hydrocarbon (HC) Emissions.

Fig. 10 shows variations of hydrocarbon emissions with loads. for diesel fuel HC emission 46ppm at low load and 110ppm at maximum load and for B36 as load increases HC emission increases from 32 ppm to 55 ppm. For CSOME-EOME compositions, the hydrocarbon emissions are lesser than that of diesel, and this may be due to complete burning. The engine operated with methyl ester inside the combustion chamber there are some areas where mixture is too rich and it cannot burn completely. Those un-burnt species are known HC emissions. As the ignition delay period growths, due to a decrease in the fuel CN, flame propagation can reach at each particles of fuel. This may be the reason for the decrease in hydrocarbon emission for blends than the diesel fuel operation.

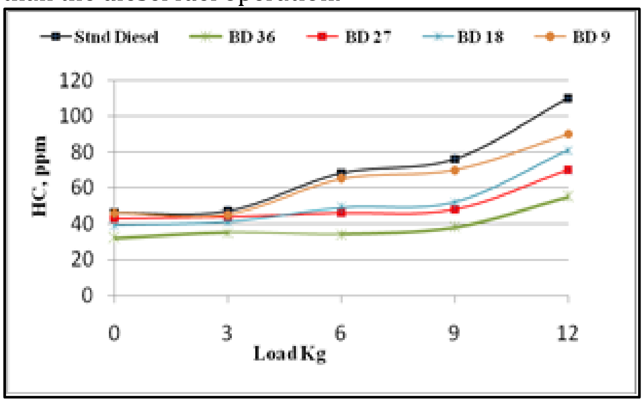

Fig.10 Variations of hydrocarbon emissions with load

- Oxides of Nitrogen (NOx) Emission

Fig. 11 shows that the deviation of NOx emission for CSOME-EOME blends as engine load changes. The increase in NOx may be due to the presence of O_2 in both of CSOME and EOME. Normally NOx formations occurs due to increase in engine temperature during burning process of fuel. For B36 blend, the NOx emission was 110ppm compare to 775 ppm of diesel fuel.

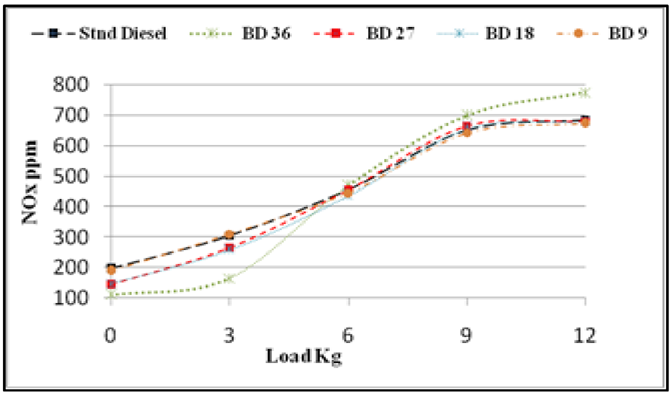

Fig. 11 Load Vs Nox Emissions

Conclusions

Single cylinder high speed diesel engine ran successfully during tests on dual biodiesels and its blends. The blends of diesel and the dual biodiesels of Cotton seed oil and Eucalyptus oil were characterized for their various physical, chemical and thermal properties. The experimental conclusions of this investigation can be summarizing as followed.

- Properties of the 27%, 36% blend of CSOME and EOME are closer to the Diesel.
- The Brake thermal efficiency (BTHE) and mechanical efficiency of Blend B36 were considerably greater than the diesel.
- Blend B18 and Blend B27 were very nearer to the diesel values.
- The specific fuel consumption (BSFC) values of dual biodiesel blends were comparable to diesel.
- Blend B27 and Blend B36 produced slightly lower CO and CO2 than diesel.
- This is a considerable advantage over diesel while using the dual biodiesel blends.
- The diesel fuel gave higher HC emission than that of dual bio-fuel mixture;.Also as proportion of blend increases NOx increases.

  Therefore, it may be concluded that dual biodiesel blends of Blend 36 and Blend B27 would be used as an auxiliary fuel for diesel in the CI engines. Various dual biodiesel Blends with diesel can be focused for further recommendations.

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