Experimental investigation on performance and emission characteristics of a single cylinder DI diesel engine using a dual biodiesel and diesel

Husainsab M. Halemasuti[1], Channappa H. Biradar[2]
[1,2] PDA College of Engineering, Kalaburgi

Abstract- *The use of methyl esters of vegetable oil is known as biodiesel. The biodiesels are increasingly popular because of their low impact on environment and full or partial substitute for fossil fuels. Biodiesel also has been receiving increasing attention because of its use does not require major modification in the engine. This paper reviews and highlights several aspects of non-edible oils which are termed as 2nd generation fuel. In addition, the present investigation is done to use dual biodiesel (i.e. Neem and Castor oil biodiesel) in a constant speed DI diesel engine with varied load condition to evaluate the effect on engine power, fuel economy and emissions parameters corresponding to fossil or diesel fuel are analyzed in detail. The various fuel blends are prepared as B10, B20, B30, B40 and B100. The fuel blend B10 has compositions of 100% Diesel, 5% Castor oil bio diesel, 5% Neem oil bio diesel and 1% Butanol, where as B20 has 100% Diesel, 10% Castor oil bio diesel, 10% Neem oil bio diesel and 1% Butanol on volume basis, likewise B30, B40 and for B100 is 50% Castor oil bio diesel, 50% Neem oil bio diesel and 1% Butanol. As the Butanol had no solubility or stability problems when blended with diesel fuel, therefore Butanol is used as additive for making proper mixture of blend. The blend B20 gives the break thermal efficiency of 24.88% and specific fuel consumption is 0.32 Kg/KW-hr which are nearer to diesel fuel. Also B20 blend has optimum emissions compared to other blends. The CO2 (Carbon dioxide), HC(Hydrocarbon), CO (Carbon monoxide) and NOx (Nitrogen oxide) emissions for B20 are 0.28%, 1 ppm, 0% and 32 ppm respectively Finally it is concluded that the blend of dual bio diesel B20 is the optimum blend for diesel engines for better performance and emissions. This review introduces a potential guideline on further research for improving engine performance and emission characteristics using different biodiesels and their blends.*

Keywords: Diesel, Neem oil, Castor oil, Butanol, Dual biodiesel, Performance, Emission

I. INTRODUCTION

In the present days, the world is mainly facing the problem of fossil fuel depletion and also environmental pollution. This scenario of energy crisis leads to the search for an alternative fuel which can become substitute for fossil fuel and also results in the reduced environmental degradation. The different sources for these alternative fuels are non-edible and edible oils, waste residue of oil seed cake, animal fats, poultry wastes and waste oils. Vegetable oils are renewable source of energy and are locally available. Since vegetable oils have low sulphur contents, therefore results into less environmental damages as compared to diesel fuel.

Presently energy demand in our country is 120575 MW but the availability of energy from all sources is 108212 MW. It shows 10.3 MW as deficit of energy. In order to overcome this energy scarcity and to meet the requirement bio fuels are introduced.

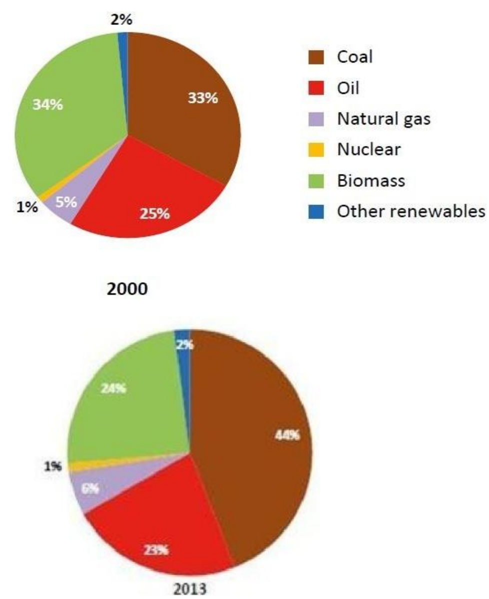

Fig.1 Primary energy demand in India by fuel (Source: India Energy Outlook Magazine, 2015)

Fig 1 shows the pictorial representation for variation of energy demand in India. Since three-quarters the energy demand in India is shows that increased demand for fossil fuels. The main reason for this is rapid usage of energy from coal consumption and a decreasing role for bio energy. Earlier day's solid biomass was used for cooking. But now day's households decreased the usage of solid biomass for cooking. The energy consumption from coal is 44% of the primary energy demand.

This increased demand for coal is due to the growth and expansion of the coal-fired power generation fleet and also the increased use of coking coal in steel industries. The easily availability of coal as compared to fossil fuels is also the reason for its increased usage, especially in the power sector. From fig.1 it can be noted that the demand for energy from alternative fuel (which consists of solid biomass, i.e. fuel wood, straw, charcoal or dung) has been decreased almost 10%.This is because of households switched from the usage of solid biomass to other fuels for cooking (i.e. Liquefied Petroleum Gas (LPG). Thus it is much necessary to the usage of alternative fuel in order to avoid the future scarcity of fossil fuel i.e. mainly petroleum products.

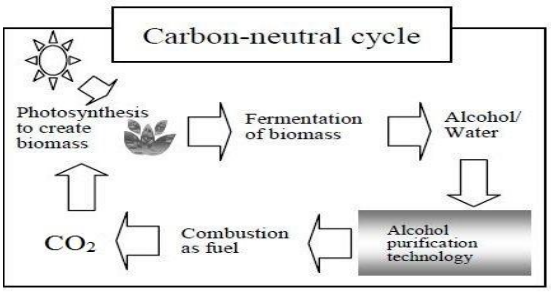

Fig.2 Pictorial view of carbon-neutral cycle (Source: Shinichi Ichikawa et al, 2003)

Fig.2 shows the pictorial view of carbon-neutral cycle. Ethanol is produced by the fermentation process using a biomass. Then Ethanol is purified by the purification technology. Ethanol can be used in the engine as an alternative fuel in diesel engine. After the combustion of ethanol as a fuel in the engine cylinder, CO_2 emission is released into the air. Again this CO_2 is reused by the plants in the photosynthesis process under the sun light. Thus the carbon-neutral cycle provides energy without increase of CO_2 concentration in the atmosphere.

Considerable research has been done on vegetable oils like Jatropha, Karanja, Rice Bran, Flax, Moringa, Waste cooking oil as well as animal wastes like Poultry waste, discarded fish parts etc. A lot of research work has been done on single biodiesel with diesel fuel. Very few experiments have been conducted with combination dual biodiesel blend with neat diesel fuel. Most of the literature suggested that Castor and Neem oil as substitute for diesel fuel. Therefore Castor and Neem oil were selected for current studies which are easily and locally available. As the Butanol had no solubility or stability problems when blended with diesel fuel, therefore Butanol is used as additive for making proper mixture of the blend. The various fuel blends are prepared as B10, B20, B30, B40 and B100. The fuel blend B10 has compositions of 100% Diesel, 5% Castor oil bio diesel, 5% Neem oil bio diesel and 1% Butanol, where as B20 has 100% Diesel, 10% Castor oil bio diesel, 10% Neem oil bio diesel and 1% Butanol on volume basis, likewise B30, B40, B75 and for B100 is 50% Castor oil bio diesel, 50% Neem oil bio diesel and 1% Butanol. The performance and emission test results of these blends are to be compared with D100 (pure or neat diesel)

II. LITERATURE REVIEW

2.1 Introduction of Neem and Castor seed oil

(J Vijay Kumar et al, 2014) Normally Neem tree can produce the many thousands of flowers and hence it gives the high yield of seeds in one flowering cycle. It will take 3-5 years after plantation to give harvestable seeds, and full production may be started in 10 years, and this will continue for long time i.e. up to 150-200 years of age. The yield Neem fruit per year is 30-50 kg by a single mature Neem tree. It is observed by the rough estimation that India has nearly 20 million Neem trees and can produce one million tons of fruits per year and approximately 0.1 million tons of kernels per year (assuming 10% kernel yield). Neem seed contains 40-60% oil and it can be used as alternative and renewable fuel in diesel engines directly and also by blending it with Methanol. The engine tests were carried out for the performance investigation of Neem oil and Neem biodiesel, and also it shows the optimum and satisfactory results as compared to fossil fuels. The tests were done in India and Bangladesh. Biodiesel is biodegradable, nontoxic, and basically free of sulfur compounds hence it can be used in different proportions with diesel with little or no modification of the engine. Fig 3 shows the pictorial view of Neem seeds.

Fig.3 Pictorial view of Neem seeds

Castor

(Roopesh Kanwar et al, 2014) It is also named as Ricinus communis L. Its colorless yellowish and non-edible oil extracted from the seeds of the castor plant. Castor plant is grown around the world because of its commercial usage in industrial chemicals like greases and lubricants, specialty soaps, surface coatings, cosmetics and personal care products, pharmaceuticals, etc. The oil yield of castor seed is 42% to 46%. The residual oil cake is used as organic manure and it contains about 5.5% Nitrogen, 1.8-1.9% Phosphorus and 1.1 % Potassium. The growing period for Castor plants is 4 to 5 months and it needs hot and humid tropical conditions. The average yield of seed per hectare is 1250 kg/hectare and oil per hectare is 550 lit/hectare. India is also the major country for production and in the export of castor oil. About 700,000 hectares of land is cultivated for plantation of castor plant in Gujarat and Andhra Pradesh under rain fed conditions. It has advantage of yield per hectare in terms of oil which varies from 350-650 kg of oil without any maintenance is applied to the crop, Fertilizers etc. Also its shorter span is comparative advantage in comparison to that of Jatropha and Pongamia. It's also helpful to the farmers to rotate or shift away easily depending on the market conditions. Fig 4 shows the pictorial view of Castor plant and seeds.

Fig.4 Pictorial view of Castor plant and seeds

2.2 Review of papers

(R. Sahitya moorthi et al, 2016) compared the performance, emission and combustion characteristics results for BN20 (Diesel 80% and 20% Biodiesel from Neem oil on volumetric percentage), BN20+ CeO_2 (Cerium Oxide) in comparison to pure or neat diesel. The results show that the BTE (Break Thermal Efficiency) for BN20+ CeO_2 higher as compared to BN20. The BTE is lower for BN20 when it's compared to diesel fuel. It is found that the CO and HC emission decreases for BN20 fuel blend. It is seen that the NO_x emission increases for biodiesel from Neem oil blends. But the addition of cerium oxide helps to reduce NO_x emission by 8.4% as compared to BN20 blend. Smoke emission for BN20+ CeO_2 decreases by 4.4% as compared to BN20 blend. Finally it is concluded that the addition of CeO_2 to the Neem oil biodiesel blend gives the improved performance, emission and combustion characteristics.

(Harsha B M et al, 2015) has done investigation on CI Engine using Neem Seed Oil as biodiesel at Different Injection Pressures (200bar, 250bar, &300bar). The brake thermal efficiency at 250bar for B30 is more due to improved atomization (i.e. 27.78% at higher loads compared to all other cases). At the 250 bar BSFC for B30 is 0.30 kg/KW-hr and it increases for injection pressure from 250 to 300 bars (i.e. increased to 0.34 kg/KW-hr). The lowest carbon monoxide emission is observed at 250bar as 0.04% for B20. For B20 and B30 lowest CO_2 emission is observed. It is observed that the HC emission for Neem biodiesel at full load is approximately 25 to 30% lower than diesel value. NO_x emissions were lower at 200 bar injection pressure. Finally optimum performance and emission characteristics were observed when the injector opening pressure is 250 bars for a diesel engine is operated with Neem biodiesel.

(L. Prabhu et al, 2013) has done experimental investigation to evaluate the performance, emission and combustion characteristics of Diesel engine with Neem oil biodiesel (i.e. B20, B40 and B100 in comparison to diesel). He concluded that the thermal efficiency is lower for B100 that of B20 and diesel. The brake specific fuel consumption of Neem biodiesel is increased for B20, B100 than that of diesel at full load. It can be observed that the CO emissions were lower for B20 and B40 and B100 are 0.5%, 0.55% and 0.04%, whereas for diesel, it is 0.55 % at full load. It can be observed that the HC emissions for B20 and B40 and B100 are 36ppm, 41ppm and 48 ppm at full load, whereas for diesel it is 32ppm at full load. Compared to base line fuel the NO_x emission is increased by 5% with the blend of Neem oil. For B20 blend show low smoke emission. Finally it is concluded that the performance, combustion and emission characteristics for B20 blend are better as compared to B100.

(Nishant Tyagi et al, 2012) has done experimental investigation to evaluate the performance and emission characteristics of Diesel engine with Neem oil biodiesel (i.e. B10, B20 and B30 in comparison to diesel). He proved that BTE (Break Thermal Efficiency) of B10 is very close to diesel. The hydrocarbons are lesser for B10 and B20 as compared to B30. It is found that slight increase in carbon monoxide in B30 because of insufficient combustion. NO_x for B30 is slightly decreased because of incomplete combustion. Biodiesel generates less smoke density as compared to pure diesel fuel; but slight increase in smoke intensity is found for B30 because of incomplete combustion. Finally blend B20 shows better performance characteristics as compared with base line fuel and better emission characteristic as compared to other blends.

(Nithyananda B. S et al, 2013) has done experimental investigation to evaluate the performance characteristics of Diesel engine with Neem oil biodiesel (i.e. B10, B20, B30, B40 and B50 in comparison to diesel). He stated that the increase in BTE (Break Thermal Efficiency) is observed for B10 blend and minimum efficiency is observed for B50 blend at full load. Specific fuel consumption decreases for all fuel blends with the increase in load. It is also observed that for B10 and B20 blends are having specific fuel consumption closer to that of diesel. Finally biodiesel blend B10 shows good results in comparison to other blends.

(H. A. Shah et al, 2014) has done experimental investigation to evaluate the emission characteristics of Diesel engine with Neem oil biodiesel (i.e. B10, B20 and B30 in comparison to diesel). It is observed that CO emission decreased with increase in blending ratio and load. It is observed that CO_2 emission increased with increase in blending ratio. It is seen that HC emissions increased with increase in blending ratio. The HC emission for B10, B20 and B30 are 60 ppm, 76 ppm and 72 ppm respectively at full load condition, where as it is for diesel is 81 ppm. The smoke density for B10, B20 and B30 are 48%, 47.7% and 46.7% at full load condition, where as it is for diesel is 41.5%. Finally it is concluded that blend B20 shows better emission characteristics as compared with base line fuel and better emission characteristic as compared to other blends.

(Maharaja Gasti et al, 2013) has done investigation for performance and combustion characteristics of a LHR (Low Heat Rejection) diesel engine with castor oil blends with diesel fuel (i.e. B20, B40, B60, B80 and B100 in comparison to diesel). He stated that the maximum BTE (Break Thermal Efficiency) for B20 blend of castor oil is 33.20% at 4 KW where as it is for diesel 34.1%. It has found that Brake thermal efficiency is improved at 180 bar pressure with LHR coating at all loads. The SFC (Specific Fuel Consumption) of neat castor oil is lowest and it is 0.305 Kg/KW- hr, whereas it is for diesel is 0.210 Kg/KW-hr. B20 and D100 have almost same mechanical efficiency but B20 is little lesser as compared to D100 due to thermal barrier coating which gives better higher brake power and indicated power. Finally it is conclude that B20 of castor can use with LHR coating in the engine.

(K. B. Yogeshwaran et al, 2014) has done investigation for performance and emission characteristics of a diesel engine with castor oil blends with diesel fuel (i.e. B5, B10, B15, and B20 in comparison to diesel). It is observed that B5 blend at all over the load range except at full load operation has higher brake thermal efficiency as compared to other blends. It is found that for B5 blend SFC (Specific fuel consumption) and highest SFC is for B100 blend, compared to other fuels. The performance characteristics of B5 blend of castor is better as compared to all other blends and it is well comparable with diesel. Performance of the castor oil is validated as results are well comparable with the results of cotton seed oil and rice bran oils. Finally it is concluded that blends up to B5 can be adopted without preheating and up to B20 with preheating can be substituted as fuel for diesel engine without any modifications in the engine.

(Pradip Lingfa, 2014) has done investigation for performance and emission characteristics of a diesel engine with castor oil blends with diesel fuel (i.e. B2, B5, and B100 in comparison to diesel).It is found that the for B10 efficiency was maximum. He reported that the BSFC (Break Specific Fuel Consumption) of Castor biodiesel blends decreases with increasing loads. BSFC increases as the increased percentage of biodiesel blends. It is observed that CO emission increases with increasing loads for all test fuels. The UBHC (Un-burned Hydro Carbon) of all the test fuels increases at higher load due to the fact fuel quantity injected. The minimum UBHC was observed for B10 biodiesel. The COBD (Castor Oil Bio Diesel) leads to higher NO_x as compared to diesel fuel. However emission characteristics like CO, HC, and Smoke were less as compared to diesel fuel. Finally it is concluded that B10 blend gives optimum performance and emission characteristics.

(S. Jafarmadar and J. Pashae, 2013) has done investigation for performance and emission characteristics of a turbo charged diesel engine with castor oil blends with diesel fuel (i.e. B5, B10, B15, B20 and B30 in comparison to diesel). He proved that maximum decrease in power is 6.1% and was observed for B5 at 50% load. It is found that the maximum increase in BSFC (Break Specific Fuel Consumption) is 10.7% as compared to diesel for B30 at 50% load. Because of poor atomization and poor volatility HC emissions were increased for B20 blend. It is observed that the NO_x emissions for B15 blend, B30 blend and diesel were 222, 214 and 235 respectively at 25% of load. Finally it is concluded that B10 and B15 blend gives optimum performance and emission characteristics.

(Pankaj Singh Jasrotia et al, 2015) has done experimental investigation to evaluate the performance, emission and combustion characteristics of Diesel engine with Castor oil biodiesel (i.e. B10, B20, B30, B50 and B30 in comparison to diesel). He reported that B10 has BTE (Break Thermal Efficiency) of 34.39% and it is 0.18% lower as compared to diesel. It was found that B10 has given lowest brake specific fuel consumption to all other blends and also it was slightly higher than that of diesel. The CO emissions were lesser for B10 blend. It is observed that HC emission for B10, B30, B100 and diesel has been given 18ppm, 19ppm, 22ppm and 24ppm respectively at full load It is observed that the B50 blend gives 397.2 ppm (parts per million) of NO_x level where as it is for diesel is 434.6 ppm hence it is almost less than diesel. CO_2 emission is less as compared diesel and it's proved for B30 blend. The B30 and neat diesel gave 3.2% and 3.3% CO_2 emission respectively. Finally it is concluded that B10 blend gives optimum performance and emission characteristics.

(Roopesh Kanwar et al, 2014) has done investigation for emission characteristics of a Diesel engine operating on percentage of blending of Castor oil biodiesel-diesel (i.e. B5, B10, B15, and B20in comparison to diesel). It is observed that the CO_2 emission increases with increase in the load therefore for B20 maximum amount of CO2 is recorded when it is compared to diesel. It is observed that the NO_x is lower when B10 blend is preferred. He stated that the major disadvantage of castor biodiesel is its viscosity and is very high as compared with diesel. Therefore it restricts blending up to B10. Hence it is concluded that B10 blend gives optimum emission characteristics.

(R. Sattanathan et al, 2015) has done experimental investigation to evaluate the performance, emission characteristics of Diesel engine with Castor oil biodiesel (i.e. B25, B50, B75, and B100 in comparison to diesel). He investigated and proved that the maximum BTE (Break Thermal Efficiency) is observed for B25. It is found that for this maximum thermal efficiency of B25 blend, the BSFC (Break Specific Fuel Consumption) is 0.342 Kg/KW- hr, where as it is for diesel is 0.281. The CO emissions for B25 and diesel are 3.51% and 1.54% respectively. The UHC (Un-burnt Hydro Carbon) for B25 blend is lower compared with all other blends. Diesel has higher smoke emission compared with all other blends of castor oil. It is found that NO_x emission for B25 blend is slightly as compared to that of diesel. Finally it is concluded that B25 blend gives optimum performance and emission characteristics.

(S. Ganesan et al, 2013) has done experimental investigation to evaluate the performance characteristics of Diesel engine with Castor oil biodiesel. The blends specification are D85+C15+E15(i.e. Diesel85+Castor15+Ethanol15) and D90+C10+E20 and compared to base fuel (i.e. neat diesel). The BTE (Break Thermal Efficiency) is observed for D85+C15+E15 and D90+C10+E20 at full load condition are 32.52 % and 32.32% respectively, where as it is for diesel is 31.55%. It is observed that the total fuel consumption for D85+C15+E15, D90+C10+E20 and diesel at full load condition are same and 1.2 Kg/hr. It is observed that the exhaust gas temperature for D85+C15+E15 and D90+C10+E20 at full load condition are 398^0C and 375^0C respectively where as it is for diesel is 429^0C. Finally it is concluded that blend D90+C10+E20 gives optimum performance characteristics as compared to diesel fuel.

2.3 Preparation of biodiesel

Transeserification:

Transesterification also called alcoholysis is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis, except that an alcohol is worked instead of water. Suitable alcohols include Butanol, methanol, ethanol, propanol, and amyl alcohol. Ethanol and methanol are utilized most frequently. This process is mostly used to reduce the viscosity of triglycerides, thereby enhancing the chemical and physical properties of biofuel and improve engine performance. Thus fatty acid methyl ester (also known as biodiesel) is obtained by transesterification. Fig 5 shows the pictorial view for flow chart of biodiesel production.

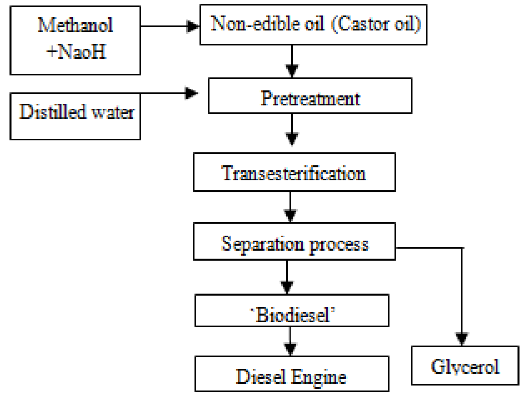

Fig.5 Pictorial view for flow chart of biodiesel production (Source: R. Sattanathan, 2015)

In the preparation of biodiesel three distinct stages will be involved,
1) Biodiesel transesterification reactions.
2) Settling of separation of glycerol.
3) Washing of ethyl ester with water.

1) Biodiesel Transesterification Reactions:

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification

2) Separation of glycerol from bio-diesel:

1) The excess methanol used in the biodiesel process collects in the glycerine layer that settles out at the bottom.
2) Separatory funnel because it is good for separating liquids that split into two layers.
3) The methoxide reacts with the oil and makes two products. One is glycerin and the other is biodiesel.
4) The glycerin will sink to the bottom and it is collected at the bottom through stopcock.

3) Washing of bio-diesel:

1) This step is optional.
2) To remove the certain amount of dissolved methanol.
3) After separating this impurity finally we get the pure corn bio-diesel.

2.4 Advantages and disadvantages of biodiesel

Advantages:

1. It is renewable source of energy.
2. We can run the engine with less modification or no modification.
3. Less green house gas emission.
4. It is biodegradable and Nontoxic.
5. Reduced foreign oil dependence
6. It is relatively less flammable as compared to fossil fuels.

Disadvantages:

1. At low temperatures biodiesel is less suitable for use
2. It may results into the clog of engine.
3. Higher capital and operating costs of alternative fuel and supporting facilities.
4. Risk involved in fuel delivery.
5. It has increased NO_x emissions.

2.5 Scope of the work

- The two biodiesels Castor oil biodiesel and Neem oil biodiesel are to be mixed with diesel fuel for making different blends like B10, B20, B30, B40 and B100. Also 1% of Butanol is used for the proper mixing of Neem and Castor biodiesel.
- The various properties such as kinematic viscosity, specific gravity and calorific value, flash point and fire point of base line fuel (i.e. with diesel fuel), biodiesels are to be determined.
- Experimental investigation on performance and emission characteristics of a single cylinder engine using a dual biodiesel and diesel.
- Identification optimum blend for performance and emission characteristics in comparison to base line fuel (i.e. neat diesel fuel)

Table.1: Properties of biodiesel and diesel fuel

Sl No	Properties	Diesel	Neem	Castor	B100
1	Density (Kg/m^3)	831	855	937	896
2	Kinematic Viscosity at 40°C (cSt)	3.6	5.58	18.5	12.31
3	Flash point (°C)	55	166	183	177
4	Fire point (°C)	67	187	245	219
5	Calorific Value (MJ/Kg-K)	45.4	37.0	36.1	36.4

III. EXPERIMENTATION

The Engine chosen to carry out experimentation is a single cylinder, four stroke, vertical, water cooled, direct injection computerized Kirloskar make CI Engine. This engine can withstand higher pressures encountered and also is used extensively in agriculture and industrial sectors. Therefore this engine is selected for carrying experiments. Pictorial view of experimental setup is shown in fig 6.

Fig.6: Pictorial view of experimental setup

3.1 Experimental procedure

Initially experimentation is carried out to get base line (i.e. for neat diesel). Then same procedure is carried out for diesel with biodiesel.

- Prepare the different fuel blends B10, B20, B30, B40 and B100 by mixing the biodiesel and diesel fuel.
- Fill the tank with the diesel fuel.
- Starting up the central control unit of dynamometer.
- Supply the cooling water and maintain the flow rate of cooling water for engine at 650 LPH and calorimeter flow at 150 LPH.
- Also ensure adequate water flow rate for dynamometer cooling and piezo sensor cooling.
- Ensure the all electrical connections and UPS back up for computer
- Switch on the computer and engine performance analysis software package “engine soft” for on screen performance evaluation.
- Specify the value of calorific value and specific gravity of the fuel in the software.

- Select run option of the software. Start the engine and let it run for few minutes under no load condition.
- The experiments are conducted for variable loads like 0, 1,2,3,4 and 5.2 KW at rated speed, with injection pressure of 200bar and cooling water exit temperature at 65ºC.
- Select the log option of the software. Turn on fuel supply knob. After one minute the display changes to input mode then enter the value of water flows in cooling jacket and calorimeter and then the file name (applicable only for the first reading) for the software. The first reading for the engine gets logged for the no load condition. Turn the fuel knob back to regular position.
- Repeat the experiment for different load and speed.
- AVL Dismoke 1000 and exhaust gas analyzer are used to record different emission parameters like CO, CO_2, NO_x, HC and smoke.
- Repeat the same procedure for fuel samples B10, B20, B30, B40 and B100.
- Finally at the end of the experiment bring the engine to no load condition and turn off the engine and computer so as to stop the experiment.

IV. RESULTS AND DISCUSSION

This chapter consists of two types of experimental analysis, first one is performance characteristics like brake thermal efficiency, specific fuel consumption, volumetric efficiency and air-fuel ratio against brake power, second one is emission characteristics like carbon monoxide (CO) carbon dioxide (CO_2), unburned hydrocarbon(HC) , NO_x against brake power.

4.1 Performance characteristics:

4.1.1 Break thermal efficiency

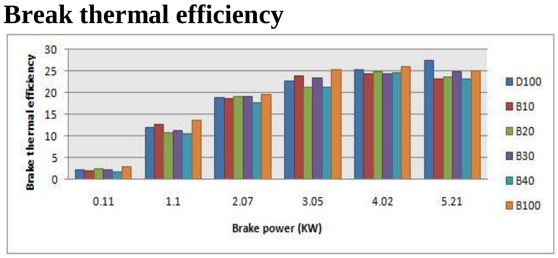

Fig.7 Variation of Brake thermal efficiency with Brake power

The variation of brake thermal efficiency with brake power for different blends is shown in fig 13. It is evident that diesel fuel has the higher brake thermal efficiency compared to dual biodiesel blends because of its higher calorific value and low viscosity as compared with dual biodiesel. With the higher calorific value the amount of heat produced in the combustion chamber is more, further lesser CO emission is evident for the complete combustion. It is seen that brake thermal efficiency increases with the increase in brake power. The break thermal efficiency for D100 is 25.13% at 75% load condition, where as for B10, B20, B30, B40 and B100 is 24.23%, 24.88%, 24.25%, 24.62% and 26.05% respectively. The reduction in brake thermal efficiency for dual biodiesel blends may be due to the combined result of their lower calorific value and increase in fuel consumption.

4.1.2 Specific fuel consumption

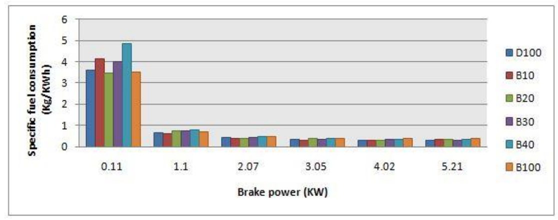

Fig.8 Variation of specific fuel consumption with brake power

The variation of specific fuel consumption with brake power for different blends is shown in fig 14. The specific fuel consumption reduced with the increase in brake power for all the fuels. It is found that the specific fuel consumption for the dual biodiesel blend is higher than diesel at all loads. This is because of the combined effects of lower heating value and the higher viscosity of the blend. Higher the proportion of dual biodiesel in the blends increases the viscosity which in turn results into the increased specific fuel consumption due to poor atomization of the fuel. The specific fuel consumption for D100 is 0.32 Kg/KW-hr at 75% load condition, where as for B10, B20, B30, B40 and B100 is 0.33, 0.32, 0.34, 0.34 and 0.38 Kg/KW-hr respectively.

4.1.3 Volumetric efficiency

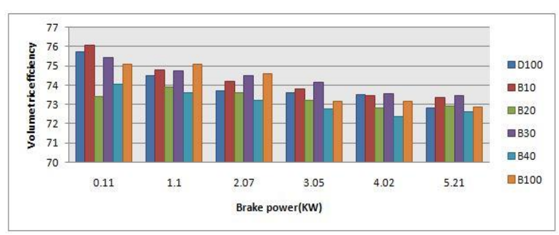

Fig.9 Variation of Volumetric efficiency with brake power

The variation of volumetric efficiency with brake power for different blends is shown in fig 15. The volumetric efficiency is reduced with the increase in brake power for all the fuels. The volumetric efficiency is observed for D100 is 73.56% at 75% load condition, where as for B10, B20, B30, B40 and B100 is 73.44%, 72.8%, 73.53%, 72.35%, and 73.15% respectively. It is observed that the volumetric efficiency is decreased for dual biodiesel blends due to less amount air induced in the engine cylinder.

4.1.4 Air-fuel ratio

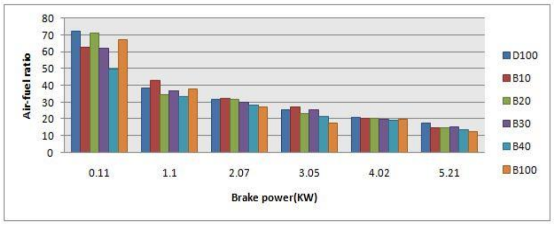

Fig.10 Variation of air-fuel ratio with brake power

The variation of air-fuel ratio with brake power for different blends is shown in fig 16. The air-fuel ratio is reduced with the increase in brake power for all the fuels. Specific fuel consumption is high for dual biodiesel blends compared to diesel hence air-fuel ratio decreases with increase in load. The air-fuel ratio for D100 is 21.12 at 75% load, where as for B10, B20, B30, B40 and B100 is 20.41, 20.18, 19.5, 19.03, and 19.81 respectively.

4.2 Emission characteristics

4.2.1Carbon dioxide

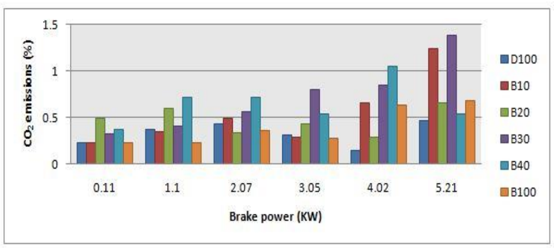

Fig.11 Variation of carbon dioxide with brake power

The variation of carbon dioxide (CO_2) with brake power for different blends is shown in fig 17. It is observed that CO_2 emission increased with increase in brake power for all blends. The CO_2 emission for D100 is 0.14% at 75% load condition, where as for B10, B20, B30, B40 and B100 is 0.65%, 0.28%, 0.84%, 1.05%, and 0.63% respectively. It is observed that the CO_2 emissions increased for dual biodiesel blends due to dissociation effect.

4.2.2 Hydrocarbons

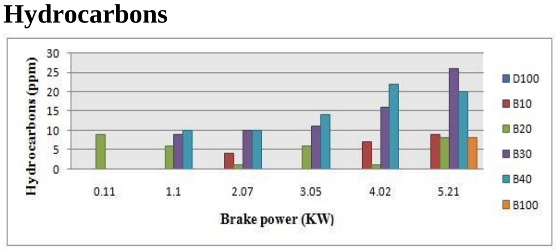

Fig.12 Variation of hydrocarbon with Brake power

The variation of hydrocarbon (HC) emission with brake power for different blends is shown in fig 18.The HC emission increases with increase in load on the engine for all fuel samples. The maximum HC emission is observed for B40 blend is 22 ppm. The HC emission for D100 is 0 ppm at 75% load condition, where as for B10, B20, B30, B40 and B100 is 7 ppm, 1 ppm, 16 ppm, 22 ppm, 0 ppm respectively. It is observed that the HC emissions increased for dual biodiesel blends due to lower air-fuel ratio, which results into incomplete combustion because of rich mixture.

4.2.3 Carbon monoxide

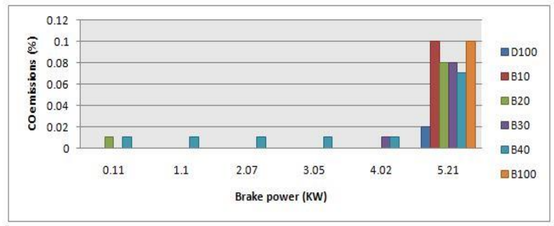

Fig.13 Variation of carbon monoxide with brake power

The variation of carbon monoxide (CO) with brake power for different blends is shown in fig 19. The CO emission increases with increase in load on the engine for all fuel samples. The CO emission for D100 is 0% at 75% load condition, where as for B10, B20, B30, B40 and B100 is 0%, 0%, 0.01%, 0.01% and 0% respectively. It is observed that the CO emissions increased for dual biodiesel blends due to lower air-fuel ratio, which results into incomplete combustion because of rich mixture.

4.2.4 Nitrogen oxide

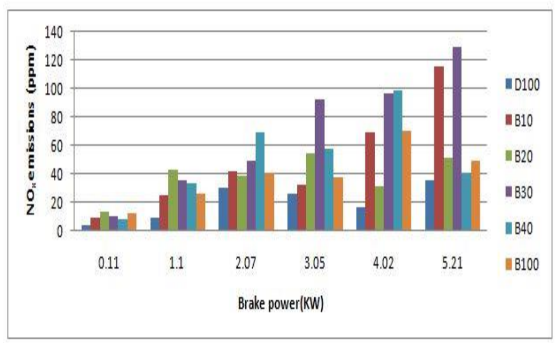

Fig.14 Variation of NO_x emissions with brake power

The variation of nitrogen oxide (NO_x) emission with brake power for different blends is shown in fig 20. The NO_x emissions are higher for dual biodiesel blend as compared with diesel fuel. The NO_x emission for D100 is 17 ppm at 75% load condition, where as for B10, B20, B30, B40 and B100 is 69 ppm, 32 ppm, 97 ppm, 99 ppm, and 71 ppm respectively. It is observed that exhaust gas temperature for D100, B10, B20, B30, B40 and B100 is 535℃, 550℃, 548℃, 564℃, 557℃ and

567℃ respectively. It is observed that the NO_x emissions increase for dual biodiesel blends due to increased exhaust gas temperature at which Nitrogen becomes unstable.

V. CONCLUSION

Experimental investigations are carried out on a single cylinder DI diesel engine to examine the suitability of dual biodiesel as an alternative fuel. The performance and emission characteristics of blends are evaluated and compared with diesel and optimum blend is determined. The following conclusions are drawn based on the experimental results of the above work.

- The brake thermal efficiency of the engine depends majorly on the heating value and viscosity. The brake thermal efficiency of diesel is 25.13%, where as for B20 it is 24.88% and is nearer to the diesel fuel.
- The specific fuel consumption for diesel is lower as compared with dual biodiesel blends. The specific fuel consumption of diesel is 0.32 Kg/KW-hr where as for B20 it is 0.32 Kg/KW-hr and is same as that of diesel fuel.
- The B20 has almost same volumetric efficiency as that of diesel fuel and also air-fuel ratio for B20 is nearer to diesel value.
- The CO_2 emissions for B20 blend is less as compared to other blends. Also HC and CO emissions are less as compared to other blends.
- The NO_x emissions increase with increase in concentration of biodiesel in blend due to higher exhaust gas temperature.

Finally it is concluded that the blend of dual bio diesel B20 is the optimum blend for Diesel engines for better performance and emissions. The dual biodiesel of Neem and Castor oil can be used as alternative to diesel.

REFERENCES

[1] A. Sanjid, H. H. Masjuki, M. A. Kalam, M. J. Abedin and S. M. Ashrafur Rahman (February 2014), "Experimental investigation of Mustard biodiesel blend properties, performance, exhaust emission and noise in an unmodified diesel engine", Elsevier publications, Vol: 10, pp: 149-153.

[2] E. F. S. M. Ramalho, J. R. Carvalho Filho, A. R. Albuquerque, S. F. de Oliveira, E. H. S. Cavalcanti, L. Stragevitch, I. M. G. Santos and A.G. Souza (October 2011) " Low temperature behavior of poultry fat biodiesel: diesel blends", Elsevier publications, pp: 149-153.

[3] H. A. Shah, B. S. Patil and A. J. Patel (2014) "Experimental study of brake power on emission for different blending ratio of Neem biodiesel in dual cylinder diesel engine", International Journal of Engineering Development and Research, Vol: 2, Issue: 1, pp: 627-630.

[4] Harsha B M, Chethana G D and Yogesh Kumar K J (November 2015) "Experimental investigation on CI engine using Neem seed oil as biodiesel at different injection pressures", International Journal of Emerging Technology and Advanced Engineering, Vol: 5, Issue: 11, pp: 129-136.

[5] India Energy Outlook Magazine (2015), International Energy Agency Publications, pp: 22-23.

[6] J Vijay Kumar and Dr. C J Rao (October 2014) "Experimental investigation of performance and emission characteristics of Diesel engine working on Diesel and Neem oil blend with Diethyl Ether as additive", International Journal of Technological Exploration and Learning, Vol: 3, Issue: 5, pp: 581-588.

[7] K. B. Yogeshwaran, G. Raghu and G. Naveenraj (2014) "Performance analysis of DI diesel engine using diesel with Castor seed oil blends", IOSR Journal of Mechanical and Civil Engineering, pp: 19-23.

[8] L. Prabhu, S. Sathish Kumar, M. Prabhahar and K. Rajan (2013) “Combustion, performance and emission characteristics of diesel engine with Neem oil methyl ester and its blends”, American Journal of Applied Sciences, Vol: 10, Issue: 8, pp: 810-818.

[9] M. Mofijur, H. H. Masjuki, M. A. Kalam, M. G. Rasul, A. E. Atabani, M. A. Hazrat and H. M. Mahmudul (2015) "Effect of biodiesel-diesel blending on physico-chemical properties of biodiesel produced from Moringa oleifera" Elsevier publications, pp: 659-669.

[10] M. Naga Phani Sastry and K. Devaki Devi (February 2016) "Experimental investigations on performance of diesel engine with Neem Oil, Cow ghee and NFA blends with atomized diesel", International Journal of Engineering Research, Vol: 5, Issue: 2, pp: 463-467.

[11] Maharaja Gasti and M. C. Navindgi (July 2013) "Comparative experimental investigation of performance and combustion characteristics in a single cylinder thermal barrier coated diesel engine using diesel and Castor biodiesel", International Journal of Engineering Research & Technology, Vol: 2, Issue: 7, pp: 503-511.

[12] Mayank Chhabra, Ajay Sharma and Gaurav Dwivedi (July 2016) "Performance evaluation of diesel engine using rice bran biodiesel", Elsevier publications, pp: 1-8.

[13] Morteza Borhanipour, Preechar Karin, Manida Tongroon and Nuwong Chollacoop, Katsunori Hanamura (March 2014) "Comparison study on fuel properties of biodiesel from Jatropha, Palm and petroleum based diesel fuel", SAE International.

[14] Neha Sharma (May 2017) "Assessment of biofuel potential in India", International Journal of Recent Scientific Research, Vol: 8, Issue: 5, pp: 17125-17127.
[15] Nishant Tyagi and Ambuj Sharma (August 2012) “Experimental investigation of Neem methyl esters as biodiesel on C.I engine”, International Journal of Engineering Research and Applications, Vol: 2, Issue: 4, pp: 1673-1679.
[16] Nithyananda B. S, Anand A and G. V. Naveen Prakash (August 2013) “Performance study on diesel engine using different blends of Neem biodiesel”, International Journal of Engineering Research and Applications, Vol: 3, Issue: 4, pp: 1778-1781.
[17] P. Garg (2012) “Energy scenario and vision 2020 in India”, Journal of Sustainable Energy & Environment, pp: 7-17.
[18] Pankaj Singh Jasrotia, Farman Khan and Radhey Sham (August 2015) “Experimental investigation to evaluate the performance, emission and combustion characteristics of diesel engine with Castor oil biodiesel”, International Journal of Engineering Science Invention Research & Development, Vol: 02, Issue: 02, pp: 118-123.
[19] Pradip Lingfa (March 2014) “A comparative study on performance and emission characteristics of compression ignition engine using biodiesel derived from Castor oil”, International Journal of Innovative Research in Science Engineering and Technology, Vol: 3, Issue: 4, pp: 124-128.
[20] R. Sathiyamoorthi, M. Puviyarasan, B. Bhuvanesh Kumar and D. Breslin Joshua (2016) " Effect of CeO2 nano additive on performance and emission characteristics of diesel engine fuelled by Neem oil-biodiesel", International Journal of Chemical Scence, Vol: 14, Issue: 2, pp: 473-484.
[21] R. Sattanathan (January 2015) “Production of biodiesel from Castor oil with its performance and emission test”, International Journal of Science and Research, Vol: 04, Issue: 01, pp: 273-279.
[22] Roopesh Kanwar, Pushpendra Kumar Sharma, Harimohan Sharma and Aditya Singh(September 2014)“Emission characteristics of a diesel engine operating on percentage of blending of Castor oil biodiesel-diesel”, International Journal of Engineering, Management & Sciences, Vol: 1, Issue: 9.
[23] S. Jafarmadar and J. Pashae (August 2013) “Experimental study of the effect of Castor oil biodiesel fuel on performance and emissions of turbocharged DI Diesel”, International Journal of Engineering, Vol: 26, Issue: 8, pp: 905-912.
[24] Shinichi Ichikawa, Satoru Tanaka, Takashi Nakane, Masanobu Aizawa, Kiminori Sato, Takehito Mizuno, Hiroyuki Chida (2003) "Zeolite membrane for dehydration of biomass alcohol : contribution to mitigation of global warming", Fuel chemistry division preprints, pp: 492-493.
[25] S. Ganesan and Dr. A. Elango (2013) "Performance analysis of CI engine using blends of Castor oil and ethanol", International Journal of Mining, Metallurgy & Mechanical Engineering, Vol: 1, Issue: 1, pp: 62-66.

Authors Biography

First Author:
Husainsab M. Halemasuti, M. Tech in Thermal Power Engineering, PDA college of engineering, Kalaburgi.

Second Author:
Channappa H. Biradar, Professor, Department of mechanical engineering, PDA college of engineering, Kalaburgi.