ISSN 2395-1621

Performance, Emission analysis of diesel engine by mixing of two biodiesels blended with diesel as alternative fuel

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ABSTRACT

Due to the increasing awareness of the depletion of fossil fuel resources and environmental issues, biodiesel became more and more attractive in the recent years. Biodiesel production is a promising and important field of research because the relevance it gains from the rising petroleum price and its environmental advantages .Many studies have shown that the properties of biodiesel are very close to those of diesel fuel. Numerous works in the utilization of biodiesel as well as its blends in engines have been done. However, most of the literatures focused on single biodiesel and its blends. Very few experiments have been conducted with the combination of dual biodiesel and diesel as a fuel. Most of the literatures suggested that Jatropha oil and Pongamia pinnata oil is a suitable substitute of diesel. So, the Jatropha oil and Pongamia pinnata oil were selected for this current study which is easily and locally available. The scope of the present study is to analyze the performance and emission analysis of diesel engine with two biodiesels from Jatropha oil and Pongamia pinnata oil and they are blended with diesel at various mixing ratios .

Keywords— Biodiesel, Dual biodiesel, Emission analysis, Minitab software.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Biodiesel is a clean burning alternative fuel produced from domestic, renewable resources such as plant oils, animal fats, used cooking oil and even from algae. Biodiesel contains no petroleum, but can be blended at any level with petroleum diesel to create a biodiesel blend. Biodiesel blends can be used in compression ignition engines with little or no modifications. Among the vegetable oils edible and non-edible oils are used to produce biodiesel. The use of edible is a great concern with food materials. So it is justified to use non edible for the production of biodiesel. Non edible trees can grow in inhospitable condition of heat, low water, rocky and sandy soils. So non-edible oil plants like karanja, jatropha, mahua, neem will be the best choice for the source of biodiesel production.For India, there is a need to take a mission approach to explore the possibility of using straight/unmodified vegetable oils, their blends or biodiesels and their blends with mineral diesel as alternative fuel in order to achieve the twin objectives of reducing the emissions from the diesel engine and to increase the energy security of the country. Jatropha seems to the answer for India's energy woes. Millions of hectares of waste land is available in India and out of which about 33 million hectares of wasteland has been found to be suitable for Jatropha cultivation. Jatropha seems to be perfectly suited for India.. The suitability of Jatropha oil blends and Jatropha biodiesel blends in running of compression ignition has been evaluated and found that the performance of Jatropha oil and Jatropha biodiesel blends is very close to performance of diesel in the compression ignition engine. The break thermal efficiency, break specific energy consumption, CO, UBHC, NOx emissions have been experimentally determined. A SWOT analysis of Jatropha with specific reference to Indian conditions has been carried out and found that Jatropha indeed is a plant which can

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make the Indian dream of self-sufficiency in energy a reality. The use of Karanja biodiesel in conventional diesel engines when used alone or with blends with petroleum diesel substantially reduces exhaust emission such as the overall life cycle of carbon dioxide (CO2), particulate matter (PM), carbon monoxide (CO), sulphur oxides (SOx) and unburned hydrocarbons(HC) with reducing the green house emission also. Regarding the power is same to that of diesel engine. The specific fuel consumption is more or less the same. The brake thermal efficiency is slightly on higher side.

II. LITERATURE REVIEW

Daming Huang et al. [1] review the history and recent developments of Biodiesel, including the different types of biodiesel, the characteristics, processing and economics of Biodiesel industry. The application of biodiesel in automobile industry, the challenges of biodiesel industry development and the biodiesel policy are discussed as well.

Mesuji Hj. Hassan and et al. [2], in this paper worldwide biofuel scenario is assessed by biofuel policies and standards. Different biofuel processing techniques are also summarized. Some guidelines on dedicated biofuel engine are prescribed. Minor modifications on the engine may not cost much; but continuous research and development is still needed.

A.M. Liaquata et al. [3], experimental study has been carried out to analyse engine performance and emissions characteristics for diesel engine using different blend fuels without any engine modifications. In this work, the engine performance and emissions of using blend fuels such as JB5, JB10 and J5W5 were investigated and compared with diesel fuel. J5W5 was found to be comparable with JB10 and produced better results except NOx.

Parag Saxenaa et.al [4], in this paper, emphasis has been given on the Biodiesel, as a potential and sustainable substitute for petro diesel. For each property, various models have been proposed, which are specific to the type of feed oil. The %ARD values for each model for a given property varies and it is not to justify the best prediction model as the model equation have been proposed for different type of FAAE.

D.John Panneer Selvam and K.Vadivel et.al [5],this paper evaluates the possibility of using methyl esters from animal fats as an alternative fuel for diesel. On the whole, methyl esters of beef tallow and its blends with diesel fuel can be used as an alternative fuel for diesel in direct injection diesel engines without any significant engine modification.

Dulari Hansdah et.al [6], this paper explores the possibility of utilizing bioethanol obtained from Madhuca Indica flower as an alternative fuel in a direct injection (DI) diesel engine. The BMDE5 emulsion gave a better performance and lower emissions compared to that of BMDE10 and BMDE15.

Anbarasu Augustine et.al [7], investigated the performance and exhaust emission of a diesel engine fuelled with preheated CSOME at different temperature and compared with diesel.they concluded that CSOME preheated upto 800C can be used as an alternate fuel for diesel fuel without any significant modification in expense of increased NOX emissions.

K. Nantha Gopal et.al [8], in this paper he studied, in-depth research and comparative study of blends of biodiesel made from WCO and diesel is carried out to bring out the benefits of its extensive usage in CI engines. The experimental results of the study reveal that the WCO biodiesel has similar characteristics to that of diesel.

Ameya Vilas Malvadea, et.al [9], Palm fatty acid distillate (PFAD) is a waste from extraction of palm oil. PFAD is used for production of biodiesel. The single cylinder, 4 stroke, water cooled diesel engine of Kirlosker Oil Engine is used for evaluating performance of PFAD biodiesel blends and diesel. The engine performance for various PFAD biodiesel blends at various loads is comparatively equal to that of diesel fuel.

Mohammed EL_Kassaby, et.al [10], wasted cooking oil from restaurants was used to produce neat (pure) biodiesel through transesterification, and then used to prepare biodiesel/diesel blends. The effect of blending ratio and compression ratio on a diesel engine performance has been investigated. Emission and combustion characteristics were studied when the engine operated using the different blends.

Swarup Kumar Nayaka, et.al [11],the paper investigates about the production of biodiesel from neat Mahua oil via base catalyzed transesterification and mixing of the biodiesel with a suitable additive in varying volume proportions in order to prepare a number of test fuels for engine application. The prepared test fuels are used in single cylinder water cooled diesel engine at various load conditions to evaluate the performance and emission parameters of the engine.

Gaurav Paula, et al. [12], studied the effect of addition of jatropha biodiesel to mineral diesel on the performance and emission characteristics of a conventional compression ignition engine have been experimentally investigated and compared with simulated data using Diesel-RK software.

J. Sadhik Basha et.al [13], an experimental investigation was conducted in a single cylinder constant speed diesel engine to establish the effects of Carbon Nanotubes (CNT) with the Jatropha Methyl Esters (JME) emulsion fuel.

N.Panigrahi et al. [14], studied the production process, fuel properties, oil content, engines testing and performance analysis of biodiesel from karanja oil which is known as Karanja oil methyl ester (KOME). Engine tests have been carried out in a water cooled four stroke diesel engine and experimental investigation have been carried out to examine properties, performance and emission of different blends of KOME.

Vivek and A K Gupta et al. [15], studied the feasibility of Karanja oil for the production of biodiesel, optimization of different parameters for high yield percentage of Karanja oil to biodieselThe engine performance with biodiesel is similar to that of diesel, while emissions are less in the case of biodiesel.

K. Nantha Gopal, et al. [16] in this work, bio-diesel from pongamia oil is prepared (PME 100), tested on a diesel engine for different blends such as PME 20, PME 40, PME 60 and PME 80. Comparison is made with diesel operation. Parameters such as brake thermal efficiency, brake specific fuel consumption, carbon monoxide, unburned hydrocarbons, and smoke and NOx emissions are evaluated.

From the review of literatures, numerous works in the utilization of biodiesel as well as its blends in engines have been done. However, most of the literatures focused on single biodiesel and its blends. From previous studies, it is evident that single biodiesel offers acceptable engine performance and emissions for diesel engine operation Very

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few experiments have been conducted with the combination of dual biodiesel and diesel as a fuel.

Most of the literatures suggested that Jatropha oil and Pongamia pinnata oil (also called as karanja oil) is a suitable substitute of diesel. So, the Jatropha oil and pongamia pinnata oil were selected for this current study which is easily and locally available.

III. MATERIALS AND METHODS

The two biodiesels (Jatropha oil and Pongamia pinnata oil) are prepared by the transesterification process. The dual biodiesel blends were prepared in different proportions as: Blend B5-Diesel 90%, JME 5% and PPEE 5% by volume basis; Blend B10 Diesel 80%, JME 10% and PPEE 10% by volume basis; Blend B15-Diesel 70%, JME 15% and PPEE 15% by volume basis, Blend B20 -Diesel 60%, JME 20% and PPEE 20% by volume basis, Blend B25 -Diesel 50%, JME 25% and PPEE 25% by volume basis.

A. Study Design

The various properties like kinematic viscosity, specific gravity, calorific value, flash point temperature and fire point temperature of baseline fuel, raw oils and two biodiesel mixed blends were determined by using ASTM methods and compared with diesel properties. The experiments were conducted on a stationary single cylinder four stroke air cooled diesel engine with electrical loading and the performance and emission characteristics were compared with baseline data of diesel fuel. Tests were conducted at a constant speed and at varying loads for all dual biodiesel blends. Engine speed was maintained at 1500 rpm (rated speed) during all experiments. Fuel consumption and exhaust gas temperatures were also measured. The exhaust emissions were measured by the Crypton make five gas analyzer. The experimental set up is shown in Fig.1.

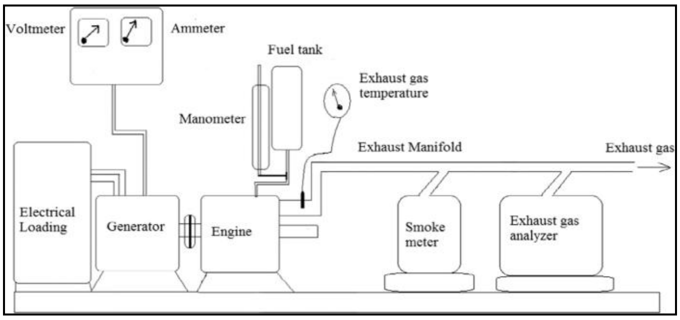

Figure No 1 Test engine setup.

IV. RESULTS AND DISCUSSION

Various physical and thermal properties of dual biodiesels of Jatropha oil and Pongamia pinnata oil and its blends were evaluated. The performance of the engine is to be evaluated using several parameters such as thermal efficiency, specific fuel consumption and exhaust gas temperature. The exhaust emission characteristics like smoke percentage exhaust gas temperatures, Carbon monoxide percentage, Carbon dioxide percentage nitrogen oxides ppm, hydro carbon ppm on brake power of a diesel engine with dual biodiesel and its blends and the results have to compare with diesel.

A. Study Design

The digital bomb calorimeter is used to find out the calorific value of fuels. shows the calorific value of different fuels. The raw vegetable oil has lower calorific value than diesel. After transesterification process, the biodiesels have slightly higher calorific value than raw oil. By blending the dual biodiesels with diesel, the calorific values of Blend B5 and Blend B10 are close to diesel which is more than single biodiesel blends. The calorific values of Blend B15, Blend 20 are almost equal to the single biodiesel blends. The calorific value of Blend 25 is lower than the single biodiesel blends due to the presence of pure biodiesel blends without diesel. Hence, dual biodiesel and its blends are utilized to analyse the performance and emission analysis experimentally.

B. Specific gravity of fuels

Specific gravity of different dual blends is measured using a precision hydrometer. The specific gravity of dual biodiesel blends Blend B5, Blend B10and Blend B15 is 0.832, 0.834 and 0.837, respectively whereas for diesel it is 0.814. The other blends have more deviation than diesel.

C. Viscosity of fuels

Calibrated Redwood viscometer is used for determining the kinematic viscosity. The viscosity of the blends increases with the blend ratio and the viscosities of dual biodiesel blends and they are higher than diesel fuel. The viscosity of the raw Jatropha oil and Pongamia pinnata oil is very high compared to diesel. However, the high viscosities of raw oils are reduced by the transesterification process. Viscosity of dual biodiesel blends Blend B5 and Blend B10 is nearer to diesel

D. Performance analysis

The effect of brake power on specific fuel consumption is shown in Fig 2. As brake power increases the SFC reduces for all the dual biodiesel blends. For the maximum load, the value of SFC of Blend B5 is ----- kg/kWh, Blend B10 is ---- kg/kWh, Blend B15 is ----- kg/kWh whereas diesel fuels have 0.31 kg/kWh. The higher SFC for the dual biodiesel fuel consumption is due to the lower calorific value of the blends. Brake specific energy consumption (BSEC) was used for comparing engine performance of fuels with different calorific values.

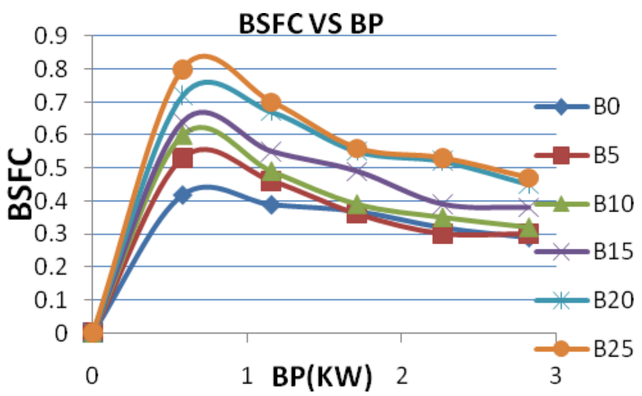

Figure No 2 BSFC Vs BP.

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The effect of brake power on Brake Thermal Efficiency is shown in Fig 3. Indicated power and engine friction are essential for calculating the mechanical efficiency of the engine. Brake Thermal Efficiency is measured as a ratio of the Brake Power to the amount of heat supplied..It measures the effectiveness of a machine in transforming the energy and power that is given as an input to the device into an output force and movement. Hence, Brake Thermal efficiency indicates how good an engine is, in converting the indicated power to useful power. Blend B5 gives the maximum mechanical efficiency of 29.78 % for the maximum break power, whereas the diesel gives 29.56% at the same brake power. For the other blends, mechanical efficiency is lower than diesel.

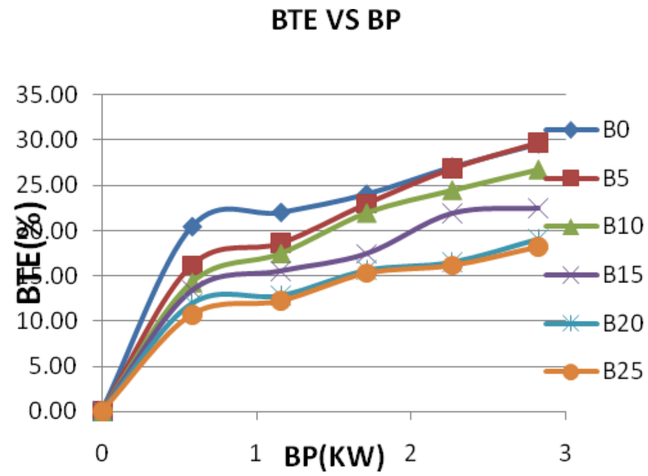

Figure No 3 BTE Vs BP

The effect of brake power on Volumetric Efficiency is shown in Fig 4. As percentage of blend increases Volumetric Efficiency decreases.

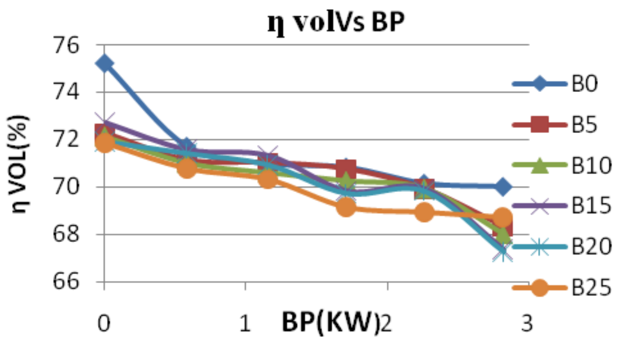

Figure No 4 η vol Vs BP

The effect of brake power on Air Fuel Ratio is shown in Fig 5.As percentage of blend increases Air Fuel Ratio decreases.

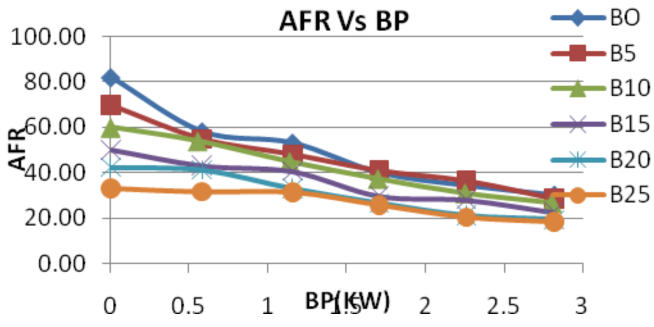

Figure No 5 AFR Vs BP

E. Emission analysis

The variations of brake power on exhaust gas temperatures are shown in Fig. 6. Exhaust temperature increases with the increase in brake power in all cases. Exhaust gas temperature is an indicative of the quality of combustion in the combustion chamber. The increase in exhaust gas temperature with engine load is clear from the simple fact that, more amount of fuel is required by the engine to produce the extra power which is also needed to take up the additional loading. At the same time, all the blends are having less exhaust temperature than the diesel values for any brake power due to its lower heating value and the improved oxygen content provided by the dual bio diesel which increases better combustion.

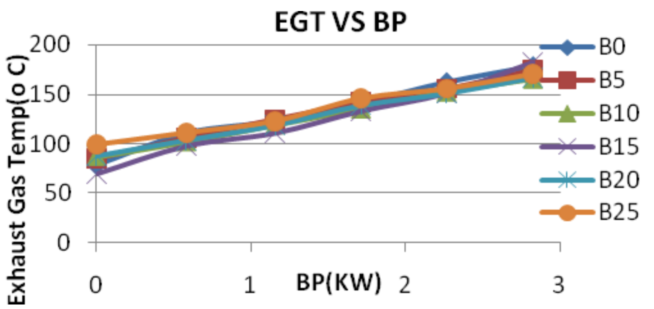

Figure No 6 EGT Vs BP

The variation of brake power on CO is shown in Fig. 7.Blend B5 and Blend B10 gives lower CO than diesel. This is due to the oxygen contents in the biodiesel which makes easy burning at higher temperature in the cylinder. The other blends are deviated from diesel. This is due to the high viscosity; the air-fuel mixing process is affected by the difficulty in atomization and vaporization of dual biodiesels..

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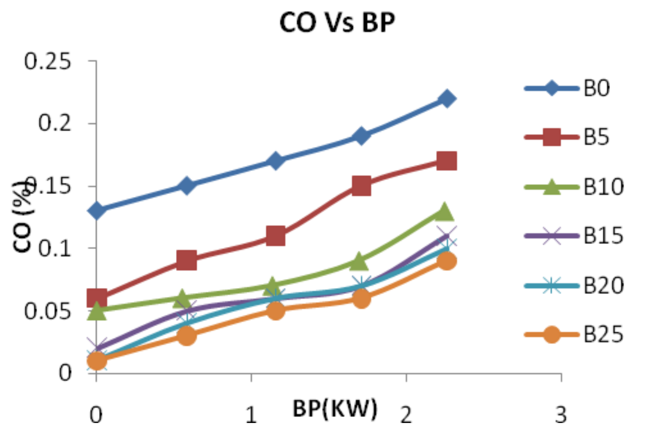

Figure No 7 CO Vs BP

The variations of brake power on CO2 is shown in Fig. 8.In engine load is higher, richer fuel-air mixture is burned and thus more CO2 is produced.

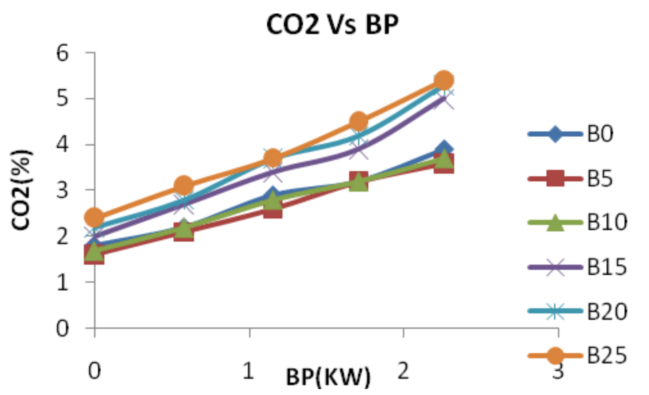

Figure No 8 CO2 Vs BP

The effect of brake power on oxides of nitrogen is shown in Fig. 9. The nitrogen oxides (NOx) increased by increasing the load for each blend. For the maximum load, Blend B5 gives 166 ppm whereas diesel gives 150 ppm, Blend B10 gives 180 ppm, Blend B15 gives 190 ppm at the same maximum load. From the results, NOx emission is higher for dual biodiesel blends than diesel. However, Blend B5 gives lesser NOx than other dual biodiesel blends. The vegetable oil based biodiesel contains a small amount of nitrogen. This contributes toward NOx production. All the blends give higher NOx than diesel. The higher average gas temperature, the presence of fuel oxygen and residence time at higher load conditions with the blend combustion caused higher NOx emissions.

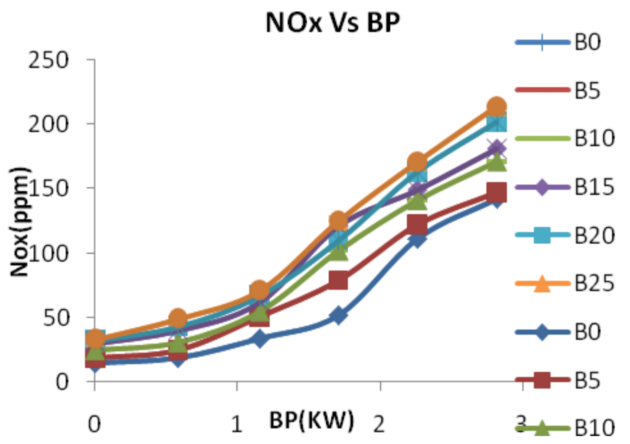

Figure No 9 NOx Vs BP

Fig. 10 shows that, the relation between brake power and hydro carbon (HC) increased by increasing the load for each blend. All the Blends give higher HC than diesel. From the results, Blend B5 gives lesser HC than other blends. The dual biodiesels and blends generally exhibit lower HC emission at lower engine loads and higher HC emission at higher engine loads. This is because of the relatively less oxygen available for the reaction when more fuel is injected into the engine cylinder at high engine load. The lower calorific value and the higher viscosity of biodiesel oil result in the highest HC emissions.

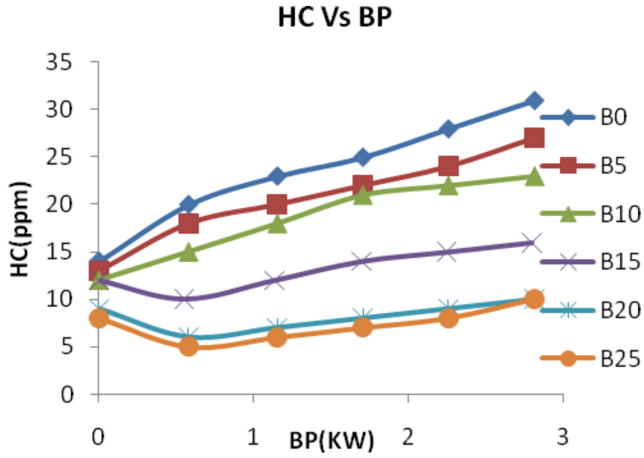

Figure No 10 CO2 Vs BP

The effect of brake power on oxygen is shown in Fig. 11. As percentage of blend increases oxygen percentage also increases.

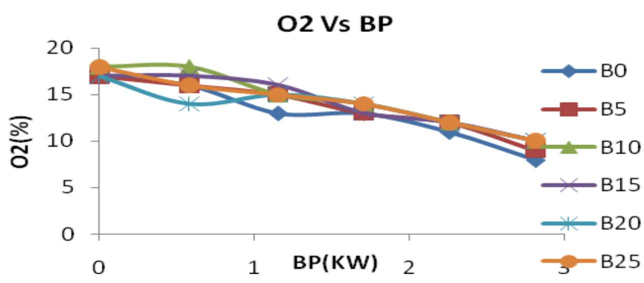

Figure No 11 O2 Vs

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V. 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 Jatropha oil and Pongamia pinnata oil were characterized for their various physical, chemical and thermal properties. From the experimental analysis results, the brake thermal efficiency of Blend B5 is slightly higher than the diesel. Blend B10 and Blend B15 were very closer to the diesel values. The specific fuel consumption values of dual biodiesel blends were comparable to diesel. Blend B5 and Blend B10 produced slightly lower CO than diesel. This is a considerable advantage over diesel while using the dual biodiesel blends. The dual biodiesel blends gave higher HC and NOx than diesel Therefore, it may be concluded that dual biodiesel blends of Blend B5, Blend B10 and Blend B15 would be used as an alternative fuel for diesel in the diesel engines. Various dual biodiesel blends with diesel can be focused for further recommendations

ACKNOWLEDGEMENT

The authors are acknowledging Indian Biodiesel Corporation Baramati for laboratory and field support.

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