Dual Biodiesel-Diesel blends Performance on Diesel engine as an Alternative Fuel

Venkateswara Rao P.

Professor, Department of Mechanical Engineering
Kakatiya Institute of Technology & Science
Warangal, Telangana, INDIA.

Abstract - This paper enlightens properties analysis and performance of C I engine with dual biodiesels – diesel blends as an alternative future fuel (pongamia pinnata and jatropha biodiesels mixture - diesel blend). The main properties such as calorific value, kinematic viscosity and flash point of diesel, mixture of biodiesels and the diesel with biodiesels blend (DPJBD) were determined by using the standard test methods. The results indicate that the calorific value of the blends decrease with an increase in concentration of biodiesels in diesel. The kinematic viscosity and flash point temperature of the dual biodiesel blends are augmented with an increase in concentration of biodiesels in the blends. The viscosity of dual biodiesel blends decreases with an increase in temperature and also reaches the viscosity of diesel at higher temperatures. The specific fuel consumption of dual biodiesel blends was comparable to diesel and provided less HC and CO emissions than diesel.

Key Words:* *Engine, Performance, Dual Biodiesels, Diesel blends, Emission, Alternate Fuel.

1. INTRODUCTION

The increase on energy demand, environmental concern of the global warming, climate change and increasing petroleum price in worldwide has greatly increased the interest of searching for new fuels as an alternative source to diesel fuel. This is only possible with the use of biodiesel which is a renewable source of energy. Though it is not possible to run a C I Engine on 100% biodiesel like Jetropha and Pongamia but without any modifications the presently available engine can be used to run with the blends of biodiesel and diesel. Biodiesel is long-chain alkyl esters which can be obtained from animal fats and plant seeds **[1]**. Biodiesel can absorb 78.5% of carbon from the atmosphere and even considered as cleaner than fossil fuels. Transesterification method is a very simple, efficient and easy process for the biodiesel production. Biodiesel is a renewable and the best alternative fuel for diesel engines and also it can be used in blend form with diesel fuel **[2]**. To replace diesel with Pongamia Pinnata Methyl Ester (PPME) experiments were conducted and concluded that with 40 percent of PPME in diesel could give better results in terms of performance, reduced emissions and energy economy **[3-4]**.

Vegetable oils have almost the same heat values as that of diesel fuel. Power output and fuel consumption of the engine are also very close when compared with that of pure diesel. Vegetable oils can directly be used in diesel engines, as they have calorific value very close to diesel fuel but high viscosity and low volatility of vegetable oil makes difficulty in atomizing the fuel. Viscosity can be reduced by preheating the oil, blending it with diesel or transesterified to use in the diesel engine **[5]**. Reducing vegetable oil viscosity improves in engine performance and emission characteristics for the biodiesel fuelled engine compared to diesel. Improvement in thermal efficiency, reduction in brake specific fuel consumption and a considerable reduction in smoke opacity were observed for the engine **[6]**. With several works on the consumption of biodiesel and its blends in diesel engines it is evident that single biodiesel offer acceptable engine performance and emissions for diesel engine operation. Very few works have been conducted with the combination of diesel and two different biodiesels blend as a fuel. Various researchers focused on single biodiesel like soybean oil, rapeseed oil, pongamia pinnata oil, cotton seed oil, neem oil, mahua oil, jatropha oil, rice bran oil etc., and its blends with diesel **[8-12]**.

The most suitable biodiesels for diesel engine are pongamia pinnata oil (PBD) and jatropha oil (JBD). In this paper, PBD and JBD mixture (PJBD) have been blended with diesel fuel at various proportions forming DPJBD. The properties were analyzed and compared with diesel fuel.

Fuel properties like density, calorific value, viscosity and flash point were tested **[7]**. Experimental tests have been carried out, to evaluate the performance and exhaust emissions of DPJBD fuel on the diesel engine.

2. MATERIALS AND METHODS

Transesterification process is selected to make biodiesel from ***Jatropha*** and ***pongamia pinnata*** oils. Raw oil is filtered using surgical cotton to eliminate water, solid particulate matter and heated at 105^{0}C temperature to remove all the water content. In acid treatment methanol of 99% pure, 120 ml per liter of oil is added to the heated oil and stirred for ten minutes. Two milliliter of 98% pure sulfuric acid is added for each liter of oil. The mixture is heated and stirred for one hour at 60^{0}C in a closed conical beaker. The mixture is allowed to settle for four hours in a decanter and glycerin is removed from methyl ester.

In the base treatment for each liter of oil, 200 ml of methanol (20% by volume) and 6.5 grams of 97% pure NaOH (Sodium Hydroxide) is added. The mixture is stirred thoroughly until it forms a clear solution called "***Sodium Methoxide***". This solution is added to the oil, heated to 60^{0}C and maintained at the same temperature with stirring at 500 to 600 rpm in a closed container. When the solution turns into brown silky in colour, which shows that the whole reaction is completed. After settlement of the mixture in decanter, bottom part of the glycerin is separated from the biodiesel. The formed methyl ester is bubble washed with distilled water for about half an hour to remove soaps and un-reacted alcohol. Washing is repeated till the methyl ester separated with clear water **[13, 14]**. Collected methyl ester is heated to remove water and formed biodiesels JBD, PBD and blends prepared with diesel fuel are taken for characterization and properties of fuels are shown in Table **1**.

Table: 1. Properties Biodiesels Blends

Fuel	Density kg/m^3	C alorific Value (kJ/kg)	Kinematic Viscosity 40ºC (cSt)	Flash Point (ºC)
Diesel	840	43500	2.86	58
PJBD	877	38950	4.57	68
D90PJBD10	844	43045	3.03	68
D80PJBD20	848	42590	3.21	77
D70PJBD30	851	42130	3.37	86

3. EXPERIMENTATION

The Kirloskar make single cylinder, four-stroke, DI diesel engine coupled with eddy current dynamometer is used for the experimental work. Experiments were conducted with varying loads of 0, 20, 40, 60, 80 and 100% for diesel, biodiesel mixture and blends with diesel (Diesel, PJBD, D90PJBD10, D80PJBD20 and D70PJBD30) at constant rated speed 1500 rpm of the engine as shown in figure **1.** Fuel consumption and exhaust gas temperatures were measured by usual procedure. The parameters like fuel consumption, brake thermal efficiency and brake specific fuel consumption are evaluated at all load conditions. The emissions characteristics are measured at steady state condition of the engine with the help of AVL make smoke meter. The exhaust gas analyzer was used to measure the carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbon emission (HC) and nitrogen oxides (NO_x). The smoke intensity was measured with smoke meter and the results were compared with the diesel fuel.

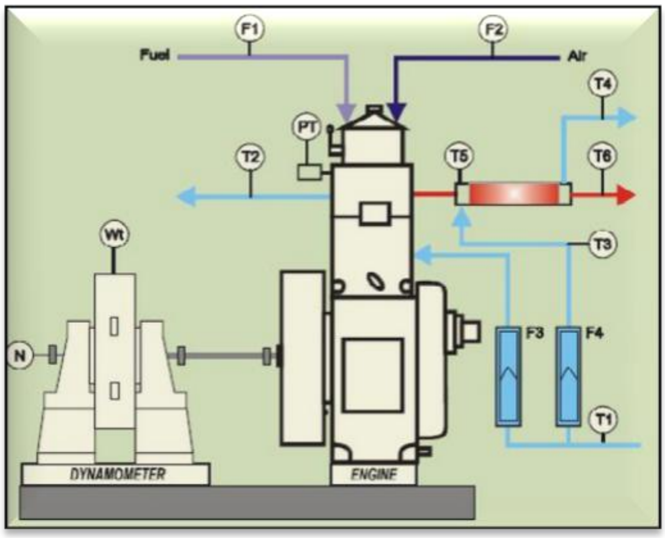

Fig.1 Experimental setup

4. RESULTS AND DISCUSSION

The *performance* and *emissions* of C I engine are *analyzed* with dual biodiesels mixture – diesel blends at different proportions and compared the results with diesel fuel.

4.1 Performance Analysis

i) Figure **2** shows the variation of brake thermal efficiency with load. It is observed that, D90PJBD10 gives the maximum thermal efficiency of 26.2% and D80PJBD20 gives 24.7% as compared to the diesel 26.6% at the same load condition. The maximum thermal efficiency obtained for D90PJBD10 blend fuel is due to the higher calorific value than other biodiesels blends. At low load conditions, thermal efficiency of the diesel engine has enhanced with increasing concentration of the biodiesels in the fuel which provides additional volatility by the multi biodiesels. The quantity of oxygen available in biodiesels is also helpful in completion of combustion.

As load increases the *BSFC* reduces for all the biodiesels blends. At maximum load, the *BSFC* value of D90PJBD10 is 0.35kg/kWh, D80PJBD20 is 0.365kg/kWh, D70PJBD30 is 0.368kg/kWh and for the diesel fuel is of 0.364 kg/kWh. As the percentage of biodiesels increase in blends the value of BSFC is increasing due to decrease in calorific value the fuel used.

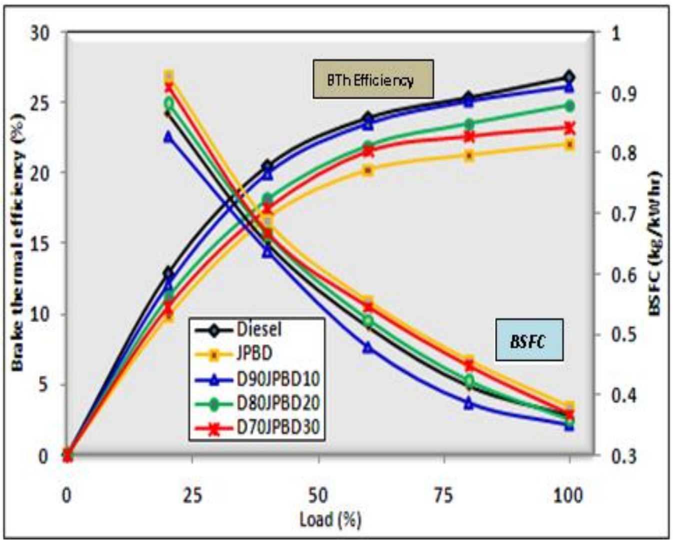

Fig.2 Thermal efficiency and *BSFC* variation with Load

ii) The exhaust gas temperature variation with load is shown in figure **3.** Temperature increases with increase in load for all cases. At maximum load, the value of D90PJBD10 is 212°C, D80PJBD20 is 243°C and D70PJBD30 is 284°C whereas diesel fuel has 196°C. The increase in temperature with load on the engine is may be due to additional fuel supply at higher loads.

4.2 Emission Analysis

i) Carbon dioxide (CO_2) emission variation with load is shown in figure **4.** The biodiesels blends give higher CO_2 than diesel. D90PJBD10 gives the CO_2 emission of 4.75% by volume, whereas diesel has 4.7%. It is due to more oxygen in biodiesels blends causes complete combustion which reduces HC and CO emissions from the engine.

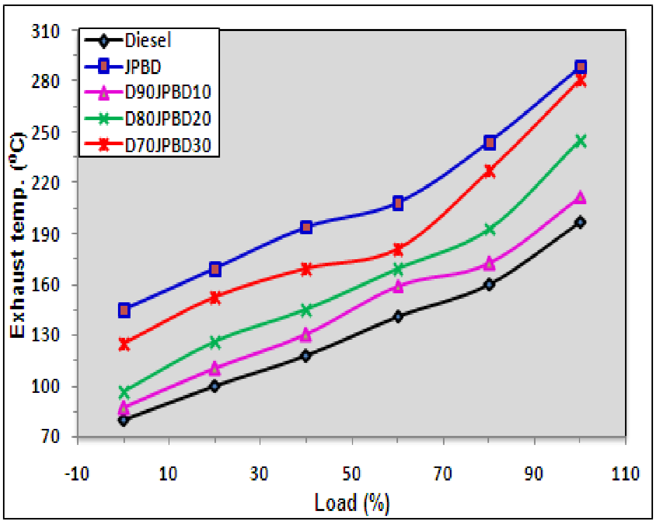

Fig. 3 Exhaust temperature variation with Load

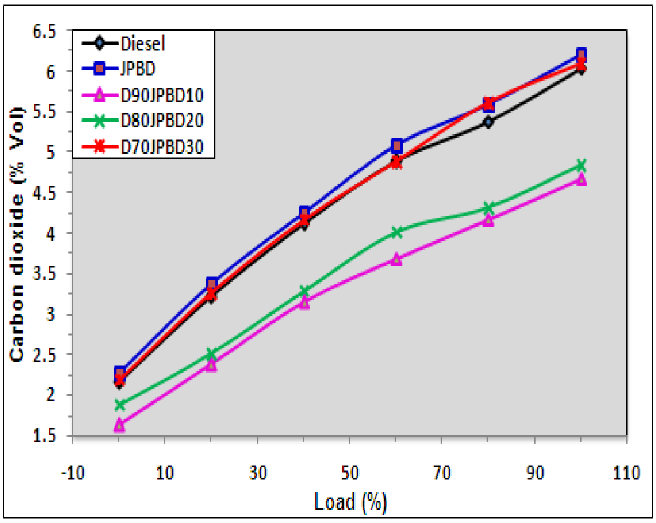

Fig. 4 Carbon dioxide variation with Load

ii) The figure **5** shows that variation of carbon monoxide (CO) with load, which is increasing with increase in load. The biodiesels blends give lower CO than diesel. This is due to the oxygen content in the biodiesel makes easy burning at higher temperature in the cylinder. At higher ratios of biodiesels in blends deviated from diesel fuel CO emission. This is due to the high viscosity of air-fuel mixing process affected in atomization and vaporization of blends of biodiesels, but at higher loads the richer fuel-air mixture is burned which produces more CO.

iii) It is observed from Figure **6** that smoke percentage increases with increase in load. At maximum load, the smoke for diesel is 33%, where as 31% and 32% for **10** and **20%** biodiesels blends respectively at maximum load.

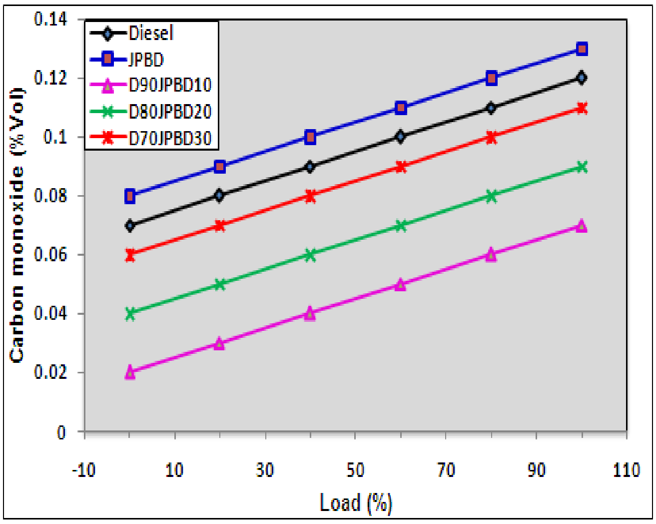

Fig. 5 Carbon monoxide variation with Load

For other blend fuels the smoke percentage is more than diesel at the same load. High density and viscosity may be the reason for more smoke emissions as compared to neat diesel. High viscosity of pure biodiesels blend decreases the fuel atomization which increases exhaust smoke.

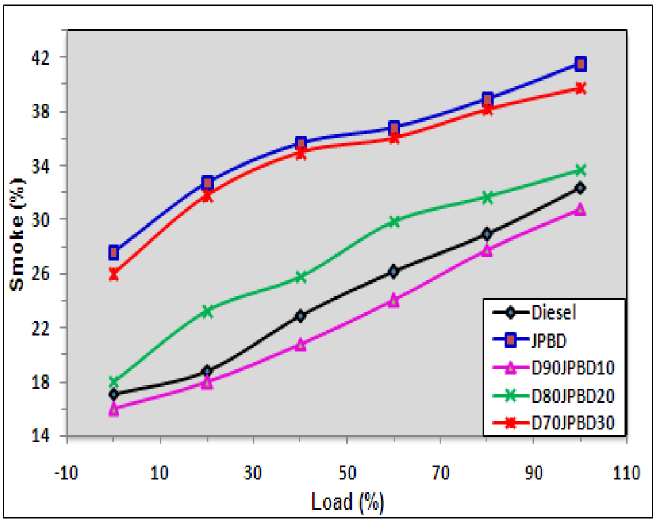

Fig. 6 Smoke variation with Load

iv) Figure **7** shows that Hydro Carbon (HC) increases with increase in load. From the results, blend **D90PJBD10** gives lesser HC than other blends and 50% lower HC than diesel at the maximum load. At lower concentration of biodiesels blends, oxygen present in the biodiesel assist for complete combustion. But as the biodiesels concentration increases, negative result attained due to high viscosity and density which reduces the complete combustion and increases the hydro carbon emission.

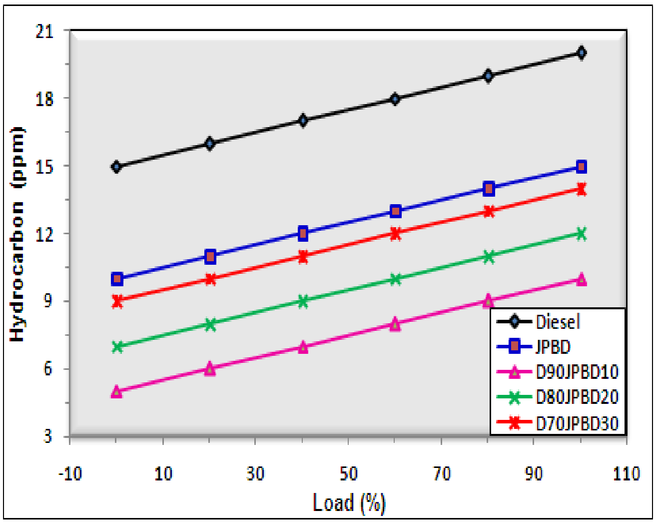

Fig. 7 Hydrocarbon variation with Load

v) The figure **8** shows that nitrogen oxides (NO_x) increases by increasing the load for each blend fuel. From the results, NO_x emission is higher for biodiesels blends than diesel; however blend **D90PJBD10** gives less NO_x than other biodiesels blends. The vegetable oil based biodiesel contains a small amount of nitrogen which contributes towards the production of NO_x. The high average temperature of gas, presence of oxygen in fuel and more residence time of gas at higher load conditions in the cylinder with dual biodiesels – diesel blends combustion caused higher NO_x emissions.

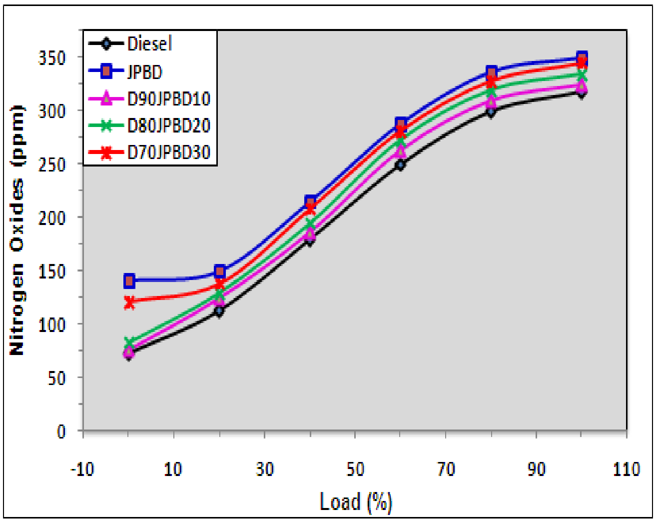

Fig. 8 Nitrogen oxide variation with Load

5. CONCLUSIONS

- The calorific value and kinematic viscosity of

- **D90PJBD10** is very closer to diesel values, which facilitates safe for transport and storage.
- The specific fuel consumption and thermal efficiency of biodiesels blends **D90PJBD10** and **D80PJBD20** were comparable to that of diesel.
- Based on these results, **D90PJBD10** and **D80PJBD20** were very closer to diesel fuel values. Hence they can be used as fuels for stationary diesel engines for the purpose of agriculture.

6. REFERENCES

1. Avinash Kumar Agarwal, "Biofuels (Alcohols and Biodiesel) Applications as Fuels for Internal Combustion Engines", *Progress in Energy and Combustion Science*, 2007; 33: 233-271.
2. Lin L, Ying D, Chaitep S and Vittayapadung S, "Biodiesel production from crude rice bran oil and properties as fuel", *Applied Energy*, 2009; 86: 681–688.
3. Sureshkumara K, Velrajb R and Ganesan R, "Performance and Exhaust Emission Characteristics of a C I Engine Fueled with Pongamia Pinnata Methyl Ester (PPME) and its Blends with Diesel", *Renewable Energy*, 2008; 33: 2294-2302.
4. Avinash Kumar Agarwal and Atul Dhar, "Experimental Investigations of Performance, Emission and Combustion Characteristics of Karanja Oil Blends Fuelled DICI Engine", *Renewable Energy*, 2013; 52: 283-329.
5. Wang Y D, Al-Shemmeri T, Eames P, McMullan J, Hewitt N, Huang Y, Rezvan S, "An experimental investigation of the performance and gaseous exhaust emissions of a diesel engine using blends of a vegetable oil", *Applied Thermal Engineering*, 2006; 26: 1684-1691.
6. Agarwal D, Kumar L, Agarwal A K, "Performance evaluation of a vegetable oil fuelled compression ignition engine", *Renewable Energy*, 2008; 33: 1147–1156.
7. Anand K, Sharma R P, Mehta P S, "A comprehensive approach for estimating thermo-physical properties of biodiesel fuels", *Applied Thermal Engineering*, 2011; 31: 235-242.
8. Srithar K, Arun Balasubramanian K, Vivar M, Skryabin I, "An experimental investigation on diesel and low heat rejection engines with dual biodiesel blends", *International Journal of Green Energy*, 2013; 10: 1041-1055.
9. Raheman H and S Kumari, "Combustion characteristics and emissions of a compression ignition engine using emulsified jatropha biodiesel blend", *Biosystems engineering*, 2014; 123: 29-39.
10. Arun Balasubramanian K, Guruprasath A, Vivar M, Skryabin I, Srithar K, "Performance and emission characteristics of double biodiesel blends with diesel", *Thermal Science,* 2013; 7: 255-262.
11. Arun Balasubramanian K and K Srithar, "Multiple biodiesel mixtures in diesel engine - performance and emission analysis", *Energy Education Science and Technology Part A: Energy Science and Research*, 2014; 32(1): 13-24.
12. Dilip Kumar K and P Ravindra Kumar, "Experimental investigation of Cotton seed oil and Neem methyl esters as biodiesel on C I engine", *International Journal of Modern Engineering Research,* 2012; 2: 1741-1746.
13. Venkateswara Rao P and Srinivasa Rao G, "Production and Characterization of Jatropha Oil Methyl Ester", *International Journal of Engineering Research*, 2013; 2(2): 145-149.
14. Venkateswara Rao P., S. Ramesh, "Optimization of Biodiesel production parameters (Pongamia pinnata oil) by transesterification process", *Journal of Advanced & Applied Sciences*, 2015, 3(3): 84-88.

AUTHOR BIOGRAPHY

Dr. P Venkateswara Rao is a professor working in KITS, Warangal, Telangana. He has obtained Doctoral degree in the field of Alternative Fuels from Andhra University. He has more than 30 years of teaching experience and more than 20 International Journal Publications.