



IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: I Month of publication: January 2018 DOI: http://doi.org/10.22214/ijraset.2018.1249

www.ijraset.com

Call: 🛇 08813907089 🕴 E-mail ID: ijraset@gmail.com

Performance, Combustion and Emission Characteristics of Major Biodiesel Blends: A Review

P. Ratna Raju¹, Dr. T. Hari Prasad², Dr. K. Hema Chandra Reddy³

^{1, 2} Department of Mechanical Engineering, Jawaharlal Nehru Technological University, Anantapur ³ Departments of Mechanical Engineering, Sri Vidyanikethan Engineering College, Tirupati

Abstract: The change in industrialisation and the increase in usage of automobile divesting the natural reserves of the fossil fuels which has driven the world towards alternative fuels especially renewable sources. One of the most prominent replaceable alternatives to the diesel is biodiesel. The research on usage of this biodiesel and modification of engines to suit these biodiesels started during the period of World War-II and the change in environmental conditions and decreasing reserves of the existing petroleum reserves formed as catalyst to accelerate this research to find better alternative biodiesel. Wide research is being done on many of the alternative biodiesels. This work mainly focuses on review of performance, emission and combustion characteristics of five most prominent biodiesels namely Jatropha, Cotton seed oil, Rubber seed oil, Mahua oil and Rapeseed oil. It is found that the brake specific fuel consumption is high for all the biodiesels because of less energy content in them in comparison with diesel. The variation of brake thermal efficiency depends on the percentage of fuel combustion and the emissions of HC, smoke and CO by Rapeseed oil is little more comparative to that of other biodiesel blends but the performance of Rapeseed oil is superior and almost similar to that of diesel when compared with other biodiesel blends. Hence forth Rapeseed oil can be suggested as better alternative biodiesel to the diesel with certain modifications like Al_2O_3 coatings to the piston which controls CO and HC emissions.

Keywords: Alternative fuels, Biodiesel, Blends, Emission, Performance, Brake thermal efficiency

I. INTRODUCTION

To move heavy vehicles economically diesel engines are modified accordingly and this increased interest of these diesel engines is all because of their thermal efficiency, which strives better fuel economy and lower emissions. The modification of these engines to improve better fuel economy and better combustion characteristics made them dominantly used. The output power of these engines is improved with the improvement of injection systems, and development of super chargers and turbo chargers. Unfortunately, the exhaust gas emissions are till high. The current research work is focused on reduction of these emissions, by the application of diesel particulate filter (DPF) and selective catalytic reduction (SCR), the particulates and NOx are reduced but they are not remarkable. The negative effect of NOx and sooth from compression Ignition (CI) engines increases on human health. Recent measurements of sooth deposition granule are almost the size of particulate matter, which increases risk of human life. On the other hand, it is depletion of the natural fuels which are non-renewable.

A search for good alternative fuel is being done from past few years, which include hydrogen, Dimethyl esters (DME), biodiesels etc... The major end-user requirements like cost, availability, efficiency, safety, supply etc. are limiting each of the different alternatives available for usage. On the other hand, each of these alternative fuels have their advantages and limitations as shown below in Table I.

Table 1. Comparison of unreferent Kenewable Sources						
Type of Fuel	Advantages	Limitations				
Hydrogen	Emissions are Zero	• Difficult to handle and store				
	Potential Renewable source	• Difficult to refill the fuel				
	• Lower heating value is very high					
Dimethyl Esters	• Cetane number is high	• Safety is one of the major				
	• Less particulate matter and NOx	concerns because of high				
	emissions	pressure tank				

Table I. Comparison of different Renewable Sources



International Journal for Research in Applied Science & Engineering Technology (IJRASET)

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887

Volume 6 Issue I, January 2018- Available at www.ijraset.com

			٠	This fuel is not as good as diesel
Biodiesel	•	It has become most potential	•	Energy content is very less
		Renewable source as a fuel		There is no certainty on NOx
	•	HC and CO emissions are less		

II. BIODIESEL PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTICS

Biodiesel fuels are gaining more importance as an alternative source in the recent years. Biodiesels cannot be used directly as a fuel in internal combustion engines, this requires changes or modifications to be done to the engine. Karthick. D et. al. has conducted experiment on single cylinder direct diesel engine by reduced compression ratios from 17:1 to 16.5:1 with different blends of diesel with Jatropha and analysed emission, combustion and performance characteristics, it is found that reducing compression ratios and usage of biodiesel produces almost similar amount of NOx but with lesser smoke [1]. M. Loganathan et. al. in their experimental investigation on emission characteristics of neat Jatropha and blended with Dimethyl Ether found that the brake thermal efficiency of the blended Jatropha is greater than that of the neat fuel, along with it was also found that the emissions like CO, HC and NOx is lesser in case of blended fuel than the neat fuel [2]. M. G. Bannikov et. al. in their experimentation on Jatropha Methyl Esters and diesel found the following variations: (1) engines fuelled with Jatropha Methyl Esters at high loads had increased specific fuel consumption, reduced NOx, unburned HC and smoke emissions, (2) increase in specific fuel consumption is because of lower heating value of the fuel, and (3) the analysis of combustion characteristics also revealed that the cetane index measured by ASTMD976 is not a proper measure for ignition quality of the fuel [3]. Bhaskar Kathirvelu et. al. in their experimentation on Jatropha and fish waste found that without major modifications to the diesel engine the emission of CO, unburned HC and soot is less but there is a slight increase in NOx at all loading conditions [5]. Rajneesh Kumar et. al. in their experimentation found that blends of Jatropha Ethyl Esters and diesel can be successfully used in diesel engines without any modifications to the engines, with superior performance and emission characteristics [4]. Venkateswarulu Chintala et. al. in their work on solar driven Jatropha biomass pyrolyzed oil on direct injection diesel engines found the following characteristics in performance and emission: (1) efficiency of the engine increased for PODB20 blends from 32% to 34% and whereas for PODB40 blends it was 35.6%, (2) there is a reduction of emission of HC, CO and smoke with both PODB20 & PODB40, whereas the emission of NOx first increased then it decreased [6]. Deep A et. al. prepared micro emulsions of jatropha and ethanol in different ratios when compared with diesel and found that in part loading conditions brake thermal efficiency and brake specific energy consumptions of blends of Jatropha and ethanol was insignificant. Where in the emission of HC, Co and smoke reduced at part load conditions [9]. Surva Dharma et. al. in their work on experimental and performance prediction of blends of Jatropha Curcas-Ceiba pentandra (J50C50) using artificial neural networks found the following variations in performance and emissions (1) initially there is a decrease in brake specific fuel consumption when the engine running condition changed from 1500 rpm to 1900 rpm and there on BSFC increases to a load of 2400 rpm this is because of lower energy content of the fuel blends. (2) high viscosity and lower calorific value of these biodiesel the brake power decreases. (3) Brake thermal efficiency of the engine decreases with the usage of this blends this is because of poor atomization, evaporation and combustion resulting from high viscosity and lower heat content of the fuel [12]. Overall it is absorved that usage of Jatropha based biodiesel and it blends increases the NOx emissions and decreases the unburnt HC and CO. V. Mathan Raj et. al. in an experiment on single cylinder four stroke diesel engine with blends of cotton seed oil and isobutanol with diesel by volume, found that brake thermal efficiency increases with decrease in specific fuel consumption lower exhaust temperatures with addition of cotton seed oil [7]. Basavaraj M. Sirigiri et. al. in their experimentation with cotton seed oil methyl ester on single cylinder four stroke direct injection system found that brake thermal efficiency at the peak loads is reduced by 5.91% and specific fuel consumption increased by 28.57%. it was also found that there is an increase in NOx emission, with slight increase in CO, smoke and HC emissions [8]. R. Senthilraja et. al. in their experimental setup of dual fuel engine on different blends of cottonseed oil Methyl Ester, diesel and CNG found that the brake thermal efficiency increases with increase in Ethanol and Cottonseed oil Methyl Ester blends, this is because of presence of higher oxygen content which makes more complete combustion. On the other side brake specific fuel consumption increases with increase in the percentages of ethanol and Cottonseed oil Methyl Ester blends, this is because of lower heating value of these blends. Increase in cottonseed oil Methyl Ester blend increases the exhaust gas temperature because of complete combustion due to presence of oxygen content. Regarding emissions, the emission of CO is little higher in lower and medium loads, whereas the emission decreases at higher loads. Because of higher density, viscosity, atomisation and inbuilt interatomic molecular oxygen the HC and NOx emissions increases with percentage increase in cottonseed

oil Methyl Ester blends [11]. M. R. Subbarayan et. al. in their work on diesel engine with cottonseed oil Methyl Ester and blends



International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887

Volume 6 Issue I, January 2018- Available at www.ijraset.com

along with petro-diesel found that the specific fuel consumption increases with the increased concentration of the blends because of their lower calorific value. The percentage increase in brake thermal efficiency of the engine for the neat diesel is greater than the blend but at full load condition the brake thermal efficiency of the blends is 0.63% greater than the neat diesel [13]. Pankaj S. Shelke et. al. in an experimental study on base diesel and cottonseed oil biodiesel (B5, B10, B15 and B20) as fuel found that ignition delay of cottonseed oil biodiesel blends decreases in comparative to the diesel which is because of the higher cetane number of these biodiesel blends. Because of lower calorific value of these blends the brake thermal efficiency decreases and there is an increase in NOx emission because of increase of premix combustion of these biodiesel blends which also increases combustion duration [14]. Over all the specific fuel consumption increases because of their lower heat content, only at full load condition the brake thermal efficiency will be better than the neat diesel, regarding emissions with the percentage increase in the blends the HC and NOx emissions also increases.

Ahmed Syed et. al. in their work on direct injection engine with dual fuel mode operating on hydrogen and Mahua Methyl Ester found that brake thermal efficiency improved by 28% with injection opening pressure of 250 bar and 75% of engine load. It was also found that brake specific fuel consumption decreases with increase in injection opening pressure for these blends. With the presence of hydrogen as fuel in dual fuel mode the HC emissions are reduced by 87% and CO emissions reduced by 86% than the pure diesel [15]. C. Solaimuthu et. al. in their work on selective catalytic reducer for direct injection diesel engine with Mahua blends found that the specific fuel consumption is very low for the blends B0 and B25 at no load and full load conditions. Along with this these blends show very low CO emissions but the HC emissions are little higher for B0 compared to other blends [23]. M. Senthil Kumar et. al. in their work on effect of high octane fuel induction on combustion behaviour with Mahua oil based dual fuel engine found a reduction in combustion duration was in dual fuel mode with Eucalyptus oil with comparatively better brake thermal efficiency [24]. Deepesh Sonar et. al. in their work on varying injection pressure on raw Mahua (Pre-heated) and Mahua Methyl Ester observed that brake thermal efficiency increases for almost all the blends with injection opening pressure, the brake specific fuel consumption for the Mahua oil blends is greater. In case of emission characteristics, it's found that CO and HC emissions are less but on the other hand because of increase in inlet temperature NOx emissions also increases [25].

Gvidonas Lebeckas et. al. in their work on off road vehicle direct injection system with Rapeseed oil found that the performance of engine with Rapeseed oil is on par with the diesel as fuel except with slightly higher brake specific fuel consumption at rated power and maximum torque [16]. M. Pexa et. al. in their work on Rapeseed oil Methyl Ester on IC engines for performance characteristics in comparison with Hydrogenated oil found that for better performance of the engine with Rapeseed oil Methyl Ester the fuel consumption will increase [17]. S. Duran et. al. in their experiment on Rapeseed biodiesel blend along with Karanja blends found that the brake thermal efficiency of the RB20 and RB50 Rapeseed blends are better than the pure diesel at full load conditions. The NOx emission is lower than the regular diesel this is because of the mean gas temperature of the RB20 and RB50 Rapeseed blends [18]. L. Labecki et. al. in their work on multi injection direct injection diesel engine found that results of pure Rapeseed oil and blends of Rapeseed oil show strong reduction in NOx emissions this is because of low inside pressure and temperatures. There is higher amount of HC and CO emissions in case of Rapeseed oil and Rapeseed oil blends because of incomplete combustion [19]. D. H. Qi et. al. in their work on direct injection diesel engine with Rapeseed oil with micro-emulsions as a fuel found that there is a lightly higher brake fuel consumption and there is a drastic decrease in smoke and NOx emissions due to presence of microemulsions. In another work on Rapeseed oil based hybrid fuel it was absorved that the smoke emissions were little lower at higher loads in comparative with diesel but there was a slight increase in HC and CO emissions at low loads. Yet in another experiment on dual cylinder agricultural diesel engine with Rapeseed oil blends found that CO and HC emissions were bit high because of unavailability of the localised oxygen, there is a bit lower in CO emissions at higher loads because of higher cylinder, better air-fuel mixture and better combustion [20, 21, 22].

V. Edwin Geo et. al. in their work on DEE port injection with Rubber seed oil found that the brake thermal efficiency of RSO (rubber seed oil) is less comparative to that of diesel which is because of poor mixture formation and regarding emission characteristics NOx, CO and smoke emissions are lowered whereas HC emission increased a little in comparative with diesel for neat Rubber seed oil [26]. M. Satyanarayana et. al. in their investigation on performance, emission and combustion characteristics of different bio oils found that the brake thermal efficiency of Rubber seed oil is around 30.5% whereas for diesel it is around 35%, HC emissions are less whereas CO and NOx are little higher [27]. Vishal V Patil et. al. in their work on influence of butanol on Rubber seed oil Methyl Ester blends found that emission of NOx reduced by 10% with increase in butanol content [28]. S. Senthil Kumar et. al. in their work on their work on CI engines with various injection pressure using Rubber seed oil found that the brake thermal efficiency of z50 bar which is closer to diesel injection system at 200 bar on



International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887 Volume 6 Issue I, January 2018- Available at www.ijraset.com

the other side the CO, HC and smoke decreased and NOx emission increased for that pressure of 250 bar. Yet in another experiment on B25 (25% Rubber seed oil Methyl Ester) on coated piston with Al_2O_3 found better engine performance in which the brake thermal efficiency is increased by 4% and the brake specific fuel consumption decreased by 9% in coated when compared to uncoated piston. The smoke, CO and HC emissions are also decreased [29, 30].

III. CONCLUSIONS

From the above literature review the study of performance, combustion and emission characteristics of the five-major biodiesel (Jatropha, Mahua, Cotton seed, Rubber seed and Rapeseed oil) blends the following observations are made;

The performance characteristics of Rapeseed oil blends is superior to that of other biodiesel blends and almost on par with the diesel Emission of smoke, HC and CO is little more in case of Rapeseed oil in comparison with other biodiesel blends

The emission of NOx is less in case of Rapeseed oil blends than that of other biodiesels

But by making small modification in the engine like coating of the piston the emission characteristics like HC, smoke and CO can be regulated which makes Rapeseed oil blends as the superior and better alternative biodiesel.

IV.ACKNOWLEDGMENT

I wish to acknowledge Dr. T. Hari Prasad, Professor, Department of Mechanical Engineering, Sri Vidyanikethan Engineering College, Tirupati, A.P and Dr. Hema Chandra Reddy, Professor, Department of Mechanical Engineering, JNTU, Anantapur; for spending their valuable time to supervise and encourage me to opt this wonderful topic of research which is very useful to the society and forth coming generations.

REFERENCES

- M. Lokhanathan, A. Anbarasu, A. Velmurugan, "Emission charectaristics of Jatropha Dimethyl Ester Fuel Blends on A DI Diesel Engine", International Journal of Scientific & Technology Research, Volume-1, Issue-8, 28-32, 2012.
- [2] M. G. Bannikov, J. A. Chattha, "Combustion and Emission Characteristics of Jatropha Methyl Ester in a Direct Injection Diesel Engine", Taylor & Francis, 396-704, 2015.
- [3] Rajneesh Kumar, Anoop Kumar Dixit, Gursahib Singh Manes, Rohinesh Kurana, "Emission and Performance Characteristics of Jatropha Ethyl Ester Blends with Diesel Fuel in CI Engines", IJAuRD, Volume-2, Issue-2, 34-47, 2012.
- [4] Bhaskar Kathirvelu, Sedilvelan Subramanian, Natrajan Govindan, Sampath Santhanam, "Emission Characteristics of Biodiesel Obtained from Jatropha Seeds and Fish Waste in Diesel Engine", Sustainable Environment Research, 283-290, 2017.
- [5] Venkateswarulu Chintala, Suresh Kumar, Jitendra K. Pandey, "Assessment of Performance, Combustion and Emission Characteristics of Direct Injection Diesel Engine with Solar Driven Jatropha Biomass Pyrolysed Oil", Energy Conservation and Management, Volume-148, 611-622, 2017.
- [6] V. Mathan Raj, L. R. Ganapathy Subramanian, and G. Manikandaraja, "Experimental study of effect of isobutanol in performance, combustion and emission characteristics of CI engine fuelled with cotton seed oil blended diesel," Alexandria Eng. J., 2017.
- [7] Basavaraj M. Srigiri, Omprakash D. Hebbal, K. Hemachandra Reddy, "Performance, Emission and Combustion Characteristics of Semi-Adiabatic Diesel Engine Using Cotton Seed and Neem Kernel Oil Methyl Esters", Alexandria Engineering Journal, 699-706, 2016.
- [8] Deep, A., Kumar, N., and Pali, H., "Study of Performance and Emissions Parameters of Single Cylinder Diesel Engine Fuelled with Micro Emulsion of Jatropha Oil and Ethanol", SAE Technical Paper 2017-01-2331, 2017.
- B. S. Chauhan, R. K. Singh, H. M. Cho, and H. C. Lim, "Practice of diesel fuel blends using alternative fuels: A review," Renew. Sustain. Energy Rev., vol. 59, pp. 1358–1368, 2016.
- [10] R. Senthilraja, V. Shivakumar, K. Thirugnanasambandham, N. Nedunchezhian, "Performance, emission and combustion characteristics of a dual fuel engine with DieseleEthanol e Cotton seed oil Methyl ester blends and Compressed Natural Gas (CNG) as fuel", Energy (Elsivier), 899-907, 2016.
- [11] Surya Dharma, Masjuki Haji Hassan, Hawai Chyuan Ong et. al., "Experimental study and prediction of the performance and exhaust emissions of mixed Jatropha curcas-Ceiba pentandra biodiesel blends in diesel engine using artificial neural networks", Journal of cleaner production, 618-633, 2017.
- [12] M. R. Subbarayan, J. S. Senthil Kumaar, M. R. Anantha Padmanaban, "Experimental investigation of evaporation rate and exhaust emissions of diesel engine fuelled with cotton seed methyl ester and its blend with petro-diesel", Transportation Research Part D, 369-377, 2016.
- [13] Pankaj S. Shalke, Nitin M. Shakare, Subhash Lahane, "Investigation of Combustion Characteristics of a Cottonseed Biodiesel Fuelled Diesel Engine", Procedia Technology, 1049-1055, 2016.
- [14] Ahmed Syed, Syed Azam Pasha Quadri, G. Amba Prasad Rao, Mohd Wajid, "Experimental investigations on DI (direct injection) diesel engine operated on dual fuel mode with hydrogen and mahua oil methyl ester (MOME) as injected fuels and effects of injection opening pressure", Applied Thermal Engineering, 118-129, 2017.
- [15] Gvidonas Labeckas, Stasys Slavinskas, "Performance of direct-injection off-road diesel engine on rapeseed oil", Renewable Energy, 849-863, 2016.
- [16] M. Pexa, J. Cedak, J. Marik, V. Honig, S. Hornickova, K. Kubin, "Comparison of the operating characteristics of the internal combustion engine using rapeseed oil methyl ester and hydrogenated oil", Agronomy Research, 613-620, 2015.
- [17] S. K. Duran, M. Singh, and H. Singh, "Karanja and Rapeseed Biodiesel: An Experimental Investigation of Performance and Combustion Measurement for Diesel Engine," vol. 6, no. 1, pp. 295–299, 2015.
- [18] L. Labecki, A. Cairns, J. Xia, A. Megaritis, H. Zhao, and L. C. Ganippa, "Combustion and emission of rapeseed oil blends in diesel engine," Appl. Energy, vol. 95, pp. 139–146, 2012.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)



ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887

Volume 6 Issue I, January 2018- Available at www.ijraset.com

- [19] D. H. Qi, C. Bae, Y. M. Feng, C. C. Jia, and Y. Z. Bian, "Combustion and emission characteristics of a direct injection compression ignition engine using rapeseed oil based micro-emulsions," Fuel, vol. 107, pp. 570–577, 2013.
- [20] D. H. Qi, C. Bae, Y. M. Feng, C. C. Jia, and Y. Z. Bian, "Preparation, characterization, engine combustion and emission characteristics of rapeseed oil based hybrid fuels," Renew. Energy, vol. 60, pp. 98–106, 2013.
- [21] D. H. Qi, C. F. Lee, C. C. Jia, P. P. Wang, and S. T. Wu, "Experimental investigations of combustion and emission characteristics of rapeseed oil-diesel blends in a two-cylinder agricultural diesel engine," Energy Convers. Manag., vol. 77, pp. 227–232, 2014.
- [22] C. Solaimuthu and P. Govindarajan, "Performance Evaluation of a Urea-water Selective Catalytic Reduction (SCR) for a Diesel Engine with Mahua Bio Diesel," Energy Sources, Part A Recover. Util. Environ. Eff., vol. 37, no. 13, pp. 1424–1431, 2015.
- [23] M. Senthil Kumar, G. Nataraj, and S. Arul Selvan, "A comprehensive assessment on the effect of high octane fuels induction on engine's combustion behaviour of a Mahua oil based dual fuel engine," Fuel, vol. 199, pp. 176–184, 2017.
- [24] D. Sonar, S. L. Soni, D. Sharma, A. Srivastava, and R. Goyal, "Performance and emission characteristics of a diesel engine with varying injection pressure and fuelled with raw mahua oil (preheated and blends) and mahua oil methyl ester," Clean Technol. Environ. Policy, vol. 17, no. 6, pp. 1499–1511, 2015.
- [25] V. E. Geo, G. Nagarajan, and B. Nagalingam, "Studies on improving the performance of rubber seed oil fuel for diesel engine with DEE port injection," Fuel, vol. 89, no. 11, pp. 3559–3567, 2010.
- [26] M. Satyanarayana and C. Muraleedharan, "Investigations on performance and emission characteristics of vegetable oil biodiesels as fuels in a single cylinder direct injection diesel engine," Energy Sources, Part A Recover. Util. Environ. Eff., vol. 34, no. 2, pp. 177–186, 2011.
- [27] V. V Patil and R. S. Patil, "Effects of partial addition of n-butanol in rubber seed oil methyl ester powered diesel engine," Proc. Inst. Mech. Eng. Part A J. Power Energy, vol. 231, no. 7, pp. 607–617, 2017.
- [28] S. Senthil Kumar, K. Purushothaman, and K. Rajan, "Performance analysis of compression ignition engine using rubber seed oil methyl ester blend with the effect of various injection pressures," Therm. Sci., vol. 20, no. x, pp. 1083–1090, 2016.
- [29] S. Senthil Kumar, K. Purushothaman, and K. Rajan, "Performance analysis of a biodiesel fuelled Diesel engine with the effect of alumina coated piston," Therm. Sci., vol. 21, no. 1, pp. 489–498, 2017.











45.98



IMPACT FACTOR: 7.129







INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 🕓 (24*7 Support on Whatsapp)