RNI Regd No: APENG/2011/47294 ISSN No: 2320-3706(PRINT)
International Journal & Magazine of Engineering, Technology, Management and Research
YUVAENGINEERS
Transforming Young Engineers for Better Tomorrow

Performance and Emission Characteristics of a Diesel Engine Fuelled with Biodiesel Blends

Prof.R.Ramachandra
Principal,
S.K.D Engineering College,
Gooty, Ananthapuramu (D.T), A.P, India.

Prof.V.Pandurangadu
Rector & Professor,
JNTUA, Ananthapuramu (D.T), A.P, India.

Abstract:
Performance and emission characteristics of diesel engine were reviewed in this work. This study was conducted using biodiesel prepared from the raw oils of Jatropha, moringa and palm. In this study, 20% biodiesel of each and 80% of diesel fuel (JB_{20}, MB_{20} and PB_{20}) has been used in a diesel engine, because 20% biodiesel blend has the fuel properties like: density, kinematic viscosity, calorific value etc similar to diesel and can be used in diesel engine without any engine modification. Biodiesel blends reduce the brake power (BP) and increase the BSFC than diesel. The CO and HC except the NO_X emissions are reduced than diesel due to the higher oxygen content in biodiesel which leads to improve the combustion. Palm biodiesel blend is found offers better performance and reduces the engine emissions than JB and MB while the performance of MB_{20} biodiesel blend is found similar to other fuels.

Keywords:
Biodiesel, Transesterification, NO_X, Emissions, Jatropha biodiesel.

1. Introduction:

Diesel engines have low fuel consumption and high efficiencies and therefore, the use of diesel engines rapidly have increased in recent times. Nowadays, diesel engines are used in transportation, energy generation, irrigation purposes and many other sectors [1] and led to increase in the demand of diesel fuel, which is presently anxious with emissions and environmental problem.. The diesel fuel can be substituted by the renewable sources of energy like biodiesel [2].

The increase in exhaust emissions from diesel engine using diesel is the main difficulty, responsible for global warming, depletion of ozone layer, and acid rains are created problems for environment and human health [3]. The rapid rise in petrolium fuel prices have caused encouraged R&D on renewable biofuels source like: biogas, ethanol and vegetable oils, etc [4]. Replacement of fossil diesel with biodiesel in diesel engines can significantly improve our environment. The main aim of our study is to comapre the emissions are exhausted by diesel engine using diesel and biodiesel blends like: Jatropha (JB_{20}), Palm (PB_{20}) and Moringa (MB_{20}) and it is found that biodiesel having lower emissions than diesel expect that NO_X at same engine speeds because biodiesel blends having higher oxygen content than diesel.

2. Biodiesel-an Alternative Fuel

Biodiesel is a renewable, clean, non-toxic, bio-degradable and eco-friendly fuel derived from vegetable oils (VO) and fats, can be used in diesel engine in blended form with diesel. Biodiesel has higher oxygen content than diesel fuel and combustion of biodiesel is better than conventional diesel and reduces the emissions [3]. Engines run on biodiesel have lower emissions like: THC, CO_2, CO, PM, sulfur oxides (SO_X) and hydrocarbons (HC), but showed that the oxides of nitrogen (NO_X) will increased as comparison of diesel fuel, this is the main failure of the biodiesel using in diesel engine.

3. Production of Biodiesel

Biodiesel is derived from various feedstocks like edible and non-edible oils and animal fats etc. It is commonly prepared by transesterification process from the feedstock of oils using a base catalyst.

RNI Regd No: APENG/2011/47294 ISSN No: 2320-3706(PRINT)
International Journal & Magazine of Engineering, Technology, Management and Research
YUVAENGINEERS
Transforming Young Engineers for Better Tomorrow

For etherification process acid catalyst, H_2SO_4 is mixed in 1% of oils and for transesterification proces base catalyst NaOH is mixed in 1% of mixture of oils and acids with methanol. Methanol is alcohol and it takes the lower reaction time and cost [5]. In this reaction, 100 ml. Triglyceride (raw oils) reacted 10 ml. of methanol in the presence of catalyst (acid) to form 100 ml. of methyl ester (Biodiesel) and 10 ml. of glycerol.

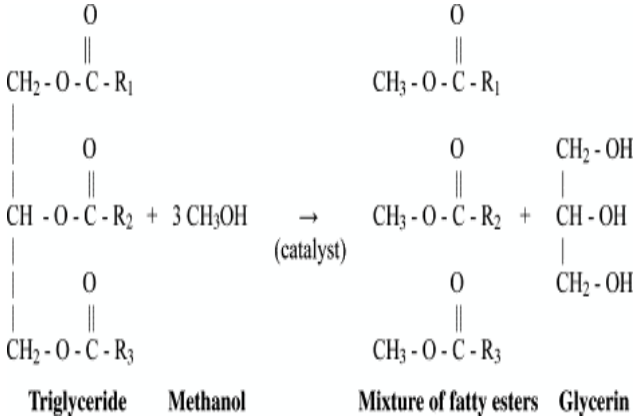

Fig.1. Transesterification process of biodiesel production [1]

Diesel engine performance and emissions characteristics are measured by the properties of biodiesel like: Heating Value, Flash Point, Lubricity, Kinematic Viscosity, Cetane Number, Physical Distillation, Water Sediment, Cloud Point, Acid Number, Total Glycerin, Alkali Metals, Blend Fraction, Stability and etc.

Biodiesel, is a fuel contained of mono-alkyl esters of long chain fatty acids derived from waste vegetable oils\animal fats, represented as B100 [6].

3.1. Properties of biodiesel:

The physicochemical properties of the biodiesel blends, such as free fatty acid composition (FFA), calorific value, flash point, density, kinematic viscosity and cetane number are shown in Table 1, which consist the properties of Palm, Moringa and Jatropha biodiesel and blends. It is represent that the PB have the highest saturated fatty acids (44.6%), followed by the JB (22.6%) and MB (18.6%).

PB has the highest cetane number (59) than followed by moringa biodiesel (56) and Jatropha biodiesel (51). Jatropha biodiesel has higher density (865.7 kg/m^3) followed by Moringa biodiesel (859.6 kg/m^3) and Palm biodiesel (858.9 kg/m^3) but Moringa biodiesel has higher kinematic viscosity (5.05 mm^2/s) followed by Jatropha biodiesel (4.73 mm^2/s) and Palm biodiesel (4.63 mm^2/s) respectively but diesel has low cetane number, density and kinematic viscosity which reduce the BSFC and increase the brake power than biodiesel blends.

Table 1. Various properties of Jatropha, Moringa, Palm biodiesel blends with diesel [7]

Properties	MB20	PB20	JB20	Diesel	MB100	PB 100	JB 100
Calorific value (MJ/kg)	44.10	44.19	43.99	45.30	40.05	40.91	39.83
Kinematic viscosity at 40 °C (mm^2/s)	3.67	3.47	3.63	3.23	5.05	4.63	4.73
Density (kg/m^3)	846.6	834.9	840.1	827.2	859.6	858.9	865.7
Viscosity index	111.6	149.8	159	90	184.6	195.8	214.7
Flash point (°C)	82.5	78.5	84	68.5	180.5	182.5	184.5
Cetane number	–	–	–	48	56	59	51
Saturated fatty acids	–	–	–	–	18.6	44.6	22.6
Unsaturated fatty acids	–	–	–	–	81.4	55.4	77.4

4. Result and Discussion

4.1. Performance characteristics

The performance of a diesel engine is measured in the term of BP and BSFC. A diesel engine is tested for biodiesel blends and thier performance characteristics are given below:

4.1.1. Brake Power (BP)

When the speed of diesel engine increase BP also increase up to 3500 rpm, after that BP reduce because of the higher frictional force [8]. Fig. 2 shows the engine BP for MB20, PB20, JB20 and Diesel at different engine speeds. The peak BP was measured for diesel than biodiesel blends PB20, MB20 and JB20 as 37, 34, 33 and 32 kW at speed 3500 rpm. The biodiesel blends PB20, MB20 and JB20 reduced the BP as 8.11%, 10.81%, and 13.51% compared to diesel fuel at engine speed of 3500 rpm.

RNI Regd No: APENG/2011/47294 ISSN No: 2320-3706(PRINT)
International Journal & Magazine of Engineering, Technology, Management and Research
YUVAENGINEERS
Transforming Young Engineers for Better Tomorrow

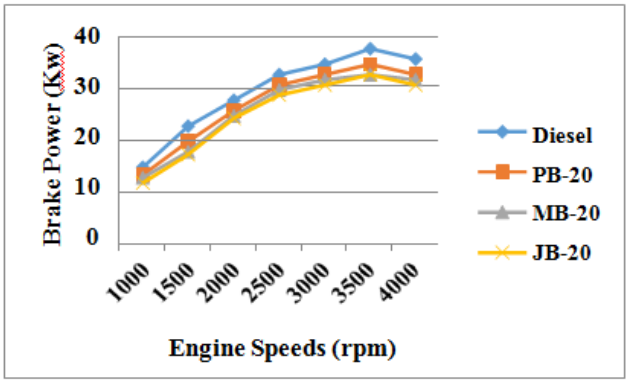

Fig.2. Brake power variation with engine speeds [7, 8]

4.1.2. Brake Specific energy consumption (BSFC):

Calorific value, density, and kinematic viscosity influence the fuel consumption in diesel engine when using the biodiesel blends [9]. Fig. 3, compares the BSFC of PB20 , JB20 , MB20 , and diesel at different engine speeds. Fig. 3 represented that MB20 shows the highest BSFC than JB20 , PB20 , and diesel which is 467, 465, 460, and 430 g/kWh, respectively at engine speed of 3500 rpm. The BSFC increased for MB20 , JB20 , and PB20 by 8.60%, 8.14% and 6.98% respectively compared to diesel fuel at engine speed of 3500 rpm. Lower calorific value and higher density of biodiesel blends results inhigher BSFC that means higher fuel quantity is required for same power output [10].

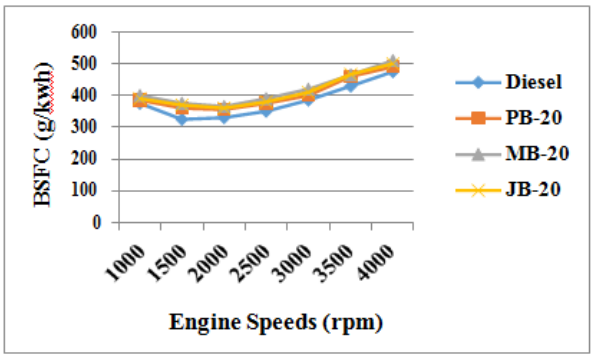

Fig. 3. Brake specific fuel consumption variation with speeds [7, 9, 10]

4.2. Emission characteristics:

The emission characteristics of a diesel engine is characterized by the CO, HC and NO_X emission from diesel engine. CO and HC emissions are reduced by using the palm, Jatropha and moringa biodiesel expect that NO_X emission is increased compared to diesel fuel at different engine speeds.

4.2.1. Carbon monoxide (CO) emission:

CO is produced from incomplete and imperfect combustion of fuel in engine cylinder during operation and the carbon particle partially oxidized. CO emission is minimum for biodiesel blends than diesel fuel over the entire speed range [11]. Fig.4 shows that the biodiesel blends JB20, PB20 and MB20 reduced the CO emission by 45.45%, 48.48% and 42.42% when compared to the diesel fuel. Higher cetane number and oxygen concentration is responsible for reducing the CO emission from biodiesel blend than diesel [12], and it is depends upon the degree of saturation level in the biodiesel.

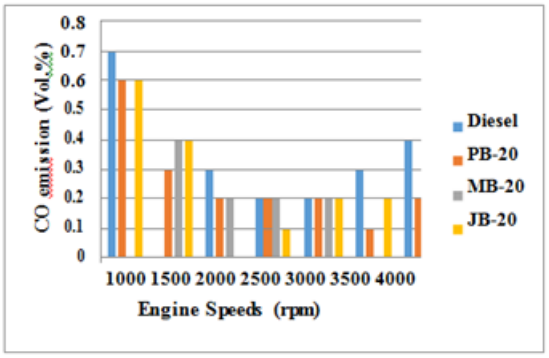

Fig. 4. CO emissions variation with engine speeds [7, 11,12]

4.2.2.Hydrocarbon (HC) emission:

When molecules of fuel does not completely burn in engine cylinder HC emissions produced and called as unburned hydrocarbon. Biodiesel blends reduces the HC emission over the whole range of engine speeds than diesel [13]. Fig. 5 shows that, MB20, PB20 and JB20 reduced HC emission by 10%, 37.5%, and 25% at speed of engine 3500 rpm. From all blends of biodiesel PB20 delivers the minimum HC emission, than followed by JB20 and MB20. Greater cetane number of biodiesel reduced the ignition delay and thus reduces the HC emission [14]. Palm biodiesel has the highest cetane number (59) above the other biodiesel blends.

RNI Regd No: APENG/2011/47294 ISSN No: 2320-3706(PRINT)
International Journal & Magazine of Engineering, Technology, Management and Research
YUVAENGINEERS
Transforming Young Engineers for Better Tomorrow

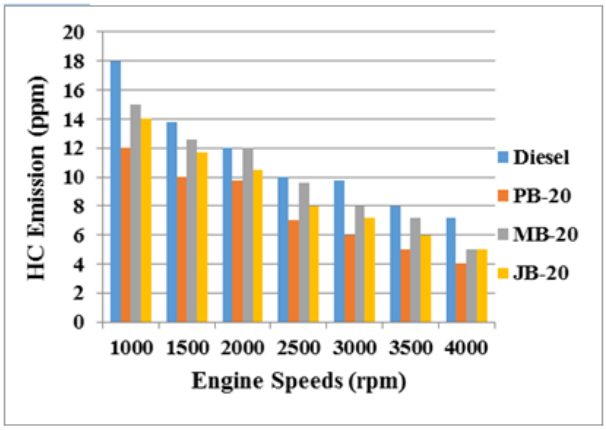

Fig. 5. HC emissions variation with engine speeds [7, 13,14]

4.2.3.Nitric oxide (NOx) emission:

NO_X formation is mainly dependent on fuel combustion temperatures, oxygen content in fuel, and reaction time [15]. Fig. 6 shows that all biodiesel blends increases the NO_X emission over the whole range of engine speed than diesel. When a test is conducted for camelina biodiesel in engine same result is obtained [16]. Biodiesel blends MB20, PB20 and JB20 increased NO_X emission by 11.57%, 5.37% and 7.43% than diesel at engine speed of 3500 rpm. Higher oxygen concentration in biodiesel improve the combustion which increases the flame temperature of the engine cylinder. All the biodiesel blends, PB20 gives the minimum NO_X emission than followed by JB20 and MB20 [17].

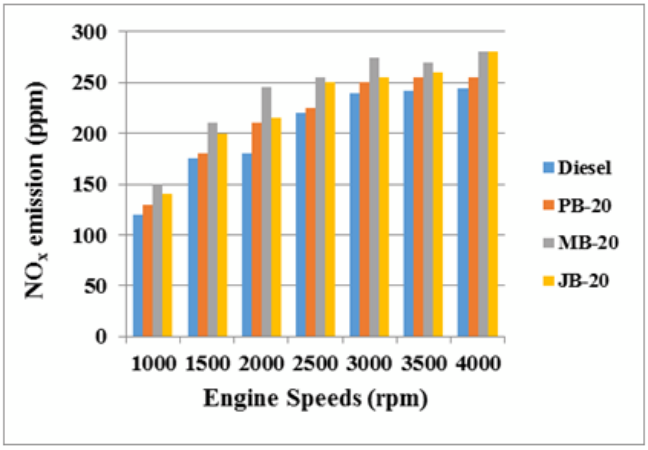

Fig. 6. NOx emissions variation with engines speed [7, 15,17]

5. Conclusion:

The purpose of this study to find out the suitable biodiesel blends for diesel engine opeartion which produce the maxium power and consumed lower BSFC and lower in CO, HC and NOx emissions. The following conclusions are obtained on the basis of review investigation: The average BP for biodiesel fuel is slightly lower 8.11% and BSFC are grater 8.60% than diesel fuel, because biodiesel and its blends having the lower calorific value as compared to diesel. Biodiesel blends reduces the CO emission 48.48% and HC 37.5%, but also increased the NO x emission by 11.57% than diesel because the blends of biodiesel having the higher oxygen content which increases the combustion process results increase the temperature of combustion and NOx emission mainly influence the temperature of combustion. From all the biodiesel blends, palm biodiesel blend shows higher performance than other biodiesel blend.

References:

[1] Verma P, Sharma M.P. Performance and Emission Characteristics of Biodiesel Fuelled Diesel Engines, IJRER, 2015:1-4.

[2]Liaquat A. M., Kalam M. A., Masjuki H. H., Jayed M. H., Engine Performance and Emissions Analysis using “Envo-Diesel” and Coconut Biodiesel Blended Fuel as Alternative Fuels, IPCBEE, 6; 2011.

[3] Shahid E.M., Jamal Y., Production of biodiesel: A technical review, Renewable and Sustainable Energy Reviews, 15(9); 2011:4732–4745.

[4] Deshmukh S. J., Bhuyar L. B., Thakre S. B., Investigation on Performance and Emission Characteristics of CI Engine Fuelled with Producer Gas and Esters of Hingan (Balanites) Oil in Dual Fuel Mode, International Journal of Aerospace and Mechanical Engineering, 2(3);2008:148- 153.

[5] Verma P., Sharma M.P., Dwivedi G., Impact of alcohol on biodiesel production and properties, Renewable and Sustainable Energy Reviews, 56;2016:319–333.

[6] Biodiesel Handling and Use Guide, fourth edition, NREL/TP-540-43672 Revised January 2009; accessed July 23, 2015.

[7] Rashed M.M., Kalam M.A., Masjuki H.H., Mofijur M., Rasul M.G., Zulkifli N.W.M., Performance and emission characteristics of a diesel engine fueledwith palm, jatropha, and moringa oil methyl ester, Industrial Crops and Products, 79;2016:70–76.

[8]Mofijur M., Masjuki H.H., Kalam M.A., Atabani A.E., Fattah I.M.R., Mobarak H.M., Comparative evaluation of performance and emission characteristics of Moringa oleifera and palm oil based biodiesel in a diesel engine. Industrial Crops and Products, 53; 2014:78–84.

[9]Palash, S.M., Masjuki, H.H., Kalam, M.A., Atabani, A.E., Rizwanul Fattah, I.M., Sanjid,A., 2015. Biodiesel production, characterization, diesel engine performance, and emission characteristics of methyl esters from Aphanamixis polystachya oil of Bangladesh. Energy Conversion and Management, 91; 2015:149–157.

[10] Öztürk, E., Performance, emissions, combustion and injection characteristics of a diesel engine fuelled with canola oil-hazelnut soap stock biodiesel mixture. Fuel Processing Technology, 129; 2015:183–191.

[11] Pali, H.S., Kumar, N., Alhassan, Y., Performance and emission characteristics of an agricultural diesel engine fueled with blends of Sal methyl esters and diesel. Energy Conversion and Management, 90; 2015:146–153.

[12] Xue, J., Grift, T.E., Hansen, A.C., Effect of biodiesel on engine performances and emissions. Renewable & Sustainable Energy Reviews, 15 (2); 2011:1098–1116.

[13] Özcelik, A.E., Aydogan, H., Acaroglu, M., Determining the performance, emission and combustion properties of camelina biodiesel blends. Energy Conversion and Management, 96; 2015:47–57.

[14] Rao, P.V., Experimental investigations on the influence of properties of jatropha biodiesel on performance, combustion, and emission characteristics of a DI-CI engine. World Academy of Science, Engineering and Technology, 75; 2011:855–868.

[15] Palash, S.M., Kalam, M.A., Masjuki, H.H., Masum, B.M., Rizwanul Fattah, I.M.,Mofijur, M., Impacts of biodiesel combustion on NOx emissions and their reduction approaches. Renewable & Sustainable Energy Reviews, 23 (0); 2013:473–490.

[16] Verma P., Sharma M.P., Dwivedi G., Evaluation and enhancement of cold flow properties of palm oil and its biodiesel, Energy Reports, 2;2016:8–13.

[17] El-Kasaby, M., Nemit-allah, M.A., Experimental investigations of ignitiondelay period and performance of a diesel engine operated with jatropha oil biodiesel. Alexandria Engineering Journal, 52 (2); 2013:141–149.