Experimental Study on the Emission Characteristics of a Diesel Engine Using Corn Oil as Fuel

V.Gopinath*, Dr.P.Suresh**‡

*Department of Mechanical Engineering, Karpagam University, Coimbatore, India

**Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India

vgopinathme@gmail.com, suresh.me2004@gmail.com

‡Corresponding Author; V.Gopinath, 15/6B Sedar Street, Sendhamanagalam, Namakkal – 637409, Tamilnadu, India.

Tel: +91 970092837, vgopinathme@gmail.com

Received: 11.06.2014 Accepted: 21.12.2014

Abstract- The consumption of energy in the form of fossil fuels has been increasing day by day. There is a need to increase energy supplies to meet basic needs and the way that promotes sustainable development. Bio-diesel is an attractive alternative fuel for diesel engines in terms of environmental benefits. In India the production of corn is increasing ever year, the corn oil is extracted from the germ of corn (maize). This paper investigates the emission characteristics of single cylinder diesel engine using biodiesel blends and compares that with diesel fuel. In this experiment, an attempt has been made to investigate four types of fuels are considered 100% Diesel, 90% Diesel+10% Corn oil Methyl Ester, 80% Diesel+20% Corn oil Methyl Ester, 70% Diesel+30% Corn oil Methyl Ester and 60% Diesel+40% Corn oil Methyl Ester. The diesel engine is run on these blends at different load conditions. The various emission parameters like NOx, Carbon dioxide and Unburned Hydrocarbon are tested with above blends and different load conditions. The experimental results show that the emission parameters for IC engine fuelled with biodiesel blends are less compared to diesel fuel at all the load conditions.

Keywords-Corn oil; Biodiesel; Engine Emission; NOx.

1. Introduction

In World, the diesel engine dominates in the field of commercial transportation and agricultural machinery because of its superior efficiency. The consumption of diesel oil is several times higher than its petrol consumption. It has been found that vegetable oil hold special promise in this need. The emission parameters such as Carbon monoxide, Carbon dioxide, Un-burnt hydrocarbons are reduced, but Nitrogen oxide is increased in diesel engine by using coconut oil, Soybean oil [1-2-3-8]. The best method to reduce the NOx emission of the engine is exhaust gas recirculation techniques (EGR) [4-5-7]. EGR will recalculate the exhaust gases back to the engine through inlet air, which will increase the air temperature and reduce the oxygen concentration in the inlet air. This will also reduce the Specific fuel consumption and increase the thermal efficiency [9].

2. Transesterification Process

The Comparison of properties of diesel and corn oil methyl ester are given in Table 1 below,

Table 1. Properties of diesel and corn oil methyl ester

Properties	**Diesel**	**Corn oil methyl ester**
Viscosity at 40°C [CST]	5	8.6
Calorific Value [MJ/kg]	42	39.5
Specific Gravity	0.853	0.875
Flash Point [°C]	57	153
Fire Point [°C]	65	161
Density [kg/m^3]	853	875

The Corn oil is treated with alcohol in the presence of a catalyst (KOH/NaOH) to form ester and glycerol. This method is used to reduce the high viscosity of the corn oil. The Corn oil and methanol is boiled separately to remove moisture

content and mixed with the reactor vessel. The catalyst is added to the solution and dissolved by constant stirring. The content after mixing thoroughly are heated to a temperature of about 50 to 60°C and it is maintained at the same temperature for about 3 hours. Then the content will be allowed to settle down for 1 day. After the settlement process, two major products are Glycerine and corn oil Methyl Esters (Biodiesel).

3. Experimental Setup

In this experiment investigation, a Single cylinder, direct injection, water cooled, diesel engine is used. Engine is equipped with thermocouples to measure temperature, manometer with air box is used to measure air flow rate and burette is used to measure fuel flow rate. The engine specifications are given in Table 2 below,

Table 2. Engine Specification

Parameter	Specification
Type	Single cylinder, four stroke diesel engine
Bore in [mm]	127
Stroke in [mm]	203.2
Rated [rpm]	750
Rated power [HP]	12
Loading	Mechanical loading
Type of cooling	Water cooled

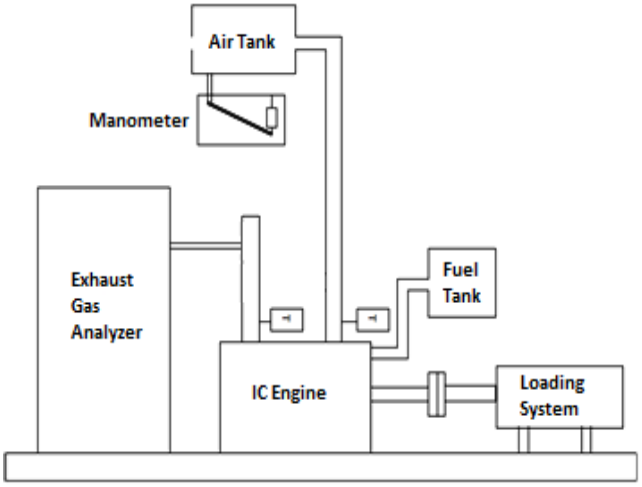

Fig. 1. Schematic diagram of Experimental Setup

The schematic diagram of experimental setup is shown in Fig.1. A slight modification is made in fuel line of the IC engine between fuel tank and fuel pump. T-valve is used to change over the fuel selection between diesel and biodiesel blend. The T-valve is the best way to change the fuel supply to engine. First the engine runs with diesel for around one hour for warming and then note down the emission parameters NOx, Carbon dioxide and Unburned Hydrocarbon with the help of exhaust gas analyzer. The exhaust gas analyzer probe is inserted into the engine exhaust pipe to measure the emission parameters. After that with the help of the T-valve, the fuel supply to IC engine is changed from diesel to biodiesel. The engine emission parameters were noted after 15 minutes to ensure that the engine runs on biodiesel blend.

4. Result and Discussion

Experiments were conducted with Diesel (D) and Corn oil Methyl Ester (B) blends having 100% D, 10%B + 90%D, 20%B + 80%D, 30%B + 70%D and 40%B + 60%D on volume basis at different loads. The experiments were conducted to evaluate the engine emission parameters such as Carbon dioxide, NOx and unburned Hydrocarbon. The engine would be allowed for some time to obtain the rated speed before the measurements were taken.

4.1 Carbon Dioxide (CO_2)

The Variation of carbon dioxide with Biodiesel blends with different loads is graphically represented in Fig.2. It was observed that the percentage of carbon dioxide in all the blends was found to be low at all load levels. At the brake power of 5.54kW, the Carbon dioxide reaches its maximum of 4.8% for 100% Diesel and 4.4% for 80% Diesel+20% Corn oil Methyl Ester. The 0.4% carbon dioxide is reduced compared to 100% diesel and also it was observed that the proportion of corn oil methyl ester in the blends increases the percentage of Carbon dioxide decreases.

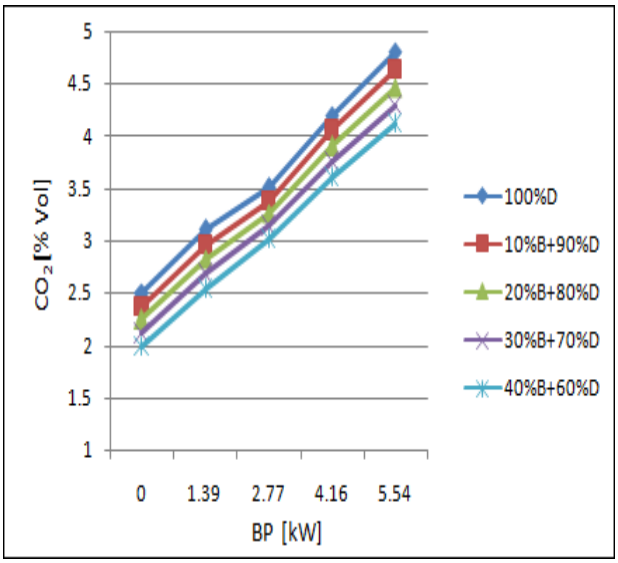

Fig. 2. Comparison of Carbon dioxide Vs Brake power

4.2 NOx

The Variation of NOx with Biodiesel blends with different loads is graphically represented in Fig.3. It was observed that the percentage of NOx in all the blends was found to be low at all load levels. At the brake power of 5.54kW, the NOx reaches its maximum of 187 ppm for 100% Diesel and 167 ppm for 80% Diesel+20% Corn oil Methyl Ester. The 20 ppm of NOx is reduced compared to 100% diesel and also it was observed that the proportion of corn oil methyl ester in the blends increases the ppm of NOx decreases.

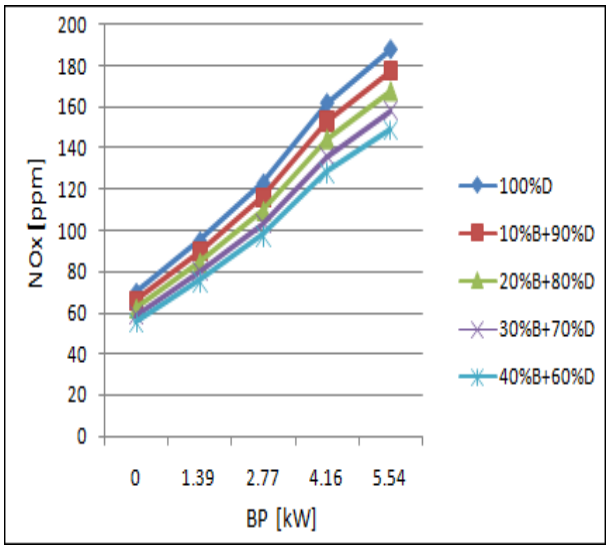

Fig. 3. Comparison of NOx Vs Brake power

4.3 Unburned Hydrocarbon (HC)

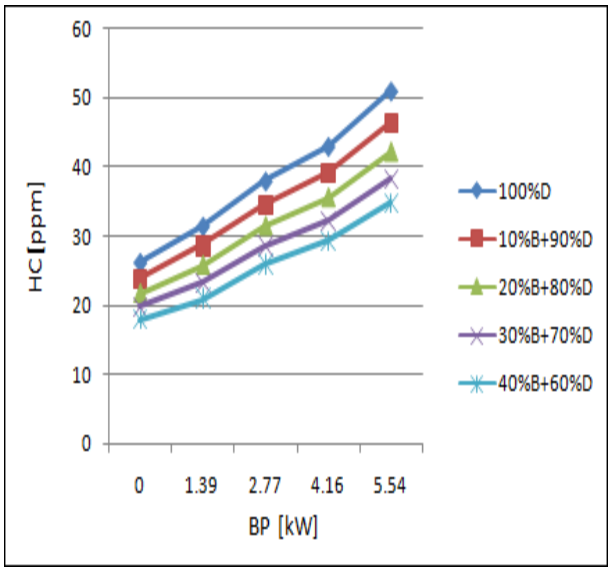

Fig. 4. Comparison of HC Vs Brake power

The Variation of unburned hydrocarbon with Biodiesel blends with different loads is graphically represented in Fig.4. It was observed that the percentage of hydrocarbon in all the blends was found to be low at all load levels. At the brake power of 5.54kW, the hydrocarbon of about 51 ppm for 100% diesel and 42 ppm for 80% Diesel+20% Corn oil Methyl Ester. The 9 ppm of hydrocarbon is reduced compared to 100% diesel and also it was observed that the proportion of corn oil methyl ester in the blends increases the percentage of unburned hydrocarbon decreases.

5. Conclusion

From the results obtained on the test, the engine emission parameters such as Carbon dioxide, NOx and Unburned Hydrocarbon for biodiesel blends are low as compared to diesel fuel. And also the proportion of corn oil methyl ester increases, the engine emissions are decreased. Hence 60% Diesel+40% Corn oil Methyl Ester can be used as fuel in IC engine without any engine modification. However the performance of the IC engine fuelled with 60% Diesel+40% Corn oil Methyl Ester was less as compared to diesel fuel. Based on the references the performance of engine fuelled with 80% Diesel+20% Biodiesel comparable to diesel fuel. Hence 80% Diesel+20% Corn oil Methyl Ester is the optimum blend for engine emission as well as performance of the engine.

References

[1] Jinlin Xue, Tony E. Grift , Alan C. Hansen, 2011 "Effect of biodiesel on engine performances and emissions" Renewable and Sustainable Energy Reviews 15, pp1098–1116.

[2] A.M. Liaquat, H.H. Masjuki, M.A. Kalam, I.M. Rizwanul Fattah, M.A. Hazrat, M. Varman, M. Mofijur, M. Shahabuddin, 2013, "Effect of coconut biodiesel blended fuels on engine performance and emission characteristics" , Procedia Engineering, pp 583-590.

[3] Mohamed F. Al-Dawody, 2011 "Effect of Soybean Oil Biofuel Blending on the Performance and Emissions of Diesel Engine Using Diesel-Rk Software" International Journal of Engineering Science and Technology, Vol. 3 No. 6, pp 4539 - 4555.

[4] Nitin Shrivastava, Dr. S.N. Varma, Dr. Mukesh Pandey, 2012 "A Study on Reduction of Oxides of Nitrogen with Jatropha Oil Based Bio Diesel "International Journal of Renewable Energy Research, Vol.2, No.3, pp 504-509.

[5] Paykani, A and M. T. Shervani Tabar, 2011 "Experimental Investigation of the Effect of Exhaust Gas Recirculation on Performance and Emissions Characteristics of a Diesel Engine Fueled with Biodiesel" International Journal of Engineering and Technology, Vol.3, No.3, pp 239-243.

[6] E. Pillay, 2012 "Engine Emissions and Performances with Alternative Biodiesels: A Review" Journal of Sustainable Development, Vol. 5, No. 4, pp 59-73.

[7] Pooja , Mayur Ghodasara, 2012 " Experimental Studies on Emission and Performance Characteristics in Diesel Engine Using Bio-Diesel Blends and EGR (Exhaust Gas Recirculation), International Journal of Emerging Technology and Advanced Engineering, Vol. 2, Issue 2, pp 246-250.

[8] D.K.Ramesha, H.N.Vidhyasagar, M, Kishore, 2012 "Diesel Engine Exhaust Emission Characteristics of CI Engine Using Non-Edible Plant Oil as Fuel" International Journal of Emerging trends in Engineering and Development, Issue 2, Vol.3, pp 293-298.

[9] R. Senthil Kumar, R. Manimaran, V. Gopalakrishnan, 2013, "Experimental investigation on D. I. diesel engine fuelled by ethanol diesel blend with varying inlet air temperature" Advances in Applied Science Research, 4(1), pp 319-329.

[10] E. Pillay "Engine Emissions and Performances with Alternative Biodiesels: A Review" Journal of Sustainable Development, Vol. 5, No. 4; April 2012.

[11] T. Hari prasad, K.Hema Chandra Reddy, M.Muralidhara Rao "Combustion, Performance and Emission Analysis of Diesel Engine Fuelled with Methyl Esters of Fish oil" International Journal of Science and Technology, Volume 1 No. 1, July 2011.

[12] Geetesh Goga, Lakhwinder Singh and R Singh "Performance Evaluation of Biodiesel from Waste Cooking Oil" International Conference on Mechanical, Automobile and Biodiesel Engineering (ICMABE'2012) Oct. 6-7, 2012 Dubai (UAE).

[13] Ibrahim Thamer "Experimental Study Of Vegetable Oil -Diesel Blends on the performance of Compression Ignition Engine" Anbar Journal for Engineering Sciences-2011, 33 Vol.4, No.2

[14] Mohamed F. Al-Dawody "Effect of Soybean Oil Biofuel Blending on the Performance and Emissions of Diesel Engine Using Diesel-Rk Software" International Journal of Engineering Science and Technology, Vol. 3 No. 6 June 2011.

[15] Jinlin Xue, Tony E. Grift , Alan C. Hansen "Effect of biodiesel on engine performances and emissions" Renewable and Sustainable Energy Reviews 15, 2011, 1098–1116.

[16] L.G. Anderson "Effects of Biodiesel Fuels Use on Vehicle Emissions" Journal of Sustainable Energy & Environment, 2012, 35-47