ENVIRONMENT FRIENDLY FUEL FOR DI DIESEL ENGINES–BIODIESEL

Pradeep Kumar A.R.[1*], Dr. Annamalai K.[2], Premkartikkumar S.R.[3], Prabhakar S.[4], Banugopan V.N.[5]

[1*]Associate Professor/Mechanical, Dhanalakshmi College of Engineering, Chennai 601 301.
[2]Assistant Professor, Department of Automobile Engineering, MIT, Anna University, Chennai 600 044.
[3]Associate Professor/Mechanical, SMK Fomra Institute of Technology, Chennai
[4,5]Research Scholars, MIT, Anna University, Chennai 600 044.

ABSTRACT

To meet increasingly stringent emission standards inautomotive engine field and to meet the depletion of petroleumfuel, extensive research has been carried out to explore variousways to reduce the emission with biodiesel and thereby indeveloping in the green environment. The target of this study isto use biodiesel blend as test fuel in DI diesel engine and toperform various tests. The biodiesel have been selected based onthe various properties compared with diesel. A comparison has beendone with neat biodiesel and B20. The test engine was asingle-cylinder naturally aspirated direct injection diesel engineof Kirloskar make, with injection timing 27° before TDC, 1500 rpm, 8 bhp. Eddy current dynamometer is usedfor applying loads to the engine. Data Acquisition system used togenerate the heat release rate curves. The various emissionparameters were obtained and characteristic curves were plotted. The experimental results show that the decrease in CO, CO_2 but increase in NOx emission. Results were discussed and thejustifications have been made. A discussion has been made at theend of the paper for further development of this research work.

Keywords: Bio diesel, transesterified oil.

I. INTRODUCTION

Biodiesel is the variety of ester based oil which is further defined as mono alkyl esters derived from vegetable oil by theprocess called transesterification. In transesterification process alcohol reacts with triglyceroids of vegetable oil, animal fats etc., in presence of catalyst to obtain the biodiesel. The modest temperature required would be 60°Cwith a strong catalyst such as potassium hydroxide or sodium hydroxide. The usage of biodiesel relatively advantageous than neat diesel because of its lubricating property due to which life of engine is increased. The biodiesel also less polluting when concerned with unburnt hydrocarbons, carbon monoxide and carbondioxide which prevails to a green environment. Biodiesel can be comfortably used in Compression ignition engines with less or no modifications. Another advantage is cost of the biodiesel which will remain stable unlike the conventional petroleum fuel.

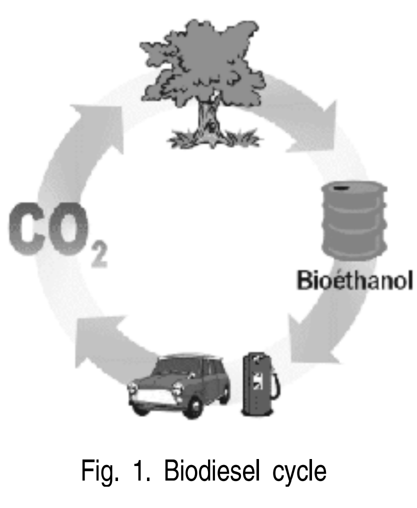

Fig. 1. Biodiesel cycle

The Figure 1, explains the usage cycle of biodiesel, in which biodiesel is obtained from plants or trees and it under goes transesterifcation process. The CO_2 emission of vehicle again inhaled by plants and trees. The lifecycle production and usage of biodiesel produces approximately 80% reduction of CO_2 and almost 100% lesser SO_2 when compared to petroleum diesel fuel.

II. LIMITATIONS OF USING NEAT VEGETABLE OIL

Neat vegetable oil has high viscosity which tends to alter the fuelspray pattern. Higher viscosity also leads to carbon deposits on combustion chamber walls and also problem in cold starting. The poor volatility of the vegetable oil also another problem invaporization and more smoke emission. The density of vegetable oilis more than neat diesel fuel and calorific value is less.

III. PRODUCTION OF BIODIESEL

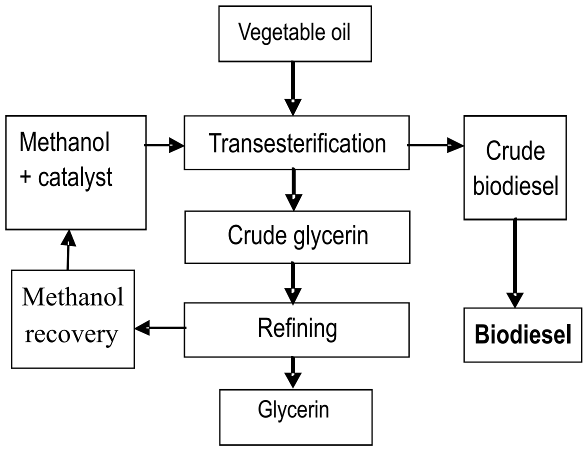

Fig. 2. Transesterification process

Vegetable oils can be chemically reacted with the alcohol inpresence of catalyst such as sodium hydroxide or potassium hydroxide [13]. Vegetable oil is first filtered then processed with alkali. The oil's triglyceroids react to form mono esters and glycerol. Glycerol is separated for industrial purpose.

IV. CHARACTERISTICS OF BIODIESEL

Bio diesel is a suitable alternative fuel for petroleum fuel which has similar properties; hence it can be used in CI engines with slight or without modification. Usage of biodiesel leads to substantial reduction in hydrocarbons, carbon monoxide and carbondioxide. Emission of Nitrogen oxides is slightly increased according to the testing methods. However suitable methods can be adopted in reducing NO_x emission. Bio diesel is biodegradable; it degrades 4 to 5 times of neat diesel fuel. The same method of storage can be adopted for storing the bio diesel also.Since bio diesel has solvent effect which releases deposits on the tanks and pipes. These deposits may clog the filters or injectors due to prolonged use. Bio diesel offers superior lubricating properties which may reduce the engine wear and leads to better engine life.

V. PROPERTIES COMPARISON OF DIESEL, PONGAMIA BIO DIESEL AND ITS BLEND

From the above table 1, it is observed that B20 blend of biodiesel has specific gravity almost close to petroleum diesel and acompromising value of calorific value. Due to the higher viscosityand lesser calorific value, B100 is not recommended forexperimental work.

Table 1. Properties Comparison

Properties	Diesel	Pongamia 100% (B100)	Pongamia 20% (B20)
Specific Gravity	0.846	0.876	0.848
Kinematic Viscosity@40°C, mm^2/sec	2.6	9.6	3.39
Flash Point °C	59	187	79
Calorific value MJ/kg	45	42.21	36.12

However, the higher viscosity may be reduced by preheating of the biodiesel before injection. But the prolonged use of B100 may lead to clogging of nozzle and cold start problems. Densities of Vegetable and biodiesel would be higher compared to diesel fuel. Calorific value would be lower on mass basis. At room temperature viscosity will be more.

VI. MERITS AND DEMERITS OF BIODIESEL

The biodiesel fuel has the following advantages:

- Self lubricating due to higher viscosity
- Less polluting when concerned with unburnt hydrocarbons, carbon monoxide
- Can be used in Compression ignition engines with less or no modifications
- Cost of the biodiesel will remain stable
- Produced from natural sources
- Diesel skilled technicians can easily service biodiesel fuelled engine.

Biodiesel has the following disadvantages:

- There may be problems of winter operatability.
- Neat biodiesel demands compatible elastomers such as gaskets, hoses etc.,

VII. EXPERIMENTAL SETUP

A four stroke, direct injected, water-cooled, single cylinder diesel engine is used for this investigation. The schematic experimental set-up is shown in Fig.3. The exhaust emissions (CO,HC, CO_2 and NO_X) are measured using Exhaust Gas Analyzer in which one end of the probe is inserted in to the exhaust pipe and the other end is connected to the analyzer which gives

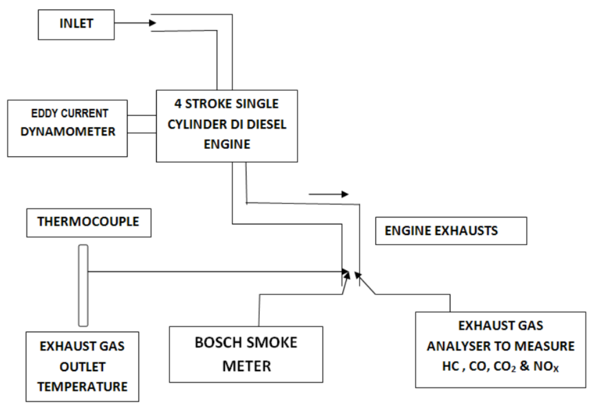

Fig. 3. Experimental setup

the emission quantities directly in ppm or in terms of percentage volume. The smoke density is measured using Bosch Smoke Meter in which a pneumatically operated pump sucks a small sample of the exhaust gas through a fixed filter paper and the blackening of the paper is evaluated by a photovoltaic cell by the quantity of light emitted by an incandescent bulb and reflected by the blackened paper. The result is given on a Bosch smoke scale. Also a high temperature thermocouple is used to measure the exhaust gas outlet temperature.

VIII. EMISSION CHARACTERISTICS

Engine performance and emission characteristics were tested by keeping the engine speed constant with diesel and bio diesel blends of 20% and 100%. Tests were conducted with pongamia bio diesel with various blends. The variation of CO produced by running the diesel engine using B20 to B100 is compared with diesel in Figure 4.

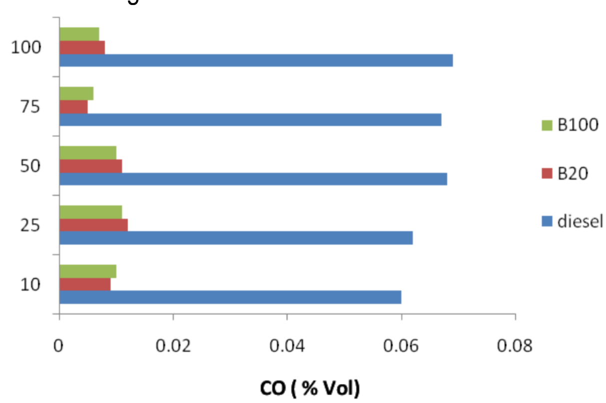

Fig. 4. Load Vs CO

Diesel engines always operate on lean side of stoichiometry. Therefore generally CO emission is always lower in CI engines compared to SI engines. 100 percent bio diesel emits less CO compared to 20% blend of bio diesel and neat diesel. The increase in CO at higher loads may be due to rich mixture of fuel and incomplete combustion.

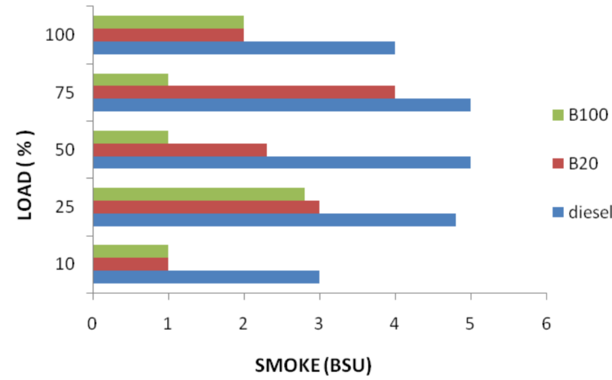

Fig. 5. Load Vs Smoke Density

The variation of smoke density produced during the test for different fuels is presented in Figure 5. The minimum and maximum smoke density produced for B20 to B100 was 1 and 3 BSU (Bosh Smoke Units) with a maximum and minimum reduction of 80% and 20% respectively as compared to diesel.

The variation of NOx with engine load for different fuels tested is presented in Figure 6. More NOx emission is due to the oxygen content and elevated combustion temperature due to complete combustion. NO_X emission was found to be more in 100% blend of bio diesel, due to more pressure caused by advancing of the injection timing. Injection timing advancing causes phase advancing CI engine combustion, which

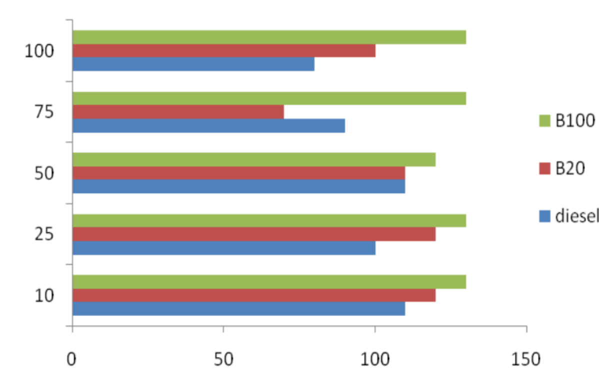

Fig. 6. Load Vs NO_X

leads to long period of combustion with the high temperature leads to NO_x formation.

IX. CONCLUSION

While running the engine with biodiesel and its blends, emissions such as HC, CO and smoke density were reduced as compared to neat diesel. These reductions of emissions could be due to use of oxygenated fuel and complete combustion of fuel. The difference between fuel consumption of biodiesel blends and diesel was not significant. However, 11 to 48% higher brake specific fuel consumption was observed in case of B20 to B100 because of reduction in calorific value and power output with increase in biodiesel percentage in the blend. From all these observations, it could be concluded that the blends of pongamia methyl ester with diesel up to 20% by volume could replace neat diesel for operating the conventional diesel engine with reduced emissions and without sacrificing the power output. This will thus help in controlling environmental pollution to a greater extent and leads to a green environment.

X. SCOPE FOR FUTURE WORK

From the experimental work it is observed use of 20% blend of pongamia oil with diesel gives a better emission results in terms of CO and smoke density. But NO_x emission is slightly is on higher side compared to neat diesel due to the higher temperature developed inside the cylinder during combustion.

Adding cetane enhancers di-tert-butyl peroxide at 1 percent or 2-ethylhexyl nitrate at 0.5 percent can reduce nitrogen oxide emissions from biodiesel and reducing the aromatic content of petroleum diesel from 31.9 percent to 25.8 percent is estimated to have the same effect [14].

ACKNOWLEDGEMENT

Authors sincerely express their heartfelt thanks to **Dr. K.Annamalai, Ph.D,** Assistant Professor, Department of AutomobileEngineering, MIT campus, Anna University for his motivation and guidance through out the experimental work for the presentation of this paper.

Author **Pradeep Kumar. A.R.**, expresses his thanks to **Dr. V.P.Ramamurthi**, ***Chairman, Dhanalakshmi College ofEngineering*** for his motivation and encouragement for successful completion of this submission.

REFERENCES

[1] Chelsea Jenkins and Al Christopher, "BiodieselBasics for the Beginner" Biodiesel Public Education Forum,2007.

[2] A.P. Sathiyagnanam, C.G. Saravanan and S.Dhandapani, " Effect of Thermal-Barrier Coating plus FuelAdditive for Reducing Emission from Di Diesel Engine",Proceedings of the World Congress on Engineering 2010 Vol II.

[3] J. Cmolik, J. Pokorny – Physical refining ofedible oils, Eur. J. Lipid Sci. Technol 2000

[4] S. Alfuso, M. Auriemma, G. Police and M.V. Prati,The effect of methyl-ester of rapeseed oil on combustion andemissions of DI diesel engines, SAE Paper 93-2801, Warrendale, Pa.,1993.

[5] N.N. Clark, and D.W. Lyons, Class 8 truck emissiontesting: effects of test cycles and data on biodiesel operation,*Transactions of ASAE*, Vol. 42, (5), pp. 1211-1219, 1999.

[6] C. Peterson and D. Reece, Emissions characteristicsof ethyl and methyl ester of rapeseed oil compared with low sulfurdiesel control fuel in a chassis dynamometer test of a pickuptruck, *Transactions of ASAE*, Vol. 39, (3), pp.805-816, 1995.

[7] C.L. Peterson, J.C. Thompson, J.S. Taberski, D.L.Reece and G. Fleischman, Long-range on road test with twentypercent rapeseed biodiesel. *Applied Engineering inAgriculture*, ASA, Vol. 15, (2), pp.91-101, 1999.

[8] A.G. Phadatare, *Performance and emission studyof power tiller engine using biodiesel*. M.Tech. thesis,Agricultural and Food engineering Department, IIT Kharagpur, India,2003.

[9] A. Srivastava and R. Prasad, Triglycerides-baseddiesel fuels, *Renewable and Sustainable Energy Reviews*, Vol.4, pp.111-133, 2000

[10] Mikkonen, S., Second-generation renewable dieseloffers advantages. Hydrocarbon Processing, 87 (2008) 2, p. 63 - 66.

[11] Rantanen, L., Linnaila, R., Aakko, P. & Harju, T.,NExBTL – Biodiesel fuel of the second generation. SAE TechnicalPaper 2005-01-3771. 18 p

[12] Kuronen, M., Mikkonen, S., Aakko, P. & Murtonen, T.,Hydrotreated vegetable oil as fuel for heavy duty diesel engines.SAE Technical Paper 2007-01-4031.

[13] Pradeep Kumar. A.R, Dr. K. Annamalai, S.R.Premkartikkumar, Performance and Emission Charactristics of twodifferent biodiesel on DI Diesel Engine, Journal of EngineeringToday, Vol. 14, Feb 2012.

[14] Anthony Radich, Biodiesel Performance, Costs, andUse, Energy Information Administration / Biodiesel Performance,Costs, and Use.