

# Emission Characteristics of Preheating Corn oil biodiesel blend in CI engine



G.Selvakumar, J.Mahendran, R.Thirunavukkarasu, R.Periyasamy, V.Gopinath

**Abstract:** *Speedy industry development and population growth have an outcome in the vigorous demand for energy. The disorganize consumption of fossil fuels has to lead to the destruction of petroleum fuels. The exhaust emission from diesel engines has caused the most important impact in troubling the environment. To rise above these harms, the focus is necessary for substitute supply. Many researchers are finding alternative fuel for fossil fuels. The substitute for petroleum products should be environmentally friendly, easily available and technically feasible. Biodiesel is derived from vegetable oils through the transesterification process. The properties of corn oil methyl ester blends were obtained are similar to diesel. However, the viscosity of biodiesel was high compared to diesel and it affects ignition delay it causes incomplete combustion. To preheat the fuel is necessary with the help of exhaust gas and it enhances the combustion process. In this experimental analysis diesel fuel, 20% Biodiesel + 80% Diesel and 40% Biodiesel + 60% Diesel at three different temperatures of fuels are 35°C, 45°C and 55°C is tested.*

**Keywords :** Preheating, HC, NOx, Engine Emission.

## I. INTRODUCTION

The consumption of petroleum fuels has been increased so that the exhaust pollutants like NO<sub>x</sub>, Carbon monoxide and Hydrocarbons and diesel demand are increased. These pollutants will affect the environment and the natural system. The exhaust gas temperature from the engine at 150°C, it will increase the atmosphere temperature and causes global warming. To reduce the exhaust gas temperature by preheating the biodiesel fuel, it will reduce the engine emission and also reduce the global warming effect. Biodiesel is one of the best alternates for diesel demand and produces fewer emission levels compare to diesel [1].

The vegetable oils are poor result in engine performance and more emission due to the viscosity of the fuel. The viscosity of oil affects the formation of fuel droplets, atomization of fuel and fuel-air mixing causes the rise of engine emission by increasing the ignition delay period [2]. The viscosity plays a major role in the use of vegetable oil in diesel engine, it can be reduced by a changing to biodiesel and preheating method [3]. The viscosity of vegetable oils can be reduced through the transesterification process. Biodiesel is non-toxic, renewable fuel and biodegradable which has the tendency to reduce engine exhaust emissions [4].

The diesel engine when fuelled with preheated 80% of Jatropha methyl ester and 20% Ethanol have the less formation of NO<sub>x</sub> compared to other fuels due to the low heating rate of ethanol, it causes to reduce the combustion temperature. Hence the formation of NO<sub>x</sub> reduced. The carbon monoxide and hydrocarbon emission also reduced, this is because pre-heated jatropha bio-diesel has lesser viscosity, which enhances the combustion process [5]. The optimized 20% of preheated thumba biodiesel produced slightly less thermal efficiency, CO, HC and NO<sub>x</sub>. The 20% of preheated thumba biodiesel gave similar results than diesel [6]. The CI engine operates on corn oil biodiesel have reduction off emission in CO<sub>2</sub>, NO<sub>x</sub> and HC and also increase in biodiesel content further drop in emission because of oxygen content and low carbon hydrogen ratio in corn oil methyl ester [7].

The diesel engine running on 100% full biodiesel is decreased by 15% of carbon monoxide, 40% of carbon dioxide and 30% of total hydrocarbons than to diesel due to low carbon-hydrogen ratio biodiesel [8]. The biodiesel having the tendency to reduce the formation of NO<sub>x</sub> due to superior cetane number [9]. The emission characteristic of preheated diesel has lower hydrocarbon and carbon monoxide, but a slight increase in NO<sub>x</sub> than unheated diesel [10].

## II. PREPARATION OF BIODIESEL

The extraction of alcohol from an ester is called a transesterification process. The vegetable oil is to be heated and permitted to react with methanol. The reaction solution is allowed with NaOH catalyst under the best possible reaction surroundings. After completion of the reaction, the reaction blend is cooled and separated. Unreacted vegetable oil, unreacted methanol, crude biodiesel, crude glycerol and soap are obtained. The excess methanol is recovered for reuse. The post-treatment method such as washing, drying and evaporation is necessary to get clean biodiesel and glycerol.

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The properties of diesel are the viscosity of 5.0CST at 40°C, Fire Point of 71°C and heating value of 42MJ/Kg. The properties of corn oil biodiesel are the viscosity of 8.6CST at 40°C, Fire Point of 161°C and heating value of 39.5MJ/Kg.

### III. TEST ENGINE SETUP

The four-stroke direct injection diesel engine used in this experiment. The engine specifications are the stroke length of 203mm, a bore of 127mm, rate power of 8kW and speed of 1500rpm.

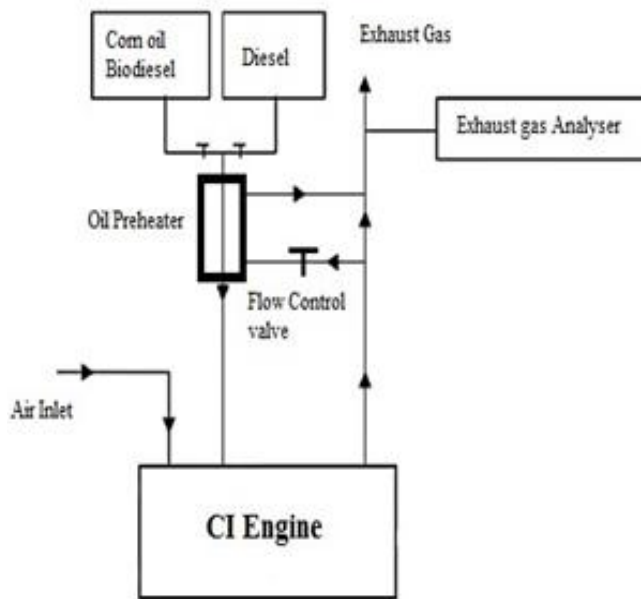


Fig 1. Schematic diagram of diesel engine setup [4]

The fuel is preheated with the help of a heat exchanger that is fixed outside the engine. The fuel is heated through the heat energy of the engine outlet gas, the waste heat is reused

and the exhaust gas temperature was reduced. The required temperature of the fuel is achieved through a control valve to control the flow rate of hot gas to heat exchanger. The required fuel temperature was maintained at each load before measurement.

### IV. RESULT AND DISCUSSION

#### A. Carbon Dioxide

The variation of CO<sub>2</sub> Vs Brake Power at various fuel temperatures for diesel, 20B and 40B are shown in figure 2.

It was found that carbon dioxide levels raised for higher brake power and decreased with an increase in biodiesel content. The Carbon dioxide for diesel is a little high compared to biodiesel due to more oxygen content present in biodiesel which reduces the formation of carbon dioxide. The CO<sub>2</sub> emission of diesel fuel at 35°C and brake power of 4.16kW is 4.2%, which is about 0.3% and 0.6% decreased for 20B and 40B blends due to oxygen enhance the combustion process. It was observed that the rise in fuel temperature the concentration of carbon dioxide emission was reduced due to good vapourization of fuel and more oxygen content present in biodiesel, its enhances the complete combustion. At fuel temperature of 45°C with brake power of 4.16kW, the CO<sub>2</sub> emission for diesel, 20B and 40B are 4.0%, 3.6% and 3.2% respectively and at fuel temperature of 55°C, the CO<sub>2</sub> emission for diesel, 20B and 40B are 3.8%, 3.5% and 3.0% respectively. The 20B was decreased by 0.3% and 0.8% for 40B when compared to diesel fuel.

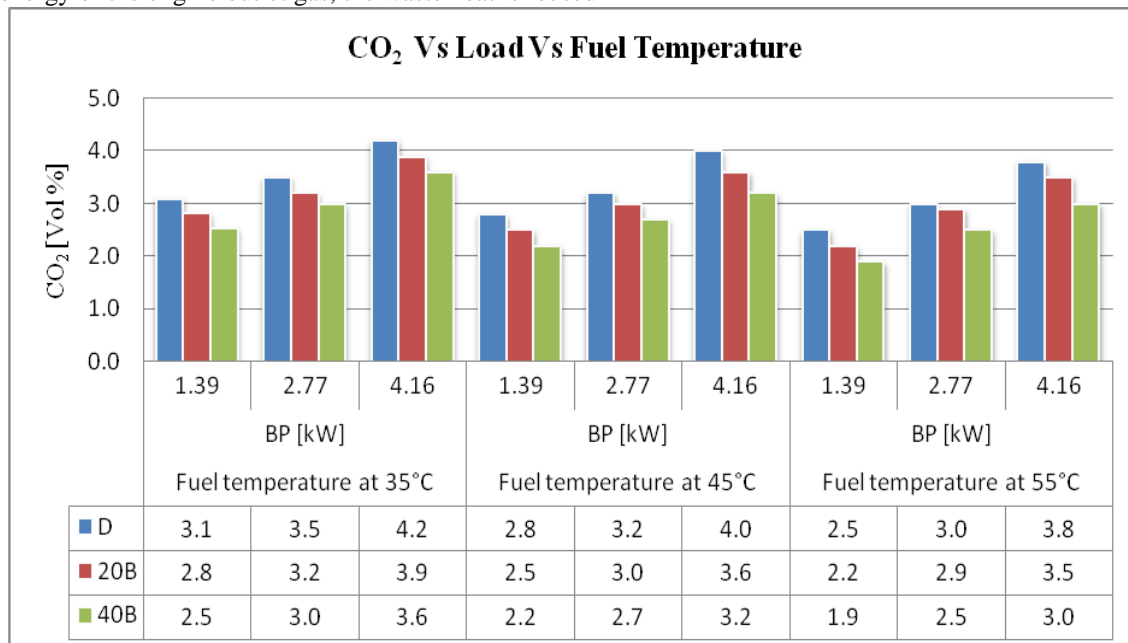
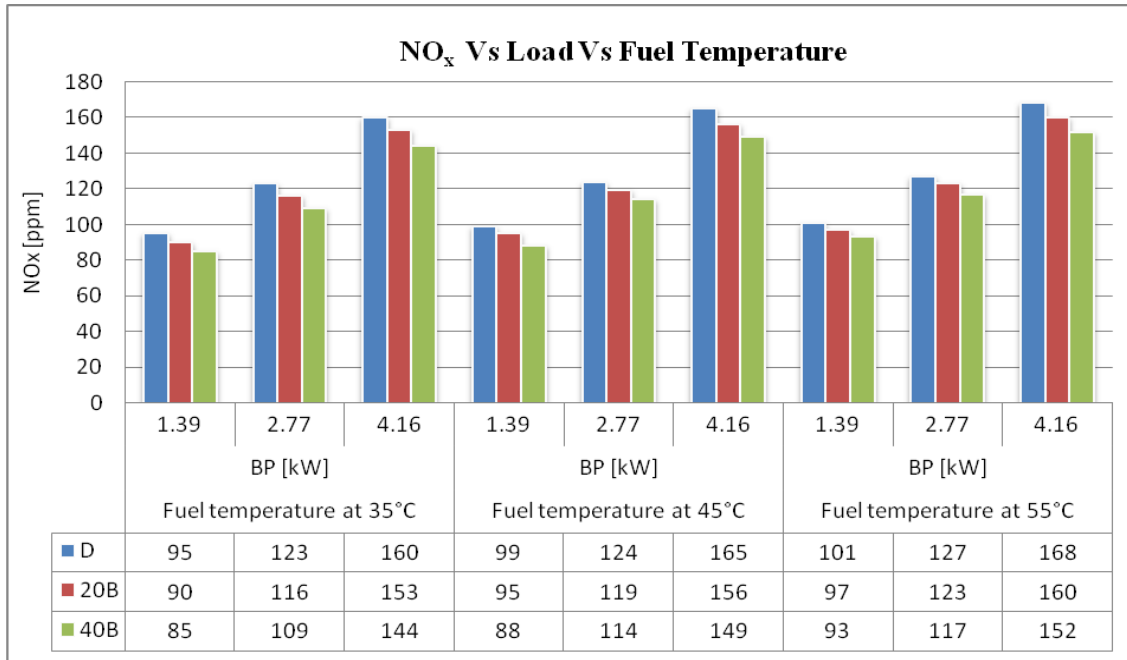


Fig 2. CO<sub>2</sub> Vs brake power Vs fuel temperature

**B. NOx**

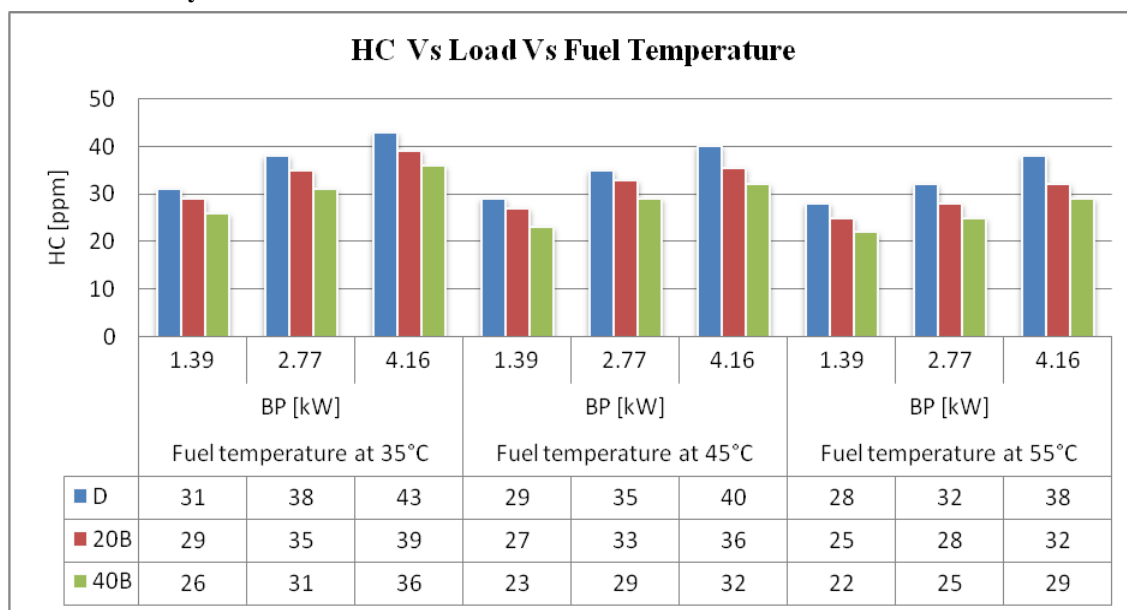


**Fig 3. NOx Vs brake power Vs fuel temperature**

Figure 3 shows the comparison of NOx Vs Brake Power at different fuel temperatures for diesel, 20B and 40B. The NOx raised with raise in brake power and reduced with an increase in biodiesel content. The oxides of nitrogen concentration of diesel fuel at 35°C and brake power of 4.16kW are 160ppm, for 20B and 40B blends which are about 7ppm and 16ppm decreased due to lesser heating value cause to reduce the combustion temperatures in the combustion chamber. It was observed that the higher the fuel temperature the concentration of NOx emission was increased due to the rise

in combustion temperature. At fuel temperature of 45°C with brake power of 4.16kW, the NOx emission for diesel, 20B and 40B are 165ppm, 156ppm and 149ppm respectively and at fuel temperature of 55°C with brake power of 4.16kW, the NOx emission for diesel, 20B and 40B are 168ppm, 160ppm and 152ppm respectively. The 20B at 55°C was 0 ppm and 8ppm for 40B decreased compared to diesel fuel at 35°C. The NOx is decreased with an increase in the concentration of preheated biodiesel.

**C. Unburned Hydrocarbon**



**Fig 4. HC Vs brake power Vs fuel temperature**

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Figure 4 shows the variation of unburned Hydro carbon Vs Brake Power at different fuel temperatures for diesel, 20B and 40B. Hydrocarbon increased with raise in brake power and decreased with an increase in the concent of corn oil methyl ester. The unburned hydrocarbon emission of diesel fuel at 35°C and brake power of 4.16kW is 43ppm, for 20B and 40B blends which are about 4ppm and 7ppm decreased due to superior content of oxygen present in biodiesel, it enhances the combustion. It was found that higher the fuel temperature the concentration of unburned hydrocarbon emission was reduced due to fuel and air are mixed in better, atomization and less viscosity of the fuel.

At fuel temperature of 45°C with brake power of 4.16kW, the unburned HC emission for diesel, 20B and 40B are 40ppm, 36ppm and 32ppm and at fuel temperature of 55°C with brake power of 4.16kW, the unburned HC emission for diesel, 20B and 40B are 38ppm, 32ppm and 29ppm. The 20B was decreased 6ppm and 9ppm for 40B, when compared to diesel fuel due to fuel and air are mixed in better and easy vaporization of the fuel.

### V. CONCLUSION

The effects of corn oil biodiesel blended with petroleum diesel at fuel temperatures of 35°C, 45°C and 55°C on the engine emissions are tested. The experimental test results are concluded as follows below,

- The CO<sub>2</sub>, NO<sub>x</sub> and unburned Hydrocarbon emissions are reduced with increase the biodiesel content, reduced with higher fuel temperature and increased with higher the brake power.
- The emission result of 40B at 55°C compared with Diesel at 35°C are, CO<sub>2</sub> was reduced by 1.2 Vol%, NO<sub>x</sub> was reduced by 8ppm and HC was reduced by 14ppm.

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### REFERENCES

1. S. Sivalakshmi and T. Balusamy, 'Performance and emission characteristics of a diesel engine fuelled by neem oil blended with alcohols' International Journal of Ambient Energy, Vol.32, No.41, pp. 170-178, 2011.
2. V.Gopinath and P.Suresh, " Experimental Study on the Emission Characteristics of a Diesel Engine Using Corn Oil as Fuel" International Journal of Renewable Energy Research, Vol.5, No.1, pp. 99-102, 2015.
3. Puneet Verma and M.P. Sharma, "Performance and Emission Characteristics of Biodiesel Fuelled Diesel Engines" International Journal of Renewable Energy Research, Vol.5, No.1, pp. 245- 250, 2015.
4. V. Gopinath, G. Selvakumar and R. Periyasamy, "Performance and Emission Characteristics of Preheating Corn Oil Methyl Ester in CI Engine" Mechanika. doi.org/10.5755/j01.mech.25.5.23135 Vol 25, No.5, pp.413-418, 2019.
5. Shiyasharan Patel and Dr. Nitin Shrivastava, "Experimental Investigation of Performance and Emission of Diesel Engine Fuelled with Preheated Jatropa Biodiesel and its Blends with Ethanol" International Journal of Renewable Energy Research, Vol.6, No.4, pp. 1482- 1490, 2016.
6. Narayan Lal Jain, S.L. Soni, M.P. Poonia, Dilip Sharma, Anmesh K. Srivastava and Hardik Jain," Performance and Emission Characteristics of Preheated and Blended Thumba Vegetable Oil in a Compression

Ignition Engine" Applied Thermal Engineering, doi.org/10.1016/j.applthermaleng.2016.10.186, 2016.

7. V.Gopinath, P. Shanmugasundaram and P.Suresh, "Emission Analysis of an Engine Operating on Corn Oil Methyl Ester Blends with Air Pre-Heater" International Journal of Renewable Energy Research, Vol.7, No.4, pp. 1682-1685, 2017.
8. Belachew Tesfa, Fengshou Gu, Rakesh Mishra and Andrew Ball, "Emission Characteristics of a CI Engine Running with a Range of Biodiesel Feedstocks" Energies, doi:10.3390/en7010334Vol.7, pp. 334-350, 2014.
9. Natchanok Pala-En , Melanie Sattler , Brian H. Dennis , Victoria C. P. Chen and Rachel L. Muncrief, "Measurement of Emissions from a Passenger Truck Fueled with Biodiesel from Different Feedstocks", Journal of Environmental Protection, doi.org/10.4236/jep.2013.48A1010, Vol. 4, pp.74-82, 2013.
10. Selvam S and Rajasekaran S, "Performance and Emission Characteristics of Pre-Heating Diesel by Using Shell and Coil Heat Exchanger in CI Engine" Journal of Chemical and Pharmaceutical Sciences, Vol. 9, No. 3, pp. 1702-1706, 2016.

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