Emission Analysis of an Engine Operating on Corn Oil Methyl Ester Blends with Air Pre-Heater

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Abstract- Diesel engine pollutants such as NOx, Carbon dioxide and unburned hydrocarbons are increasing day by day due to usage of fossil fuel in automobiles. Diesel engine emits exhaust gases at high temperature, which will affect the environment and exhaust pollutants cause hazards to the environmental. In order to reduce these pollutants, alternative fuels can be used, which are biodegradable and turn out complete combustion due to more oxygen content in biodiesel. In this work the waste heat energy from the exhaust gas is reused by preheating the inlet air, which will reduce the emission level due to shorten the ignition delay period.

Keywords Corn oil methyl ester, Emission, Air preheater, NOx.

1. Introduction

Now a day's usage of diesel fuel in IC engine has been increased as a result the exhaust emissions and diesel fuel demand are increased. Diesel engine emissions like carbon dioxide, NOx and hydrocarbons are affecting the environment. To reduce the diesel engine pollutants and demand of fossil fuel, biodiesel and energy reusing methods are the best solution for this problem. Biodiesel is one of the most promising alternatives for diesel demand and less emission compared to diesel [1]. The raw vegetable oils are producing poor performance and high emission due to high viscosity [2]. The viscosity of oil affect the droplet formation, atomization, vaporization and fuel–air mixing are influencing the engine emission by increasing the ignition delay period and exhaust gas temperature [3].

The preparation of biodiesel from vegetable oils can be using four methods a) transesterification b) micro emulsion c) pyrolysis d) blending. From all these methods, the transesterification is an effective and convenient method for reducing viscosity [4]. The transesterification process was most the effective method for reducing viscosity of the vegetable oils [5].

Vegetable biodiesel is non-toxic, renewable fuel and biodegradable with the abilities to reduce engine exhaust emissions [6]. The oxygen content of biodiesel could not cause any increase in NOx formation because diffusion combustion occurs mainly in regions with oxygen-fuel ratio and higher cetane number [7]. The formation of NOx, CO_2 and unburned hydrocarbon are reduced due to more O_2 content, higher cetane number and low carbon – hydrogen ratio [8]. Higher inlet air temperature will reduce the formation of HC, CO_2 and NOx due to better mixing of air and fuel, easy vaporization and reduces the ignition delay [9, 10].

2. Transesterification

The formation of corn oil methyl ester by transterification of corn oil required 3 moles of methanol. The corn oil first reacts with methanol in the presence of sodium hydroxide to produce corn oil methyl ester and by product of glycerin. The properties of 20B are viscosity of 5.72CST at 40°C, Density of 857kg/m^3, Flash Point of 76°C, Fire Point of 84°C and Calorific value of 41500KJ/Kg. The properties of 40B are viscosity of 6.44CST at 40°C, Density of 862kg/m^3, Flash Point of 95°C, Fire Point of 103°C and Calorific value of 41000KJ/Kg.

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 tank is used to measure air flow rate and burette is used to measure fuel flow. The engine specifications are given in Table 1 below,

Table 1. 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

A T-valve is used to change over the fuel selection between diesel and biodiesel blend. The exhaust gas analyzer probe is inserted into the engine exhaust pipe to measure the emission parameters. The fuel supply to IC engine is changed from diesel to biodiesel with the help of T-valve. The engine emission parameters are noted after 15 minutes to ensure that the engine runs on biodiesel blend.

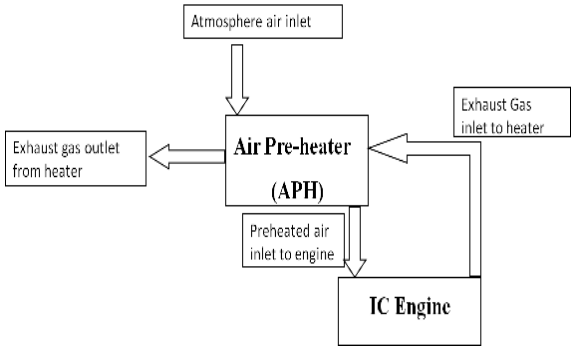

Fig. 1. Air pre-heater

In this work, an external air pre-heater set up is attached to the engine as shown fig-1. The main purpose of air pre-heater is to extract the heat energy from the exhaust gas and used to reduce the exhaust emission by the way of increasing the inlet air temperature. Air pre-heater (APH) is one of the most effective methods for reducing carbon dioxide, NOx and hydrocarbon emission of engines.

4. Results and Discussion

4.1 Carbon Dioxide

The comparison of Carbon dioxide Vs Brake Power at different inlet air temperatures are represented graphically in fig-2. The carbon dioxide increased with increase in brake power and decreased with increase in inlet air temperature. The emission of carbon dioxide is more in the engine fuelled with diesel as compared to 20B and 40B. The CO_2 concentration of diesel at brake power of 4.16kW is 4.2%, for 20B and 40B blends which are about 7.14% and 14.28% are reduced compared to diesel. The main difference in ester based fuel compared to diesel is O_2 content which reduces the formation of carbon dioxide. There is more amount of oxygen content present in Corn oil methyl ester and its blends help for complete combustion. It was observed that higher the inlet air temperature the concentration of carbon dioxide emission reduced. At inlet air temperature of 45°C with brake power of 4.16kW, the CO_2 emission for engine fuelled with diesel, 20B and 40B are 3.8%, 3.5% and 3.25%. The 20B was found to be reduced by 7.9% and 14.47% for 40B when compared to diesel fuel.

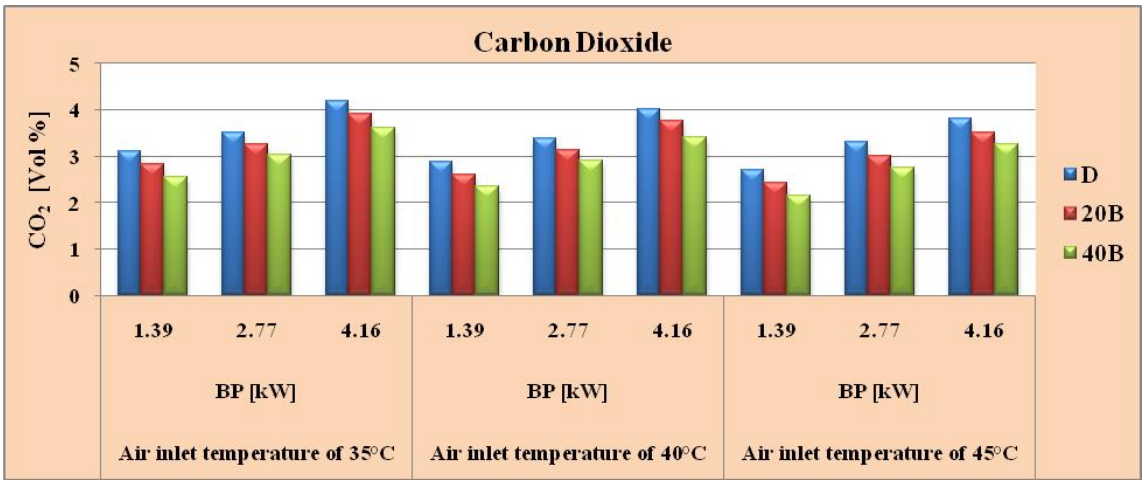

Fig. 2. CO_2 Vs BP at inlet air temperature of 35°C, 40°C and 45°C

4.2 NOx

The comparison of NOx Vs Brake Power at different inlet air temperatures are shown in fig-3. The NOx increased with increase in brake power and decreased with increase in inlet air temperature. The NOx concentration of diesel at brake power of 4.16kW is 162ppm, for 20B and 40B blends which is about 10.98% and 20.8% reduced compared to diesel due to higher cetane number. Hence engine fuelled with diesel emits more NOx when compared to 20B and 40B. The flame temperature for biodiesel was slightly below that of diesel, which caused to reduce the NOx formation. The presence of oxygen on the ester molecule does not lead to increases in NOx formation. It was observed that as the inlet temperature of the air increases the concentration of NOx emission tends to decrease. At inlet air temperature of 45°C with brake power of 4.16kW, the NOx emission of the engine fuelled with diesel, 20B and 40B are 136ppm, 121ppm and 108ppm. The engine fuelled with 20B was reduced by 11.02% and 20.58% for 40B when compared to diesel fuel. Higher the inlet air temperature caused to reduce the ignition delay, so that formation of NOx has been reduced.

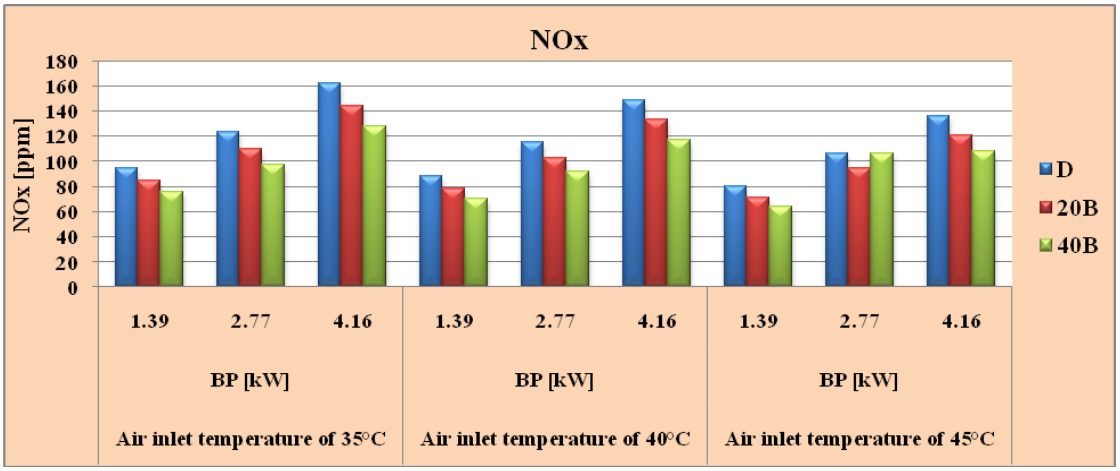

Fig. 3. NOx Vs BP at inlet air temperatures of 35°C, 40°C and 45°C

4.3 Unburned Hydrocarbon

The comparison of Unburned Hydro carbon Vs Brake Power at different inlet air temperatures is shown in Fig-4. The hydrocarbon increased with increase in brake power and decreased with increase in inlet air temperature. The unburned HC concentration of the engine fuelled with diesel at brake power of 4.16kW is 43ppm, for 20B and 40B blends which are about 17.44% and 31.62% was reduced compare to diesel due to properties of fuel and low carbon hydrogen ratio. The reduction of HC emission is due to higher oxygen content in biodiesel, which enhance the combustion process. The formation of hydrocarbon emission is reduced due to the oxygen quantity and fuel atomization. It was observed that higher the inlet air temperature the concentration of unburned hydrocarbon emission reduced. At inlet air temperature of 45°C with brake power of 4.16kW, the unburned HC emission for diesel, 20B and 40B are 40ppm, 33ppm and 27.5ppm. The 20B was reduced by 17.5% and 31.25% for 40B when compared to diesel fuel. Higher inlet air temperature reduced the formation of HC due to better mixing of air – fuel and easy vaporization of fuel.

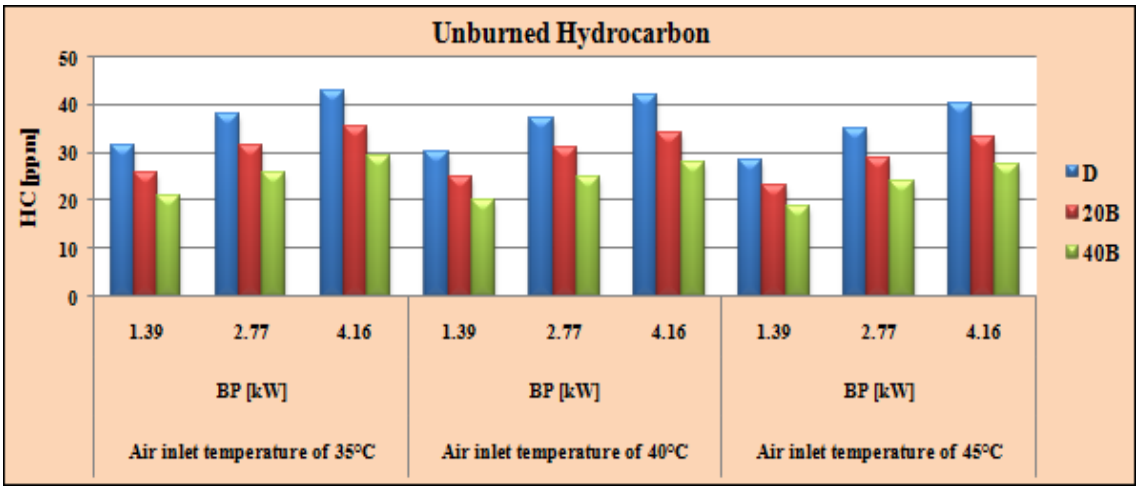

Fig. 4. HC Vs BP at inlet air temperatures of 35°C, 40°C and 45°C

5. Conclusion

Based on the above results, the following conclusions have been summarized,

It was noted that the diesel engine running with corn oil methyl ester highlights a significant reduction in CO_2, NOx and HC. Moreover, biodiesel content increases a further reduction in emission because of oxygen content and low carbon hydrogen ratio in corn oil methyl ester. The engine fuelled with 40B of CO_2, NOx and HC are reduced by 14.28%, 20.8% and 31.62% compared to diesel. The inlet air temperature of 45°C for 40B of CO_2, NOx and HC are reduced by 14.47%, 20.58% and 31.25% compared to diesel. Higher the inlet air temperature the engine emissions were reduced gradually. From the above conclusions, the 40B of corn oil methyl ester blended with diesel performed less carbon dioxide, NOx and hydrocarbon emissions without any modification in engine.

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