Performance and Emission Characteristics of Corn oil blended with Diesel

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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 . This paper investigates the performance and emission characteristics of single cylinder diesel engine using biodiesel blends. In this experiment, an attempt has been made to investigate four types of diesel-corn oil mixtures. The diesel engine is run on these blends at different load conditions and various emission parameters like NOx, Carbon dioxide and Unburned Hydrocarbon and Carbon monoxide, and performance parameters like brake thermal efficiency, Specific fuel consumption Exhaust gas temperature are measured.*

Keywords- Corn oil; Biodiesel; Engine performance, Engine Emission

I. INTRODUCTION

India is one of the fastest developing countries with a stable economic growth, which multiplies the demand for transportation in many folds. Fuel consumption is directly proportionate to this demand. India depends mainly on imported fuels due to lack of fossil fuel reserves and it has a great impact on economy. India has to look for an alternative to sustain the growth rate. Bio-diesel is a promising alternative for our Diesel needs. The blend of Bio diesel with fossil diesel has many benefits like reduction in emissions, increase in efficiency of engine, higher Cetane rating, lower engine wear, low fuel consumption, reduction in oil consumption etc. The oils that are extensively studied include Sunflower, Soya bean, Peanut, Rapeseed, Rice bran, Karanji etc.,[1,2]. One of the disadvantages of using these oils in diesel engines is nozzle deposits, which drastically affects the engine performance and emissions. The refining processes of vegetable oil gives better performance compared to crude vegetable oil [3,4,5,6]. R. J. Bothast . M. A. Schlicher[11] and Dan Somma Æ Hope Lobkowicz[12] have explained the Ethanol has been utilized as a fuel source in the United States extracted from corn .Goering et al [7] studied the characteristic properties of eleven vegetable oils to determine which oils would be best suited for use as an alternative fuel source. Of the eleven oils tested, corn, rapeseed, sesame, cottonseed, and soyabean oils had the most favorable fuel properties. Krishnaiah.T et al [8] ,Gopinath .V et al [9], Santhan Kumar.U et al [10] and D. K. Ramesha et al [13] have studied the performance and emissions with Corn oil blended with diesel experimentally and their results have discussed bellow. Krishnaiah.T et al [8] have studied the CORN blended with diesel bio fuel extremely in a four-stroke direct injection single cylinder diesel engine. From the experimental investigation, the following conclusions are drawn. Most Important characteristics of Corn and its blends with diesel fuel were similar to those of diesel fuel when compare with each other. The CORN content blends with 5 and 20 %,(B5, B20) has improved BTE of the diesel engine and slightly increased BSFC. The maximum BTE increased to 27.58% with B20. Furthermore, B5 and B20 improved exhaust emissions. The highest CORN content blend (B25) resulted in significant improvements in emissions, but they did have better performance characteristics than diesel fuel. Nonetheless, small modifications may provide significant improvements in the performance of B25. Gopinath .V et al [9] have 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 and emission parameters like NOx, Carbon dioxide and Unburned Hydrocarbon are measured. 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 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. U. Santhan Kumar[10] have been examined the use of diesel-corn oil mixtures in diesel four-stroke engine. From the experimental results, the following conclusions are drawn. The specific fuel consumption of the 0.31kg/kw-hr was observed with the blend B15 the SFC is lower for above blend than that of other blends and pure diesel. In the combustion analysis, the maximum cylinder pressure observed as 69 bar for B60 blends than all the other blends at maximum brake power of the engine. The heat release rate is also higher for B30 blend than pure diesel and all the other blends. The CO_2 percentage increased with increase of loads. The minimum value occurred at B45&B60.The hydro carbons are also lower for all the blends compared with diesel.D. K. Ramesha et al [13]. have presents the results of investigation carried out in studying the properties and behavior of methyl esters of corn seed oil, fish oil and its blends with diesel fuel in a C I Engine. Engine tests have been carried out to determine the performance, emission and combustion characteristics of the above mentioned fuels. The tests have been carried out in a 4-stroke, computerized, single cylinder, constant speed, direct injection diesel engine at different loads. The loads were varied from 0% to 100% of the maximum load in steps of 25%. The Methyl Ester blends of 10%, 20% and 30% by volume with diesel were used. The engine test parameters were recorded with the help of engine analysis software and were studied with the help of graphs. The results showed that the properties of the above mentioned oils are comparable with conventional diesel. The 20% blend performed well in running a diesel engine at a constant speed of 1500 rpm. It substantially reduced the emissions with acceptable efficiency. Hence the oils can be used as suitable additives for diesel in compression ignition engine.

II. TRANSESTERIFICATION PROCESS

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 Glycerin and corn oil Methyl Esters (Biodiesel).

Table1. Properties of diesel and corn bio-diesel.

PROPERTIES	DIESEL	CORN BIO-DIESEL
Density [kg/m^3]	855	878
Calorific Value [kJ/Kg]	42,000	37,200
Viscosity at 39^{0}C	4	6.2
Specific Gravity	0.855	0.878
Flash Point [^{0}C]	58	132
Fire Point [^{0}C]	66	138

III. EXPERIMENTAL SET UP AND PROCEDURE

The various components of experimental set up are described below.

(i) The engine

(ii) Dynamometer

(iii) Exhaust gas analyzer

The Engine

The Engine chosen to carry out experimentation is a single cylinder, four stroke, vertical, water cooled, Kirloskar make CI Engine. This engine can withstand higher pressures encountered and also is used extensively in agriculture and industrial sectors. Therefore this engine is selected for carrying experiments. The specifications of the engine given Table 2. Fig1. shows the actual photos of the C.I. Engine and its attachments.

ENGINE SPECIFICATIONS

Table 2. Engine Specifications

Engine	Four stroke, single cylinder, water cooled, diesel engine, Kirloskar engine Ltd
Ignition System	- Compression Ignition
Bore	0.0875m
Stroke	0.11m
Compression ratio	17.5:1
Speed	1500 rpm

Fig.1 Experimental set up

Dynamometer

The engine has a DC electrical dynamometer to measure its output. The dynamometer is calibrated statistically before use. The dynamometer is reversible i.e., it works as monitoring as well as an absorbing device. Load is controlled by changing the field current. Eddy-Current Dynamometer's theory is based on Eddy-Current (Fleming's right hand law). The construction of eddy-current dynamometer has a notched disc (rotor) which is driven by a prime mover (such as engine, etc.) and magnetic poles (stators) are located outside with a gap. The coil which excites the magnetic pole is wound in circumferential direction. When current runs through exciting coil, a magnetic flux loop is formed around the exciting coil through stators and a rotor. The rotation of rotor produces density difference, and then eddy current goes to stator. The electromagnetic force is applied opposite to the rotational direction by the product of this eddy-current.

Five Gas Analyzer

All emissions like Carbon monoxide, Carbon dioxide,Un-Burnt Hydrocarbons, Nitrogen oxide and unused oxygen are found in Indus 5 gas emission analyzer of model “PEA-205” is used. In this cable one end is connected to the inlet of the analyzer and the other end is connected at the end of the exhaust gas outlet. Continuous charging of the analyzer is essential to work in an effective way.Fig.2. show the actual photos of Exhaust Gas Analyzer attached to engine at the exit.

Fig. 2 Five Gas Analyzer

The performance and emission parameters of pre-pared diesel fuel blends (B10, B20, B30, B40) with corn oil have been studied and compared with diesel fuel at constant speed for different loads. Operating Parameters, including fuel consumption, Brake power, brake specific fuel consumption, brake thermal efficiency and exhaust gas Temperature were computed without Al_2O_3 Nano additives. Emissions, including carbon dioxide (CO_2), carbon monoxide (CO), nitro-gen oxide (NO_x) and unburned hydro carbon (HC) were measured using an Five gas analyzer. All measurements values were recorded .Engine performance and emissions characteristics are presented according to engine load. The experiments results at different loads and the performance and emission parameters of diesel fuel and blends (B10, B20, B30, B40) with corn oil have been discussed below.

IV. RESULT AND DISCUSSIONS

From the Experimental work, the performance and emission parameters of pre-pared diesel fuel blends (B10, B20, B30, B40) with corn oil at constant speed for different loads were discussed.

Brake thermal efficiency.

Variations in brake thermal efficiency (BTE), with respect to Brake Power, for all of the fuels of diesel and its blends are shown in Figure below BTE of all the tested fuels initially increased with engine load until it reached a maximum value and then decreased slightly as engine load continued to increase. From the figure it is observed that the Corn content increases, BTE decreases by increasing BP.BTE of all Corn blends are less than the Diesel. Maximum brake thermal efficiency was 26.03% for B10, which was almost equal to that of diesel (26.78%). Maximum brake thermal efficiency was 25.32 for B20, which was lower than that of diesel fuel due to CORN’s higher viscosity. Although the addition of the CORN to diesel fuel decreased its heating value, higher BTE was obtained with B10 and B20.

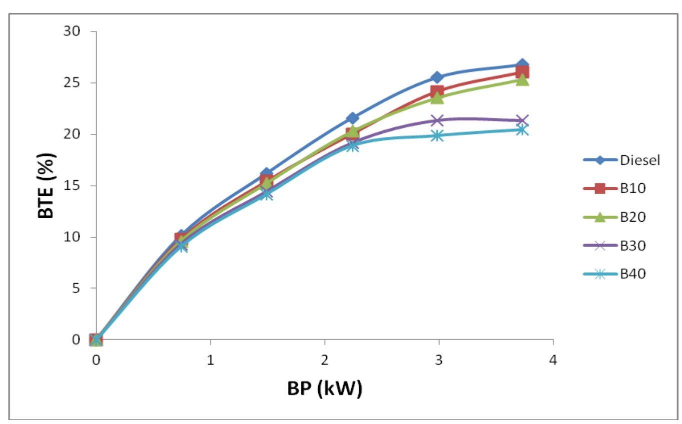

Fig.3 Variation of Brake thermal efficiency with BP

Brake Specific fuel consumption.

Variations in brake specific fuel consumption (BSFC), with respect to engine load are shown in Figure below. For all of the fuels tested, BSFC had a tendency to decrease as engine load increased until it reached a minimum value, and then slightly increased as engine load continued to increase. BSFC initially decreased slightly as CORN content in the blends increased up to 20%, but increased as CORN content increased further due to CORN's lower calorific value and higher viscosity. For blends B10 and B20, BSFC were 0.33, 0.34kg/kW.hr, slightly more than diesel (0.31).

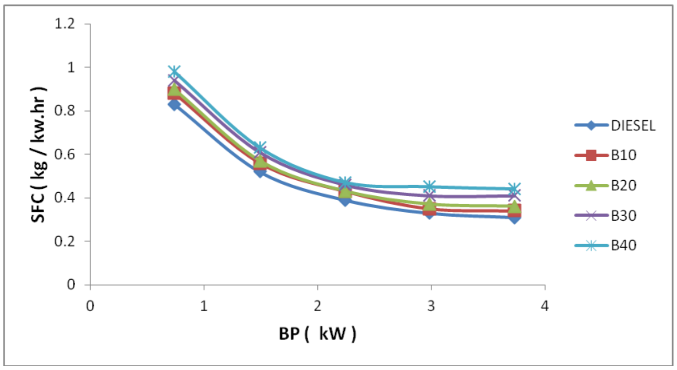

Fig.4 Variation of SFC with BP

Exhaust gas temperature.

Exhaust gas temperature (EGT) varied with load and the results for different fuels are presented in Figure. EGT of all the tested fuels increased with load. EGT of B10 and B20 was lower than that of diesel fuel at the highest load due to the blends' higher viscosities, lower calorific value which resulted in poorer atomization, poorer evaporation, and extended combustion during the exhaust stroke. When CORN content increased, viscosity increased, calorific value decreased and, as a result, EGT of the blends were lower than that of diesel. Maximum EGT at peak load for Diesel, B10, B20, B30 and B40 were 276 $^{\circ}$C, 273^{o}C, 270^{o}C, 265^{o}C and 260 ^{o}C respectively.

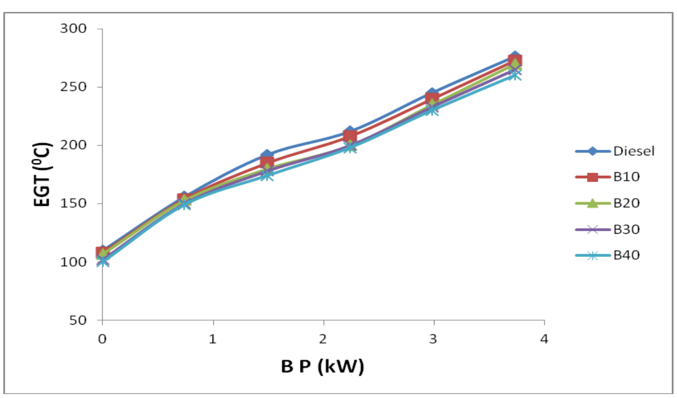

Fig.5 Variation of EGT with BP

Engine exhaust emission.

Carbon Monoxide (CO).

Below figure compares the carbon monoxide (CO) emissions, with respect to engine load. CO emissions of all the fuels had a tendency to increase with load. CO emissions were decreases with increasing CORN content. The CO emissions of all blends were less than that of Diesel for loads. The percentage of CO emissions of Diesel, B10, B20, B30 and for B40 were 3.012, 2.921, 2.894, 2.810, 2.801 respectively.

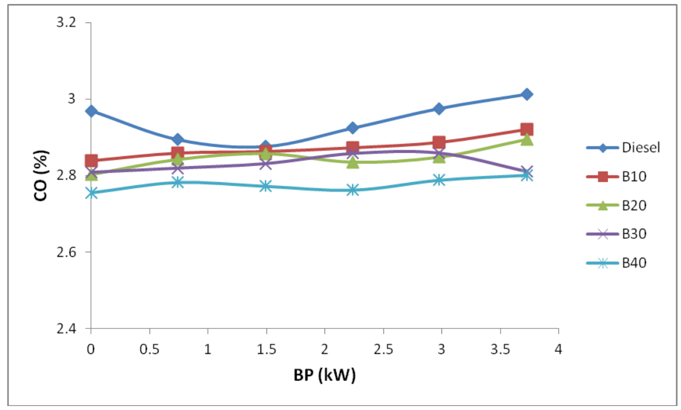

Fig.6 Variation of CO with BP

Carbon Dioxide (CO_2).

The Variation of carbon dioxide with Biodiesel blends with different loads is graphically represented in Fig 7. It was observed that the percentage of carbon dioxide in all the blends was found to be low at all loads as compare to Diesel. At the brake power of 3.73kW, the percentage Carbon dioxide of Diesel,B10, B20, B30, and for B40 were 8.55, 7.96, 7.46, 6.63, and 6.20 respectively. For B10 and B20 the percentage of carbon dioxide is reduced compared to 100% diesel were 0.59 and 1.09 respectively.

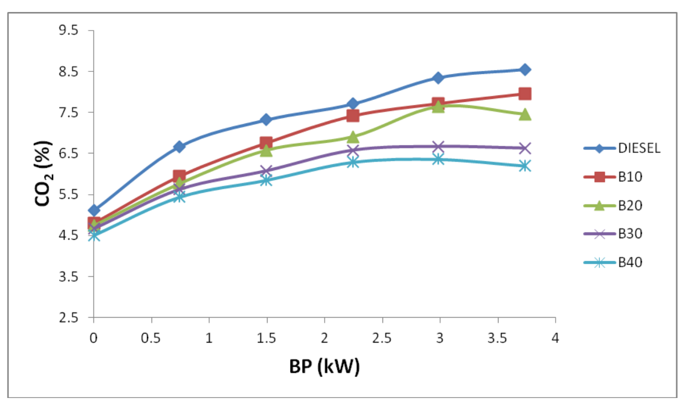

Fig.7 Variation of CO_2 with BP

HC Emission.

The Variation of unburned hydrocarbon with Biodiesel blends with different loads is graphically represented in Fig.8. It was observed that the percentage of hydrocarbon in all the blends as compared to diesel was found to be low at all loads. At the brake power of 3.73kW, the hydrocarbon of about 1607 ppm for 100% diesel and 1604 ppm for B10. The 03 ppm of hydrocarbon is reduced compared to 100% diesel and also it was observed that the proportion of corn oil blends increases the percentage of unburned hydrocarbon decreases.

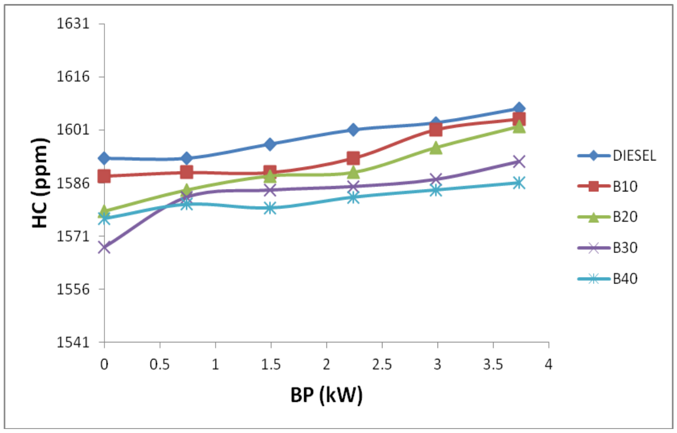

Fig.8 Variation of HC with BP

NOx Emission.

The Variation of NOx with Biodiesel blends with different loads is graphically represented in Fig. It was observed that the percentage of NOx in all the blends was found to be low at all load as compared to diesel. At the brake power of 3.73kW, the NOx reaches its maximum of 798 ppm for 100% Diesel and 610 ppm for B10. The 188 ppm of NOx is reduced compared to 100% diesel and also it was observed that the proportion of corn oil blends increases the ppm of NOx increases.

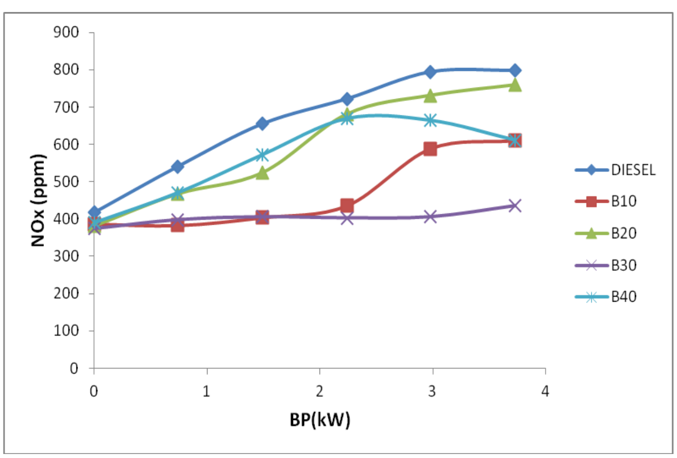

Fig.9 Variation of NOx with BP

V. CONCLUSION

The performance, combustion and emission characteristics of diesel and CORN bio diesel were investigated on four stroke single cylinder vertical water cooled diesel engine. The conclusions of this investigating at are as follows.

Maximum brake thermal efficiency 26.03% was observed for B10, which was almost equal to that of diesel (26.78%) at Brake power 3.73 kW, for B20, it was 25.32.
It was observed for blends B10 and B20, SFC were 0.33, 0.34 kg/kW.hr, slightly more than diesel (0.31).

It was observed from the figure 5.3, EGT of the blends were lower than that of diesel. Maximum EGT at peak load for Diesel, B10, B20, B30 and B40 were 276 ^{0}C, 273^{o}C, 270^{o}C, 265^{o}C and 260 ^{o}C respectively.

The CO emissions of all blends were less than that of Diesel for loads. The minimum value occurred at B30 & B40.

It was observed that the percentage of carbon dioxide (CO_2) in all the blends was found to be low at all loads as compare to Diesel. The minimum value occurred at B30 & B40.

It was observed that the percentage of hydrocarbon in all the blends as compared to diesel was found to be low at all loads. The minimum value occurred at B30 & B40.

It was observed that the percentage of NOx in all the blends was found to be low at all load as compared to diesel. The minimum value occurred at B10 & B30.

From the results, it is clear that, Corn blends B10 & B20 are the optimum blends for IC engine.

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