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Investigation of Canola Oil Methyl Ester Blends with Diesel on a Compression Ignition Engine to Improve Performance and Control Emissions

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Abstract
This paper presents the experimental investigation of canola oil produced by the transesterification process and glycerin as a by-product. Canola oil methyl ester blends with diesel blends were used in a compression ignition (diesel) engines to analyze the emission characteristics. Experimental results show that canola methyl ester blends meet the emission and performance requirements of a diesel engine. These blends provide less concentration of exhaust gas emissions. However, apart from its advantages, it produces low HC, CO and higher NOx exhaust gas emissions as compared to diesel fuel. Thus, canola oil methyl ester can be considered as an alternative source of renewable energy to meet the energy demands of the future.

Keywords*: Biodiesel, Canola oil methyl ester, Compression ignition engine, performance, emissions*

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I. INTRODUCTION

Bio fuels thought about as another fuel for the fossil fuels that area unit depleting in no time and that they produce harmful environmental pollutions. The bio fuels area unit typically thought about recently area unit completely different sorts of bio fuels area unit grain alcohol and biodiesel.1 Shehata et al. studied that by mistreatment corn and soybean blends with diesel oil over a large vary of engine speeds, masses while not modifying the engine components. He completes that the brake thermal potency for diesel, two hundredth bio fuels area unit reciprocally consistent with their viscousness or density and O content and at constant time their arrangement in descendent ordering relating to the heating values.2Also complete that the height pressure of the cylinder for diesel oil is over that for corn and soybean blending fuels with all engine conditions. Reducing the oxides of atomic number 7 and soot to meet the demanding emission standards received extensive attention in diesel combustion chemistry.3 Aqwu et al.experimentally complete that the soybean biodiesel with diesel blends was found that by mistreatment soybean blended with rock oil diesel, the engine worked well.4 Lebeckas et al. used oil in a very ICE, the facility output reduced and also the brake specific fuel consumption inflated. Bio fuels thought about as another fuel for the fossil fuels that area unit depleting in no time and that they produce harmful environmental pollutions. The bio fuels area unit typically thought about recently area unit completely different sorts of bio fuels area unit grain alcohol and biodiesel.1 Shehata et al. studied that by mistreatment corn and soybean blends with diesel oil over a large vary of engine speeds, masses while not modifying the engine components. He completes that the brake thermal potency for diesel, two hundredth bio fuels area unit reciprocally consistent with their viscousness or density and O content and at constant time their arrangement in descendent ordering relating to the heating values.2Also complete that the height pressure of the cylinder for diesel oil is over that for corn and soybean blending fuels with all engine conditions. Reducing the oxides of atomic number 7 and soot to meet the demanding emission standards received extensive attention in diesel combustion chemistry.3 Aqwu et al.experimentally complete that the soybean biodiesel with diesel blends was found that by mistreatment soybean blended with rock oil diesel, the engine worked well.4 Lebeckas et al. used oil in a very ICE, the facility output reduced and also the brake specific fuel consumption inflated. the closer performance with the neat diesel. Rengasamy et al. [3] extricated Oil from Artocarpusheterophyllus (Jackfruit) seeds and concentrated its application in biodiesel creation. This investigation incorporates the optimization of oil from feasible methods with respective solvents and the optimization dependent on the measure of oil yield. The most efficient yield was gotten in microwave oven extraction procedure resulting about 19.8% of yield utilizing methanol was solvent. The biodiesel yield got was about 92% by transesterification at 650C reaction temperature, 1: 9 molar ratios of oil: methanol and 400 rpm of stirring speed for 120 minutes with 1 wt% of sodium hydroxide as catalyst. Satish Kumaret al. [4] presented a third-generation bio diesel resource called ManilkaraZapota Seed Oil. They have been produced rough ManilkaraZapota oil (MZO) from ManilkaraZapota Seed by a mechanical expelled and found the physicochemical properties of unrefined MZO and ManilkaraZapota Methyl Ester (MZME) after transesterification process. At long last they have affirmed that new bio diesel ManilkaraZapota Methyl Ester satisfies the EN14214 bio diesel guidelines and could be a reliable substitute to the diesel in diesel engine applications.

II. MATERIALS AND METHODS

Transesterification process, the canola oil is used as a raw material to produce biodiesel. For a basic catalyst, either sodium hydroxide (NaOH) or potassium hydroxide (KOH) is generally used with methanol or ethanol. In this process, Alcoy is produced before the chemical reaction to improve efficiency to produce bio diesel, the alkaline catalyst is used with methanol by transesterification. The alcohol/catalyst mix is charged into a closed reaction vessel and the vegetable oil is added. The mixture is heated to the temperature of 50 to 60°C which is the boiling temperature of the alcohol. After agitation, the chemical reaction stopped and the mixture separates into an upper layer of methyl esters and a lower layer of glycerol diluted with un-reacted methanol. Two major products are produced: glycerin and biodiesel (methyl ester). The by-product glycerin contains unused catalyst and soaps. The crude glycerin is sent for storage. The methyl ester produced from the reaction is then washed with hot water and separated out by centrifugation. Blends of 20% canola oil esters are generally shown better efficiency without any major modification in the engine. The compression ratio effects have not been analyzed for the canola methyl ester - diesel blends. This canola oil methyl ester can be an alternate fuel for the conventional diesel fuel. Hence, the study of the canola oil methyl ester on a diesel engine for variable compression ratio is essential. In the present work, the effect of the compression ratio of canola oil methyl ester with diesel blended fuels on the performance and emission characteristic of fuel has been studied. The presence of oxygen in POME biodiesel which enhances the combustion as compared to diesel and biodiesel is more lubricant than diesel that provides additional lubrication. Canola oil biodiesel has higher viscosity, higher density, and lower calorific value than diesel.

Table-1: Properties of Canola Oil Methyl Ester and Diesel

S. No.	Fuel Property	Unit	Diesel	Canola Oil Methyl Esters
1	Cetane Number	--	45	53
2	Specific Gravity @15°C	Kg/m^3	830	876
3	Calorific Value	MJ/kg	42.5	38
4	Flash Point	°C	49	132
5	Kinematic Viscosity @40°C	cSt	3.52	4.78

B10 B20 B30 B40

Fig.2.1 Different Blends of canola oil

III. EXPERIMENTAL PROCEDURE AND TEST SET-UP

The present Study was led on a 4-stroke, single chamber, C.I. motor (Kirloskar Engines). Performance, emission and combustion characteristics was analyzed from no load to full load. Each fuel blend mentioned in various plots was tested for performance and emission parameters thrice and average values are taken for final graphical representation. The experimental set-up used for the present research work was presented in Fig.3.1.An eddy current dynamo meter was coupled to the engine to apply the load on the engine. The fuel stream rate was estimated by timing the utilization for known amount of fuel (10cc) from a glass burette. Various emission parameters such as HC, CO and NOx and performance parameters such as BSFC, BTE were evaluated. The fundamental reason for smoke estimation was to evaluate the dark smoke discharging from the diesel engine. Perceivability was the fundamental standard in assessing the power of smoke. Bosch meter was utilized for estimating the diesel motor smoke. It comprises of a testing siphon and assessing unit. The examining siphon was utilized to move almost 300cc of exhaust gas by methods for a spring worked siphon and discharged by pneumatic activity of middle abdomen. The gas test was additionally drawn through the separating paper obscuring it. The spot made on the filter paper was evaluated by means of a recalibrated photocell reflect meter to give precise assessment of the intensity of the spot. The intensity of the spot was measured on a scale of 10 in arbitrary units, called Bosch smoke units for white to black. Flow rate of air can be measured using Air-box method. Air was initially sucked into the orifice present at the entry of air-box. The difference in pressures at the orifice and before orifice was taken using U-tube differential manometer in terms of water column. The water column is converted in to equivalent air-column. This obtained head of air can be used to calculate volumetric efficiency. However, there are certain external factors which affect the performance, emission and combustion parameters of the engine.

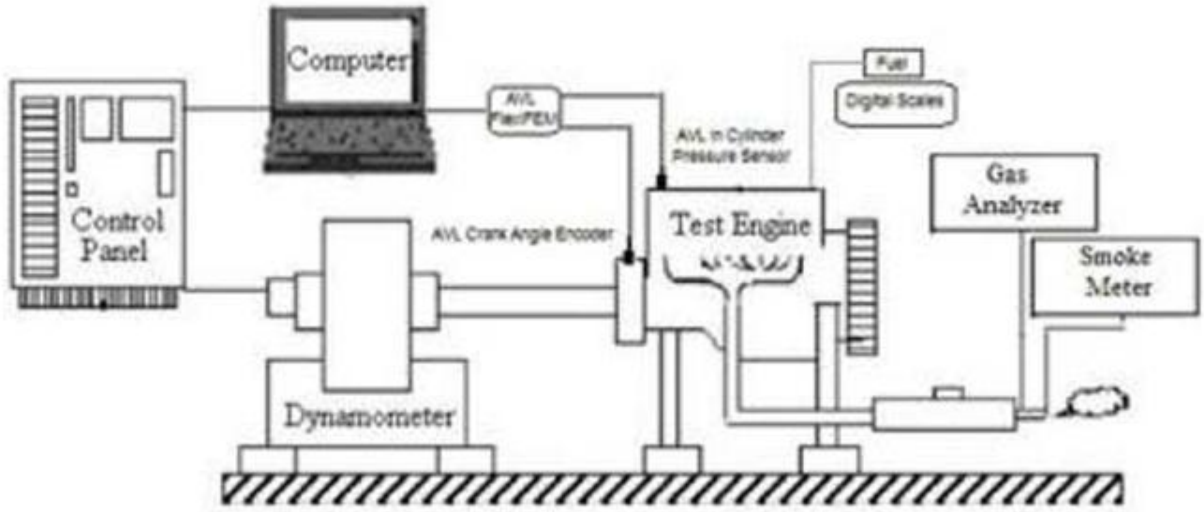

Fig.3.1 Experimental line diagram

IV.RESULTS AND DISCUSSIONS

4.1 Performance Analysys Using Pure Diesel and Its Blends of COME

In this stage various performance parameter characteristics are discussed in below for diesel, COME -diesel blends.

4.1.1 Brake Thermal Efficiency

The variation of brake thermal efficiency with brake power for different fuels is presented in Fig.4.1. In all cases, it is increase with brake power. This was due to reduction in heat loss and increase in power with increase in load. The maximum thermal efficiency for B20 at full load (34.02%) was higher than that of diesel (32.16%). Increase in thermal efficiency due to % of oxygen presence in the biodiesel, the extra oxygen leads to causes better combustion inside the combustion chamber. The thermal efficiency of the engine is improved by increasing the concentration of the biodiesel in the blends and also the additional lubricant provided by biodiesel. The reason may be the leaner combustion of diesel and extended ignition delay resulting in a large amount of fuel burned.

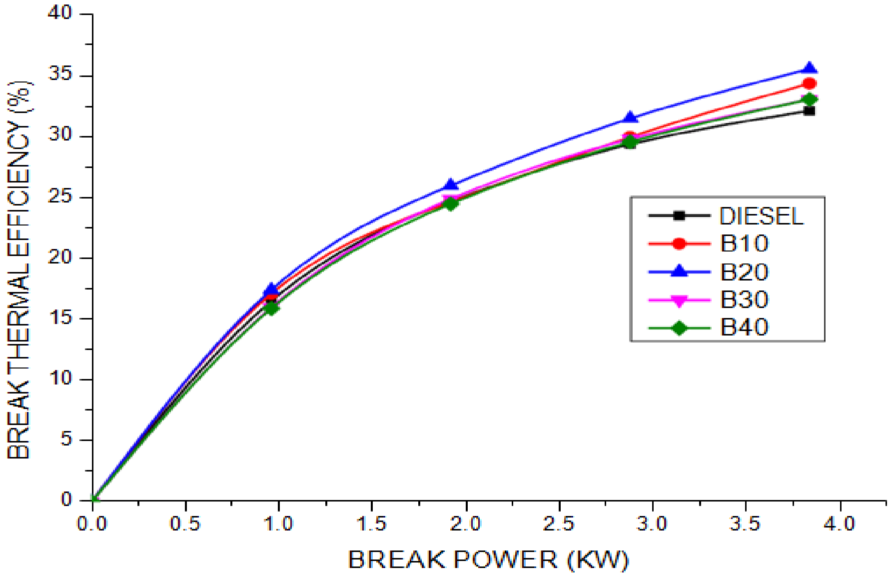

Fig.4.1 Variation of Brake Thermal Efficiency with Brake power using Diesel COME Blends

4.1.2 Mechanical Efficiency

The comparison of Mechanical efficiency for various biodiesel blends with respect to brake power shown the Fig.4.2. From the plot it is observed diesel and its blends like B20 nearly equal at full load conditions. But considerable improvement in mechanical efficiency was observed by the blends B20 is 67.69% because of lowest frictional powers compared to diesel. Because of sufficient lubricating property of this blend frictional powers are reduced drastically and considerable improvement in mechanical efficiency has been observed and calorific value of this blend is more compared to after other blends and compared to other blends B20(67.69) it give maximum efficiency.

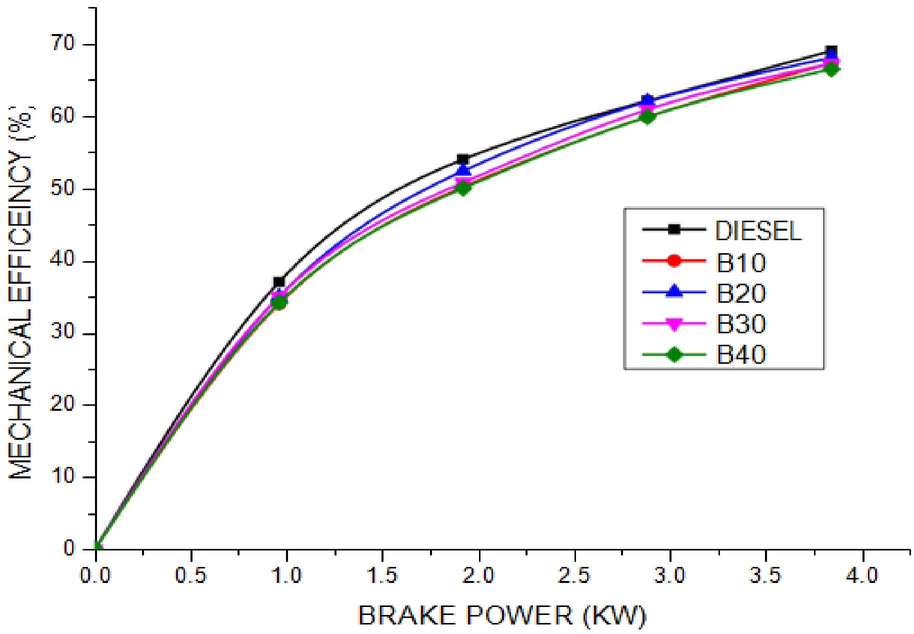

Fig.4.2 Variation of Mechanical Efficiency with Brake power using Diesel COME Blends

4.1.3 Brake Specific Fuel Consumption

The variation in BSFC with brake power for different fuels is presented in Fig.4.3. Brake-specific fuel consumption (BSFC) is the ratio between mass fuel consumption and brake effective power, and for a given fuel, it is inversely proportional to thermal efficiency. BSFC decreased sharply with increase in brake power for all fuels. The main reason for this could be that the percent increase in fuel required to operate the engine is less than the percent increase in brake power, because relatively less portion of the heat is lost at higher loads. It can be observed that the BSFC of 0.27kg/kW-hr were obtained for diesel and 0.239 kg/kW-hr B20 at full load. It was observed that BSFC decreased with the increase in concentration of COME in diesel. The BSFC of Bio-diesel is decreases up to 4.56% as compared with diesel at full load condition.

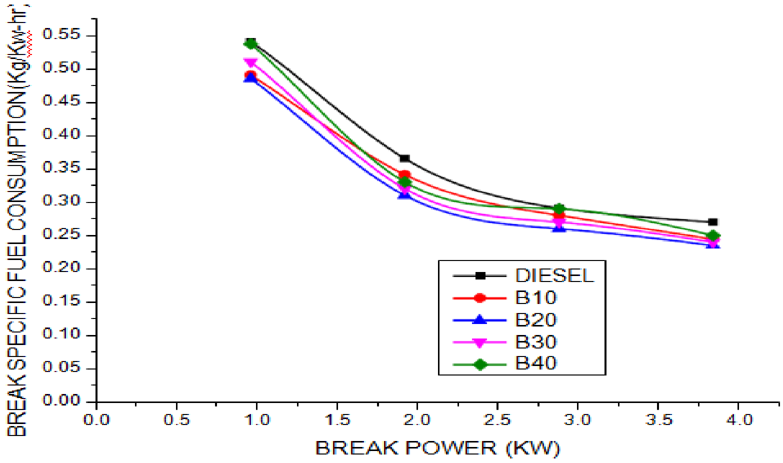

Fig.4.3 Variation of Brake specific fuel consumption with Brake Power using Diesel COME Blends

4.1.4 Indicated Specific Fuel Consumption

The variation of Indicated Specific Fuel Consumption with brake power is shown in Fig.4.4 it is observed that from the graphs B20 is reduced than diesel. At full load ISFC of diesel is 0.19 kg/kW-hr and for B20 are 0.165 kg/kW-hr. The ISFC of bio-diesel is decreases up to 0.165 kg/kW-hr as compared with diesel at full load condition. ISFC at different loads with all percentage of blending was found slightly decreased from 0.208 kg/kW-hr to 0.165 kg/kW-hr for B20, in the same way for all blends B10, B30, B40 decrement was occurred. This improvement in ISFC was perhaps due to better combustion of the fuel, which may be attributed to the presence of oxygen in the blend. Esterification also helps to lower the temperature reaction and better combustion. Since the cetane number of esterifies canola oil was high; hence ISFC in B20 blend was reduced from 0.165 kg/kW-hr compared to diesel fuel at full load condition.

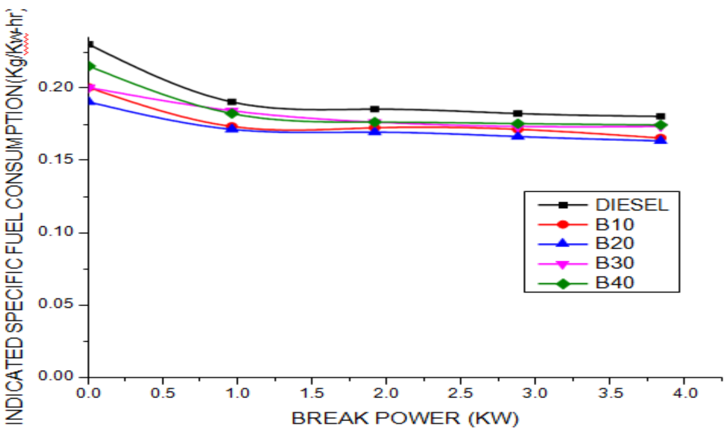

Fig .4.4 Variation of Indicated specific fuel consumption with Brake Power using Diesel COME Blend

4.2 EMISSION ANALYSYS USING PURE DIESEL AND COME BLEND

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying loads. Various emission parameters in the sense of smoke density, unburned hydrocarbons, carbon monoxide, unused oxygen and oxides of nitrogen are discussed below.

4.2.1 Carbon Monoxide (CO)

The comparison of carbon monoxide for various biodiesel blends with respect to brake power shows in Fig.4.5. Carbon monoxide (CO) occurs only in engine exhaust, it is a product of incomplete combustion due to insufficient amount of air or insufficient time in the cycle complete combustion. In diesel engine combustion takes places normally at higher A/F ratio, therefore sufficient oxygen is available to burn all the carbon in the fuel fully to CO_2 it was noticed that CO emission of 0.12% for diesel and the values for B10, B20, B30 and B40 are 0.10, 0.09, 0.11, 0.10 For COME carbon monoxide emission level is lower than that of diesel, in order to gives 10% to 20% extra oxygen. Due to the presence of extra oxygen, additional oxidation reaction takes place between O_2 and CO .The decreased CO emissions is 40% than diesel fuel for B20 at full load. It is observed that the CO emissions for COME and its blends are lower than for diesel fuel. These lower CO emissions of biodiesel blends may be due to their more complete oxidation as compared to diesel. Some of the CO produced during combustion of biodiesel might have converted into CO_2 by taking up the extra oxygen molecules present in these- chain and thus reduced CO formation. It can be observed from figure that the CO initially decreased with load and later increased sharply up to full load. This trend was observed in all the fuel blends tests.

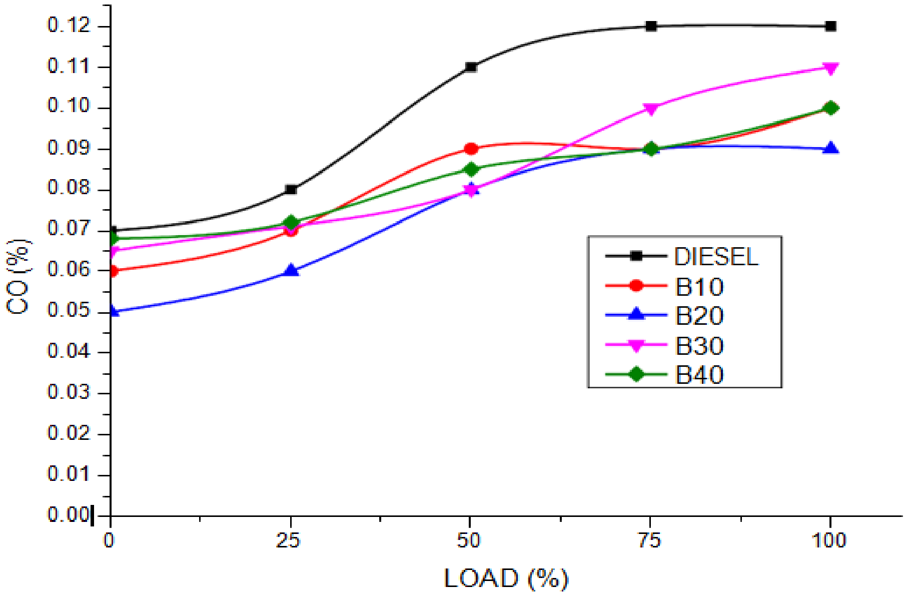

Fig.4.5 Variation of Carbon monoxide emissions with Brake power using Diesel COME Blends

4.2.2 Carbon Dioxide (CO2)

The variation of carbon dioxide with brake power is shown in Fig.4.6. The CO_2 emissions from a diesel engine indicate how efficiently the fuel is burnt inside the combustion chamber. The ester-based fuel burns more efficiently than diesel. Therefore, in case of COME, the CO_2 emission is greater. At full load diesel contains 6.0 % of CO_2 emissions where as in case of B20 it is 6.9 %.The increase in CO_2 emissions is 1.2 %. The CO_2 emissions increased with load for all the fuel modes. At varying loads, the oxygen content in the COME improves the combustion process, which leads to a complete combustion and hence increased CO_2 emission than that of diesel and B20 .Then increased to combustion takes place increase the CO_2 compare to other blends.

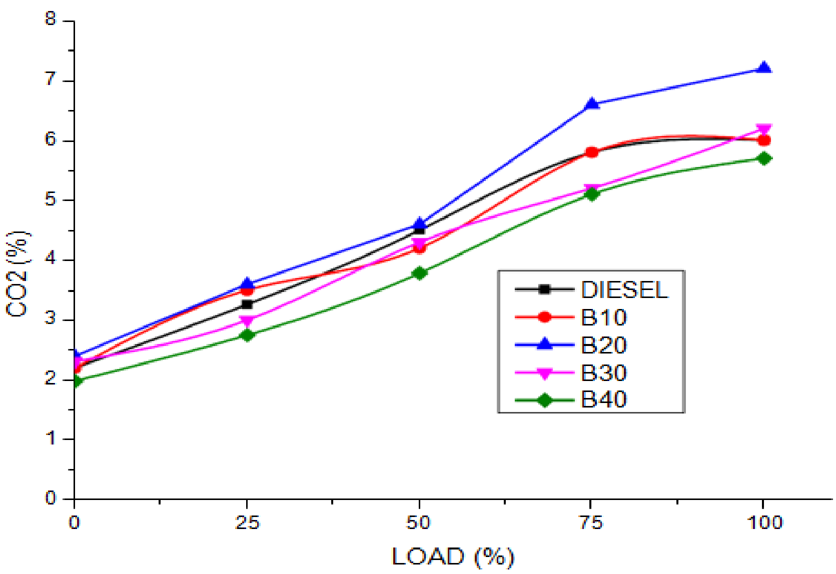

Fig.4.6 Variation of Carbon Dioxide with Brake power using Diesel COME Blends

4.2.3 Oxides of Nitrogen (NO_X)

Variation of NOx with engine brake power for different fuels tested are presented in Fig.4.7. The nitrogen oxides emissions formed in an engine are highly dependent on combustion temperature, along with the concentration of oxygen present in combustion products. The amount of NOx produced for B20 is 284 ppm, where as in case of diesel fuel is 450 ppm for diesel fuel. From figure it can be seen that an increasing proportion of biodiesel in the blends was found to increase NOx emissions slightly increased. This may be due to higher combustion temperature inside the cylinder at higher load. In general, the NOx concentration varies linearly with the load of the engine. As the brake power increases, the overall fuel-air ratio increases, resulting in an increase in the average gas temperature in the combustion chamber, and hence NOx formation increase. The reason could be the higher average gas temperature, residence time at higher load conditions. The oxides of nitrogen increases for all diesel blends compared with diesel fuel at all loads. This can be reduced by retardation spark timings and modifications of engine design.

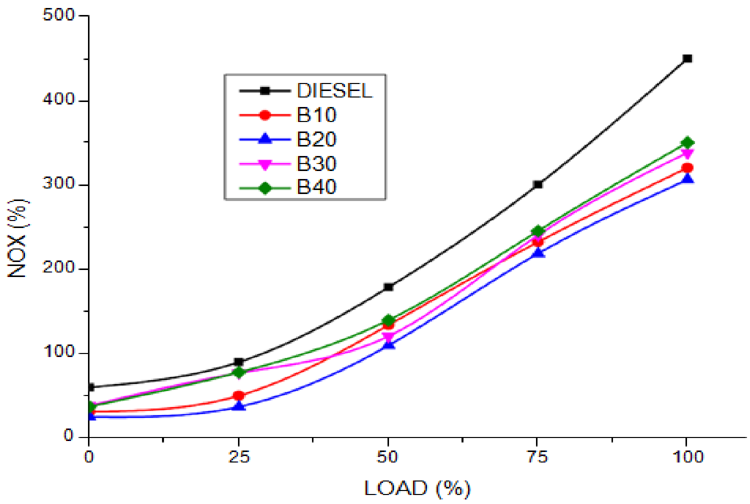

Fig.4.7 Variation of Oxides of Nitrogen emissions with Brake power using Diesel and COME Blends

4.2.4 Hydrocarbons Emissions (HC)

The hydrocarbons (HC) emission trends for blends of methyl ester of canola oil and diesel are shown in Fig.4.8. That the HC emissions decreased with increase in brake power for all biodiesel blends (B10, B20, B30 and B40) at all loads. In case of diesel fuel HC emissions are decreases with load, because of there is oxygen content present in diesel fuel. At full load diesel contains 58ppm where as in case of B20 it is 28ppm at same load. So there is a reduction from 42ppm to 32ppm at full load these reductions indicate a more complete combustion of the fuel. The presence of oxygen in the fuel was thought to promote complete combustion. As the cetane number of ester based fuel is higher than diesel, it exhibits a shorter delay period and results in better combustion leading to low HC emission. Also the intrinsic oxygen contained by the biodiesel was responsible for the reduction in HC emission. Therefore the decreased in HC emissions is 43.74% in case of B10 at full load. At full load condition B20 contains 29 ppm which is less than diesel. The reduced amount of HC emissions up to11ppm compared to B20.

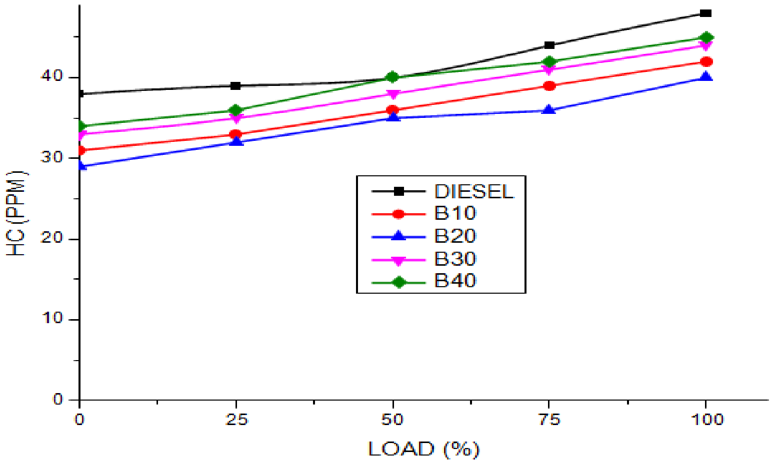

Fig.4.8 Variation Unburned hydrocarbons emissions with Brake power using Diesel and COME Blends

4.2.5 Smoke Density

The variation of Smoke density emissions with brake power for diesel fuel, biodiesel-blends is shown in the Fig.4.9. The smoke is formed due to incomplete combustion in engine. The smoke density is lower for B20 compared to B10, B30, B40 and D100.The maximum smoke density recorded for the diesel was 79.66 HSU, 63.96 HSU for B10, 56 HSU for B20, 64.16 HSU for B20 and 58.2ppm at maximum load. The decrease in smoke density of B20 compared to other blends and also compared with diesel fuel at full load. In case of COME, the smoke emission is low. This is because of better combustion of COME. The smoke density increased with the load for diesel fuel and diesel blends. The smoke opacity of the pure biodiesel was higher than those of all the other fuels used generally. Smoke opacity of the blends B10, B20, B30 and B40 were lower than those of the diesel fuel at all loads on the engine.

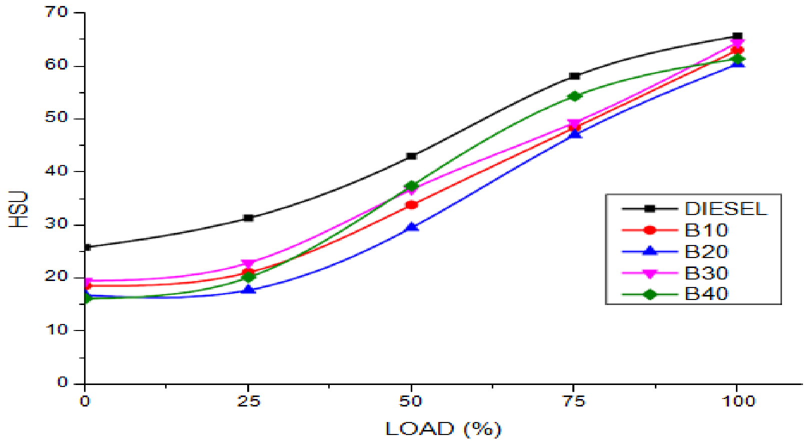

Fig.4.9 Variation Smoke density with Brake power using Diesel and COME Blends

V. CONCLUSION

The performance and emission characteristics of conventional diesel, diesel and biodiesel blends were investigated on a single cylinder diesel engine. The conclusions of this investigation at full load are as follows:

- The brake thermal efficiency increases with increase biodiesel percentage. Out of all the blends B20 shows best performance and emissions parameters. The maximum brake thermal efficiency obtained is 334.02% with B20 blend.
- As a CI engine fuel, B20 blend results in an average reduction of 20.8% smoke densities.
- Maximum reduction in CO emissions is 40% compared to diesel.
- Significant increases in NOx emission is 12.4% when compared with diesel.
- Reductions in unburned hydrocarbon emissions were 8.1% compared to diesel.
- Since B20 blend reduces the environmental pollution, high in thermal efficiency when compared with diesel it will be a promising renewable energy source for sustaining the energy.

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