RESEARCH ARTICLE OPEN ACCESS

EFFECT OF EXHAUST GAS RECIRCULATION ON PERFORMANCE AND EMISSION CHARECTERISTICS OF CORN OIL METHYL ESTER BLENDED FUEL C.I. ENGINE

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Abstract:

Petroleum diesel consumption increases leads to depleting the diesel fuel and increasing the environmental pollution. One of the alternatives is producing a biodiesel to meet the energy demand. Corn oil methyl ester (COME) is produced by transesterification process and prepared the blends (B0, B20, B40, B60 & B100) with diesel to compare the Engine performance and Emission characteristics with and without exhaust gas recirculation (EGR) at different loads. The result shows the brake thermal efficiency (BTE) and emissions of B20 is almost nearer to diesel. The BTE with EGR is higher than the BTE without EGR for all the blends.

The BSFC and EGT with EGR is lower than values obtained without EGR for all the blends. Emissions of CO and HC of engine for all blends are slightly increased, while NOx emissions are found to get decreased with use of EGR. The better engine characteristics were obtained with use of EGR compare to without use of EGR.

Index Term-- **Biodiesel, Corn oil methyl ester, performance, emission, BTE, BSFC and EGT.**

I. Introduction.

As population increases day by day, the utilization of petroleum diesel usage also increases. This leads to depletion of the diesel within few years as well as the environmental pollution increases. Then it is required to search for alternative fuel. Among various alternatives, biodiesel is one of the alternatives obtained from vegetable oils, which is renewable and environmental friendly fuel. Ahmet necati ozsen, Mustafa canacki [1] investigated experimentally on canola oil methyl ester (COME) and waste (frying) palm oil methyl ester (WPOME). They found that the brake power reduced by 4–5%, while the brake specific fuel consumption increased by 9–10%. On the other hand, methyl esters caused reductions in carbon monoxide (CO) by 59–67%, in unburned hydrocarbon (HC) by 17–26%, in carbon dioxide (CO) by 5–8%, and smoke opacity by 56–63%. Sukumar puhan et al. [2] studied the performance of methyl, ethyl, butyl esters of mahua oil, and they concluded that the mahua oil methyl esters had better performance than other esters and diesel. They also expressed that except NO_x emissions remaining emissions (HC,CO) are from mahua oil using acid (H_2SO_4) and alkaline (KOH) catalysts and suggested that the KOH is a better catalyst for production. Pugazhvadivu et al. [4] conducted the experiments to investigate the suitability of preheated mahua oil as fuel in diesel engine and they concluded that preheated mahua oil can be used in emergency. Sukumar puhan et al. [5] also studied the performance of methyl ester of mahua oil and explained the suitability of MOME to diesel engine. Banapurmath et al. [6] studied the effect of biodiesel derived from honge oil and its blends with diesel when directly injected at different injection pressures and injection timings in a single cylinder water cooled C.I. engine. The results show that honge oil and honge oil methyl ester gave better results for B20 blend at retarded injection timing of 19◦ BTDC and injection pressure of 260 bar. Anirudh Gautam et al. [7] studied performance, emission and combustion characteristics of a cotton seed biodiesel fueled in four stroke locomotive diesel engine. They suggested that B20 can be implemented because it shows the performance same as the diesel. This has one more advantage that it produces less smoke. Raheman et al. [8] studied the performance of C.I. engine with mahua biodiesel. They found that BSFC increases as percentage of biodiesel increases and

decreases with increasing load. BTE of B20 is found to be higher than diesel due to increased oxygen content and increased combustion rate. Exhaust gas temperature increases with increase of load and percentage of blend at the same time smoke density decreases with increase of blend percentage. They also observed that the CO and HC emissions got reduced with increase of blends, but NOx emissions increases with increase of blend. Sukumar puhan et al. [9] studied the performance and emission characteristics of ethyl ester of mahua oil in a four stroke natural aspirated direct injection diesel engine. The results shown that brake thermal efficiency is almost same as diesel and emissions are lower for mahua oil ethyl ester when compared with diesel. Bhatt et al.[10] conducted tests on diesel engine to evaluate the performance of the engine with mahua oil and diesel fuel blends (20 %, 40%, 60% and 80 %) as fuel by varying the compression ratio from 16 to 20. They concluded that the properties of blends are almost same as diesel, and blends are suitable up to 40% as fuel for short term operation of engine. They also mentioned that the performance of engine increases with increasing compression ratio.

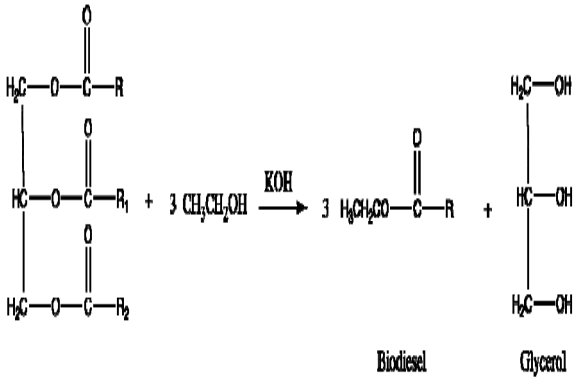
II. Production of biodiesel.

The chemical process commonly used make bio-oils less viscous, turning them into “biodiesel” is called “Transesterification”[11].

A. Transesterification process.

Corn oil was used as the raw oil to be transesterified with methanol in a reacting tank. The temperature values are below the boiling point of methanol (630C), to prevent the methanol in the reactant mixture from evaporating [12].The potassium hydroxide was stirred with methanol for 10 minutes using an electric-magnetic stirrer to form potassium methoxide, which was then poured into the reacting tank and mixed with the corn oil [13]. The total reaction time was 60 minutes. Almost total conversion to corn oil bio diesel was achieved quickly after a few minutes from the start of the reaction, depending on the ambient conditions.

The chemical formula for biodiesel Transesterification is:



B. Fuel properties

Fuel Properties	Diesel	Corn Oil Methyl Ester	Apparatus used
Fuel density in kg/m^3	830	849.3	Hydrometer
Calorific value (kJ/kg)	42500	37942.18	Bomb calorimeter
Flash point in ^oC	56	173	Pensky-martein’s Apparatus
Fire point in ^oC	65	179	Pensky-martien’s apparatus
Kinematic viscosity at 40 ^oC in m^2/s	$3.9x10^{-6}$	$9.65x10^{-6}$	Redwood viscometer

Table -1: properties of fuel

III. Present work.

In this work, blends are prepared by adding Corn oil methyl esters (biodiesel) to conventional diesel with suitable percentages. B0, B20, B40, B60, and B100 blends are prepared and used in experiment. The blends are used as fuel in a C.I. engine to compare its performance and emission characteristics with(5% EGR) and without EGR

IV. Experimentation.

The engine used for the investigation was computerized single cylinder, four stroke, water cooled and direct injection compression ignition engine with eddy current dynamometer. The necessary modifications were carried out to develop EGR setup in the engine. Air box with diaphragm is installed in the EGR route to minimize the pressure pulses of exhaust gas coming out of the engine during exhaust stroke at high pressure. A “U” tube manometer was used to measure the EGR rates. The quantity of EGR was controlled with manually operated valve. A typical schematic of experimental set up is shown in fig. 1. The technical specifications of the engine are given in table 2.

Fig -1: Experimental set up

Table -2: Engine Specifications

Sl No	Parameters	Specification
01	Manufacturer	Kirloskar oil engines Ltd. India
02	Model	TV-SR, naturally aspirated
03	Engine	Single cylinder, DI
04	Bore/stroke	87.5mm/110mm
05	C.R.	16.5:1
06	Speed	1500 RPM, constant
07	Rated power	5.2KW
08	Working cycle	Four stroke
09	Response time	4 micro seconds
10	Type of sensor	Piezo electric
11	Crank angle sensor	1-degree crank angle
12	Injection pressure	200bar/23 def TDC
13	Resolution of 1 deg	360 deg with a resolution of

Digital control panel was used to collect the required engine data. Carbon mono oxide (CO), Hydro carbon (HC) and oxides of nitrogen (NOx) emissions are measured using exhaust gas analyzer. Corn Oil Methyl Ester (COME) produced by Transesterification process was used to run the engine for this study.

V. Results and discussions.

Experiments have been conducted to study the performance and emission characteristics for different blends B0, B20, B40, B60 and B100 with (5% EGR) and without EGR. Characteristics like BTE, Specific fuel consumption, Exhaust gas temperature and emissions of CO, HC, NO_x, have been discussed.

C. Performance characteristics

1. Brake thermal efficiency:

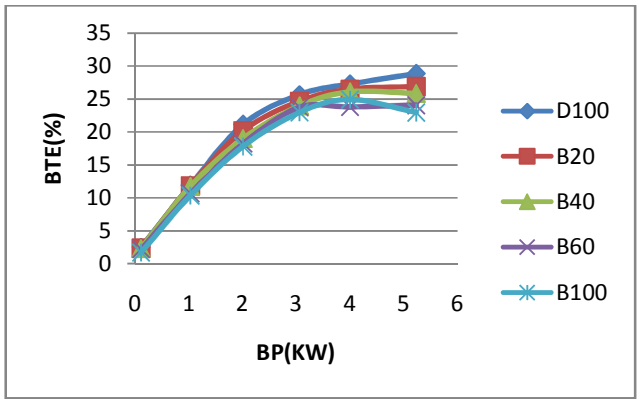


Fig -2(a): Variation of brake thermal efficiency with brake power without EGR

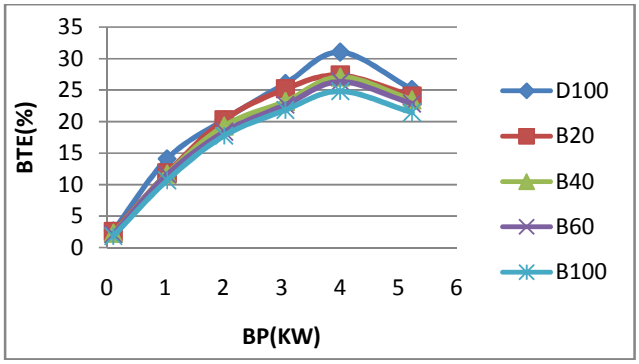


Fig -2(b): Variation of brake thermal efficiency with brake power with EGR(5%)

Figures 2(a) and (b) explain the variation of BTE with the change in load for different blends of 0%, 20%, 40%, 60 and 100% COME in diesel without and with 5% EGR respectively. As shown in the Figure 2, there is substantial increment in BTE with increase of load. The same trend is observed for all the blends. However, BTE of different blends found to be closer at lower loads and at higher loads, the BTE of same blends are yielding more difference. The BTE of blends with 5% EGR is slightly increased when compared without EGR for all blends. This may be happening due to higher operating temperature. The BTE of B20 is almost nearer to diesel. The BTE decreases with increase of blend due to lower calorific value of biodiesel when compared with diesel.

2. Specific fuel consumption:

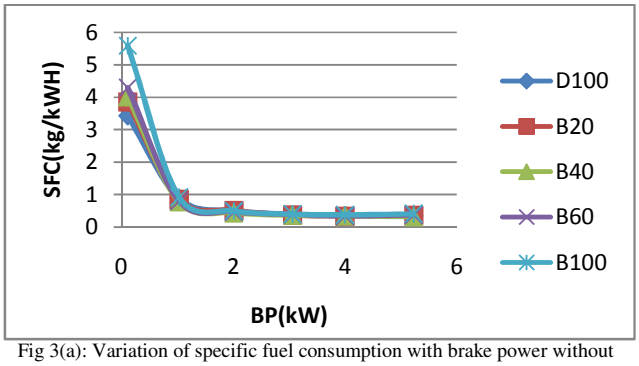


Fig 3(a): Variation of specific fuel consumption with brake power without EGR

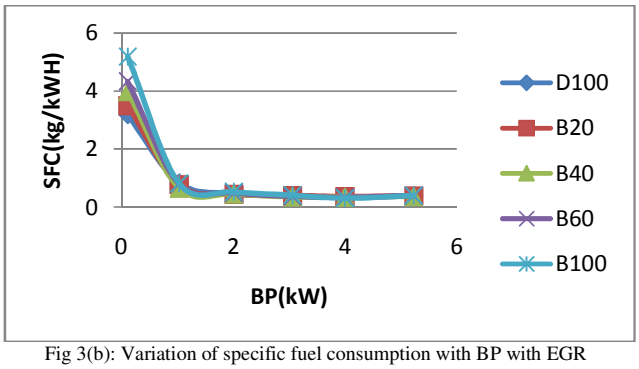


Fig 3(b): Variation of specific fuel consumption with BP with EGR

Figures 3(a) and (b) explain the variation of SFC with the change in load for different blends of COME in diesel without and with 5% EGR respectively. As shown in the Figure 3, there is a decrease in SFC with increase of load. The BSFC of blends with 5% EGR is slightly decreased when compared to without EGR for all blends. This is due to utilisation of unburnt hydrocarbons when exhaust is recirculated in combustion chamber.

3. *Exhaust Gas Temperature:*

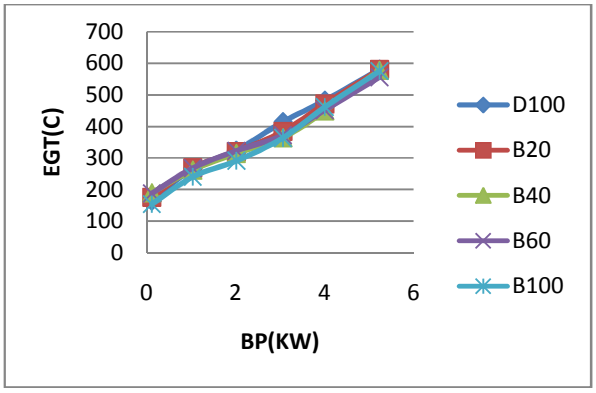


Fig -4(a): Variation of exhaust gas temperature with brake Power without EGR

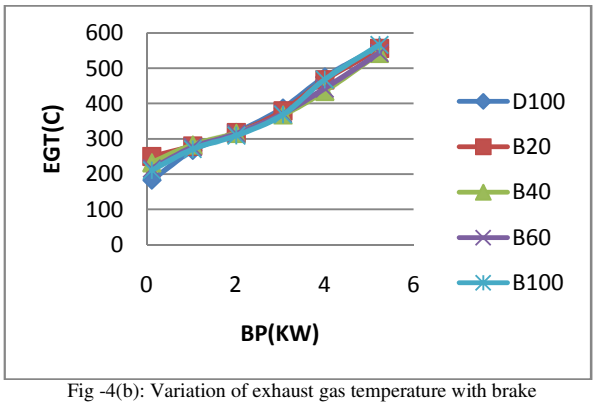


Fig -4(b): Variation of exhaust gas temperature with brake Power with EGR

The variation of exhaust gas temperature for different blends with respect to the brake power without and with EGR is indicated in Figure 4(a) and 4(b) respectively. The exhaust gas temperature for all the fuels tested increases with increase in the brake power. Exhaust gas temperature is an indicative of the quality of combustion in the combustion chamber. At all loads, diesel was found to have the highest temperature and the temperatures for the different blends showed a downward trend with increasing concentration of biodiesel in the blends.EGT is found to be decreased with use of EGR. Relatively lower availability of oxygen for combustion and higher specific heat of intake air mixture are the reasons for exhaust gas temperature reduction with EGR.

D. Emission characteristics

1. *Carbon monoxide*:

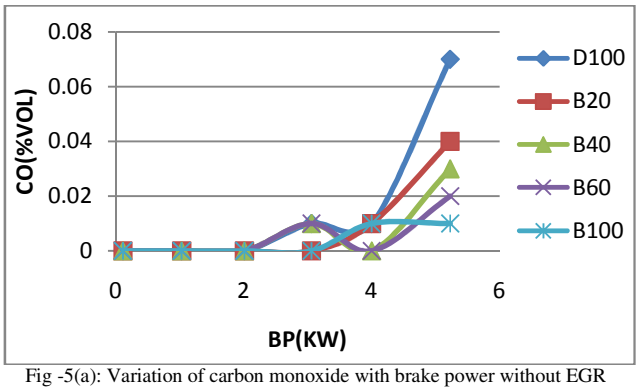


Fig -5(a): Variation of carbon monoxide with brake power without EGR

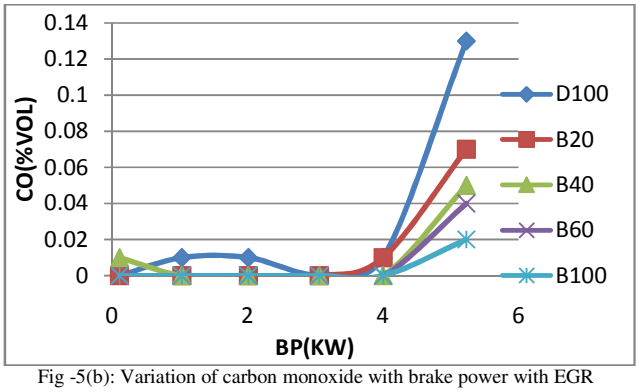


Fig -5(b): Variation of carbon monoxide with brake power with EGR

Figures 5(a) and 5(b) depicts the variation of CO emissions without and with EGR at different loads for all the blends. As load increases CO emissions are slightly increases up to three fourth load and followed by rapid increase in emission. As blend percentage increases CO emissions increase with and without EGR. This may be due to higher viscosity of blends. It was also observed that the CO emissions are getting increased with EGR when compared without EGR due to lower availability of oxygen with EGR which leads to incomplete combustion resulting in the increase of CO emission.

2. *Hydrocarbon:*

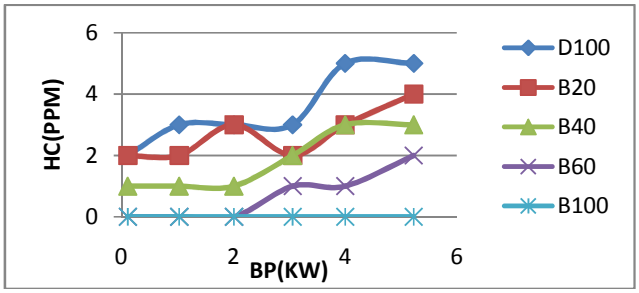


Fig -6(a): Variation of hydrocarbon with brake power and without EGR.

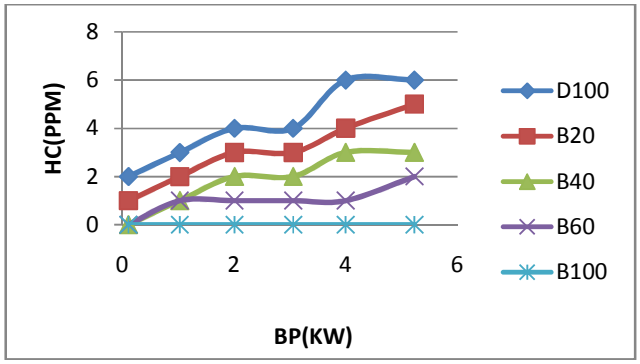


Fig -6(b): Variation of hydrocarbon with brake power and EGR.

Figures 6(a) and 6(b) depicts the variation of HC emissions without and with EGR (5%) at different loads for all the blends. As load increases HC emissions increases up to part load after that the emissions found to be increased for remain loads. It is observed that HC emission increases with use of EGR. As EGR is used, less amount of oxygen is available for combustion resulting in rich mixture which results in incomplete combustion, leads to higher HC emission.

3. No_x.

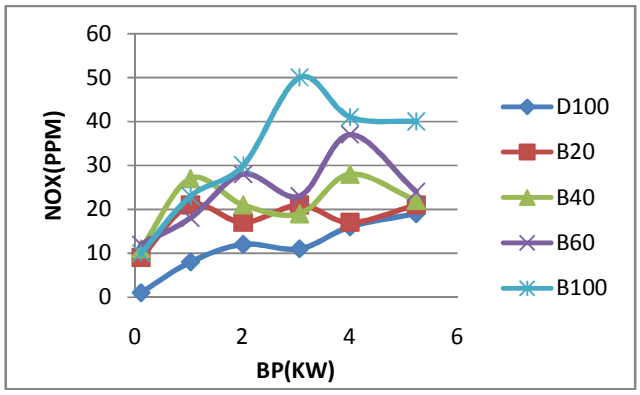


Fig -7(a): Variation of NOx with brake power without EGR

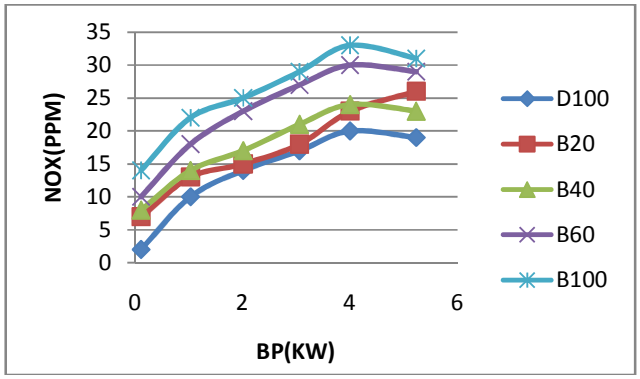


Fig -7(b): Variation of NOx with brake power with EGR

The variation of NO_x emission without and with EGR at different loads for all the blends as shown in figure 7(a) and 7(b) respectively.. NO_x emissions increase with increase of load due to high exhaust gas temperature at higher loads. As blend percentage increases, NO_x emission increases with and without EGR. The NO_x emissions are reducing with EGR when compared without EGR due to reducing exhaust gas temperatures.

VI. Conclusions.

In the present work, COME is prepared by transesterification process and tested in single cylinder 4-stroke C.I. engine to evaluate its performance and emission characteristics and compared with 5% EGR and without EGR at different loads. Characteristics like BTE, SFC, EGT and emissions of CO, HC and NOx have been studied. The following conclusions can be drawn from this work:

1. The B20 can be utilized as a fuel in diesel engine without modification of the engine, since its performance is almost nearer to diesel.
2. With the use of EGR, B.T.E for all blends slightly improved.
3. With the use of EGR, SFC for all blends is less compared to its values obtained without use of EGR.
4. With the use of EGR, EGT for all the blends is less compared to values obtained when operated without EGR.
5. With the use of EGR, emissions of CO and HC of engine for all blends slightly increased, while NOx emissions are found to get decreased.

Finally, EGR can be suggested to implement due to its higher efficiency and lower emissions.

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