Performance Evaluation of Canola Blends in DI Diesel Engine with EGR System

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Abstract— **A world wide search for the petroleum fuels is going on due to the rapid depletion of the fossil fuels and the pollution created by them. This intensified the research to ascertain the new type of engine design and alternative fuels for better control over pollution. Among various types of alternates produced by the farmers of our country canola oil is proved to be best based on its credits. But the properties of canola oil restricted the usage of pure oil in the diesel engines. So in the present work, this oil is blended with diesel in different proportions. The efficiency of diesel engine can be improved by utilizing the heat recovery system of exhaust. In this experimental work we focused on the efficiency and emission characteristics of blends of canola oil with exhaust gas recirculation. The obtained data is analyzed for various blends of canola and diesel blends and is presented. It is concluded that 30% canola diesel blend showed best performance.**

Keywords—Biodiesel, Canola ester oil, EGR.

1. Introduction

Canola Oil: Its scientific name is Brassica Napus. Canola is Canada oil it contains low acids. Can' stands for 'CANADA', 'O' stands for 'OIL', 'La' stands for 'LOW ACID'. It has 6% of low acids those are saturated and poly unsaturated fats. So it consider as a benefit for good performance of the engine even at cold weather conditions. It has high oil content compared to the other vegetable oils. Such as neam, coconut, soybean etc.

A.Paykani et al. had done experiment on single cylinder four stroke water cooled indirect injection diesel engine with various blends of canola and diesel (Diesel – COEE (canola oil ethyl ester)). It is concluded from the experiment that, when the engine uses COEE, the brake thermal efficiency decreases compared to neat diesel fuel due to its lower calorific value of the canola oil. But the same efficiency increases with low EGR ratios. The increasing of EGR ratios resulted decreasing the brake thermal efficiency for both diesel and COEE. It's stated that the engine performance was inferior when using diesel-COEE blend. The NO_X emissions also increased, the CO and HC are decreased with increasing the biodiesel percentage.

V. Manieniyan et al. had done the experiment on single cylinder DI diesel engine with EGR. It is concluded that with the EGR the specific fuel consumption was lower compared to without EGR system. For that the Brake Thermal Efficiency of biodiesel is increased at all loads with EGR. With increasing the ratio of EGR HC and CO emissions also increased for biodiesel. This was due to oxygen content in biodiesel compensating for oxygen deficiency and facilitating complete combustion. In all loads up to 20% EGR level NO_X was reduced in both diesel and biodiesel with increase in EGR level. Investigation of combustion parameters has also indicated equivalent heat release rates and cylinder pressures for biodiesel, with and without EGR. Thus the experimental investigation has proved minimized pollution and enhanced performance with neat diesel and biodiesel using EGR system.

2. OBJECTIVE

The main objective of the present investigation is to prove experimentally whether engine efficiency can be improved with exhaust gas recirculation. The total experiment consists of

(i) Preparation of Canola oil

(ii) Conducting the investigations with different blends of canola oil

Preparation of canola oil

Canola also one type of rapeseed oil, it is one of the leading edible oil in world. The canola oil is prepared with the canola seeds by slightly heating and crushing. It have high oil content and also low acids (6%) that is saturated fat & poly unsaturated fat compare to all major vegetable oils (coconut, peanut, palm, soybean, sunflower, corn, olive, etc.) The low acids means improved cold weather performance. It contains 40% oil by weight. Production of the rapeseed oil is more majorly in Canada, India, China, and Europe. Production has increased faster over the past two decades. Last 15 years, rapeseed oil can achieved growth rate is 7% compared with other oil seeds. Normally it contains 10% oxygen by weight. This promotes the combustion process and reduces the HC, CO emissions and PM. The major advantages of this canola oil is its higher flash point, higher oil content, biodegradable characteristics. The Canola plant and the seeds are shown in the following figures.

Fig 1. Canola Flowers

Fig 2. Canola Seeds

The process of preparing the biodiesel from the canola plant is shown in the following flow chart.

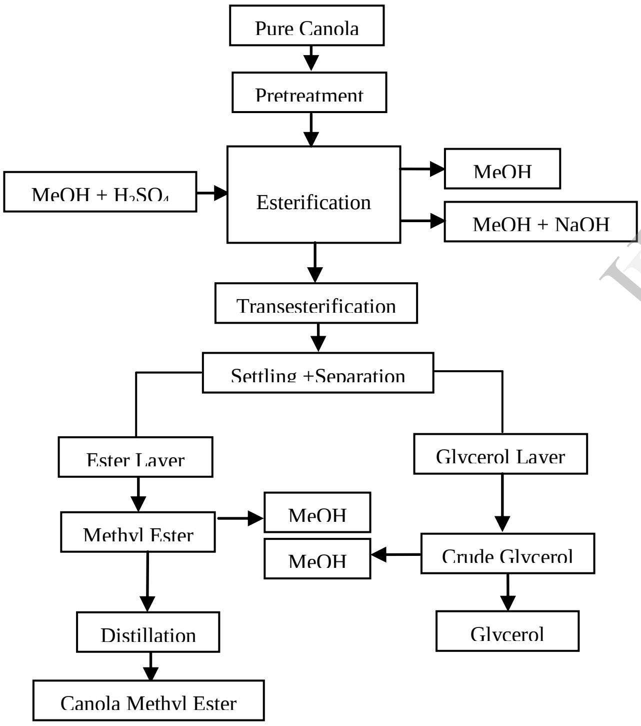


Fig: 3 Preparation of Canola Oil

For the experiment the canola oil is blended with diesel fuel in various proportions and the properties are mentioned below.

Properties	B10 Canola	B20 Canola	B30 Canola	B40 Canola
Specific Gravity	0.856	0.863	0.870	0.877
Calorific Value(kj/kg)	42286	41993	41770	41407
Flash Point (^{o}c)	51	57	63	70
Fire Point (^{o}c)	61	69	77	85
Kinematic Viscosity(cs)	7.503	12.3	17.10	21.91

Table: 1 Properties of Canola oil at Various Blends

Experimental Procedure

The experiments are conducted on single cylinder, water cooled, four stroke 3.68 kW kirloskar diesel engines with EGR setup. The EGR system is connected from the exhaust manifold to the inlet manifold with required pressure gauges and gate valves. As the viscosity of the canola oil is slightly higher than diesel fuel, less amount of fuel is injected in to the combustion chamber. So in the present experimental work the fuel injection pressure is increased to 200 bar and is kept constant throughout the experiment. With the injection of canola oil more oxygen is retained in the chamber which is supplied to the incoming fresh charge and makes combustion complete. The concentrations of exhaust gases are measured with exhaust gas analyzer. The experimental setup is shown in figure 4.

Fig: 4 Photo View of the Experimental Setup

Exhaust Gas Recirculation System (EGR)

The Exhaust Gas Recirculation (EGR) system is designed to reduce the amount of oxides of nitrogen (NO_X) created by the engine during operating periods that usually result in high combustion temperatures. NO_X is formed in high concentrations if combustion temperature exceeds about 2500 ^{o}F. The EGR system reduces NO_X production by recirculating small amount of exhaust gases into the intake manifold where it mixes with the incoming air/fuel charge, by diluting this mixture under these conditions, peak combustion temperature and pressures are reduced, resulting in an overall reduction of NO_X output. Mixing of exhaust gases with intake air, it increases the specific heat of the EGR which is much higher than fresh air; hence EGR increases the specific heat of the intake charge, thus decreasing the temperature rise of the same heat release in the combustion chamber.

EGR ratio is calculated as:

$$EGR\ (\%) = (M_{EGR} / M_i) \times 100$$

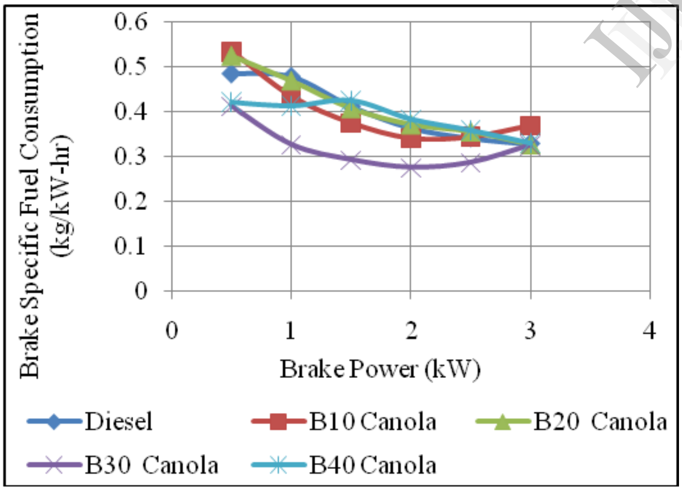
Where

M_{EGR} = mass of recirculated gas

M_i = mass of total intake air of the cylinder

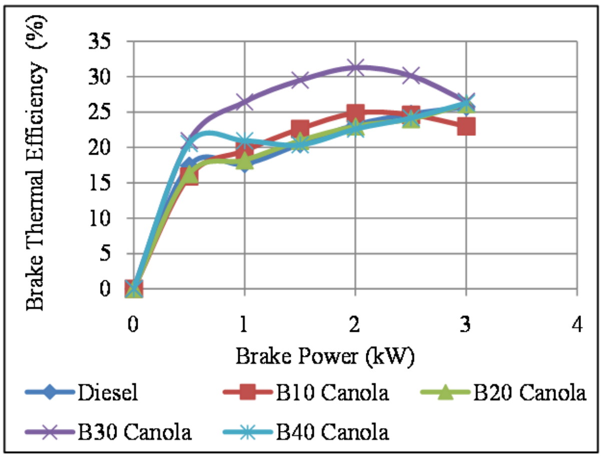
3. Results and Discussions

Experiments were conducted on B10, B20, B30, and B40 Canola oil and compared the same with pure diesel with exhaust gas re-circulated system. All the corresponding results are presented in the form of Graphs.



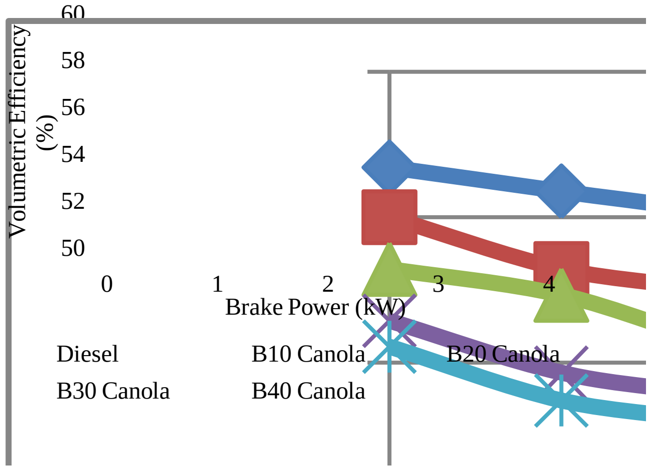
Graph: 1 Brake Power vs Brake Specific Fuel Consumption

Graph 1 shows the variation of Brake Specific Fuel Consumption (BSFC) for various blends of canola with the Brake Power (BP). It is observed that, BSFC for B30 is less than all other blends. This is due to the presence of oxygen in the canola oil. The oxygen acts as a combustion promoter which improves the combustion process and hence higher temperature in the combustion chamber. This makes the combustion complete. For B10, B20 the BSFC is more because of less oxygen amount in that. For B40, BSFC is more and is due to its higher viscosity which reduces the combustion efficiency. Hence it is observed that, at rated load the BSFC for B30 is 0.28 kg/kW-hr. The BSFC for B10, B20 and B40 are increased by 22%, 30% and 32% respectively compared with B30.



Graph 2: Brake Power vs Brake Thermal Efficiency

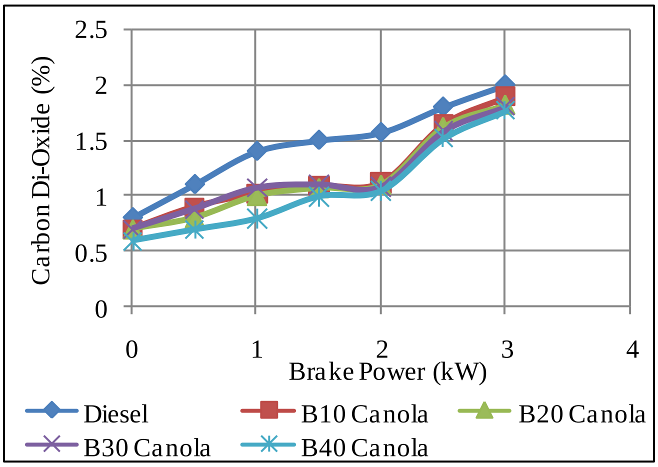
Graph 2 shows the variation of Brake Thermal Efficiency (η_{bth}) for various blends of canola with the Brake Power (BP). It is observed that, η_{bth} for B30 is increased due to the less fuel consumption. For B10, B20 and B40 the η_{bth} are less due to the more fuel consumption. Hence it is observed that, at rated load the η_{bth} for B30 is 30.74%. The η_{bth} for B10, B20 and B40 are decreased by 19.5%, 23% and 23.8% respectively compared with B30.



Graph 3: Brake Power Vs Volumetric Efficiency

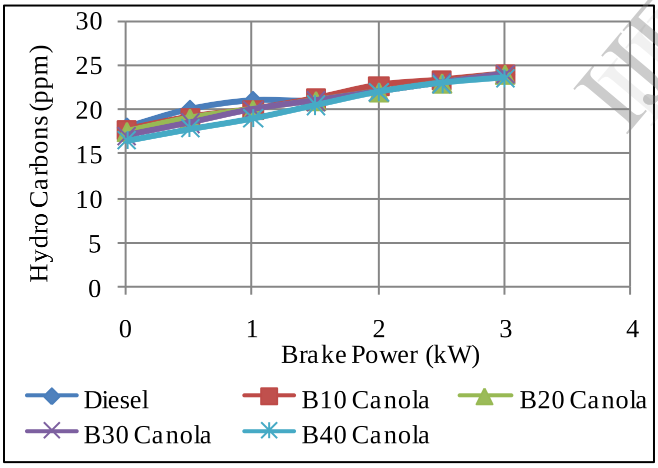
Graph 3 shows the variation of Volumetric Efficiency (η_{vol}) for various blends of canola with the Brake Power (BP). It is observed that, η_{vol} for B30 is increased due to the less fuel consumption. For B10, B20 and B40 are reduced due to the more fuel consumption. So it depends on the charge into and out of the cylinder. Hence it is observed that, at rated load the η_{vol} for B30 is 53.64%. The η_{vol} for B10, B20 are increased by

3.45%, 2.08% respectively. For B40 is decreased by 0.75% compared with B30.



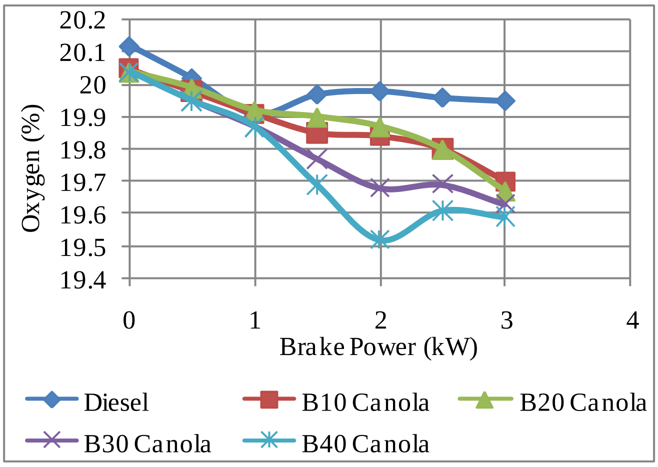
Graph 4: Brake Power vs Carbon Di-Oxide

Graph 4 shows the variation of Carbon Di-Oxide (CO_2) for various blends of canola with the Brake Power (BP). It is observed that, the CO_2 is reduced when compared to diesel while the compositions of canola blends are increased. CO_2 is a byproduct that is produced when the carbon from the fuel is fully oxidized during the combustion process. Hence it is observed that, at rated load the CO_2 for B30 is 1.33. For B10, B20 the CO_2 is increased by 3.75%, 2.2% respectively. For B40 the CO_2 is decreased by 3.3% compared with B30.



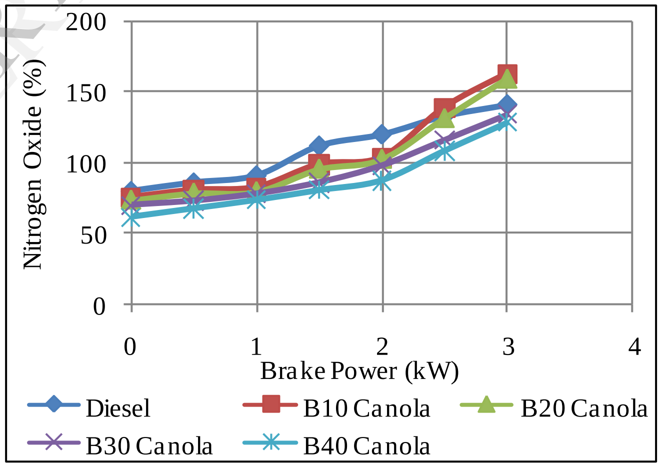
Graph 5: Brake Power vs Hydro Carbons

Graph 5 shows the variation of Hydro Carbons (HC) for various blends of canola with the Brake Power (BP). It is observed that, the HC levels are reduced when compared to diesel while the compositions of canola blends are increased due to the oxygen supplementary are higher in biodiesel. Hence it is observed that, at rated load the HC for B30 is 22.5 ppm. For B10 the HC is increased by 2.2%. For B20 and B40 the HC are similar to B30.



Graph 6: Brake Power vs Nitrogen Oxide

Graph 6 shows the variation of Nitrogen Oxide (NO_X) for various blends of canola with the Brake Power (BP). It is observed that, the NO_X is reduced when compared to diesel while the compositions of canola blends are increased due to increasing the specific heat in the combustion chamber so it reduces the higher flame temperatures at rated load. Hence it is observed that, at rated load the NO_X for B30 is 107. For B10, B20 the NO_X is increased by 13.5%, 9.8% respectively. For B40 the NO_X is decreased by 7.9% compared with B30.



Graph 7: Brake Power vs Oxygen

Graph 7 shows the variation of Oxygen (O_2) for various blends of canola with the Brake Power (BP). It is observed that, the O_2isgreatly reduced when compared to diesel while the compositions of canola blends are increased due to increasing the engine load. Hence it is observed that, at rated load the O_2 for B30 is 19.68. For B10, B20 the O_2 is increased by 0.71%, 0.76% respectively. For B40 the O_2 is decreased by 0.15% compared with B30.

4. CONCLUSIONS

The conclusions are given below after the analysis of Performance and Emissions parameters of canola blends and diesel on C.I engine working at rated load with exhaust gas re-circulation.

The BSFC for B30 canola is 0.28 kg/kW-hr. The BSFC for diesel is increased by 25.7% compared with B30 canola.

The Brake Thermal Efficiency (η_{bth}) for B30 canola is 30.74%. This is due to the inherent oxygen with the canola.

With the complete combustion of the fuel in the combustion chamber, the temperature in the chamber is more. The Volumetric Efficiency (η_{vol}) for B30 canola is 53.64%.

The inherent oxygen content in the oil reacts with the Co and converts that into Carbon Di-Oxide (CO_2). The CO_2 for B30 canola is decreased by 26% compared with diesel.

The Hydro Carbons (HC) for B30 canola is 22.5 ppm. The HC for diesel is almost similar compared with B30 canola.

The Nitrogen Oxide (NO_X) for B30 canola is 107%. The NO_X for diesel is increased by 18.2% compared with B30 canola.

Therefore it is proved experimentally, for B30 canola the Performances are increased and Emissions are reduced greatly.

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