INFLUENCE OF CANOLA OIL ON THE EMISSION AND PERFORMANCE CHARACTERISTICS OF FOUR STROKE DIESEL ENGINE AS A BIO FUEL

T. NANCHARAIAH*, P. RAVI KUMAR & D. SAMEER KUMAR

Department of Mechanical Engineering, Bapatla Engineering College, Bapatla, Andhra Pradesh, India

ABSTRACT

The present work focuses on the experimental investigation on performance characteristics and emission analysis conducted with canola biodiesel. The raw diesel and canola oil mixed diesel in proportions of 10%, 20% and 30% named as B10, B20, B30 blends were considered in the current study. The behaviour of these blends on the performance and emission characteristics are examined using 4 stroke single cylinder diesel engine (Kirloskar engine) integrated with AVL437C smoke meter. It is observed that the increased percentage of canola oil reduced the emissions but the calorific value is decreased. Therefore, from the investigation presented here, B20 combination of canola oil mixed diesel is an optimum mixture to achieve the reduced emissions with improved performance.

KEYWORDS: Emissions, Canola Oil, Bio Fuel, Alternate Fuel, Diesel Engine, Biodiesel

INTRODUCTION

The main reasons contributing to the quest for renewable energy are environmental dilapidation and the unavailability of fossil fuels. Fossil fuels actually account for 86% of the world's power usage and almost 100% of the resources used in the transport industry [1]. The accessible oil reservoirs across the globe are slowly dwindling and appropriate long-term strategies are required to focus on the usage of renewable fuel, which slowly offset decreasing supply of fossil fuels. Furthermore, the rising of CO$_2$ amount in the atmosphere have made an alarm for the young researchers to work on bio fuels which can reduce environmental harm and balance the eco system. The numerous nitrogen and oxygen compounds formed during combustion are hydrocarbons (HC), carbon monoxides (CO) and nitrogen oxides (NOx). The air used for combustion contains both HC and CO. When HCs and NOx are mixed with sunlight, smog occurs. This smog may induce a variety of health issues, including chest pains, respiratory collapse and coughing. Therefore, one of the best way to reduce NOx emissions is to use biodiesels.

Biodiesel is a good substitute to diesel fuel and a sustainable option in an economic point of view. NOx, HC, CO, CO$_2$ and Particulate Matter (PM) are reduced when biodiesel is used in diesel engines [2]. However, greater density and higher viscosity of biodiesel can cause issues to injector and fuel lines hence direct usage of biodiesels not suggested in diesel engines. Thus, biodiesel is typically blended with diesel fuel in various amounts without changes in engine configuration [3,4].

Canola seeds based bio diesel is a well adapted biodiesel by many researchers for having higher oil (about 40-45 percent) than other oily seeds [5]. One of the benefits of Canola biodiesel is the level of oxygen as large amounts of oxygen can maximize the combustion. Canola oil is very much environment friendly with higher cetane number so that it can reduce the concentrations of exhaust pollutants (PM, CO and HC)[6]. Mohamed KafeelDelvi et al. [7] reviewed various emission and performance features of bio diesels while Fa M et al. [8] and Mittelbatch et
al. [9] reported the making methods and innovations in making of biodiesels. Jun Cong Ge et al. clearly described the Canola bio diesel preparations, benefits and advanced studies carried in the recent years [10].

Therefore, this work estimates the performance analysis and HC, CO and NOx emission behaviour obtained from canola oil blends in a four stroke diesel engine operating at different loads and at different percentage of mixtures. Bio diesel preparation and experimental conditions are presented in Section 2 while results are discussed in section 3 followed by conclusions.

**EXPERIMENTAL**

**Canola Bio Diesel Preparation**

Canola oil is normally converted into biodiesel via a transesterification cycle. The oil is combined with alcohol to the remove the glycerine content. The transesterification method, which facilitates the reaction between alcohol and oil, is commercially catalysed with sodium hydroxide or methanol. Pure canola in variable quantities is mixed with diesel petroleum. In the present work, the transesterified canola fuel is blended in 10, 20 and 30% to diesel and named as B10, B20 and B30. A magnetic stirrer is used for better agitation and to prepare the blends for experimentation (Figure 1).

![Figure 1: Canola Oil Blended Bio Diesel Preparation using Magnetic Stirrer.](image)

A sample of one litre is carried out for the experimentation on the 4 stroke single cylinder diesel engine. Some important properties of the blended bio diesels are mentioned in Table 1.

| Type of Blend Properties | Diesel | B10 | B20 | B30 |
|--------------------------|--------|-----|-----|-----|
| Density, Kg/m³           | 830    | 858 | 866 | 872 |
| Calorific Value, KJ/Kg   | 42000  | 41758 | 41208 | 40658 |
| Flash Point, °C          | 58     | 71  | 84  | 97  |
| Fire Point, °C           | 77     | 81  | 89  | 118 |
| Viscosity at 40 °C (c St)| 2.70   | 2.94 | 3.15 | 3.29 |

**Experimental Setup**

The experimental setup involves a 4 stroke – single cylinder diesel engine (Kirloskar TV1) having 5.20 KW power at 1500 rpm. It is also coupled with current dynamometer. The cylinder bore is 87.50mm along with stroke length of 110.00mm.
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ALV 437C smoke meter is attached to engine to measure the percentage of emissions out of smoke. The inlet temperature of smoke into the smoke meter is 250°C through control valve and the whole process is monitored with computer interfacing. As shown in Figure 2 (a & b).

RESULTS AND DISCUSSIONS

Performance Analysis

The engine performance with Canola oil blends is calculated in terms of Brake Power (BP), Indicated Power (IP), Brake Thermal Efficiency (BTE), Indicated Thermal Efficiency (ITE), Mechanical Efficiency (Mech. Eff) and Specific Heat by using the equations 1-6.

Brake Power (BP) in KW = \( \frac{2 \pi NR (W \times 9.81)}{60 \times 1000} \)  \hspace{1cm} \text{Equation 1}

Where \( N \) = Speed of the Engine in rpm; \( W \) = applied in N; \( R \) = Radius of the dynamometer arm length
Indicated Power (IP) in KW = \frac{1000000 \times IMEP \times L \times A}{60 \times 1000} \quad \text{Equation 2}

Where IMEP = Indicated Mean Effective Pressure in bar; \( L \) = Stroke Length in m; \( D \) = Cylinder diameter in m; \( A \) = Cylinder area in m\(^2\)

Brake Thermal Efficiency (BTE) in % = \frac{BP \times 100}{TFC \times CV} \quad \text{Equation 3}

Where TFC = Total Fuel Consumption = \frac{q \times \text{Density}}{t} \text{ in Kg/s}; q = Volume of fuel consumed; t = time taken for 10 g fuel consumption in ‘s’; CV = Calorific Value of corresponding fuel

Indicated Thermal Efficiency (ITE) in % = \frac{IP \times 100}{TFC \times CV} \quad \text{Equation 4}

Mechanical Efficiency (Mech. Eff.) in % = \frac{BP \times 100}{IP} \quad \text{Equation 5}

Specific Fuel Consumption (SFC) in kg/kWh = \frac{TFC}{BP} \quad \text{Equation 6}

The performance characteristics (Eq 1- Eq 6) are calculated using the corresponding data of diesel and blends mentioned in Table 1 and the values are tabulated in Table 2.

| Parameter | Load In % | Torque (Nm) | BP (kW) | IP (kW) | BTE (%) | ITE (%) | Mech. Eff. (%) | SFC (kg/kWh) |
|-----------|-----------|-------------|---------|---------|---------|---------|----------------|--------------|
| Diesel    | 0         | 0.21        | 0.03    | 2.20    | 0.97    | 62.37   | 1.55           | 8.74         |
|           | 25        | 8.20        | 1.30    | 3.64    | 20.17   | 56.30   | 35.83          | 0.42         |
|           | 50        | 16.41       | 2.59    | 4.82    | 29.33   | 54.60   | 53.71          | 0.29         |
|           | 75        | 24.68       | 3.83    | 5.95    | 32.60   | 50.62   | 64.40          | 0.26         |
|           | 100       | 33.02       | 5.04    | 6.97    | 34.31   | 47.45   | 72.30          | 0.25         |
| B10       | 0         | 0.22        | 0.03    | 1.98    | 0.97    | 55.36   | 1.75           | 8.89         |
|           | 25        | 8.26        | 1.31    | 3.46    | 20.02   | 52.72   | 37.97          | 0.43         |
|           | 50        | 16.38       | 2.58    | 4.57    | 26.96   | 47.78   | 56.43          | 0.32         |
|           | 75        | 24.64       | 3.80    | 5.65    | 31.81   | 47.29   | 67.26          | 0.27         |
|           | 100       | 33.05       | 5.02    | 6.75    | 33.62   | 45.21   | 74.35          | 0.26         |
| B20       | 0         | 0.21        | 0.03    | 1.96    | 0.97    | 54.79   | 1.77           | 8.99         |
|           | 25        | 8.22        | 1.30    | 3.34    | 19.93   | 51.12   | 38.99          | 0.44         |
|           | 50        | 16.66       | 2.62    | 4.55    | 27.50   | 47.83   | 57.50          | 0.32         |
|           | 75        | 24.69       | 3.81    | 5.61    | 31.99   | 47.17   | 67.82          | 0.27         |
|           | 100       | 33.14       | 5.06    | 6.75    | 32.70   | 43.62   | 74.95          | 0.27         |
| B30       | 0         | 0.21        | 0.03    | 1.96    | 0.96    | 55.34   | 1.73           | 9.23         |
|           | 25        | 8.35        | 1.32    | 3.36    | 20.31   | 51.68   | 39.31          | 0.44         |
|           | 50        | 16.53       | 2.60    | 4.58    | 27.49   | 48.44   | 56.75          | 0.32         |
|           | 75        | 24.65       | 3.80    | 5.66    | 30.60   | 45.63   | 67.06          | 0.29         |
|           | 100       | 33.09       | 5.04    | 6.80    | 32.82   | 44.27   | 74.13          | 0.27         |

From Table 2, it has been observed that the load increment has a highest and significant contribution on the engine performance of engine characteristics tested with bio diesel. The amount of chemical energy from bio diesel converted to purposeful work is denoted by the term Brake Thermal Efficiency (BTE). The BTE value is observed to be increased with increase in load percentage. Mechanical efficiency is also another important factor that gives the
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The performance of an engine in converting the input energy to output energy. It mainly relies on Brake power and Indicated power. The mechanical efficiency of B20 blend is higher than the other categories mentioned in the current work. Specific Fuel Consumption is the ratio between fuel consumption to brake power. The SFC decreases with load on the engine. From the present work carried, the SFC values are almost similar. At 100% load pure diesel has an SFC value 0.25 while B20 and B30 have 0.27. These blends have 80% improved SFC with the addition of Canola oil. The results obtained from this investigation are closely related to the work carried by other researchers [6].

Emission Characteristics

Figures 3-5 describe various emission features of blended canola biodiesels. Figure 3 describe the variation of hydrocarbon emissions with load percentage. It is observed that the emissions are observed to decrease with increase percentage of canola oils and the emissions are low in case of 30% canola blended diesel. B20 and B30 blend releasing almost near HC emissions. B20 mixture is able to produce low emissions even at higher load of 80% while for other percentages, the emissions are increasing at rapid rate when load is increasing. Figure 4 represents CO emissions of all blends varied with load percentages. As soon as the load percentages are increasing the emissions are found to be increasing. B20 exhibited lower emissions when compared to pure diesel and to all kinds of other blends. This may be attributed because of uniform distribution of 20% of canola in diesel [6]. Figure 5 represents NOx emissions of the proposed blends in diesel. Similar and almost near values were observed for all blends. Though, B30 and B20 exhibited similar kind of emission phenomenon in all kinds of emission characteristics, the calorific value of B30 blend was observed to be low (as seen in Table 1). Hence, B20 can be considered as a good choice of blend in view of emission characteristics.

![Figure 3: Load vs Hydro Carbon Emissions (HC) for Different Blends.](image-url)
CONCLUSIONS

The present work investigated the emission and performance characteristics of single cylinder diesel engine by using canola oil based diesel. The concentration of biofuels at 10%, 20%, 30% at different conditions have influenced the output characteristics. Blended bio diesel shown improved mechanical efficiencies than pure diesels. It is also observed that CO, HC, NOx emissions are reduced with bio diesels. A B20 and B30 mixture has possessed similar characteristics but the calorific value is decreased. Therefore, from the present work, it can be concluded that B20 mixture has ideal characteristics in view of improved performance and low emissions.

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