Experimental investigation of performance and emission characteristics of CI engine fuelled with linseed oil blended diesel fuel with camphor as additive

Rishi Malhotra*1, G Manikandanraja2 and V Mathanraj3

1 B.Tech student, Department of Mechanical Engineering, SRM institute of science and technology, Chennai, India
2, 3 Assistant professor, Department of Mechanical Engineering, SRM institute of science and technology, Chennai, India

*Corresponding author: rishi.malhotra091996@gmail.com

Abstract. The paper investigates the performance and emission characteristics of CI engine fuelled with linseed oil blended diesel fuel with camphor as additives. Experiment was conducted on the single cylinder four stroke water cooled diesel engine at constant speed of 1500 rpm for different operating loading conditions. Diesel, B10 linseed oil (linseed oil 10% and diesel 90%), B10 0.5% camphor and B10 1% camphor were tested. The result showed that brake thermal efficiency was found higher for diesel when compared to blended fuel at lower load conditions but brake thermal efficiency for blended fuels becomes higher as the load increases. Addition of camphor was found with providing good significance in brake thermal efficiency. Blended fuel was found with higher brake specific fuel consumption when compared to diesel because of lower calorific value. Exhaust gas temperature for blended fuel was found higher than diesel because of higher viscosity. Emission parameters such as CO, CO2, HC was found higher for blended fuel than diesel. NOx emission was also found higher for blended fuel than diesel. Addition of camphor showed a decrease in all the emissions at all loading conditions.

Keywords. CI Engine, Linseed oil, Camphor

1. Introduction

Fossil fuels form the major part of the world today. They are the valuable sources of energy, but if they have to be used in future, there is an urgent need of using them in a judicious manner. Self-efficacy is every nation’s major requirement and in order to achieve it, they sometime indulge in the activities that lead to over exploitation of useful resources. Various empirical studies show that the petroleum, a major source of energy, is depleting at such an alarming rate that it may come to an end in the near future. Due to trends of such an alarming decrease in petroleum levels there is a need to shift to some alternate fuels so that the rate at which petroleum is decreasing can be minimised.

A biodiesel, tested by various researchers over decades has always proved to be a good alternative for pure diesel. The research in the field of biodiesel started in the year 1853, when Rudolf Diesel was able to run an IC engine with biodiesel. The biodiesel he prepared, which he used to a run a
diesel engine was nothing but a blended mixture of peanut oil and diesel. Since then many other researchers have also tried running a diesel engine with various biodiesels blended in various blending ratios. Several researches have been carried over the time and many additives have been found out that helps in increasing both the performance and emission characters of biodiesel and make them better to that of even pure diesel. In present investigation, an effort was made for determining the efficiency and other aspects of CI engine fuelled with linseed oil blended diesel fuel with camphor as additive.

2. Methods and methodology

Diesel, B10 linseed oil (linseed oil 10% and diesel 90%), B10 0.5% camphor and B10 1% camphor were tested. Experiment was conducted on the CI engine coupled with eddy current dynamometer by varying the load 0, 20%, 60%, 40% and 80% at constant speed of 1500 RPM. Experimental test rig is shown in the figure and its details are given in the table. Air flow rate was measured using air box method. Orifice with U-tube manometer is attached on the air box is used to measure the air flow rate. Fuel measurement was carried by gravimetric type. Time taken for 10CC was noted to determine the fuel consumption. Emission parameters CO₂, CO, unburnt hydrocarbon and oxides of nitrogen were measured using AVL di gas analyzer whose specifications are given in the table. Fuel was blended on the volume basics whose details are given in the table.

![Figure 1. Engine setup](image1)

| Figure 1. Engine setup |
|-------------------------|
| 1 AVL gas analyzer |
| 2 Burette |
| 3 Temperature indicator |
| 4 Fuel tank |
| 5 Air tank |
| 6 U-tube manometer |
| 7 Load indicator and speed indicator |
| 8 Speed sensor |
| 9 Loading sensor |
| 10 Cooling water inlet temperature |
| 11 Cooling water outlet temperature |
| 12 EGT thermocouple |

Table 1. Specifications of engine

| Description | Specification |
|-------------|---------------|
| Make        | Kirloskar     |
Table 2. Specifications of measuring instruments

| Instrumentation   | Component | Measuring range | Accuracy | Resolution |
|-------------------|-----------|-----------------|----------|------------|
| AVL gas Di gas    | HC (ppm)  | 0-20000         | ±10ppm   | 1ppm       |
| 444 Analyser      | Co (% by vol) | 0-10%by vol | ±0.5%    | 0.01% vol  |
|                   | Co₂(%by vol) | 0-20%by vol | ±0.5%    | 0.1% by vol|
|                   | O₂ (%by vol) | 0-22% by vol | ±0.1%    | 0.01% by vol|
|                   | NOx (ppm) | 0-5000ppm       | ±50 ppm  | 1ppm       |

Table 3. Properties of fuels

| PROPERTY              | Linseed | B10(Linseed) | B10(linseed 0.5%) | B10(linseed 1%) |
|-----------------------|---------|--------------|-------------------|-----------------|
| FLASH POINT (⁰C)      | 240     | 70           | 58                | 55              |
| FIRE POINT (⁰C)       | 260     | 78           | 62                | 60              |
| DENSITY(g/cm3)        | 0.929   | 0.910        | 0.909             | 0.909           |
| CALORIFIC VALUE(MJ/Kg)| 39.3    | 41.975       | 41.955            | 41.935          |
| KINEMATIC VISCOSITY (CST)| 22.2  | 5.415        | 5.463             | 5.014           |
| CETANE INDEX          | 34      | 47           | 47                | 50              |
3. Result and discussion

3.1 Brake thermal efficiency:

![Figure 2. Variation of brake thermal efficiency with respect to load](image)

Variation of brake thermal efficiency with respect load is shown in the graph 1. Brake thermal efficiency was increasing with increase in load acting on the engine. Brake thermal efficiency was found higher for diesel at low load condition than blended fuels but decreases and becomes less at higher load conditions. Addition of camphor leads to increase in the brake thermal efficiency of engine at all loading conditions of the engines. At medium loading condition, camphor blended diesel fuel has good brake thermal efficiency when compare to diesel and B10 mixture.

3.2 Brake specific fuel consumption:

Variation of the BSFC with respect to different loading conditions is shown in graph 2. Brake specific fuel consumption inversely varies with respect to brake thermal efficiency. At lower loading conditions, diesel was found with lower BSFC values. But at higher loading conditions, BSFC of the blended fuels decreases and becomes significantly equal to that of diesel because of supply of more oxygen rich fuel. Addition of camphor to the blended mixture significantly reduced the BSFC at all loading conditions.

3.3 Exhaust gas temperature:
Figure 3. Variation of the BSFC with respect to load acting on the engine

Figure 4. Variation of the exhaust gas temperature with respect to load

Variation of the exhaust gas temperature is shown in the graph 3. Exhaust gas temperature was found increasing with increase in load acting on the engine. Diesel has the lowest exhaust gas temperature at all loading conditions when compare to B10 and fuel with camphor. B10 linseed oil 1% was found to have has highest exhaust gas temperature at higher load conditions because of combustion of a more oxygen rich mixture in combustion chamber.

3.4 Carbon monoxide:
Variation of the CO is shown with respect to different load acting on the engine. CO emission was found lower for diesel at different loading conditions because of the lower viscosity when compare to other fuels. CO emission for B10 and B10 1% camphor oil was found highest at no load condition. CO emission was found to be decreasing with increase in loading conditions. Camphor was found to be playing a significant role in reduction of CO at high loading conditions.

3.5 Carbon dioxide:

Variation of the CO is shown with respect to different load acting on the engine. CO emission was found lower for diesel at different loading conditions because of the lower viscosity when compare to other fuels. CO emission for B10 and B10 1% camphor oil was found highest at no load condition. CO emission was found to be decreasing with increase in loading conditions. Camphor was found to be playing a significant role in reduction of CO at high loading conditions.

Figure 5. Variation of the CO with respect to load

Variation of the CO is shown with respect to different load acting on the engine. CO emission was found lower for diesel at different loading conditions because of the lower viscosity when compare to other fuels. CO emission for B10 and B10 1% camphor oil was found highest at no load condition. CO emission was found to be decreasing with increase in loading conditions. Camphor was found to be playing a significant role in reduction of CO at high loading conditions.

3.5 Carbon dioxide:

Variation of the CO is shown with respect to different load acting on the engine. CO emission was found lower for diesel at different loading conditions because of the lower viscosity when compare to other fuels. CO emission for B10 and B10 1% camphor oil was found highest at no load condition. CO emission was found to be decreasing with increase in loading conditions. Camphor was found to be playing a significant role in reduction of CO at high loading conditions.
3.6 Hydrocarbon:

Variation of the unburnt hydrocarbon with respect to load is shown in the graph 6. Incomplete combustion of the fuel leads to unburnt hydrocarbon emission. At no load conditions diesel was found with lower HC emission. B10 1% camphor was found with highest HC emission at medium loading condition. Good oxygen content of the B10 linseed oil supports for reduction of unburnt hydrocarbon emission. At higher loading conditions, addition of Camphor in the blended fuel leads to decrease in the emission of unburnt hydrocarbon because of supply of oxygen rich mixture.

3.7 Oxides of nitrogen:

Figure 8. Variation of NOx with respect load
Variation of the NO\textsubscript{x} with respect different loading conditions is shown in the graph 7. Main reason for the NO\textsubscript{x} emission is attainment of high temperature and more oxygen content of the fuel. NO\textsubscript{x} was found lower for diesel. All the blended fuels were found with higher NO\textsubscript{x} because of the high oxygen content of the fuel. NO\textsubscript{x} emission was found to be increasing for all the fuels with increase in load. NO\textsubscript{x} emission was found to be highest for B10 0.5% camphor at high load condition.

4. Conclusion
1. By adding the linseed oil to diesel fuel leads to decrease in brake thermal efficiency because of high viscosity of fuel formed when compared to diesel fuel. Addition of camphor leads to increase in brake thermal efficiency because it contributes in lowering down the viscosity.
2. SFC was found lower for diesel fuel when compared to blended fuel because of higher calorific value of fuel. However, addition of camphor leads to higher SFC because of oxygen rich blended mixture formed.
3. EGT was found less for diesel fuel when compared to blended mixtures with and without camphor additive.
4. Co emission was found higher for blended mixtures when compared to diesel fuel because of higher viscosity. Addition of camphor somewhat leads to deduction in Co emissions.
5. Co\textsubscript{2} emission was found higher for B10 with camphor additives because of higher oxygen content and higher calorific value of blended fuel.
6. Unburnt hydrocarbon was found lower for diesel when compared to blended mixtures at low load condition. But, at higher load conditions, diesel fuel was with more HC emissions.

5 References
[1] Nirendra N. Mustafi, 2013 “Combustion and Emissions characteristics of a dual fuel engine operated on alternative gaseous” Fuel, \textbf{109}, 669–678.
[2] Mohammad Fatouraie, 2015 “Comparative study on alcohol–gasoline and gasoline–alcohol Dual-Fuel Spark Ignition (DFSI) combustion for engine particle number (PN) Reduction” Fuel, \textbf{159}, 250–258
[3] R. Mohsin, 2014 “Effect of biodiesel Blends on engine performance and exhaust emission for diesel dual fuel engine.” Energy Conversion and Management, \textbf{88}, 821–828.
[4] M.Taherkhani, 2018 “ An improvement and optimization study of biodiesel production from linseed via in-situ transesterification using a co-solvent.” Renewable Energy, \textbf{119}, 787-794.
[5] Ayhan Demirbas, 2009. “Production of biodiesel fuels from linseed oil using methanol and ethanol in non-catalytic SCF conditions.” Biomass and Bioenergy, \textbf{33}(1),113-118.
[6] Savita Dixit, 2012, ‘Linseed oil as a potential resource for bio-diesel: A review’ Renewable and Sustainable Energy Reviews, \textbf{16}(7),4415-4421.
[7] Rajeev Kumar, Alkali, 2013 ‘transesterification of linseed oil for biodiesel production.’ Fuel, \textbf{104}, 553-560.
[8] Agarwal, Avinash Kumar, 2007 ‘Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines.’ Progress in Energy and Combustion Science, \textbf{33}, 233-271.
[9] Agarwal, A K., 2005 ‘Experimental investigations of the effect of biodiesel utilization on lubricating oil tribology in diesel engines.’ Proc. IMechE, \textbf{219}, 703-713.