Experimental investigation of performance and emission characteristics of CI engine fuelled with linseed oil with di-ethyl carbonate

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ABSTRACT: In the current investigation non-consumable Linseed oil is was utilized as alternative source for diesel engine fuel. The examination was done by utilizing diesel, linseed oil-mix and Di-ethyl carbonate as an additive at different loads from 0 kg to 16 kg. The blends arranged were B20, B40, B60, B80, B100. The fuel was by tested by performance and emission characteristics on a single chamber four stroke diesel engine. Performance parameters, for example, Brake thermal efficiency, Brake specific fuel consumption were studied and emission parameters, for example, CO, CO₂, O₂, NOx, and HC were estimated. The Brake thermal efficiency increments with increment in load however its lower when contrasted with diesel. The Brake specific fuel consumption likewise decreases with increment in load. The blends give somewhat lesser CO₂ at medium and most extreme load when contrasted with diesel. In any case, different emissions are greater than diesel at all loads.

1. Introduction

Linseed Oil otherwise called flax oil or flax seed oil and it is a clean to yellowish drying oil. It got by squeezing or by dissolvable extraction. The climatic and soil state of our nation is helpful for the creation of linseed crop. Linseed oil is non-consumable oil and it comprises of fatty oil, as different fats. Linseed is particular for its enormous measure of α-linolenic corrosive, which has unmistakable response with oxygen in air. Karthikeyan et al. [1] directed analysis utilizing linseed oil as biodiesel by changing injection timing, discovered that performance and emissions were expanded when injection expanded. P.Jayanthi et al. [2] directed examination with the impact of copper oxide added to biodiesel on DI diesel engine . The performance qualities were improved at full load condition. The copper oxide added substance is powerful in charge of emission gases at full load condition. Mr. Kanji et al. [3] led an investigation on performance and emissions on DI diesel engine working on linseed oil and diesel oil blend. From the test they observed that the performance characteristics were decreased. Further CO emission is decreased, HC and NOX emission is increased by increased in blend extent. Ashutosh Kumar Rai et al. [4] led a test on the diesel engine fuelled with linseed oil and diesel blends. The BTE was decreased and BSFC was increased. The oxides of nitrogen (NOx) were lower than diesel fuel. The
emissions were discovered higher than diesel fuel during the entire trial range. S.K. Mahla et al. [5] carried out an Experimental investigation to examine the properties, performance and emission of different blends (B15, B20, and B30) of linseed oil methyl ester in comparison to diesel. B15 and B30 blend shows reasonable efficiencies and lower load conditions. B20 gave best results so it could be considered as an optimum fuel blend in terms of performance and reduced emission. K. Vamsi Krishna, et al. [6] conducted an experiment on experimental investigations on exhausts emissions of low grade semi adiabatic diesel engine fuelled with linseed oil and its biodiesel. It decreased the particulate emission and increase in NOx emission at full load condition. Advance injection timing and increase in injection pressure improved exhaust emission. Nurun Nabi et al. [7] conducted experiment using linseed oil methyl esters with diesel and bio-diesel fuels. Observed that lower CO and PM while slightly higher NOx emission was experienced. Sukumar Puhan et al. [8] showed the effect of injection pressure on performance, emission and combustion characteristics of high linoleic linseed oil methyl ester in a four stroke DI diesel engine. The inferences made were that linseed oil having high viscosity and low volatility is unsuitable for a diesel engine and the injection pressure of 240 bars could improve performance and emissions. L.Saravanakumar et al. [9] conducted an experiment with on Methyl Esters blended Diesel with di-Methyl Carbonate Additives. It is observed that the DMC added with CIME –diesel blends has improved the BTE and a rise in BSFC. Further, for the B20+A blend there is marginal reduction of exhaust emission. S. Mohite et al. [10] carried out investigations on Performance and Emission Characteristics of Mix Oil Biodiesel Blends and observed BSEC increased with the biodiesel blend proportions increasing. B30 was found to cause the lowest CO emissions and the lowest HC emissions.

2. Methodology and properties of fuel blends

The methodology used for preparing the blend is done by direct mixing. The different blends of linseed oil and diesel were prepared, analysed and compared with diesel fuel.

The testing was directed on a test arrangement of a solitary chamber four-stroke diesel water cooled motor associated with a swirl flow dynamometer, which is utilized to apply load on motor (a safe distance of 0.185m) consequently giving burden over a scope of 0kg to 18kg which is utilized uniquely to max heap of 16kg. The motor is of consistent speed type with a steady speed of 1500rpm. The emission values were gotten utilizing AVL Di Gas 444 analyzer. It gives readings for the accompanying gases to be specific CO, CO2, NOx, HC and O2.

**Figure 1:** Experimental Setup

2.1 Properties of fuel blends
Table 1: Basic Properties

| FUEL/ADDITIVE | LINSEED OIL | DEC | DIESEL | METHOD          |
|---------------|------------|-----|--------|-----------------|
| DENSITY (kg/m³) | 900        | 820 | 840    | Weighing machine |
| Kinematic VISCOSITY (centistokes) | 50.50      | 3.22 | 7.298  | Redwood Viscometer |
| Dynamic Viscosity (centipoise) | 41.680     | 8.37 | 6.028  | Redwood Viscometer |
| CALORIFIC VALUE (kJ/kg) | 35569.06   | 35158 | 42500  | Bomb Calorimeter |
| FLASH POINT (°C) | 289        | -   | 50     | Open cup method |
| FIRE POINT (°C) | 294        | -   | 58     | Open cup method |

Table 2: Properties of Base Blends

| BLENDS         | DENSITY (kg/m³) | CALORIFIC VALUE (kJ/kg) |
|----------------|-----------------|-------------------------|
| B20+10%DEC     | 859.7           | 39082.1                 |
| B40+10%DEC     | 871.7           | 37695.9                 |
| B60+10%DEC     | 883.7           | 36309.7                 |
| B80+10%DEC     | 895.7           | 34923.5                 |
| B100+10%DEC    | 907.7           | 33537.3                 |

3. Performance Characteristics:

3.1. Brake thermal efficiency

From the figure 2, if the BTE increases with load increments. Thus, the BTE for B20 is the most minimal and B60+5% has the highest efficiency at all loads besides at greatest load (16 kg), the increased amount of linseed oil in the blends, builds BTE. In this way, on expansion of DEC as an added substance the BTE efficiency is greater than mixes without additive.
Table 3: Properties of Blends With DEC.

| BLENDS (ml) | DENSITY (kg/m³) | CALORIFIC VALUE (kJ/kg) | KINEMATIC VISCOSITY (centistokes) | DYNAMIC VISCOSITY (centipoise) |
|-------------|-----------------|--------------------------|-----------------------------------|--------------------------------|
| B20         | 852             | 41113.8                  | 10.407                            | 8.596                          |
| B40         | 864             | 39727.6                  | 14.852                            | 12.268                         |
| B60         | 876             | 38341.4                  | 20.486                            | 16.921                         |
| B80         | 888             | 36955.2                  | 32.112                            | 26.525                         |
| B100        | 860             | 35569                    | 50.50                             | 41.68                          |

Figure 2. BTE (%) vs Load (kg)

3.2 Brake Specific Fuel Consumption:

Figure 3. BSFC (kg/kWh) vs Load (kg)
The Figure 3 has the highest SFC for B100+10% mix which expresses that the fuel has been burned-through additional for a same amount of power output. The most minimal value is for the blend B60 which increases the BTE of the system and can be seen that it is less when contrasted with diesel.

4. Emission characteristics:

4.1 Carbon monoxide Emission:

![Figure 4. CO (% vol) vs Load (kg)](image)

From figure 4, the principal purpose behind CO emission is because of ill-advised burning of the fuel which is a consequence of low pinnacle temperature at lower loads and lower air fuel proportions at higher loads. The blends show lower CO emission because of the property of rich oxygen content which increasing as the amount of DEC in the blend increments. This guides the formation of CO.

4.2 Carbon Dioxide Emission:

![Figure 5. CO₂ (% vol) vs Load (kg)](image)
The Figure 5 show that blends with additive have lower CO₂ emission at all load condition. B100 has the highest CO₂ emission at all load except at no load condition. B20+5% show the lowest emission than diesel at all loads except at no load condition.

### 4.3 Hydrocarbon Emission:

![Figure 6: HC (ppm) vs Load (kg)](image)

From the figure 6 blend B40 has higher emission at no load and lower load condition and blend B60 has higher emission at medium and maximum load condition. This is because of the higher viscosities prompting helpless atomization. B20 has lower HC emission when compared diesel at 0kg and 4kg load condition.

### 4.4 NOx Emission:

![Figure 7: NOx (ppm) vs Load (kg)](image)
From the Figure 7 we can observe that NO\textsubscript{x} value is higher for B60+5\% and lowest is for B20 at maximum load. B20+10\% has lower NO\textsubscript{x} value and B60+5\% has higher emission at lower load. B20 is less polluting blend as compared to other blends with respect to NO\textsubscript{x} emission.

4.5 Smoke

From the figure 8 observe that B60+5\%DEC has the lowest smoke level at all load except at maximum load (16kg). At maximum load B40+5\%DEC has the lowest smoke level.

5. Conclusion

In the current work, the expansion of Linseed oil in a diesel without added substance expands its thickness; consistency and oxygen content yet diminish the calorific estimation of the blends. The BTE of fuel continues expanding as the measure of linseed oil increments in the mixes and simultaneously decreases the Brake specific fuel utilization as the load increments. The emissions were influenced as the estimation of NO\textsubscript{x}, CO\textsubscript{2}, CO; HC discharges are least for B20. When contrasted with diesel the outflows are higher because of the following reasons high ignition temperature, A/F proportion is nearer to stoichiometric proportion, helpless atomization prompts fragmented burning.

- The expansion of Di-ethyl carbonate as an added substance in linseed-diesel mix builds the oxygen content however decreases its calorific value, density. The expansion of DEC has an acceptable impact on the exhibition attributes of the fuel. For example, it builds the BTE of the mixes and having the opposite impact on the particular fuel consumption i.e., decrease it.
- The emission have radically diminished on the expansion of DEC which is a decrease in HC, CO\textsubscript{2}, and CO (10\% DEC) and expansion in the NO\textsubscript{x} and HC with 5\% DEC. At the point when we look at the smoke level, B60+5\%DEC has the least smoke level at all heap besides at most extreme burden. The burning qualities are acceptable at a lower load.
The test results reveal that Linseed oil and Di-methyl carbonate can be used as fuel additive because it shows better performance results and also the emission parameters have shown decrease in emission values. Blend B60+5% DEC is most suitable blend except the NOx emission.

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