Use of animal fat methyl ester blend as a fuel in a CI engine

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Abstract. A Direct Injection Simpson make (S217). Diesel engine examined for the characteristics of performance and emission fuelled with Diesel, methyl ester of waste animal fat (B100) and Diesel – methyl ester of waste animal fat (B20) blends. At constant engine speed, the parameters of emission and performance were determined for different loading conditions at constant engine speed. The peak cylinder pressure registered as 90 bar, 90.48 bar, and 89.93 bar respectively for Diesel, B100 and B20. Unburned HC and CO emissions remained declined in manner for B100 and B20 when related to diesel fuel.

Keywords: Alternative fuel, animal fat biodiesel, performance, emission.

1. Introduction

Nowadays the society highly depends on petroleum products for its day today activities. However several environmental problems are raising such as NOx, carbon dioxide etc. Diesel engines are used in almost all the fields due to high power and low operating cost. Around 30% of the global energy demand rise slowly enlarged between the period of today and 2040 [1]. Hence, there is an emergency to develop alternative fuels to diminish the need on conventional fuel. The world energy supply heavily depend on the derived fuels from the crude oil out of which 90 % is utilized for transportation and energy generation.

In the present condition, crude oil reserves depleted in a very fast manner due to the faster rate of consumption. Therefore, this scenario started and continued the interest in identifying renewable alternative fuels. Diesel engines use vegetable oils in three forms namely 1. neat or pure vegetable oils 2. Vegetable oils blends and diesel fuel, and 3. Trans-esterified vegetable oils. The first and second forms have problems associated with the long term performance of diesel engines for the reason that higher viscosity of fuel. But the esters of vegetable oils have lower viscosities than the neat or blended vegetable oil fuels and hence the viscosity related problems like clog engine components such as fuel injectors are greatly reduced. The most promising applications is esters of vegetable (edible and non-edible) used as a diesel engine fuels. Methyl, ethyl and butyl esters are prepared by the method of trans-esterification of vegetable oils.

Currently, the well-known method of biodiesel usage is blending it with conventional diesel fuel. Biodiesel (or biofuel) refers to animal fat or containing of long chain alkyl esters of vegetable oil fuel. Normally diesel, mixed with Biodiesel or biodiesel alone used as a diesel engine fuel. Now a days, in
India, most suitable feed stock for biodiesel is non-edible oil, for the reason that the requirement for the edible oil go beyond the domestic supply. Shahir et al [2] go through the usage of biodiesel advantage, when it is compared to the neat diesel. Lapuerta et al.[3] evaluated the diesel engine performance and emissions running on 1.waste animal fat biodiesel and 2. 50% animal fat & 50% soybean oil. They stated that biodiesel fuels reduces the HC emissions, opacity of smoke, and PM. NOx was increased for 50:50 soybean oil and animal fat but decreased in manner with pure animal fat. Oner and Altun [4] reported that, methyl ester of animal tallow reduces the emissions of CO, NOx, smoke opacity and SO2. Velmurungan and Shaafi [5] was conducted an experiment on a Simpsons make DI compression ignition engine with 21 kW power at 1500 rpm when running on Diesel, B20 and B100. The engine characteristics were carefully measured at various engine loads from Zero to 100 percentage. The following conclusion were arrived as B20 blend thermal efficiency was lower when compared to other two fuels and the exhaust gas temperatures are high for B20 blend compared to other fuels used it, owing to the more amount of fuel was burnt. Lin and Li [6] studied the mixed marine fish (discarded species) were used to produce the biodiesel. They testified that, biodiesel of fish-oil has greater NOx, smoke opacity and a lower bsfc rate, CO emission when compared with WCO biodiesel. Ivana et.al [7] reviewed the different methods adopted for production of biodiesel and they presented the possibilities of exploitation of waste animal fats. Awad et.al [8] found the correlation between the parameters of combustion parameters and properties of fuels. Preheated condition of animal fat used as a fuel in a CI engine without any deterioration in performance of the engine.[9]. Mugilan and Shaafi [10] conducted an experiment on a diesel engine consists of twin cylinder was running using palm oil biodiesel and diesel-palm oil biodiesel blend. The loads of the engine are varied to 25%, 50%, 75% and 100% and the performance and emissions of exhaust were measured accordingly. They noticed that emissions of CO and HC were low and at the same time, higher NOX emissions when compared to diesel fuel. Diesel with 20% methyl ester of palm oil blend was viable as an alternate fuel for diesel engine. Shahir et.al [11] found that the use of enormous amount of animal fat biodiesel would solve the pollution created from the waste of meat.

Based on the literature survey, limited work has been concentrated on animal fats biodiesel as an alternate fuel in a CI engine. In this paper, a Simpson make (S217). DI Diesel engine examined for the performance and emission characteristics, fuelled with Diesel, methyl ester of waste animal fat (B100) and Diesel – methyl ester of waste animal fat (B20) blends.

2. Materials and Methods

2.1. Description of the engine

A Direct Injection Simpson make (S217). Diesel engine was examined for the characteristics of performance and emission fueled with Diesel, waste animal fat methyl ester (B100) and Diesel -waste animal fat methyl Ester (B20) blends. The Figure.1.shows the photographic view of the diesel engine with loading device and the specifications of the engine are shown in table.1.

| Model               | SIMPSON S 217 |
|---------------------|---------------|
| Capacity            | 21 kW         |
| Bore                | 91.44 mm      |
| Stroke              | 127 mm        |
| No.of cylinders     | 2             |
| Compression ratio   | 18.5 : 1      |
| Combustion system   | Direct Injection |
2.2. Fuel properties

Table 2. Showing the diesel, waste animal fat methyl ester and its blend properties of the tested fuel. Biodiesel density is higher in order and the heating value is lower in order when compared to the diesel. Figure. 2 shows the prepared methyl ester of waste animal fat.

Figure. 1 Diesel Engine with loading device

Figure. 2 Prepared waste animal fat methyl ester
**Table 2** Properties of the tested fuel

| Fuel  | Diesel | B100 | B20  |
|-------|--------|------|------|
| Density kg/m³ | 830    | 829  | 814  |
| Kinematic viscosity | 1.96   | 2.93 | 2.57 |
| Calorific value kJ/kg | 47000  | 36835| 37418|
| Cetane Index | 46     | 53   | 55   |

### 3. Results and Discussion

#### 3.1 Brake thermal efficiency

Figure 3 shows the variation of brake thermal efficiency at various loading conditions. Owing to the higher viscosity of B100 and B20 (related to conventional diesel) fuels are leads to 1. dwindled atomization 2. poor fuel vaporization and incomplete combustion. Hence, the efficiency of brake thermal for B100 and B20 are lower at higher loads than the diesel fuel.

![Figure 3. Brake thermal efficiency at various load.](image-url)
3.2 Cylinder Pressure

The cylinder pressure variation is shown in Figure 4. A slightly reduced peak pressure recorded for B20 and B100 related with diesel. The pressure rise rate is also highest for diesel fuel and lowest for B20. Higher peak pressure occurs between the crank angles from 0 to 10 degree.

![Figure 4. Variation of Cylinder Pressure](image)

3.3 Exhaust temperature

The variations of exhaust gas temperature of the tested fuels are shown in Figure 5. The EGT of B20 fuel is lower than tested the other two fuels at all the loads. Variations of the EGT indicates the kind of fuel used and brake loads have the effect on the temperature of the exhaust. The maximum EGT is recorded 530℃ at full load for diesel.

![Figure 5. Exhaust gas temperature variation](image)
3.4 CO emission

Figure 6 shows the emissions of CO variation for diesel, B100 and its blends. Due to higher viscosity the CO emission increased in trend from lower load to higher load. Up to 25% of the load there is no much difference for all the tested fuels.

![Figure 6. CO emission variation](image)

3.5 UBHC emission

Figure 7 shows HC emissions variations for diesel, biodiesel and its blend. There is rise in hydrocarbon emissions for B20 and B100 are higher at loads from 75% to 100%. Elevated combustion temperature and oxygen content availability in the biodiesel which promote the oxidation of hydrocarbon emissions. At a lower load, the B20 and B100 are having lower HC emissions compared to diesel.

![Figure 7. UBHC emission variation](image)
3.6 NOX Emission

NOx emission variation for diesel, B100 and B20 are shown in Figure 8. Cetane number influences the NOx emissions for CI engines. Higher EGT and higher NOx formation are occurs owing to the lower value of cetane number causes the increase in ignition delay for B20 and B100, but when it compared with neat diesel the magnitude was low.

![Figure 8. NOx emission variation](image)

3.7 Smoke emission

Figure 9. shows the density of smoke variation with diesel, biodiesel and its blend. The density of the smoke decreases for B20 and B100, owing to the availability of lesser carbon content in the biodiesel and its blend.

![Figure 9. Smoke emission variation](image)
4. Conclusion

In this work, performance and emissions of a DI compression ignition engine running on B100, B20 were examined and compared with diesel.

The conclusions were summarized as follows:

- due to diminished atomization and poor fuel vaporization, B100 and B20 brake thermal efficiencies are lower at higher loads than the diesel fuel.
- B20 blend fuel, exhaust temperature is lower compared to the tested other two fuels at all the engine load.
- The density of the smoke decreases for B20 and B100. The availability of low carbon content in the biodiesel noticed that delivered very low smoke density emission.

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