Performance and emission characteristics of citronella oil as an alternative fuel

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Abstract. The diesel engine fuelled by direct injection with DEE and biodiesel mix of Citronella oil is observed for performance and emission. The properties of Citronella biodiesel fuel are observed and blended with diesel fuel in diverse ratio. Also the experiments were conducted with and without Diethyl Ether additive. As the citronella is available crop all over the globe and especially in India, the source would be perennial. Based on the experimental result, graphs were plotted to indicate the performance and it is found that the emission of carbon monoxide (CO), Carbon dioxide (CO₂), Oxides of nitrogen (NOₓ), Unburnt hydrocarbons (HC) and smoke were less compare with base fuel.

Key words: Citronella oil, diesel, Diethyl Ether, Performance, Emission

1. Introduction

The world is facing many challenges with limited available sources in automobile field particularly in engine fuels. The requirement of the combustible fuels has been enormously increasing day by day and the quest for alternative fuels is enlarged. The advancement in science and technology as made the exploration on the possibilities of using the non-fossil fuels for engine combustion. Among the non-fossil fuels, bio-fuels are gaining more importance due to its better properties. In this project an attempt will be made on systematic investigation of combustion ignition engine with different bio fuel blends.

In modern days, a lot of attempt has been taken to downsize the actual need of fossil fuels. The approaches towards the biofuel have leaped a greater effort and betterment in the applications. The bio based fuels may also develop the agricultural sector in increasing the utilization of fuel crops. Bio-fuel is a vital alternative fuel for internal combustion engines, though there are few major limitations in production, cost and maintenance. Citronella oil has a rose like odour and bitter taste [1-2].

The extensive augment in the requirement for essential oils is related to the expansion of customer industry which in turn is related with the growing purchasing power. Citronella oil is being produced in the north-eastern states of India [3-4]. Considering the incentives offered by the Government for exports, an export demand of 1000 tpa may exist. The most favorable planting period of citronella is during April to September though planting during other seasons is also possible with irrigation [5-6].

The Regional Research Laboratory, Jorhat is producing citronella oil. Extraction of citronella oil is a distillation process. Renewable fuels may also significantly aid to reduce the global...
climate change. Ethanol is not premium compression-ignition oil. Diethyl ether (DEE) is well known cold start aid and the same could be used as a blend with diesel fuel [7-8]. Dimethyl ether is a low-emission, high-quality diesel fuel replacement. DEE or simply ether is an organic compound in ether class. It is a monochrome, highly impulsive inflammable liquid.

The objective of the paper is diesel engine fuelled by direct injection with and without Diethyl Ether (DEE) and biodiesel mix of Citronella oil is observed for performance and emission

2. Materials and methods

The determination of density, calorific value, viscosity, flash point and fire point are carried out using a hydrometer, a Redwood viscometer, a bomb calorimeter and Pensky–Martin’s closed cup apparatus respectively. It is observed that properties like density, viscosity, flash point and fire point of Citronella oil is higher whereas the calorific value is lower when compared with diesel. Table 1 shows the physicochemical properties of Citronella oil and diesel

| Fuel properties                | Diesel | Citronella oil |
|-------------------------------|--------|----------------|
| Kinematic viscosity, cSt at 40°C | 3.9    | 52.4           |
| Specific gravity at 15°C      | 0.84   | 0.94           |
| Flash point, °C               | 56     | 94             |
| Fire point, °C                | 64     | 100            |
| Calorific value kJ/kg         | 44500  | 41400          |
| Density, kg/m³                | 0.83   | 0.89           |

3. Experimental setup & observations

The proposed research was conducted in multi fuel variable compression ratio engine able of running with diverse fuel blends. The engine is attached with smoke meter and five gas analyzer with an ability of analyzing exhaust gases as well.

Table 2 Engine specifications

| Make/model | Kirloskar TAF 1 |
|------------|-----------------|
| Brake power (kW) | 3.8 |
| Rated speed (rpm) | 1500 |
| Bore (mm) | 87.5 |
| Piston type | Bowl-in-piston |
| Compression ratio | 17.5:1 |
| Nozzle opening pressure (bar) | 220 |
| Injection type | 23 BTDC |

Before commencing experiments, the proper conditions of the test engine are checked for correctness. The engine was tested at different load conditions 0 kg, 3 kg, 6 kg and 9 kg at different blend ratios. The blend ratios were 80:20 and 60:40. The experimental trial was conducted first without Diethyl ether as additive and later with Diethyl ether for the above mentioned blend ratios. : hydrocarbon (HC) emission, carbon monoxide (CO) and carbon dioxide emission, nitrogen oxides (NOX) emission and smoke emission and Smoke were measured for the blend ratios of 20 and 40 with and without DEE additive.
4. Results & discussion

4.1 Emission Analysis

The experiments were conducted with various blends of citronella oil and biodiesel fuel with and without DEE. The various parameters were analyzed. It is observed from fig. 1 that the CO Emission is comparatively decreasing and achieves saturation on constant increase in load condition. Similarly the HC Emissions levels are shown in Fig. 2 also lower for blends on comparison with Diesel fuel. The NOx are also reduced is shown in figures 3. It could be observed from the figure 1, 2, 3, without DEE and with DEE, that the emission levels are considerably decreasing for the blends and also assuring the possibility of using Citronella oil as an alternative to the fossil fuel. Mostly, In India the citronella oil is grown in North east, further research in using this oil would also help in developing agricultural prospects in these areas.

![Figure 1 CO Emission – Diesel and Citronella oil](image1)

![Figure 2 HC Emission – Diesel and Citronella oil](image2)

CO emission based on the citronella oil, the percentage volumetric of the CO emission as noted for pure diesel and citronella oil B20 and B40 with different blend is 0.55, 0.5, 0.49, 0.48 & 0.45 (% Vol) respectively. Similarly the Hydro Carbon (HC) emission noticed that parts per million is 38, 35, 32, 31 and 30 (PPM) respectively. The Nitric oxide (NOx) emission for pure biodiesel and Blended tyre oil is 428, 445, 472, 483 and 188(PPM). With an increase in load citronella oil B20 fuel compared to diesel fuel due to higher Nitric oxide content, the NOx emissions for citronella oil B40 and other blend increased compare to the other emission levels.
4.2 Performance Analysis

On contrast the Brake thermal efficiency is reduced for blends. When the same load conditions are analysed with DEE, the emission levels are further reduced that could be observed from figure 4 to 5.

Brake thermal efficiency is characteristics as how fuel energy is converted to the effective power. The effects of diesel, citronella oil B20 and B40 on brake thermal efficiency (BTE) versus engine load. Lower BTE was computed with B20 and B40 due to lower calorific value of waste tyre oil. Maximum BTE was obtained as 29.5% for B20 and pure diesel at 31.4 full engine loads. However BTE decreased by about 11.1% with B40 at the same engine load.

Specific Fuel Consumption (SFC), for biodiesel blends has been higher than the diesel, because of lower heating value of biodiesel. Compare to diesel fuel, a little amount of power loss
occurs in biodiesel blends due to higher viscosity and density. We have determined the optimum performance of this citronella biodiesel is obtained when 60% of diesel is blend with 10% of additive and 40% of citronella oil. Additive 10% of Diethyl Ether with blend of 40% citronella oil can be more secure for our environment because there not produce more amount of nitrogen oxides (NOx), carbonmono oxides (CO), carbon di oxides (CO2), hydrocarbons (HC). So, that the mixture of additive with oil is more useful and more advantage than normal diesel.

5. Conclusion
The performances of single cylinder four stroke diesel engines have been operated with different fuel blends at rated rpm and rated load conditions have been experimentally investigated in the present study and the following results were obtained.

HC (5%) and CO2 (6%) emissions were reduced in the 20% concentration of citronella oil with diesel. CO emission was as same as the emission of diesel. It showed that, there was very less chance for incomplete combustion than diesel fuel. NOx emission was increased by 26% for citronella oil when compared to the pure diesel.

Brake thermal efficiency (ηbth) slightly increases with 20% concentration of citronella oil-diesel blends as compared with pure diesel fuel. This is only because of the fuel properties such as lower density, lower viscosity and higher calorific value

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