Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 5, No. 1, May : 2023

EXPERIMENTAL INVESTIGATION OF PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE OPERATING ON LEMON GRASS OIL BLENDS.

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Abstract
This experimental work involves Performance and Emission analysis on Diesel engine Operating on varying blends (20 %, 30 % and 40 %) of Lemongrass oil with diesel. Raw lemongrass oil extracted through steam distillation was converted to biodiesel through a chemical process called transesterification. The experimental results reveal enhanced Brake Thermal Efficiency and reduced Brake Specific Fuel Consumption with the increment to Biofuel Blend percentage. On the emission front Carbon monoxide emission and Hydrocarbon emission decrease with increase of Biofuel percentage while Oxides of Nitrogen increase with the raise of Biofuel percentage.
Keywords: LGO, Brake Thermal Efficiency, Brake Specific Fuel Consumption.

I. Introduction

Alternative fuels have become increasingly important in recent years due to concerns over environmental pollution and the depletion of fossil fuels. Vegetable oils have emerged as a promising source for biodiesel production, which can be used as an alternative to conventional diesel fuel in internal combustion engines (IC engines).

A number of studies have investigated the performance and emissions characteristics of IC engines fueled with biodiesel produced from different vegetable oils. Prabhu et.al (2017)(1) studied the performance and emission characteristics of a diesel engine fueled with biodiesel derived from waste cooking oil. Yesilyurt, M. K. (2019) (2) characterized and utilized biodiesel produced from waste cooking oil and studied the effects of preheating the waste cooking oil biodiesel-diesel blends on engine performance and emissions.

Vellaiyan (2020)(3) and Serac et al. (2020) (4) investigated the combustion performance and emissions of a diesel engine fueled with biodiesel derived from soybean oil. Rajesh et.al (2020) (5) and Jena et.al (2020) (6) studied the utilization of karanja oil biodiesel in a diesel engine, while Arun Kumar et.al (2021) (7) investigated the use of castor oil biodiesel.

Rosha et.al (2019) (8) and Uslu et.al (2020) (9) investigated the performance and emissions characteristics of a diesel engine fueled with crude palm oil biodiesel. In addition, Nanthagopal et al(2019) (10) and Sharma et.al (2019) (11) studied the utilization of Calophyllum inophyllum biodiesel in a diesel engine.

A comparative study on the effects of biofuels on engine performance and exhaust emissions was conducted by Rajak et al. (2019) (12).

These studies collectively demonstrate the potential of vegetable oils as a viable alternative to diesel fuel. In this research work, the performance and emission analysis of a diesel engine fueled with a blend of lemon grass oil and diesel (20%, 30%, and 40%) will be investigated. Lemon grass oil is a potential source for biodiesel due to its unique properties such as high oxygen content, low sulfur content, and high cetane number, which make it an attractive option for use in diesel engines. The

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investigation will provide insights into the feasibility of using lemon grass oil as a fuel source and its potential as a sustainable alternative to diesel fuel.

II. Material and Methods

2.1 Extraction and Transesterification

Lemongrass oil was extracted using steam distillation method. In the steam distillation method, the plant material is placed in a distillation chamber, and steam is passed through it. The steam carries the volatile oil with it and is then condensed to form a liquid. The liquid obtained is then separated into the lemongrass oil and water. The extracted lemongrass oil was then be used for the production of biodiesel.

The production of biodiesel from lemongrass oil involves the transesterification process. In this process, the lemongrass oil is mixed with methanol in the presence of a catalyst (usually NaOH). The reaction involves the replacement of the ester group of the lemongrass oil with the alcohol group from the methanol molecule. The resulting mixture separates into biodiesel and glycerol. The biodiesel was then washed with water to remove impurities, neutralized with acid to remove any remaining catalyst, and dried to remove any remaining water. The resulting biodiesel is a renewable, non-toxic, and biodegradable alternative to fossil fuel-derived diesel.

$$3\ RCOOR' + 3\ CH_3OH \rightarrow 3\ RCOOCH_3 + R'OH + 3\ NaOH$$

where R and R' are the hydrocarbon chains of the fatty acid components of the lemongrass oil and the alcohol, respectively.

Table 1. Physiochemical Properties of Blends Used

PROPERTIES	DIESEL	LGO	LGO 20%	LGO 30%	LGO 40%
Flash point ^{o}c	62	50	52.4	53.6	54.8
Fire point ^{o}c	70	56	58.8	60.2	61.6
Kinematic viscosity	2.75	4.8	4.39	4.185	3.98
Calorific value(MJ/KG)	43.8	37.1	38.44	39.11	39.79
Density @20^{o}c(kg/m^3)	830	980	950	935	920

2.2 GCMS of Lemon Grass Oil

GCMS analysis of Lemon Grass Oil is a technique used to separate and identify the chemical components of the oil. Lemongrass oil is an essential oil that is extracted from the leaves and stalks of the lemongrass plant. It is commonly used in aromatherapy and in the food industry as a flavoring agent.

The GCMS analysis of lemongrass oil typically involves the following steps:

1. Sample preparation: The oil is extracted from the plant material using a solvent such as hexane or ethanol. The solvent is then evaporated to leave behind the oil.
2. Gas chromatography: The lemongrass oil is then injected into a gas chromatograph, which separates the different chemical components of the oil based on their boiling points and other properties.
3. Mass spectrometry: The separated components are then analysed using mass spectrometry, which identifies the chemical structures of each component based on their molecular weight and fragmentation patterns.

The results of the GCMS analysis of lemongrass oil typically show that it contains a number of different compounds, including Oleic acid, Stearic acid and Palmtic acid. The Oxygen content in lemon grass oil suggests it is suitable for combustion.

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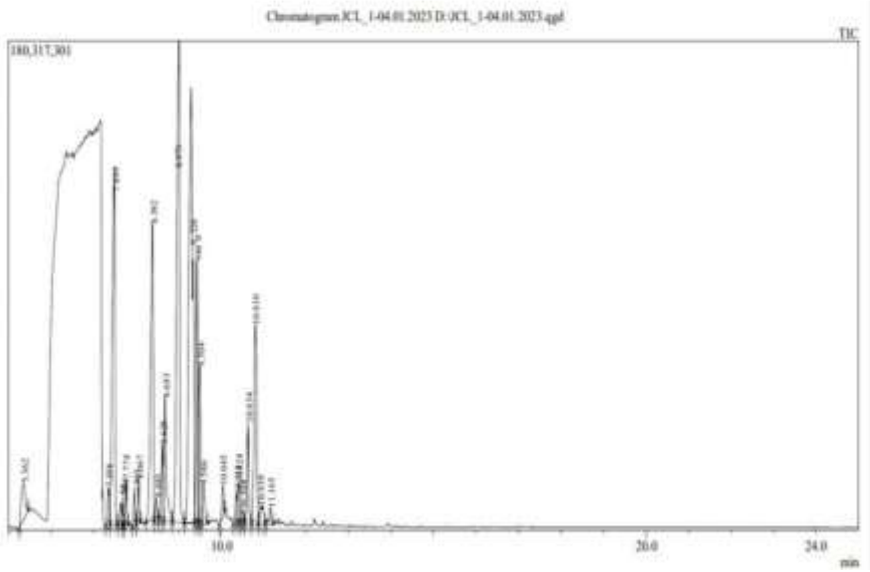

Figure 1 GCMS Analysis of LGO

III. Engine and Emission Measuring Instruments

The experiments are carried out in single cylinder diesel engine with Computerized data acquisition system of specifications as given in table. Emissions are recorded using AVL Gas Analyzer and smoke meter.

Table 2. Specification of Engine

Type	DI Diesel engine
Strokes	4
Cooling	Water cooled
Max.Power	3.5 kW
Rated Speed	1500 rpm
Diameter of Cylinder Bore	0.085 m
Stroke Length	0.112 m
Compression Ratio(r)	17:1

IV. Results and Discussions

4.1 Brake Thermal Efficiency

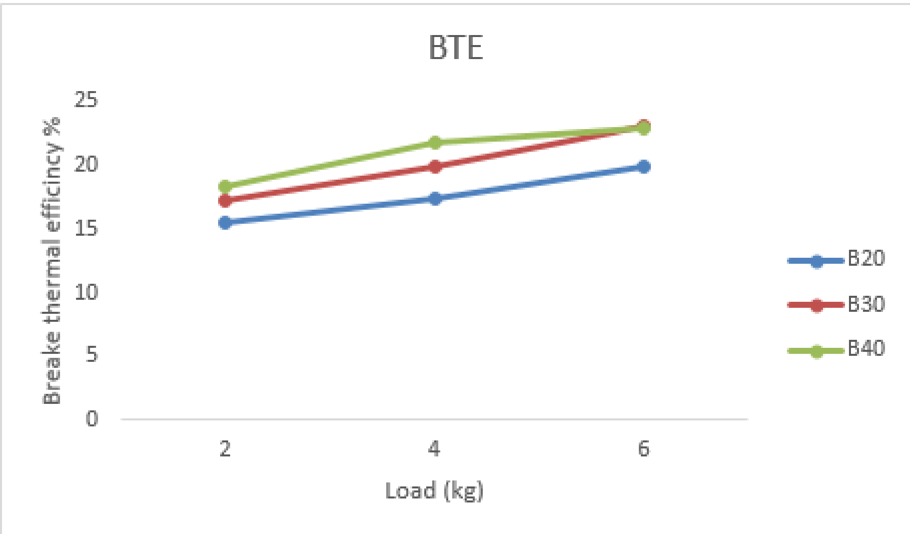

Figure 2 LOAD vs BTE

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ISSN: 0970-2555
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Brake Thermal Efficiency is the mathematical representation of fraction of energy supplied to engine as fuel converted as power in crank shaft. The increase of Thermal efficiency with load across all blends may be due to higher temperatures with increasing loads make the combustion complete hence increasing the efficiency(13). Brake Thermal Efficiency was found to increase with increase of Lemon Grass Oil Blend owing to its higher Oxygen Content in the form of fatty acids(14).

4.2 Brake Specific Fuel Consumption.

From the above plot it is evident that Brake Specific Fuel consumption decreases with increase of load. As the load on the engine increases, the combustion process becomes more efficient, resulting in a decrease in BSFC. This is because a higher load requires more fuel to be injected into the engine, and the combustion process becomes more complete at higher loads, resulting in more mechanical work being produced for the same amount of fuel consumed(15). The increase of Brake specific Fuel Consumption with increase of Biofuel Blend may be attributed to the lower Calorific value of Lemon Grass oil as compared with Diesel (16)

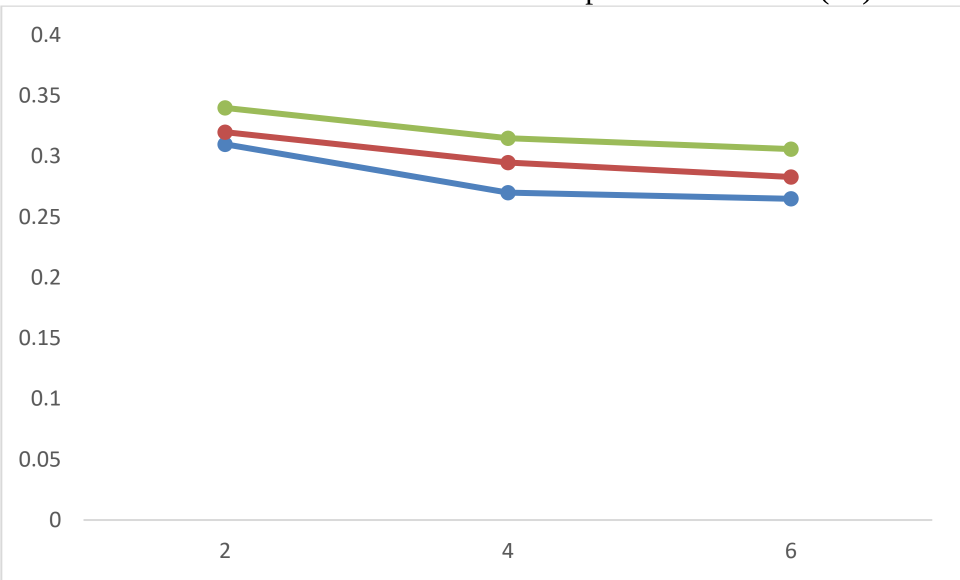

Figure 3 LOAD vs BSFC

4.3 Carbon Monoxide Emissions

Emissions are inevitable bi products of combustion process. Carbon Monoxide emissions are products of incomplete combustions. From the plot we could decipher that with increase of engine load CO emissions increases. The above phenomenon may be due to shortage of requisite air for combustion at higher temperature owing to higher loads (17). Prescence of in bound Oxygen content in form of fatty acid in Lemon Grass Oil promotes better combustion as Biofuel blend increases leading to decreased Carbon Monoxide emissions(18)

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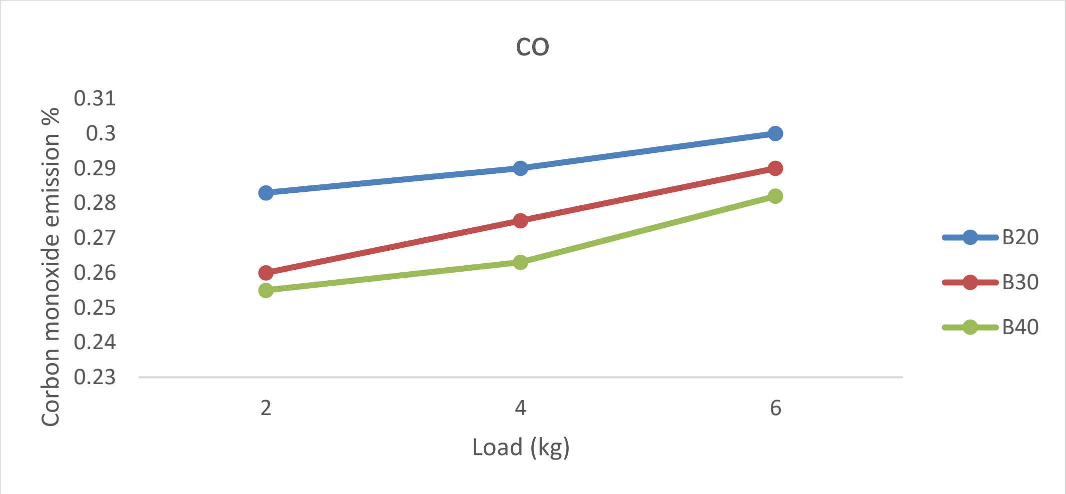

Figure 4 LOAD vs CO

4.4 Hydrocarbon Emissions

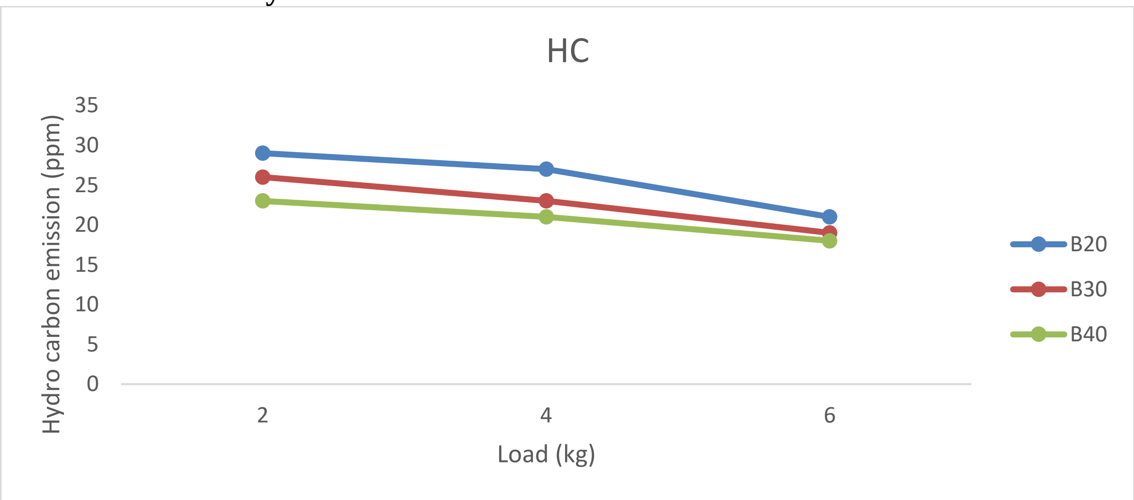

Figure 5 LOAD vs HC

Hydrocarbon Emissions are formed due to in-efficient combustion as result of shortage of Oxygen for combustion. With increase of Load, Hydrocarbon emission decreases. As a result of higher oxygen content in the fuel Hydrocarbon emission decreases with augmentation of Biofuel blend percentage (19 & 20).

4.5 Oxides of Nitrogen emissions

Nitrogen oxides (NOx) are a group of highly reactive gases that are formed during the combustion process in internal combustion (IC) engines. NOx emissions are a significant environmental concern because they contribute to the formation of photochemical smog and acid rain, and are also harmful to human health. Nitrogen Oxide emissions increases with the augmentation of load as a result of increased engine temperatures (21). With the increase of Biofuel percentage Oxides of Nitrogen increases as a result elevated combustion temperature as a result of High oxygen content in fuel (22).

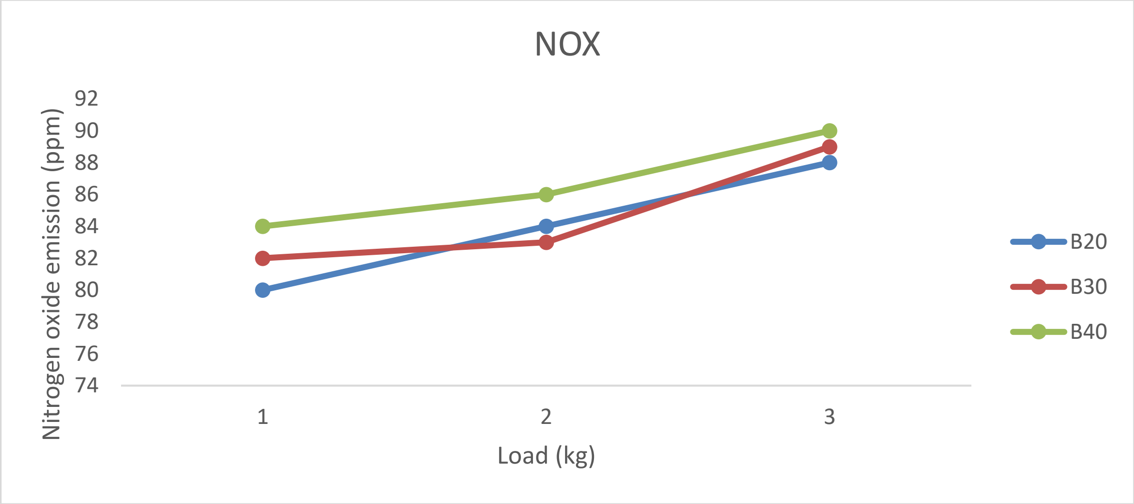

Figure 6 LOAD vs NOx

V. Conclusions

The experimental investigations were performed in single cylinder Diesel engine with varying blends of Lemon Grass Oil biodiesel. The results inferred are stated below.

- Raw lemon Gas Oil was converted into Lemon Grass Oil Methyl Ester through a chemical process called Transesterification. The physiochemical properties of blends in the investigation were examined and conformance with ASTM standards were confirmed.
- Brake Thermal efficiency increases with increase of load. Highest Brake Thermal Efficiency was observed while operating in 40 percent blend of Lemon Grass Oil methyl ester with diesel.
- Brake specific Fuel Consumption was maximum for 40 percent blend of Lemon Grass Oil methyl ester with diesel as a reflection of lower Calorific Value of LGO as compared to Diesel.
- CO and HC emissions which can be inferred as products of incomplete combustion decreases with increase of Biofuel percentage while NOx emissions increase with increase of Biofuel percentage.

In future the experiments may be performed with increased blend ratios and varying engine parameters such as Nozzle configuration, Compression ratio, Combustion Chamber Geometry along with Optimization of significant parameters.

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