Effects of Lemongrass Oil as Fuel in Diesel Engine

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Abstract: *The rapid increase of diesel engines and diminishing of diesel fuel creates a challenge for researchers to find alternative fuel. The present experiment is performed on a 3.5 kW diesel engine. Here, diesel is replaced with pure lemongrass oil (LGO) of10%, 20%, and 30% by volume with diesel. The obtained data from the experimental work may exhibit the Brake Thermal Efficiency (BTE) of LG20 equivalent to pure diesel. The specific fuel consumption (SFC) of LGO blends shows an increase compared to diesel, due to the lower heating value for LGO blends. On the other hand, LGO blends show lower emissions of NO_X, due to the lower peak flame temperature. When compared to the other samples, the LG30 gives a maximum reduction in NO_X emissions; of 10.33%. When compared to biodiesel blends, diesel fuel shows a significant increase in the Net Heat Release rate (NHR).*

Key Words: *lemongrass oil, performance, emission, combustion, diesel engine, specific fuel consumption*

1. INTRODUCTION

In previous periods, the diesel price was very low and its availability was higher. After the 19^{th}century, the diesel price has risen steadily to the present days [1]. So, researchers are trying to adopt a variety of fuels i.e. biodiesel, gaseous fuels, alcohols, etc. The biodiesel was first invented by a Belgian in 1937 [2].

There has been more research on biodiesel as a fuel in CI engine in which the percentage has been varied by 5% to 100%. Biodiesel has shown increased performance and reduced emissions. The different types of biodiesel fuels like cotton seed oil, jatropha oil, lemongrass oil, mahuaoil, palm oil, Neem oil, etc are widely used in current researches [3].

Nurun Nabi et al. [4] observed a lower thermal efficiency of biodiesel produced from cottonseed oil than that of the diesel fuel. Particles and smoke were reduced by 24% and 14% for 10% biodiesel. On the other hand, CO also decreased by 24%, and NO_X increased by 10% to 30% for biodiesel.

Mohamed Saied Sheath [5] investigated a diesel engine fuelled with various biodiesel. They noticed that braking power (BP), BTE decreased for biodiesel (palm, cotton, flax) due to their lower heating values. The emissions of CO decreased and NO_X increased for biodiesel fuels. Rashed et al. [6] found lower BP and an increase in BSFC for biodiesel (palm, and jatropha). The emissions of CO showed a reduction from 32.65 to 22.93%, HC increased largely/greatly from 11.84 to 30.26% and NO emission increased slightly from 6.91 to 18.56% compared to diesel fuel.

Avinash Alagumalai [7] observed a reduction of work per cycle due to the lower NHR and an increased rate of pressure when using the lemongrass oil as fuel, due to the effect of mechanical stress on the crank drive.

It has been observed that NO_X and smoke emissions are reduced in dual fuel mode. Sathiyamoorthi et al. [8] experimented with a diesel engine and found a slight enhancement of BTE and BSFC for lemongrass oil blends.

The emissions of unburnt HC reduced and NO_X increased for lemongrass oil-diesel blends. Ashfaque Ahmed et al. [9] investigated using lemongrass as fuel for a diesel engine. They observed that there was an increase in BTE for blended lemongrass oil (B100).

The SFC is higher for blended lemongrass oil (B20 and B60) compared to diesel. Sathiyamoorthi et al. [10] further investigated using additives in a diesel engine and found that BTE increased for LG025 (lemongrass oil 25%) with additives.

Acharya et al. [11] investigated the oxidation stability of jatropha biodiesel and they found an improvement when the jatropha was added with mahua biodiesel. Mathan Raj et al. [12] found that BTE has increased significantly with the addition of 5 and 10% of iso-butanol with biodiesel.

The emissions of NO_X decreased and HC increased due to iso-butanol content in blends. Madiwale et al. [13] investigated the fuel properties like density and heat content when biodiesel was mixed with the ethanol.

They found that there was a reduction in density and kinematic viscosity. This gives a better spray pattern and enhanced the quality of combustion.

Senthil Raja et al [14] observed the increase in BTE and BSFC with a rise in the amount of ethanol. Basavaraj Shrigiri et al. [15] conducted experiments on Low Heat Rejection (LHR) engine.

They found lower BTE for the LHR engine fuelled with methyl esters.

2. METHODOLOGY

2.1 Lemongrass oil ($C_{10}H_{16}O$)

Lemongrass has a fast-growing nature and is suitable for Indian climatic conditions. It is generally extracted by a steam distillation process; it contains around 75% of Citral.

The chemical compositions of lemongrass oil are citral, farnesol, nerol, citronellal, and geranyl acetate.

The pure lemongrass oil was used for the blending with diesel without any transesterification process.

2.2 Fuel properties

The various properties of the diesel and bio diesel samples were measured by using various apparatus.

Density was measured by the volume mass basis, the viscosities of fuels were measured by using Redwood viscometer 1 and the calorific value was determined by using bomb calorimeter.

Flash and fire points were measured by using the Pensky Martens apparatus [16]. The fuel properties are shown in Table 1.

Table 1: Properties of fuels

S. No.	Type of fuel	Density (kg/m^3)	Calorific Value (kJ/kg K)	Flash Point (°C)	Fire point (°C)
1	Diesel	830	43,962	52	58
2	LG10 (10% LGO+ 90% diesel)	847	42,251	57	62
3	LG20 (20% LGO+ 80% diesel)	866	41,319	59	64
4	LG30 (30% LGO+ 70% diesel)	887	40,938	61	66

2.3 Research setup

Experimental work runs on a water-cooled diesel engine with a hydro dynamometer loading system. The research engine was connected to the piezoelectric pressure transducer for measuring the diesel line and cylinder pressures with a data acquisition system.

The engine was operated at various loads from the no-load condition to full load. Figure 1 shows the engine setup.

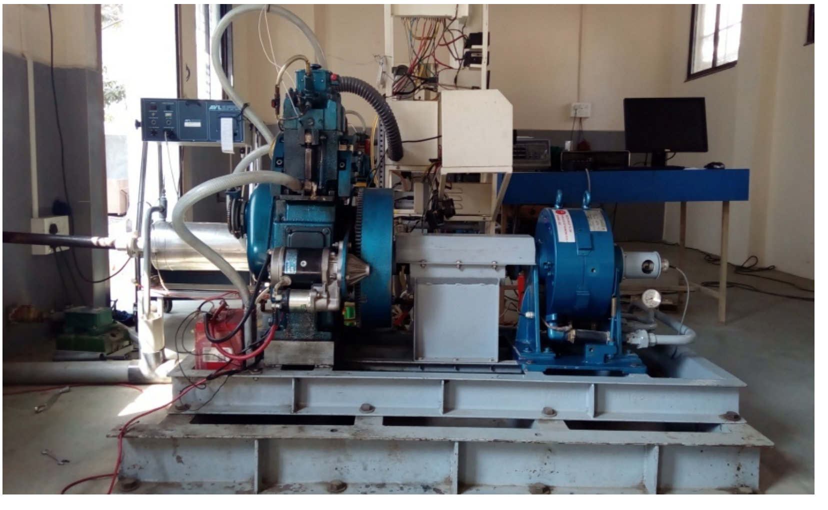

Figure 1. Engine Setup

3. RESULTS AND DISCUSSIONS

The various blends such as LG10, LG20, and LG30 were fuelled in the diesel engine. The obtained results of the blends were compared with the diesel fuel operation in terms of performance, emission, and combustion characteristics.

3.1 Performance Parameters

3.1.1 Brake thermal efficiency

Figure 2 shows a comparison between the load and the brake thermal efficiency. The LGO blends have shown lower BTE than the diesel fuel by the effect of lower heating value and higher density of blends [17]. From the results, it is noted that the BTE for diesel is higher than the blends of lemongrass oil. Here, LG 20 gives quite similar trend to the diesel BTE. This is high as compared to the remaining LGO blends.

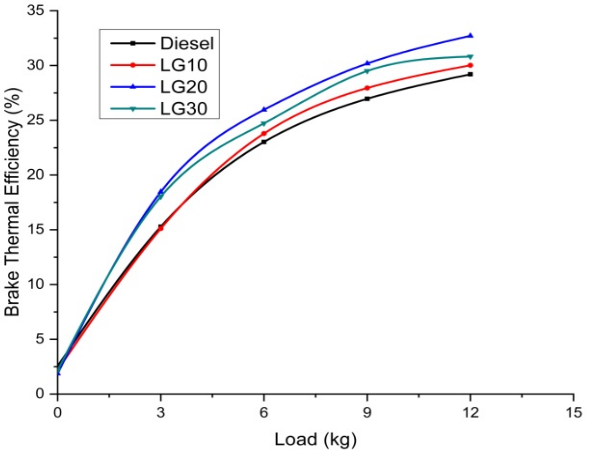

Figure 2. Load versus BTE

3.1.2 Specific Fuel Consumption

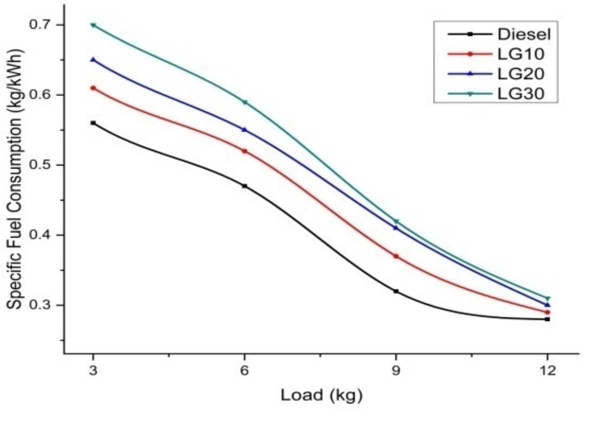

Figure 3. Load versus SFC

SFC is a significance of the fuel efficiency about burns fuel and produces power [18]. Figure 3 depicts the relation between SFC and Load. Specific fuel consumption if very high for diesel as compared to other Lemon Grass oils due to its high calorific value. The fuel consumption of LG30 showed higher SFC than the other samples, being around 10.71% higher than the neat diesel operation BSFC.

3.2 Emission Parameters

3.2.1 NO_X Emissions

Specifically, the flame temperature is directly responsible for the formation of nitrogen oxide. Figure 4 shows NO_X emissions for different load conditions. It is evident from the figure that diesel gives higher NO_X emission when compared to other biodiesel blends, due to the effect of lower NHR of LGO blends. It is observed that LG 30 gives 10.33% less NO_X emissions than the diesel.

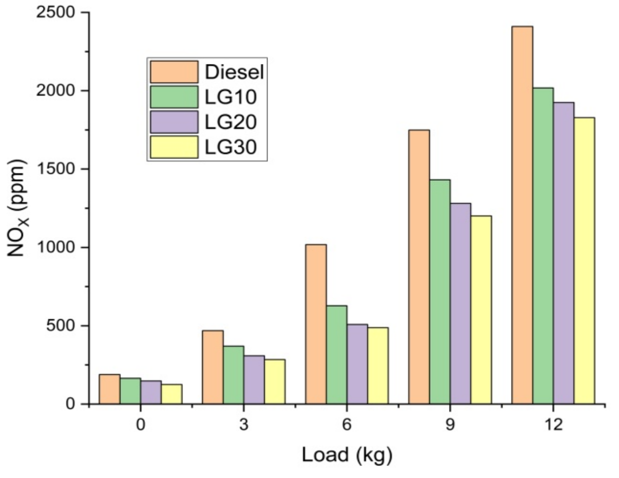

Figure 4. Load versus NO_X emissions

3.2.2 HC Emissions

Inadequate combustion of the fuel leads to the unburned hydrocarbons (HC). Figure 5 depicts the HC emissions for the pure diesel and LGO blends at various loads. The HC emissions show a continuous increase with increasing load. HC emissions are less for diesel than for the LGO blends and the HC emissions increase with the increase of LGO blend. The blend LG30 showed 17.24% higher HC emissions than the pure diesel.

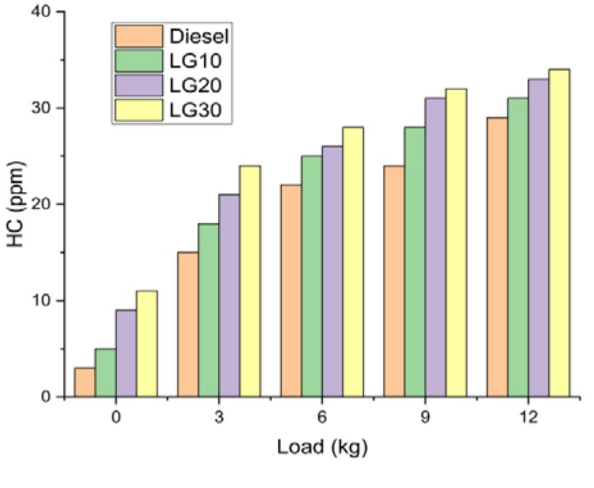

Figure 5. Load versus HC emissions

3.2.3 Smoke

Smoke is an important aspect while discussing emissions. Figure 6 focused on the behaviour of smoke for several fuel samples. According to the results, diesel operation discharges more amounts of smoke emissions when compared to the LGO blends. LG 20 gives a maximum reduction of smoke compared to the other fuel samples. LG 20 showed 23.27% lower smoke percentage of diesel.

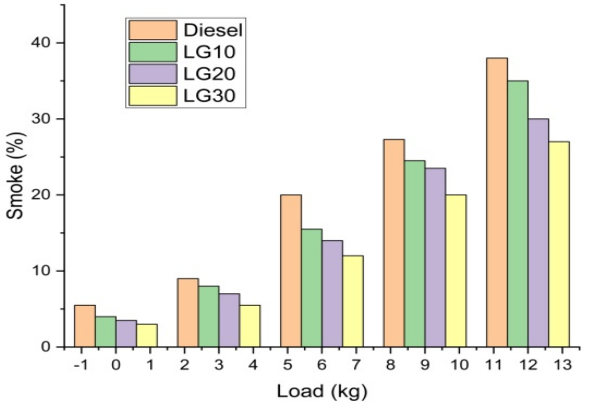

Figure 6. Load versus Smoke

3.3 Combustion Parameters

3.3.1 Cylinder Pressure

The pressure developed inside the cylinder was analysed by crank angle encoder with the data acquisition system. The Graph 7 depicts similar path for all samples of fuel, it correlates crank angles with cylinder pressure. The diesel fuel operation showed the lower cylinder pressure than the other fuel samples. LG20 expressed a higher cylinder pressure than the other sample fuels because of the higher oxygen content in the LGO blend.

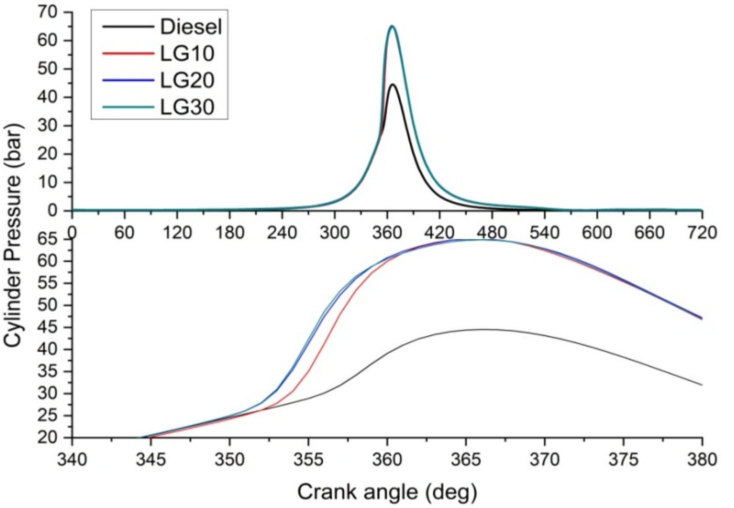

Figure 7. Crank Angle versus Cylinder Pressure

3.3.2 Net heat release rate

The crank angle data play a key-role in interpreting the combustion phenomenon of the engine. The behaviour of Net heat release rate at a different crank angle is shown in Figure 8. It is observed that all the fuel blends follow the same path. However, the net heat release rates of lemongrass oil blends are lower than diesel. This is because of their lower heating value and higher density.

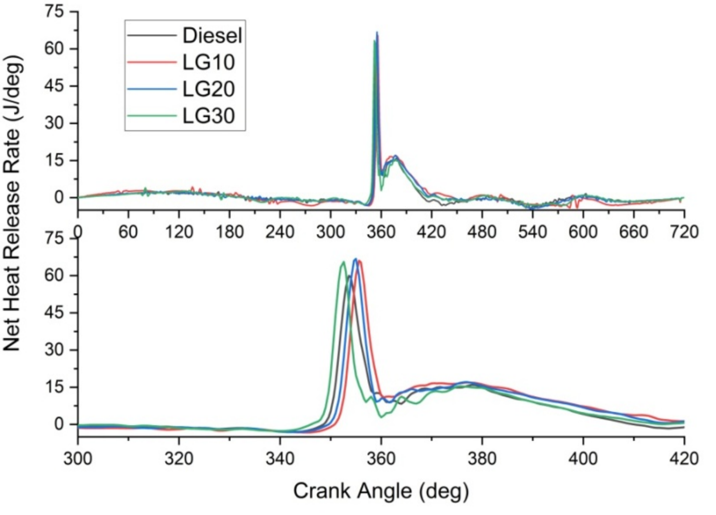

Figure 8. Crank Angle versus Net Heat Release Rate

4. CONCLUSIONS

Based on the above experimental investigation, the following conclusions can be drawn.

i) The lemongrass oil does not require any transesterification process when used as a fuel in an engine.

ii) The BTE of LG20 blend is approximately equal to that of the diesel fuel and higher than in case of the other samples.

iii) The lemongrass oil blends emit a reduced amount of NO_X when compared to the diesel fuel. LG30 gives an utmost reduction of NO_X compared to the other samples.

iv) LG 20 emits the lower amount of smoke compared to other samples.

v) The heat release rate of lemongrass oil blends is slightly lesser than for the diesel fuel.

REFERENCES

[1] R. K. Gopidesi and P. S. Rajaram, A Review on Emulsified Fuels and Their Application in Diesel Engine, *Int. J. Ambient Energy*, https://Doi.Org/10.1080/01430750.2019.1667435, pp. 1–9, 2019.

[2] R. K. Gopidesi and S. R. Premkartikkumar, Evaluating the Characteristics of a Diesel Engine Fuelled with Water in Diesel Emulsion and Hythane Gas in a Dual-Fuel Mode, *Int. J. Ambient Energy*, https://Doi.Org/10.1080/01430750.2019.1670258, pp. 1–5, 2019.

[3] S. R. Premkartikkumar and R. K. Gopidesi, Review on Effects of Performance, Emission and Combustion Characteristics of Emulsified Fuel in Bifuel Engine, *Prog. Ind. Ecol. An Int. J.*, Vol. **12**, No. 1/2, P. 59, 2018.

[4] M. N. Nabi, M. M. Rahman, and M. S. Akhter, Biodiesel from Cotton Seed Oil and its Effect on Engine Performance and Exhaust Emissions, *Appl. Therm. Eng.*, Vol. **29**, No. 11–12, pp. 2265–2270, 2009.

[5] M. S. Shehata, Emissions, Performance and Cylinder Pressure of Diesel Engine Fuelled by Biodiesel Fuel, *Fuel*, Vol. **112**, No. X, pp. 513–522, 2013.

[6] M. M. Rashed, M. A. Kalam, H. H. Masjuki, M. Mofijur, M. G. Rasul, and N. W. M. Zulkifli, Performance and Emission Characteristics of a Diesel Engine Fueled with Palm, Jatropha, and Moringa Oil Methyl Ester, *Ind. Crops Prod.*, Vol. **79**, pp. 70–76, 2016.

[7] A. Alagumalai, Combustion Characteristics of Lemongrass (Cymbopogon Flexuosus) Oil in a Partial Premixed

Charge Compression Ignition Engine, *Alexandria Eng. J.*, Vol. **54**, No. 3, pp. 405–413, 2015.

[8] R. Sathiyamoorthi and G. Sankaranarayanan, Experimental Investigation of Performance, Combustion and Emission Characteristics of Neat Lemongrass Oil in Di Diesel Engine, *Int. J. Curr. Eng. Technol.*, Vol. **1**, No. 3, pp. 25–30, 2014.

[9] D. Ganjewala, Cymbopogon Essential Oils : Chemical Compositions and Bioactivities, *Int. J. Essent. Oil Ther.*, Vol. **3**, No. April 2009, pp. 56–65, 2009.

[10] R. Sathiyamoorthi and G. Sankaranarayanan, Effect of Antioxidant Additives an the Performance and Emission Characteristics of a Dici Engine Using Neat Lemongrass Oil-Diesel Blend, *Fuel*, Vol. **174**, pp. 89–96, 2016.

[11] N. Acharya, P. Nanda, S. Panda, and S. Acharya, A Comparative Study of Stability Characteristics of Mahua and Jatropha Biodiesel and Their Blends, *J. King Saud Univ. - Eng. Sci.*, 2017.

[12] V. Mathan Raj, L. R. Ganapathy Subramanian, and G. Manikandaraja, Experimental Study of Effect of Isobutanol in Performance, Combustion and Emission Characteristics of Ci Engine Fuelled with Cotton Seed Oil Blended Diesel, *Alexandria Eng. J.*, 2017.

[13] S. Madiwale, A. Karthikeyan, and V. Bhojwani, Properties Investigation and Performance Analysis of a Diesel Engine Fuelled with Jatropha, Soybean, Palm and Cottonseed Biodiesel Using Ethanol as an Additive, *Mater. Today Proc.*, Vol. **5**, No. 1, pp. 657–664, 2018.

[14] R. Senthilraja, V. Sivakumar, K. Thirugnanasambandham, and N. Nedunchezhian, Performance, Emission and Combustion Characteristics of a Dual Fuel Engine with Diesel–Ethanol – Cotton Seed Oil Methyl Ester Blends and Compressed Natural Gas (Cng) as Fuel, *Energy*, Vol. **112**, pp. 899–907, 2016.

[15] B. M. Shrigiri, O. D. Hebbal, and K. H. Reddy, Performance, Emission and Combustion Characteristics of a Semi-Adiabatic Diesel Engine Using Cotton Seed and Neem Kernel Oil Methyl Esters, *Alexandria Eng. J.*, Vol. **55**, No. 1, pp. 699–706, 2016.

[16] R. K. Gopidesi and N. R. Gangolu, Assessment Of Diesel Engine Characteristics Fuelled By Jatropha With Tamarind Seed Oil Biodiesel, *Incas Bull.*, Vol. **12**, No. 1, Pp. 51–57, Https://Doi.Org/10.13111/2066-8201.2020.12.1.5, 2020.

[17] R. K. Gopidesi and S. R. Premkartikkumar, Performance , Emission and Combustion Analysis of Diesel Engine Fuelled with Emulsified Biodiesel, *Prog. Ind. Ecol. – An Int. J.*, Vol. **13**, No. 3, pp. 292–301, 2019.

[18] R. K. Gopidesi, G. R. Sankar, A. D. P. Kumar, A. S. Kumar and B. Srimal, Evaluating the Performance and Emission Characteristics of CI Engine with Waste Plastic Oil, *International Journal of Mechanical and Production Engineering Research and Development,* Vol. **9**, issue 3, pp. 1015-1020, 2019.