Assessment of diesel engine characteristics fuelled by Jatropha with tamarind seed oil biodiesel

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Abstract: *The present experimentation is carried out on a diesel engine using biodiesel as a fuel. The combination of lemongrass and tamarind seed methyl ester has replaced the diesel at various percentages. This investigation used three blends of biodiesels i.e. 10% of mixed methyl ester and 90% of pure diesel (B10) similarly B20, and B30. From the obtained results it was observed the enhanced brake thermal efficiency (BTE) for biodiesel blends as compared to the diesel. The blend B20 shows enhanced BTE than other samples, being around 20% higher than the diesel. The biodiesel blends show a reduction in HC and CO emissions and enhancement in CO_2 and NO_X emissions than the diesel. The highest heat release rate observed for B20 at a crank angle of 355° is 68.77 J/deg.*

Key Words: *Performance, biodiesel, lemongrass oil, tamarind seed oil, emission, combustion*

1. INTRODUCTION

Energy plays a key role in the progress of the national economy, technology and industries [1]. At present energy is extremely dependents on the conventional energy sources like petroleum products, coal, and natural gases [2] which are limited in nature. Societies overall economic development both in urban and rural areas depend upon the wide use of energy devices in domestic purpose, industries, transportation and agriculture[3]. Nowadays the utilization of diesel engines is drastically increasing due to the higher fuel to power ratio [4]. However, diesel engines contribute heavily to environmental pollution and diesel fuel is diminishing rapidly. Bio-diesel is easy to utilize, biodegradable, non-toxic, and free of sulphur and aromatics [5].

The problems that occurred in CI engines by using neat vegetable oils are replaced by Bio-diesel derived from vegetable oils which were referred to as mono-alkyl esters of long chain fatty acid. Dhana Raju et al., [6] worked on a diesel engine by using nano-particles with tamarind seed fuel. From that they observed the maximum BTE around 36% for TSME20 ANP60ppm. And also, it showed lower HC and CO for the Alumina with a TSME20 biodiesel blend. Sathiyamoorthi et al., [7] evaluated the diesel engine fuelled with lemongrass oil with ethanol as fuel. From that, they noted enhanced combustion pressure, NHR and BTE when compared to the neat diesel operation.

On the other hand they found lower smoke and HC and higher NO_X and CO_2 exhaust emissions. Dhana Raju et al., [8] focused on tamarind seed methyl ester with Dimethyl carbonate (DMC) and 1-Pentanol as oxygenated fuel additives to evaluate the effect on a diesel engine. From that, they concluded the enhanced performance and lower emissions for TSME20-DMC 10% blend when compared to the neat diesel. Radha Krishna Gopidesi et al., [9] primarily focused on the impact of emulsified fuel in a diesel engine on environmental pollutant reduction. From that, they observed higher water content emulsified fuel showed the maximum diminishing of oxides of nitrogen (NO_X) emissions.

2. ENGINE SETUP AND METHODOLOGY

Initially, the diesel engine runs with diesel fuel at the no-load condition at a constant speed of 1500rpm until it reaches a stable position. After that, diesel was replaced by the lemongrass and tamarind seed oils biodiesel and the same tests were conducted without any modifications to the current diesel engine for the blend of 90% diesel and 10% biodiesel (B10), 80% diesel and 20% biodiesel (B20), and 70% diesel and 30% biodiesel (B30). The research engine setup is shown in Figure 1.

It is connected to the piezoelectric transducer for measuring the in-cylinder pressure and the fuel line pressure.

The AVL 444 Digas analyser is used for measuring the exhaust gas emissions; smoke and opacity are measured by an AVL smoke meter [10]. The various fuel properties are shown in Table 1.

Table 1. Fuel Properties

Property	Diesel	Lemon Grass Oil	Tamarind Seed Oil
Specific Gravity	0.826	0.902	0.896
Calorific Value	42531	36270	37490
Density	826	902	896
Flash Point	56	98	87
Fire Point	63	105	93

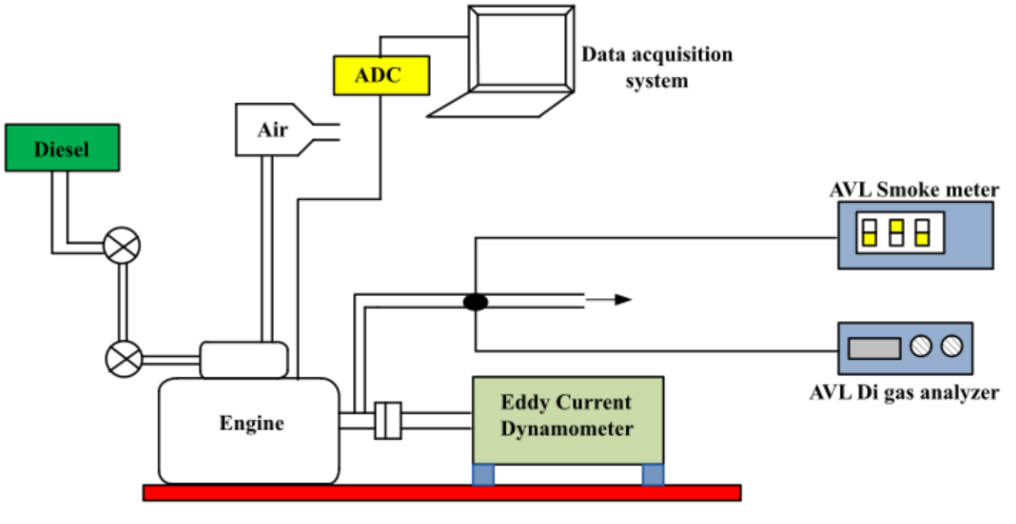

Figure 1. Research engine setup

3. RESULTS AND DISCUSSIONS

In this section mainly focuses on the three parameters, namely performance, emissions, and combustion characteristics.

3.1 Performance Characteristics

In this present section the performance characteristics of BTE and Brake Specific Fuel Consumption (BSFC) are discussed. The BTE represents the useful power developed from chemical energy. Figure 2 depicts the relation between BTE and Brake Power (BP). From that, one can observe higher BTE for biodiesel blends as compared to the neat diesel. This is because of higher oxygen content in the biodiesel.

The blend 20 showed the highest BTE as compared to the other blends and neat diesel. It is around 20% higher than the diesel with the effect of the higher net heat release rate of B20. BSFC is the quantity of fuel needed to produce the kW of power. Figure 3 showed the variation of BSFC for blended fuel and neat diesel to the BP.

For all the fuel samples BSFC is reduced with the increase of BP [11]. BSFC is very low for neat diesel when compared with biodiesel blends. This is because of the lower heating value of biodiesel blends.

The B30 showed the highest BSFC as compared to other samples, and it is approximately 39% greater than the neat diesel. Here, we observed the increase of BSFC with the rise of biodiesel content, with the effect of reduction in the lower heating value of the fuel.

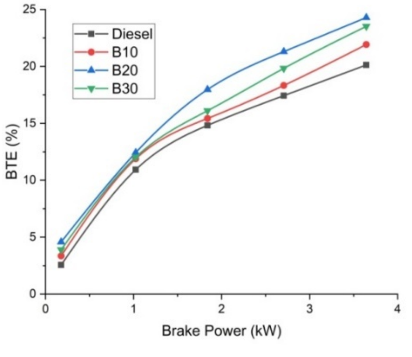

Figure 2. BP versus BTE

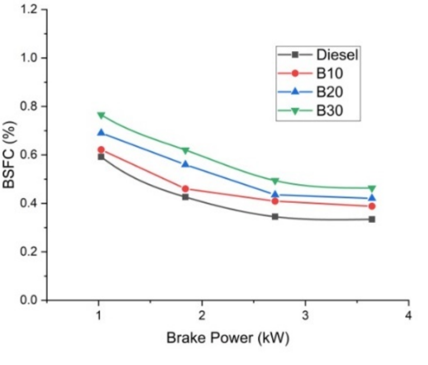

Figure 3. BP versus BSFC

3.2 Emission Characteristics

The diesel engines cause the continuous increasing of exhaust pollutants like CO, CO_2, HC, and NO_X.

3.2.1 Carbon monoxide (CO)

CO emissions result from the improper combustion of the fuel due to the lower oxygen content. Figure 4 depicts the CO emissions with BP for all the fuel samples and there are the same trend lines for all fuels. The CO emissions are reduced with the increase of BP due to the increase in the combustion rate.

The blends of biodiesel had shown lower CO emissions than the neat diesel operation with their higher oxygen content. The blendB30 showed the lowest CO emission percentage of all other samples. It showed a drastic reduction of CO emissions by around 69% than the neat diesel operation.

3.2.2 Carbon dioxide (CO_2)

The burning of fossil fuels in diesel engines contributes to a large amount of CO_2 emissions[12].

After industrialization, they increased a lot, with about 40% compared to the pre-industrialization period.

Figure 5 showed the CO_2 emissions with BP. The CO_2 emission is less for neat diesel when compared with biodiesel blends.

From the graph one can observe the same trend line for all the samples which increases with the rise in load.

The higher biodiesel blends showed an increase in CO_2 emissions. This is because of the higher oxygen content in the blended biodiesel. The blend B30 showed 24.16% higher CO_2 emissions than the neat diesel operation.

3.2.3 Unburned hydrocarbon (HC)

An unburned hydrocarbon represents the incomplete combustion of the fuel. Figure 6 depicts the unburned hydrocarbons with BP.

From that figure one can observe the continuous decrease of HC emissions with an increase of load due to an increase in combustion rate; there is the same trend for all fuel samples.

The biodiesel blend contains higher oxygen content so it gives lower HC emissions than the neat diesel operation.

The increase of methyl ester content in the biodiesel leads to the decrease in HC emissions [13]. Blend B30 showed the lowest HC emissions than the other biodiesel blends. B30 showed around 50% of HC reduction than the neat diesel operation.

3.2.4 Nitrous oxides (NO_X)

The higher combustion temperature leads to NO_X emissions. The combustion temperature increases with a rise in load on the engine. Figure 7 depicts NO_X emissions versus BP.

The NO_X emissions are lower for the neat diesel operation than the biodiesel blends. The increase in methyl ester in the biodiesel showed higher NO_X emissions.

This is the effect of higher oxygen content in the biodiesel. The diesel fuel showed the lowest NO_X emission of 775ppm at full load condition and B30 showed the highest NO_X emission of 993ppm.

It is around 19% higher than diesel.

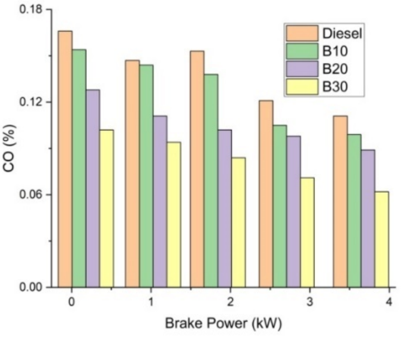

Figure 4. BP versus CO

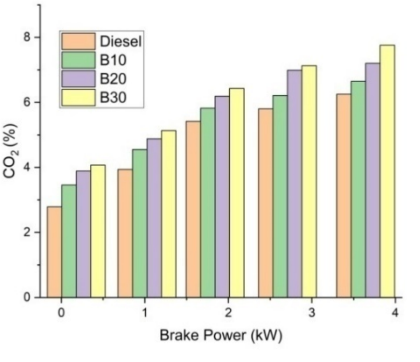

Figure 5. BP versus CO_2

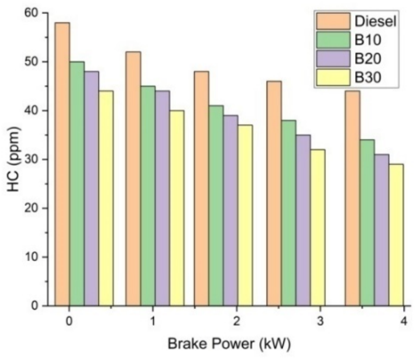

Figure 6. BP versus HC

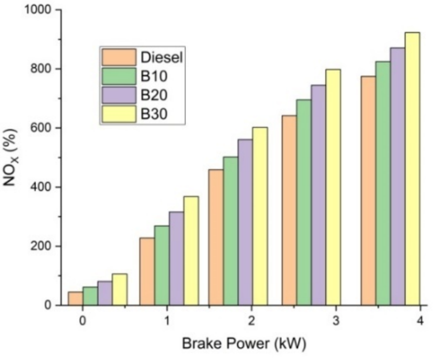

Figure 7. BP versus NO_X

3.3 Combustion Characteristics

3.3.1 In-cylinder Pressure

The quantity of fuel burnt in the combustion phase gives the expansion of pressure in a cylinder [14]. Figure 8 depicted the pressure variations with crank angle (CA) at full load. From that figure one can observe a similar trend pressure line for all tested fuels.

The peak in-cylinder pressure is found for the blend B20 when compared to the other samples. The highest in-cylinder pressure observed for B20 at a crank angle of 366° is 62.45 bars, which is slightly higher than the neat diesel operation by 3.81%.

3.3.2 Net Heat Release Rate (NHR)

The content of heat when the fuel burnt in the combustion chamber is known as the heat release rate. By using the 1st law of thermodynamics, the net heat release rate is estimated by analysing the available in-cylinder pressure [2].

The highest heat release rate observed for B20 at a crank angle of 355° is 68.77 J/deg. It happens for biodiesel blends with a higher oxygen content, at higher burning rate [15].

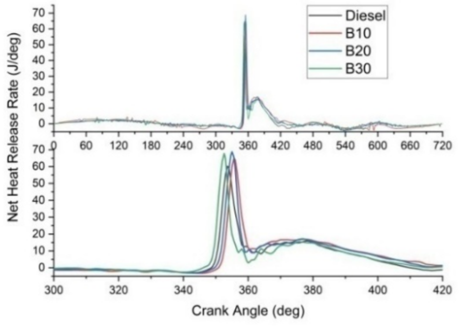

Figure 8. Crank Angle versus Net Heat Release Rate

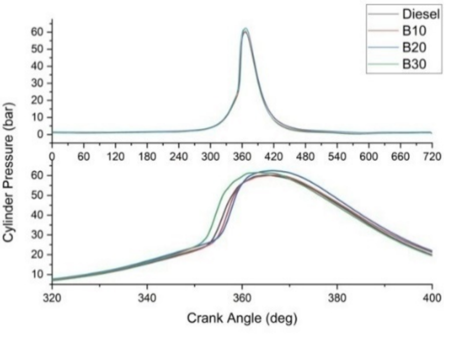

Figure 9. Crank Angle versus Cylinder Pressure

4. CONCLUSIONS

The entire experimentation is carried out on a single fuel mode with diesel as base fuel and blends of lemongrass oil and tamarind seed oil with diesel as an alternative fuel. The experimental results can be summarised into the following points.

The neat diesel operation showed lower CO_2 emissions than the other blends.

The blended fuel sample showed higher BTE compared to the diesel and B20 had a maximum enhancement in BTE, it is around 20% higher than the neat diesel operation.

Also biodiesel blends showed a drastic reduction of HC emissions due to a higher combustion rate.

The blend B30 exhibits an approximately 51% reduction in HC when compared to the neat diesel operation.

But the biodiesel blends leads to an increase in NO_X emissions having as effect higher in-cylinder combustion temperatures.

At a crank angle of 366° biodiesel blend B20 showed 62.45 bar pressure which is slightly higher than the neat diesel operation around 3.81%. The highest heat release rate observed for B20 at a crank angle of 355° is 68.77 J/deg.

SCOPE OF FUTURE WORK

In the present investigation, all the biodiesel mixtures showed higher brake thermal efficiency when compared with neat diesel fuel operation. The further investigation is needed to carry on by varying various engine parameters like injection timing, injection pressure, and compression ratio. And also a large scope available on tribology studies on engine components of cylinder liner and piston for analysing the lifetime of the engine.

ABBREVIATIONS

BTE	-	Brake Thermal Efficiency
BSFC	-	Brake Specific Fuel Consumption
BP	-	Brake Power
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
HC	-	Unburned hydrocarbon
NO_X	-	Nitrous oxides
NHR	-	Net Heat Release Rate
CA	-	Crank Angle
B10	-	10% of mixed methyl ester and 90% of pure diesel
B20	-	20% of mixed methyl ester and 80% of pure diesel
B30	-	30% of mixed methyl ester and 70% of pure diesel
DMC	-	Dimethyl carbonate

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