Study of performance and emission characteristics of a compression ignition engine using tamarind biodiesel

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Abstract

The objective of this communication is to demonstrate engine performance, and emission characteristics of biodiesel used in compression ignition (CI) engines. Now a days biodiesels have been studied extensively and gaining huge importance as a promising alternative energy resource owing to global fossil fuel crisis and emission problems. India is the largest producer of tamarind (300000 tons annually) in world. Tamarind biodiesel is tested in four stroke single, single cylinder water cooled diesel engine and results are compared with pure diesel. From the results, it is reported that biodiesel (blends of Tamarind) containing up to 15% biodiesel have almost same properties as diesel and results have shown that as compare to diesel, biodiesel provides a slightly higher brake thermal efficiency(BTE) and volumetric efficiency, reduction in exhaust gas temperature (EGT) but the NOx emission are observed slightly higher. Biodiesels are anticipated to reduce the dependence on imported petroleum and revamp the economy by increasing demand and prices for agricultural products. From the review, it is also concluded that blends of biodiesel with a small content by volume can be used in existing CI engines without any modifications.

Keywords

Tamarind biodiesel, Brake thermal efficiency, Volumetric efficiency, Exhaust gas temperature, Oxides of nitrogen, Smoke density.

1.Introduction

At present, India is the biggest producer of tamarind in the world. Tamarind seed is a by-product obtained from the processing of tamarind fruit and may contain the oil yield of 20 to 40%. In general, Tamarind seed oil is extracted by means of hexane over the tamarind seed and also by using solvent extraction technique. Every year availability of tamarind seed is in the range of 2,00,000–2,50,000 tons in India. The crude tamarind seed oil is highly viscous and low volatile. *Figure 1* shows a sample of tamarind oil. The chemical reaction of fatty acids with alcohol results in to tamarind methyl ester and the glycerin. In the past few decades, fossil fuels, mainly petroleum-based liquid fuels, natural gas and coal have played an important role in fulfilling this energy demand. However, because of their non-renewable nature, these fossil fuels are expected to be exhausted in future and further situation has worsened with the rapid increase in energy demand worldwide.

Therefore, the demand for neat & clean, sustainable and economically feasible renewable energy sources has led researchers to intensify research in this domain.

1.1Objectives

1. To find a viable source of energy and consequently reduce the dependency on fossil fuel.
2. To find a clean fuel so that environmental pollution can be reduced

Dhana and Kishore [1] tested methyl ester of tamarind seed oil (TSME) blended with diesel. The best results are obtained for TSME 20 which showed lesser emissions comparable to other blends.

Dhana et al. [2] investigated performance, combustion and emission characteristics with three different methyl esters of biofuels and among them for Tamarind methyl ester the optimum conditions are obtained.

Patangi et al. [3] suggested that the biodiesel used is Tamarind and its blends with diesel fuel. The

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performance characteristics such as BSFC, BTE, volumetric ratio were found for blends B20, B40, B50, B60. The 60% blends performed well in running a diesel engine at a constant speed of 1500 rpm.

Pohit and Misra [4] performed with Karanja oil methyl ester. The performance and exhaust emissions were investigated and an attempt was made to optimize the engine responses using Taguchi method.

Nigade [5] used the blend of MadhucaIndica biodiesel. Grey relational theory is adopted to determine the best input parameters that give lower emissions.

Rao and Rao [6] tested blended Mahua methyl ester with ethanol and observed that CO and HC emission reduces while efficiency increases slightly.

Natarajan et al. [7] using grey relational grade and signal-to-noise ratio as a performance index, a combination of input parameters was prefigured so as to achieve optimum response characteristics.

Avinash et al. [8] worked on the optimization of performance and emission characteristics in diesel engine using biodiesel blend with Pongamia and found optimum operating parameters.

Venkatanarayana and Ratnam [9] suggested that the present study deals with the use of Taguchi approach to optimize. Biodiesel used is Karanja oil methyl ester called KOMe.

Aydin and Bayindir [10] cottonseed oil methyl ester-diesel fuel with blends (B5, B20 and B50) are chosen. Results showed that with the increase of CSOME in the blends, the best results are obtained.

Gopinath et al. [11] conducted a study with respect to injection pressure and number of holes at three levels with the diesel, waste cooking oil and rape seedoil. The optimum conditions are 30.31% for BTE and IP 190 bar.

Kumar et al. [12] suggested the response parameter BTE is optimized using Taguchi's methodology. The B80 blend is found to be most suitable blend for use in the diesel engine.

Kandasamy et al. [13] suggested that the biodiesel used is rice bran and pongam oil blended with diesel fuel i.e., B20, B40, B60. The performance of the engine is found to be good for the B40 blend.

Jawre and Lawankar [14] suggested that the Biodiesel used Iskum methyl ester on the performance and emission of diesel engine at different load and constant speed. Thus optimum value is obtained.

Vasukumar et al. [15] suggested that the vegetable oil like bio-diesel, rice-bran oil, Sunflower oil, cotton seed oil can be used as a blended fuel. Ethanol can be used to improve performance and to reduce emission.

Figure 1 Tamarind bio-diesel (T100)

2. Experimental procedure

The experiment is performed using Tamarind biodiesel and also with neat diesel. Thus the comparison is made with the three different blends such as T5 (5% Tamarind oil + 95% diesel), T10 (10% Tamarind oil + 90% diesel) and T15 (15% Tamarind oil + 85% diesel) at three different pressures 190bar, 230bar and 270bar operated under three load conditions such as 0%, 60% and 100%. *Figure 2* shows a photographic view of the experimental setup and *Table 1* presents the specification of this engine.

Figure 2 Photographic view of experimental setup

Table 1 Specifications of engine used in the experiment**Engine: kirloskar made, four-stroke, vertical, single-cylinder, constant speed, water-cooled diesel engine.**

Bore	80mm
Stroke	110mm
Rated output	3.68kW
Rated speed	1500rpm
Fuel injection timing	27° BTDC
Fuel injection pressure	190 bar
Compression ratio	16:1
Combustion system	Open chamber

The Tamarind biodiesel properties density, Flash point, Fire point, Viscosity and Calorific value are measured and compared with pure diesel and ASTM standards. The properties of biodiesel are listed in *Table 2* and density of various blends in *Table 3*.

Table 2 Properties of biodiesel

Fuel properties	Units	Diesel	Bio-Diesel
Kinematic viscosity	mm ² /sec	2.75	5
Density	g/cc	0.83	0.86
Flash point	°C	100-170	>100
Fire point	°C	-	>100
Calorific value	KJ/Kg	42000	38880

Table 3 Density of tamarind blends

Blends	Density(G/CC)
T5	0.81
T10	0.82
T15	0.83

In order to estimate the performance and emission characteristics following steps are followed:

Step 1: experiments were conducted with pure diesel.

Step 2: In the second phase of work, the engine was operated with diesel-Tamarind biodiesel blend ratio T5, T10, T15, injection operating pressures 190bar, 230bar and 270bar at different loading conditions.

Levels of varying parameters (Blend, Pressure and Load) are given in *Table 4*.

Table 4 Levels of varying parameters/factors

Levels	Parameters/Factors		
	Blend	Pressure(bar)	Load (%)
1	T5	190	0
2	T10	230	60
3	T15	270	100

3. Results and discussions

Figure 3 demonstrates brake thermal efficiency (BTE) versus percentage of Tamarind blends at different Injection pressures. From figure it is clear that BTE increases with respect to percentage of Tamarind blend and BTE also increasing with injection pressure. From *Figure 4*, it is observed that volumetric efficiency is higher in case of pure diesel and decreases after blend but exhibiting a nearly constant trend at different injection pressures.

Figure 3 Demonstrates that corresponding to BTE, volumetric efficiency manifesting the similar trend

Figure 4 Volumetric efficiency versus percentage of blends at different injection pressures

Figure 5 manifests that exhaust gas temperature (EGT) is higher with pure diesel and decreases with blend. It is also observed that EGT decreases insignificantly with increasing injection pressures.

Figure 6 tells that smoke density is drastically higher with pure diesel and has decreased significantly after blending. It is also found that smoke density is

decreasing with injection pressure. From *Figure 7*, it is clear that NO_x percentage has increased after blending and also with injection pressure. The increase of NO_x formation may be attributed to higher oxygen molecules of Tamarind Biodiesel.

Figure 5 EGT versus percentage of blend at different injection pressures

Figure 6 Smoke density versus percentage of blends at different injection pressures

Figure 7 NOx percentage versus percentage of blends at different injection pressures

The cooling of exhaust gases before mixing with fresh air introduced to the engine does not affect its volumetric efficiency but it absorbs the heat of combustion. This leads to the increase in NOx emissions and improve in thermal efficiency.

4. Conclusion and future work

This study concludes that most of the performance parameters: BTE, volumetric efficiency, EGT, smoke density are in favor of Tamarind blend except oxides of nitrogen. The results shown that the Suitability of the liquid product obtained from tamarind seed can be chosen as an alternative fuel. In future, percentage of tamarind blend can be increased further with certain modifications in the engine to study the implications on engine performance and environmental pollution. Also this study can be extended to find out the economic viability of this project.

Acknowledgment

None.

Conflicts of interest

The authors have no conflicts of interest to declare.

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