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Impact of Tamarindus Indica biodiesel blends on performance and exhaust emissions characteristics of light duty compression ignitionengine

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Abstract

Tamarind (*Tamarindus Indica*) is an integral part of South Indian cuisine. Its pulp is used to add sourness to south Indian curries. However tamarind seeds which are having a considerable amount of lipid in it are thrown away. Our main objective is to produce Tamarind biodiesel (TB) from tamarind seed oil and investigate its effect on performance and exhaust emissionsof CI engine. Oil was extracted from Tamarind seeds and was converted to biodiesel by transesterification process with NaOH as catalyst. Tests were performed using TB5, TB10, TB15 blends with 1500 rpm rated speed and compression ratio of18. The performance test results revealed that BTE of B15 was greater in comparison to other blends as well as diesel. However BSFC for TB blends were greater compared to neat diesel. Considerable reductions in exhaust emissions were observed with TB blends. TB10 showed apical reduction of 27% in CO and 15% reduction in smoke. TB5 showed 25% HC reduction followed by TB10 with 19.25% reductions. TB15 showed 19.36% of highest NO_x reduction followed by TB10 with 10.7% NO_x reduction. TB10 proved to give optimum test results for performance and emissions. From the results it can be concluded that TB can be considered as a viable option for biodiesels.

Introduction

It is estimated that there will be a steep rise in energy consumptionglobally by 2030 [1], [2]. Whether its transportation, agriculture or industrypetroleum fuel, play a key role as they are easily available and have excellent combustion properties. Consumption of petroleum fuels results in hazardous emissions which effects human being and also environment. But the emissions produced by it has a grave effects on human body as well as environment. We human beings cannot sustain without air. Normal human beings breathe10.8 m^3 of air per day. Majority of the portion of air comprises of nitrogen and oxygen [3]. The NO_x emissions from burning of petroleum fuels forms smog in the air, which leads to respiratory problems in human beings [4]. Rapidly depleting petroleum reserves are

a major concern as most of power producing engines and power consuming engines are highly dependent on it. Exhaustion of Non renewable sources, increasing price of crude oil and global warming has generated more interest in alternative and environmentally friendly sources of fuel. Consequently it becomes very important to explore renewable alternative fuels options that are easily available, has less negative impact on environment, and it should be technically feasible. Biodiesel reflects identical characteristics as that of ND and is also renewable source of energy [5]. It can be producedfrom edible and non-edible oils. Large variety of biodiesels can be extracted from castor, canola, soybean, mahua, coconut, sunflower, palm oil etc. for compression ignition engine by transesterification method by adding methanol in presence of catalyst.

Many authors have studied the impact of methyl esterson performance and on light duty as well as heavy duty engine. In one such study diminution in torque and BP and increment in BSFC with all three coconut blend samples were perceived by author [6]. Similar results were obtained with biodiesel from waste mustard oil with superior calorific value of 40.404 MJ/kg. It showed 8–13% higher BSFC and 5–6% lower BTE compared to neat diesel [7]. Lower BP value with biodiesel is accounted to lower CV, high density and high viscosity than ND. Formation of poor mixture also decreases BP. High specific gravity of biodiesel increases the BSFC as more mass of fuel in induced per fuel injection. Contrary to this study, Jatropha biodiesel and Mahua biodiesel showed increase in brake power and brake thermal efficiency with torque for all prepared test fuels [8], [9]. Tests were conducted with biodiesels on twin cylinder engine with Cardonal biodiesel. It was observed that the brake power increased and brake specific energy conversion decreased with increase in brake power. Brake thermal efficiency increased with higher brake power and emission levels (CO,HC,NO_X) were nominal up to 20% blends [10]. Many researchers have reported low carbon monoxide, unburned hydrocarbon and smoke opacity emissions with biodiesel [11]. However NO_X remains matter of concern with the use of biodiesel as reported in many literatures. Percentage of biodiesel in neat diesel also effects the performance of the engine. Decrease in BTE and increment in BSFC for higher proportion of Pongamia biodiesel were reported [12]. High viscosity and density is the major reason for increased BSFC for Pongamia biodiesel. High density causes more mass to induce in the CC consequently increasing BSFC. Lower CV also plays important role in increased BSFC of biodiesel as more fuel is consumed to produce the same power out. Decrement in CO and HC have been reported with increase in Pongamia biodiesel proportion in ND which can be accounted to excess oxygen molecules in biodiesel which promotes efficient combustion [13]. More availability of oxygen molecules may also result in excess NOx emissions in case of biodiesel as more oxygen molecules will rise the combustion temperature in CC. Increased proportion of Pongamia in ND has resulted in ascending NOx emissions at engine exhaust [14]. Contradict to above explanation some researchers have claimed considerable reduction in NOx with increase in Pongamia biodiesel [15].

Tamarind (Tamarindus Indica) isgrownpan India. Tamarind fruit is used excessively in cooking in southern parts of India. Seeds of tamarind are generally thrown away. Few studies conclude that seed of Tamarind contain oil and fatty acids which makes it a viable option as a renewable energy source [16], [17]. Very few researches have experimented with this oil. In a study different blends of tamarind methyl esters were tested at three different injection pressures [18]. It was reported that blend with 15% of Tamarind biodiesel had the same properties as diesel. BTE increased as the proportion of biodiesel as well as injection pressure increased. Blends showed diminished smoke with increment in injection pressure. T15 showed optimum results, however its NO_x emissions were higher than all the blends. Addition of additives to tamarind biodiesel emanated in significant reduction in smoke emissions [19]. However NO_x and specific fuel consumption increasedwith additives.

Section snippets

Experimental method

Tamarind oil was preheated to 60 °C to ensure that moisture content is completely removed. Methanol of 30% by volume was added to the heated oil in the presence of catalyst NaOH 1% by weight. NaOH was used as catalyst to increase the reaction rate as it was readily available and is less expensive. The solution was stirred continuously for

half an hour and was then kept to settle for 24 h in separating funnel. This resulted in formation of glycerin which settled down at bottom and biodiesel at…

Engine performance characteristic analysis

BSFC descends with increment in BP as depicted in Fig. 2a. BSFC was observed to be higher at lower loads and minimum at full loadfor TB blends as well as for ND. TB5 and TB10 depicted 4% and 5% increase in the BSFC as compared to ND. TB 15 showed less fuel consumption than rest of the blends as well as ND by 3% [22], [23], [24].However at peak load, all fuel samples showed the same BSFC. With the ascending load BTE decreases for TB blends and ND as depicted in Fig. 2b.TB5, TB10 and TB15 blend…

CO emissions

Incomplete combustion is one of the reasons for CO concentrationsin engine exhaust. With increment in load CO emission diminishes for TB blends and NDas discerned from Fig. 3a.CO concentration diminished for TB blends than ND. Reduced CO emissions of 19%,27% and 22% were observed for TB5, TB10 and TB15 blends againstND. Higher CN of TB blends resulted in a lower possibility offormation of a fuel-rich zone which promoted less CO emissions [25]. Also biodiesels contain more oxygen molecules which …

Conclusions

Above experiment focussed on engine performance and emission characteristics using TB blends against ND. TB5, TB10, TB15 andND were used for test. The BSFC values for TB blends were lower compared to ND as percentage increase of brake power with load was higher in comparison to expending fuel. TB15 showed the least BSFC value. BTE of TB blends were higher than the ND which can be accounted to high oxygen content of the biodiesel which assists in efficient combustion. TB blends showed excellent…

CRediT authorship contribution statement

N. Jayashri Nair: Conceptualization, Methodology, Software, Writing - review & editing. **Y V.V. Satyanarayana Murthy:** Data curation, Writing - original draft.…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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…In general, the EGR method has resulted in the best results in substantial reductions in NOx emissions. Nair and Murthy [19] recommended the use of tamarindus Indica biodiesel for diesel engine applications due to its improved engine performance and lowered exhaust emissions at full load. Manieniyan et al. [14] studied the effect of EGR on the characteristics of diesel engine operated with vegetable oil refinery waste added multi-walled carbon nanotubes.…

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