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Full Length Article

Investigation on performance and emission characteristics of a variable compression multi fuel engine fuelled with Karanja biodiesel–diesel blend

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A R T I C L E I N F O

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The performance and emission of a single cylinder four stroke variable compression multi fuel engines when fueled with 20%, 25% and 30% of Karanja blended with diesel are investigated and compared with standard diesel. Experiment has been conducted at compression ratios of 15:1, 16:1, 17:1, and 18:1. The impact of compression ratio on fuel consumption, brake thermal efficiency and exhaust gas emissions has been investigated and presented. Experimental analysis on the performance of biodiesel over diesel was evaluated by response surface methodology to find out the optimized working condition. The overall optimum is found to be 25% biodiesel–diesel blended with a compression ratio of 18.

1. Introduction

The large increase in the number of automobiles and fast depletion of world petroleum reserves have resulted in a great demand for petroleum products [1]. The worlds energy demand in the last two decades has encouraged the world towards searching for the alternative energy sources [2]. The developing country like India is desirable to produce bio-diesel from non-edible oils which can be extensively grown in the waste land of the country [3]. The usage of bio-diesel has reduced the tail pipe emission of carbon monoxide (CO), Hydrocarbons (HC) and particulate matter (PM) [4]. Bio diesel acts as a promising alternative fuel to diesel oil. Vegetable oils are a very promising alternative to diesel oil since they are renewable and have similar properties. Many researchers have studied the use of vegetable oils in diesel engines. Vegetable oils offer almost the same power output with a slightly lower thermal efficiency when used in diesel engines. Reduction of engine emissions is a major research aspect in engine development with the increasing concern on environmental protection and the stringent exhaust gas recirculation. Biodiesel such as Jatropha, Karanja, sunflower, rapeseed are some of the popular biodiesel that are currently considered as substitutes for diesel. These are clean burning, renewable, non-toxic, biodegradable and environmentally friendly transportation fuels that can be used in neat form or blended with petroleum derived in diesel engines. Vegetable oil esters particularly karanja appear to be the best alternative fuel to diesel.

Diesel engines have a negative effect on environment since they include high amounts of sulphur and aromatics. CO, SO_X, NO_X and smoke are produced from fossil fueled diesel engine exhaust emissions [5]. It has been observed that engine parameters such as injection timing, compression ratio have considerable effects on the performance and emissions of diesel engines running on biodiesel blends. Many innovative technologies are developed to tackle these problems. Modification is required in the existing engine designs [6,7].

Jindal et al. [8] studied the effects of the engine design parameters such as compression ratio, fuel injection pressure and the performance parameters such as fuel consumption, brake thermal efficiency, emissions of CO, HC, NO_x, CO_2, and smoke opacity with jatropha methyl ester as fuel. The highest performance is achieved by the engine at 250 bar injection pressure and compression ratio of 18 at which BSFC improves by 10% and BTE improves by 8.9%. With regard to emission aspects increase in compression ratio leads to an increase in emission of HC and exhaust temperature whereas smoke and CO emission reduces.

Muralidharan et al. [9] investigated the BTE and found out that the blend B40 with waste cooking oil is slightly higher than that of standard diesel at higher compression ratios. Waste cooking oil blends give higher combustion pressure at high compression ratio due to longer ignition delay, maximum rate of pressure rise and lower heat release rate when compared with diesel. Brake thermal efficiency of the blends increases with increase in applied load.

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Nomenclature

B20	20% biodiesel + 80% diesel
B25	25% biodiesel + 75% diesel
B30	30% biodiesel + 70% diesel
BP	brake power
BTE	brake thermal efficiency
BSFC	brake specific fuel consumption
CO	carbon monoxide
CO_2	carbon dioxide
UHC	unburnt hydrocarbon
CR	compression ratio
IMEP	indicated mean effective pressure
NO_x	nitrogen oxides
VCR	variable compression ratio

Vasudevan et al. [10] Conducted experiments on variable compression ratio engine and found the maximum brake thermal efficiency at full load is 38.46% for B40 of waste cooking oil which is 4.1% higher than that of diesel using variable compression ratio engine at compression ratio 21. In 2009 Arul Mozhi Selvan et al. [11] compared the combustion characteristics of single-cylinder four strokes DI variable compression ratio engine under compression ratio of 15:1, 17:1 and 19:1 when using diesel and Biodiesel-ethanol blends as fuel. It has been observed that the cylinder gas pressure, maximum rate of pressure rise and heat release rate increase with higher ethanol concentration due to longer ignition delay. The exhaust gas temperature was found to be less and it has been observed that performance and emissions have been reduced on a variable compression ratio engine. Ganapathy et al. [12] studied the effect of injection timing along with engine operating parameters in Jatropha biodiesel engine is important as they significantly affect its performance and emissions. Advancing the injection timing (5 crank angle degree from factory settings (345 CAD) causes reduction in BSFC, CO, HC and smoke and increase in BTE, peak cylinder pressure, HRRmax and NO emission with Jatropha biodiesel operation. In 2012 L. Labecki, et al. [13] studied the combustion and emission characteristics of rapeseed plant oil (RSO) and its blends with diesel fuel in a multi-cylinder direct injection diesel engine and found out the NOx emissions for RSO and its blends are lower when compared to diesel fuel but their soot emissions are much higher than diesel. Saravanan et al. [14] analyzed the combustion characteristics of crude rice bran oil methyl ester blend in a direct injection compression ignition engine and found that the cylinder pressure was comparable whereas the delay period and the maximum rate of pressure rise was lower than that of diesel. Kasiraman et al. [15] studied the performance and combustion analysis of a neat cashew nut shell oil (CSNO) as a fuel in direct injection diesel engine The cashew nut shell oil 70% and camphor oil 30% blend (CMPRO30) Performs closer to diesel with respect to performance, emission and combustion characteristics. The brake thermal efficiency of CMPRO 30 blend is 29.1% at peak load compared to diesel brake thermal efficiency of 30.14% whereas it is 23.1% for neat CSNO. At peak load the NO emissions of CMPRO 30 blend, diesel fuel and neat CSNO are 1040 ppm, 1068 ppm and 983 ppm, respectively. The smoke emissions are higher for neat CSNO with a value of 4.22 BSU. For CMPRO 30 blend it is 3.91 BSU whereas it is 3.64 BSU for diesels. The peak pressure, maximum rate of pressure rise, ignition delay, combustion duration and heat release rates of CMPRO 30 blend and diesel fuel are comparable. Yang et al. [16] investigated the performance, combustion and emission characteristics of diesel engine fueled by biodiesel at partial load conditions Due to the lower calorific value of biodiesel, the BSFC increases with the increasing biodiesel blend ratio at all engine loads. With regard to the impact of partial loads, it is found that the percentage Increase in BSFC of B100 as compared to diesel increases with the decreasing engine load. The largest increase in BSFC is found tobe at 10% load where a 28.1% increase in BSFC is observed. As for BTE, the experimental results show that the use of biodiesel results in a reduced thermal efficiency at lower engine loads and an improved thermal efficiency at higher engine loads. Raheman and Ghadge [17] studied the performance of RicardoE6 engine using bio diesel obtained from mahua oil (B100) and its blend with high speed diesel at varying compression ratio, Injection timing and engine loading. The brake specific fuel consumption and exhaust gas temperature increased, whereas brake thermal efficiency decreased with increase in the proportion of biodiesel in the blends for all compression ratios (18:1–20:1) and injection timings (35–45 before TDC). The authors concluded that, bio diesel could be safely blended with HSD up to 20% at any of the compression ratio and injection timing tested for getting fairly accurate performance as that of diesel.

Some optimization approach has to be followed so that the efficiency of the engine is not compressed. As far as the internal combustion engines are concerned the thermal efficiency and emission are the important parameters for which the other design and operating parameters have to be optimized. The most common optimization techniques used for engine analysis are response surface method, grey relational analysis [18–20]; artificial neural network has been employed to predict output parameters of the engine [21]. Taguchi technique has been popular for parameter optimization in design of experiments. Multi objective optimization of parameters using non linear regression has found optimum value to be 13% biodiesel–diesel blend with an injection timing of 24°Btdc [21]. Karnwal et al. [22] used the Taguchi method for analyzing the role of operating and injection system parameters on low noise, performances and emissions. Ganapathy et al. [23] reported the performance optimization of jatropha biodiesel engine model using Taguchi approach. Many researches about optimization and modification on engine low temperature performances of engine; new instrumentation and methodology for measurements should be performed when petroleum diesel is substituted completely by biodiesel [24]. Most of the research studies concluded that in the existing design of engine and parameters at which engines are operating a 20% blend of bio-diesel with diesel works well [25].

From the review of literature, it can be seen that while lot of work has been carried out to improve the performance of biodiesel fueled compression ignition engine. However, it has to be noted that the study on variable compression ratio engine using bio diesel is limited. The effect of compression ratio on engine parameters, emission and combustion characteristics have not been studied extensively. Hence this study has been devoted to find suitable compression ratio which gives optimum performance. In this research, Karanja oil and its blends with diesel is chosen as fuel for variable compression ratio multi fuel engine. The various blends of Karanja and standard diesel fuel are prepared and the following investigations are carried out. The performance, emission and combustion characteristics of variable compression ratio

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