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Alternate fuels in compression ignition engines: A review

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ABSTRACT

The current work described the various research studies on biofuels available in India and their utilization in compression ignition engines. The various methods of producing these fuels are also the important concern. It is observed that biodiesel from various edible and non-edible oils are the best alternative fuels of compression ignition engines in terms of reduced emission contents without any modification

Keywords: Biofuels, Compression ignition engines, trans-esterification, emissions

INTRODUCTION

Biofuels are found in almost every part of India and is readily used in the production of biodiesels. Many researchers [Dhingra et al., 2013a; Dhingra et al., 2013b; Dhingra et al., 2014a; Dhingra et al., 2014b; Dhingra et al., 2014c; Dhingra et al., 2014d; Dhingra et al., 2014e; Ramadhas et al., 2005; Ramadhas et al., 2006] worked on these fuels and found the best alternate energy to compression ignition engines. Few research works are discussed in detail as below:

The production of rubber seed oil methyl ester and evaluation of its performance and emission parameters in a diesel engine operating on biodiesel-diesel blends were investigated by Ramadhas et al. (2005). The performance of rubber seed oil, its biodiesel-diesel blends and diesel was compared in a compression ignition engine. It was found that pure rubber seed oil did not perform well due to high free fatty acid (FFA) present in it but its biodiesel has an ability to perform well due to pre-treatment process for reduction FFA contents. The results indicated an increase in brake thermal efficiency and reduction in brake specific fuel consumption at lower biodiesel-diesel blends while decrease in exhaust gas emissions with higher biodiesel-diesel blends. Thus rubber seed oil methyl ester was suggested as an alternative fuel to diesel in compression ignition engines by blending it with diesel. Subramanian et al. (2005) utilized the liquid bio-fuels in automotive engines for the evaluation of various performance parameters and compared them with diesel fuel.

Ramadhas et al. (2006) developed artificial neural network model for the prediction of cetane number of biodiesel fuel. The training of ANN networks was performed by considering fatty acid compositions of biodiesel and experimental cetane number for occurrence of regressions. The results revealed that actual centane number was in close agreement with the value predicted by ANN. Thus ANN can be a reliable tool for prediction of cetane number.

A mahua (Madhuca indica) biodiesel was used (blended with diesel) by Raheman and Ghadge (2007) in a CI engine for predicting the performance and emission behavior. The various properties of mahua biodiesel were found to be closer to commercial diesel, American and European biodiesel standards of biodiesel. A 20 % blending was suggested for required performance (brake specific fuel consumption, brake thermal efficiency and exhaust gas temperature) and emission (CO, smoke density and NO_x) parameters. Hashemi and Clark (2007) investigated the emissions of heavy duty diesel vehicles in Southern California by using artificial neural network (ANN). The data for chassis dynamometer trained in ANN was used to predict the emission parameters (NO_x, CO_2, HC and CO) of diesel vehicles. Yang et al. (2007) evaluated regulated air emissions and polycyclic aromatic hydrocarbons by varying the amount of biodiesel in diesel engine under durable testing.

Kalam and Masjuki (2008) experimentally analyzed the effect of 100 % diesel fuel (B0), 20 % palm diesel and 80 % diesel (B20) and B20 with X % additive (B20X) in a biodiesel-diesel fuelled computerized diesel engine for evaluating specific fuel consumption, exhaust emissions and anti wear characteristics. The engine speed was varied in the range of 1000-4000 rpm and emission tests were conducted at 50 N-m load with a constant speed of 2250 rpm. The results revealed that B20X had better overall performance (increased brake power and reduced exhaust emissions) and anti wear characteristics as compared to normal biodiesel-diesel blend (where X is the percentage of additive in B20 fuel, in this analysis X= 1 %).

Lapuerta et al. (2008) studied the effect of biodiesel-diesel blends on standard test diesel engines from different research articles. He reported that due to the loss of heating value, specific fuel consumption was considerably increased with increase of biodiesel blend in diesel as compared to straight diesel. Also an increase in brake thermal efficiency and reduction in emissions (except NO_x and particulate matter) was observed.

Meng et al. (2008) prepared the biodiesel from waste cooking oils through trans-esterification via alkali catalyst by applying orthogonal analysis of parameters with four factors and three level tests. The biodiesel yield of 89.8 % was produced at methanol to oil molar ratio of 9:1, 1.0 wt. % KOH concentration, and temperature of 50˚C in 90 minutes. Performance of produced biodiesel was tested in a biodiesel-diesel fuelled YC6M220G turbo charged diesel engine and compared with pure diesel. A significant reduction in HC and CO emissions were observed at 20 % blending of biodiesel in diesel as compared to straight diesel without any modification in engine. Further, an increase in blending ratio (up to 50 %) resulted in higher emission (CO and HC) contents.

Basha et al. (2009) reviewed various research articles of biodiesel produced from various oils and their performance tests. The vegetable oils were found to be the possible alternative to diesel for short term engine tests while for long term tests higher carbon built up and lubricating oil contamination took place resulting in engine failure. To prevent these, blends of vegetable oils and diesel were used for successful performance of compression ignition engines. The combustion characteristics of biodiesels were found to be almost similar to that of diesel. It was also concluded that base catalysts were more effective than acid catalysts.

Canakci et al. (2009) applied five artificial neural networks for the prediction of performance and exhaust emissions of waste frying palm oil based biodiesel blends of 50 %, 20 % and 5 %. Back propagation learning algorithm was used for single hidden layer and scaled conjugate gradient (SCG) with Lavenberg-Marquardt (LM) was used for the variants of algorithm. The results indicated that fifth network had predicted R^2 of 0.99 while mean % error was smaller among them except for some emissions. However higher mean errors were obtained for CO, NO_x and unburnt hydrocarbons (UHC).

Ghabadian et al. (2009) considered waste cooking biodiesel fuelled four stroke diesel engine to predict performance and emission parameters by the application of artificial neural network (ANN). The authenticity of produced biodiesel was checked by comparing various fuel properties with ASTM biodiesel standards. ANN model was predicted through back propagation algorithm with multilayer perception network (MLP). The data proposed for training and testing was obtained from the performance of biodiesel-diesel blends operating at different engine loads. The results revealed that correlation coefficients of above 99 % were found for specific fuel consumption, CO and HC emissions in the prediction of performance and exhaust emissions.

Deh Kiani et al. (2010) adopted artificial neural network (ANN) for the prediction of performance and exhaust emissions in a SI engine using ethanol-gasoline blends. An ANN model was created through back-propagation algorithm for the engine using some experimental data for training. The results showed that performance of ANN was closer to the observed values. Also ANN was considered to be the fast, accurate and reliable in the prediction or approximation affairs when numerical and mathematical methods fail.

Gumus (2010) prepared biodiesel from hazelnut kernel oil with methanol in the presence of KOH as catalyst and a comprehensive experimental investigation of combustion parameters (cylinder gas pressure, rate of pressure rise and ignition delay) and heat release parameters (rate of heat release, cumulative heat release, combustion duration and center of heat release) of a compression ignition engine (direct injection) running on biodiesel-diesel blends was carried out. The engine input parameters varied were: injection timing, injection pressure, load and compression ratio at various biodiesel-diesel fuel blends.

It was concluded that kernel oil biodiesel has a good scope to run the compression ignition engines without any modifications. Further with change in injection timing, injection pressure and compression ratio, significant improvement in combustion and heat release characteristics were observed. The effect of injection pressure on the ignition and combustion characteristics of a direct injection diesel engine was investigated by Kuti at al. (2010). The two types of biodiesel (from palm and cooking oil) were used and improved ignition and combustion parameters were observed as compared to standard diesel.

Pal et al. (2010) developed thumba (Citrullus colocyntis) biodiesel through hydrodynamic cavitation and suggested an optimum value of 30 % thumba biodiesel in diesel (TB30) running on a four cylinder, direct injection water cooled diesel engine at variable speed. The performance, combustion and emission characteristics were significantly improved at TB30 with a favorable pressure-crank angle (p-ϴ) diagram as compared to conventional diesel. The results of the experiments revealed that biodiesel production through hydrodynamic cavitation technique was simple, efficient, time saving, eco-friendly and industry viable process. Also thumba biodiesel can be used as an alternative fuel in compression ignition engines by blending with diesel. Valente et al. (2010) checked the performance (fuel consumption and emissions) of castor and soybean biodiesels in a diesel powered generator. The comparison was then analyzed with straight diesel as a fuel in a generator.

CONCLUSION

I. Broad literature review suggested that biofuels are the best source of alternate fuels of compression ignition engines
II. The trans-esterification process is an effective method for the production of biodiesels.

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