Review On Performance and Emission Characteristics of Compression Ignition Engine Running Through Biodiesel Blends

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Abstract— The performance of biodiesel based engine is evaluated by mixing of a biodiesel with diesel in a suitable ratio and then statistical tool is applied in order to optimize the engine output. Studies of various research works revealed engine input and output parameters. Furthermore, 20 % (v/v) biodiesel to diesel ratio is recommended for predicting performance and emission characteristics.

Key words: Performance characteristics, Emission characteristics, Bidiesel based compression ignition engine

I. Introduction

Literature review indicates that biodiesels from various oils can be the alternative fuels to run the compression ignition engines due to their similar physio-chemical properties as that of diesel. 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., 2016a; Dhingra et al., 2016b] have tested compression ignition engines by using biodiesels in order to evaluate performance, combustion and emission parameters. The performance of biodiesels has been analyzed by varying engine input parameters and is summarized as below:

Bhattacharyya et al. (1994) studied various properties of different vegetable oils and their blends. Most of the oils were the promising source of fuel in diesel engines for short term engine tests but the problem of lubricant contamination, carbon deposits on engine surfaces were generally observed for long term tests. To overcome these problems, vegetable oils blended with diesel were used in a compression ignition engine in order to perform well for long-term tests. Also trans-esterification of vegetable oils helped in developing alternate fuel to diesel. Among vegetable oils: sunflower, soybean and rapeseed oil were found to be the most promising for biodiesel production.

The biodiesel produced from vegetable oils through trans-esterification was used in a CI engine. There was significant reduction in peak thermal efficiency and smoke opacity when compared with straight diesel. A 20 % blending of biodiesel in diesel was observed to be the optimum value for use in a compression ignition engine [Agarwal and Das, 2000]. Krijnsen et al. (2000) applied ANN for control of the reductant flow in selective reduction of NO_x in diesel exhaust. The average deviation between predicted and actual value of NO_x emissions was found to be 6.7 %. The results showed ANN was a promising tool in terms of high accuracy with short computation times (0.2 ms/data point).

De Lucas et al. (2001) developed mathematical model to evaluate particulate emissions considering the effect of fuel composition parameters (aromatic content, cetane index, gross heat power, nitrogen and sulphur content) at operating conditions (torque and engine speed) using neural networks. The range of confidence level for experimental results was found to be 87-90 % and allowed simulation of emissions at steady conditions within the experimental range of parameters.

Pramanik (2003) considered jatropha curcas oil as an alternative fuel for a single cylinder CI engine by blending it with diesel. The effects of temperature on viscosity of jatropha oil-diesel blends and pure jatropha oil were also studied which were then compared with diesel. Significant improvements in the engine performance and slight reduction in specific fuel consumption & exhaust gas temperature were observed at 50 % jatropha oil-diesel blend as compared to straight diesel. Hence 40-50 % jatropha oil-diesel blend was suggested as a fuel in the diesel engine without any modification.

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.

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.

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.

II. CONCLUSION

The input parameters of compression ignition engine that affect the output are: blending ratio of biodiesel to diesel, compression ratio, load, injection timing, injection pressure and engine speed.

The performance, combustion and emission parameters of compression ignition engines are found to be: brake thermal efficiency (BTE), brake specific energy consumption (BSEC), brake specific fuel consumption (BSFC) and exhaust gas temperature (EGT) [Performance parameters]; cylinder pressure (P), ignition delay (ID), heat release rate (HRR), combustion duration (CD), peak cylinder pressure (P_{max}) and maximum rate of pressure rise [Combustion parameters]; and carbon monoxides (CO), carbon dioxides (CO_2), nitrogen oxides (NO_x), hydrocarbons (HC), smoke opacity and un-burnt oxygen (O_2) [Emission parameters]. These parameters are studied by varying one engine input parameter at a time. Hence there is a need for simultaneous study of various input and output engine parameters.

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