Abstract

The aim of the present study is to analyze the performance, emission and combustion characteristics of a variable compression ratio (VCR), compression ignition (CI) engine using a suitable biodiesel as fuel. The biodiesel selected to conduct this experimental investigation is Karanja biodiesel. The selection of Karanja biodiesel is based on an extensive review of literature which indicated that this is relatively unexplored as fuel on a VCR diesel engine. The experimental analysis is followed by a computational study consisting of optimization and modeling for predicting the optimum performance parameters and emission constituents of the engine.

The experimental study is conducted on a four stroke, VCR diesel engine using Karanja biodiesel and its blends with diesel. The thermal performance and emissions characteristics are evaluated by operating the engine at different preset compression ratios (CRs) of 14, 15, 16, 17, 17.5 and 18, different injection pressures (IPs) of 150 bar, 200 bar and 250 bar and varying loads from 0kg to 12 kg in steps of 3kg.The thermal performance parameters evaluated are brake thermal efficiency (BTHE), brake specific fuel consumption (BSFC), brake mean effective pressure (BMEP), volumetric efficiency, heat equivalent of brake power (HBP), heat with exhaust gas (HGas) and exhaust gas temperature (EGT). The emission constituents measured are carbon monoxide (CO), unburnt hydrocarbons (HC), oxides of nitrogen (NO_x), carbon dioxide (CO_2), oxygen (O_2) and SO_x (Oxides of sulphur). Along with emission constituents, the smoke intensity is also measured in terms of Hartridge Smoke Units (HSU). A combustion analysis of the engine running on pure Diesel oil and Karanja biodiesel at full load, IP of 200bar and at different preset CRs of 14, 16 and 18 is also conducted. The combustion parameters analysed are cylinder pressure, net heat release, rate of pressure rise, mass fraction burnt, mean gas temperature, cylinder pressure-volume (PV) plot, cumulative heat release rate and injection pressure.

The experimental study conducted provides large number of results. But, it is impossible to select the input parameters such as CR, IP and blend for obtaining optimum thermal performance and emissions from the engine. Hence, a suitable computational study is required to be carried out in order to meet the objective of finding the optimum combination of the input parameters under different preset priorities.

The problem of finding the optimum working conditions from the point of view of maximising BTHE, minimising BSFC, EGT and proportion of exhaust gas emission constituents poses a multi-objective scenario. Thus, multi-objective optimization of thermal performance and emission characteristics using GA technique for the engine is carried out in order to find optimum CR, IP and blend at full load. In this study MATLAB genetic algorithm (GA) toolbox is selected as the implementation tool for optimization. Further, artificial neural network (ANN) is used to obtain the output parameters using the optimised input parameters. ANN modeling consists of very complex techniques capable of modeling different functions and processes. Various softwares can be used to model ANN. In this study, EASYNN software is selected for the purpose.

From the present study, it can be inferred that blend B20 operates closest to Diesel oil with respect to thermal performance. However, there is not much deviation between the performance of Karanja biodiesel and Diesel oil at higher CRs. Hence higher CRs particularly CR of 18 should be the mode of operation when engine is fuelled with Karanja biodiesel. Also, higher IP of 250bar is preferable for Karanja biodiesel due to its relatively higher viscosity. The emission characteristics evaluation indicates that the blend B100 gives minimum harmful emissions amongst all the blends. Further, at a higher CR of 18 and IP of 250bar fairly reduced exhaust emissions are observed irrespective of blend. Therefore, operating the diesel engine with Karanja biodiesel at a CR of 18 and IP of 250bar results in minimum emissions. It is inferred from the combustion analysis that as the CR increases from 14 to 18 at full load and IP of 200bar, the difference in performance between Karanja biodiesel and diesel reduces i.e. the operation of the engine fuelled with Karanja biodiesel tends towards that fuelled with diesel. The combustion characteristics of diesel engine using Karanja biodiesel is similar to that using pure diesel at higher CR of 18 which is very promising as far as Karanja biodiesel as an alternative fuel in diesel engines is concerned. In short, based on thermal performance, emissions constituents and combustion analysis, it is observed that the optimum CR is 18 which is also suggested by multi-objective optimization. However, the optimum IP and blend are 228bar and B70 respectively. The outputs corresponding to the combination of the optimised CR, IP and blend are not readily available through the hardware experiments conducted. Therefore, an ANN model simulating the actual engine behaviour is built to obtain the outputs corresponding to the optimized CR, IP and blend.