Abstract

The present study was aimed to prepare a stable cerium oxide nanoparticles added water emulsified Mahua biodiesel blend (NWEB) and to study its fuel properties, combustion, performance and emission characteristics in a four stroke, single cylinder 10 kW diesel engine vis a vis diesel, B20 and water emulsified Mahua biodiesel blend (WEB). Initially, dispersion stability of CeO_2 nanoparticles dispersed in water (pH 7.3) with 20, 40, 60, 80 and 100 mg/L concentration was measured using electrophoretic light scattering method. The highest stability (zeta potential -46.4 mV) of CeO_2 nanoparticles was observed with 60 mg/L concentration and it was selected for preparing more samples of NWEB. The Mahua biodiesel was produced following acid-base transesterification process and B20 blend was used as base fuel to prepare emulsified fuels. The data of NWEB prepared with different levels of water amount, surfactant amount and stirring speed were used in radial basis function neural network-particle swarm optimization (RBFNN-PSO) technique to predict the optimal emulsifying parameters to prepare a stable NWEB with lesser surfactant amount and stirring speed so as to save chemical and electricity. The combination of optimal emulsifying parameters i.e. 10% water, 1% surfactant and 2500 rpm of stirrer was selected with which actual separation from emulsion layer was found to be 0.84% after 30 h as compared to a predicted separation of 0.90%. The fuel properties of NWEB and base fuels were measured following the ASTM Standards and were found within the limits of American, European and Indian Standards for diesel, biodiesel and biodiesel blends. NWEB was used to run a four stroke, single cylinder, water cooled, direct injection 10 kW diesel engine to investigate its combustion, performance and emission characteristics at 0, 20, 40, 60, 80 and 100% of rated load as per Indian Standard and to compare the same with diesel, B20 and WEB. The mean peak pressure for NWEB with all loads tested was measured to be 61.55 bar as compared to 62.48, 60.31 and 61.14 bar for diesel, B20 and WEB, respectively. The peak heat release rate for NWEB was found to be lower than diesel and WEB due to lesser heating value and shorter ignition delay. The blending of CeO_2 nanoparticles with WEB increased the fuel reactivity which reduced the ignition delay up to 0.35 °CA as compared to WEB. The fastest combustion was observed with NWEB by which mean total combustion duration at all engine loads reduced by 4.65%, 5.09% and 3.43% as compared to that of diesel, B20 and WEB, respectively. The engine was found to be more efficient at 80% engine load for all the fuels tested where maximum BTE (30.41%) and minimum EGT (646 °C) were obtained with NWEB as compared to other test fuels. However, mean BSFC for NWEB was found to be 8.6% higher as compared to that of diesel (346.7 g/kWh) due to its lesser energy content and higher density. The mean CO, HC and NO_x emissions obtained with NWEB were reduced by more than 12%, 30% and 14%, respectively as compared to diesel and WEB due to improved air-fuel mixing, increased fuel reactivity and lower residence time at higher cylinder temperature.

Keywords: Mahua biodiesel; Water emulsified fuel; Cerium oxide; Stability; Diesel engine; Combustion characteristics; Performance; Exhaust emissions