Abstract

The present study was undertaken to develop a decentralized power generating system using de-oiled Jatropha seed cake (JSC) and Jatropha biodiesel (JB) to help in rural electrification. A pelleting machine capable of producing JSC pellets at the rate of 25 kg/h was developed and the performance of the pellets in terms of percentage of pellet formation, length, density and compressive strength were evaluated. A power generating system consisting of a downdraft gasifier (12.5 Nm^3/h) with cooling and cleaning system, a 5.6 kW diesel engine coupled to a 5 KVA generator was developed to produce 4kW-h electricity using producer gas obtained from gasifier using pellets of JSC and JB. The combustion characteristics (ignition delay, cylinder pressure, heat release rate), performance parameters (brake specific energy consumption, BSEC; brake thermal efficiency, BTE; exhaust gas temperature, EGT) and exhaust emissions (CO, HC, CO_2, NO_x) of the engine used in the power generating system were studied at six different levels of system load (no load, 20%, 40%, 60%, 80% and 100% of rated capacity) as per the ISO standard. JB, high speed diesel (HSD) and their blends (B10 and B20) were used in single fuel mode and with producer gas (PG) in dual fuel mode. The PG was obtained from the gasification of pellets of diameter 18 mm made from de-oiled JSC with a gasification efficiency of 43%. The ignition delay of different fuels in dual fuel mode operation was prolonged on an average by 11.45% as compared to their respective pilot fuels in single fuel mode. Peak cylinder pressure and heat release rate (HRR) of biodiesel blends in single fuel mode and with producer gas in dual fuel mode were observed to be decreased on an average by 5.10% and 7.71% as compared to HSD. The increments in load on the engine increased the BTE, EGT and lowered the BSEC for all the fuels tested in both single and dual fuel modes of operation. Exhaust emissions like CO, CO_2 and HC were found lower in biodiesel blends compared to HSD in single fuel mode however, in dual fuel mode, increase in CO, CO_2 and HC emissions and reduction in NO_x were observed compared to single fuel mode of operation. An average of 48.25% reduction in NO_x emission was observed with all the fuels in dual fuel mode as compared to HSD. Based on Taguchi-grey analysis taking into consideration the performance (minimum BSEC and EGT with maximum BTE), emissions (minimum CO, HC, CO_2 and NO_x) and reduction in HSD consumption, biodiesel blends up to 10% (B10) in single fuel mode and B10PG (B10 with producer gas) in dual fuel mode were recommended for power generation at higher system loading with the developed system. Economic analysis of the developed power generating system costing Rs. 12,00,000/- was carried out. The cost of producing kWh of electricity with B10 and HSD in dual fuel mode with producer gas was found to be Rs. 67.71 and 49.50, respectively as compared to Rs. 49.59 and 46.83 for the same fuels in single fuel mode resulting in 49% saving of pilot fuel. Compared to single fuel mode, while operating with the power generating system in dual fuel mode, there was reduction in BTE and system efficiency up to 40% and 50%, respectively with significantly lower NO_x and higher CO, CO_2 and HC.

Keywords: Pellet; Jatropha seed cake; Producer gas; Biodiesel; Combustion characteristics; Brake specific energy consumption; Exhaust emissions.