

## ABSTRACT

Non-edible grade filtered soybean oil (SbO) and ethyl ester of soybean oil (SbOE) blended with high speed diesel (HSD) were tested for their use as a substitute fuel of diesel in the diesel version of a Ricardo (E 6/S) variable compression, single cylinder, naturally aspirated engine at the Indian Institute of Technology, Kharagpur, India. HSD, SbO-HSD fuel blends (20, 30, 40, 50, 60 per cent) and SbOE-HSD fuel blends (20, 40, 60, 80, 100 per cent) were used for conducting the short term engine performance tests at varying loads (0, 25, 50, 75 and 100 per cent), engine speeds (1200, 1350 and 1500 rpm), compression ratios (18:1, 19:1, 20:1) and fuel injection timings (35, 40, 45°bTDC). The engine performance indices like fuel consumption, exhaust gas temperature and exhaust emissions (CO, CO<sub>2</sub>, HC, NO<sub>x</sub>, SD) and sound level were recorded as response variables on each setting of independent variables. The brake specific fuel consumption (BSFC) and brake thermal efficiency (BTE) were calculated from the recorded data. The term exhaust emission index (EEI) was introduced to take care of the combined effect of exhaust emissions by allocating weightage to each emission component.

To attain the optimum combination of engine operating parameters, such as, compression ratio, fuel injection timing, fuel blends, engine speed and load for achieving minimum BSFC, maximum BTE and minimum EEI, the statistical analyses of the data were carried out separately for SbO-HSD and SbOE-HSD fuel blends. A linear multiple regression analysis was performed in each case and the effect of each independent variable (CR, FIT, speed and load) on different response variables (BSFC, BTE and EEI) was assessed according to experimental levels of independent variables.

The result of transesterification of soybean oil showed that the molar ratio of oil to anhydrous ethanol of 1:5.1, 1.6% of NaOH catalyst to the oil weight, 60°C temperature and two hour reaction time were the optimum combinations for maximum percentage of ester conversion (95%). The soybean oil and soybean oil ethyl ester displayed higher densities, viscosities, flash, cloud and pour points but lower gross calorific values compared to high speed diesel. The best engine performance based on lower brake specific fuel consumption and higher brake thermal efficiency was observed at the compression ratio 20:1, fuel injection timing 45°bTDC, engine speed 1200 rpm and 100 per cent load for SbO-HSD and SbOE-HSD fuel blends. From emission point of view the neat soybean oil ethyl ester was found to be the best fuel as it showed less exhaust emission index compared to HSD. The overall results showed that the soybean oil ethyl ester and high speed diesel blend of 20:80 (v/v) could be used as substitute fuel for compression ignition engines satisfactorily with about 10 per cent higher brake specific fuel consumption than high speed diesel.

**Key words:** Diesel engine, substitute fuel, soybean oil, soybean oil ethyl ester, fuel properties, engine performance, emission characteristics.