CHAPTER- 9

OVERALL COMPARISON OF TEST FUELS

In this chapter the experimental results obtained from the CHAPTERS 6, 7 and 8 are compiled to evaluate the best test fuel based on engine performance, emission and combustion results.

9.1 BRAKE SPECIFIC FUEL CONSUMPTION

The variation of brake specific fuel consumption of all the test fuels with respect to brake power is presented in Fig.9.1. For base line diesel, tobacco seed oil, pongamia oil, mahua oil, treated tobacco seed oil, treated pongamia oil, treated mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, pongamia oil + mahua oil blend and tobacco seed oil + pongamia oil + mahua oil blend operation the brake specific fuel consumption was decreased with increase of brake power up to 80% load and there after an increasing trend in brake specific fuel consumption is seen in all the cases. The lowest brake specific fuel consumption obtained at 80% load for base line diesel, tobacco seed oil, pongamia oil, mahua oil, treated tobacco seed oil, treated pongamia oil, treated mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, pongamia oil + mahua oil blend and tobacco seed oil + pongamia oil + mahua oil blend are 0.305, 0.370, 0.390, 0.365, 0.368, 0.375, 0.372, 0.362, 0.372, 0.351 and 0.375 Kg/kWh respectively. The brake specific fuel consumption value of pongamia oil + mahua oil blend at 80% load is lowest compared to all the test fuels except base line diesel. When compared to tobacco seed oil, pongamia oil and mahua oil there is 5.41%, 11.1% and 3.98% decrease in brake specific fuel consumption with
pongamia oil + mahua oil blend respectively. When compared to treated tobacco seed oil, treated pongamia oil and treated mahua oil there is 4.84%, 6.83% and 5.98% decrease in brake specific fuel consumption with pongamia oil + mahua oil blend respectively. When compared to tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, and tobacco seed oil + pongamia oil + mahua oil blend there is 3.13%, 5.98% and 6.83% decrease in brake specific fuel consumption with pongamia oil + mahua oil blend respectively. However there is 15% increase in brake specific fuel consumption with pongamia oil + mahua oil blend due to lower heating value and poor spray characteristics leading to inefficient combustion of pongamia oil + mahua oil blend when compared to base line diesel.

**9.2 EXHAUST GAS TEMPERATURE**

Fig.9.2. shows the variation of exhaust gas temperature with brake power of all the test fuels. The exhaust gas temperatures with all the test fuels except treated pongamia oil and treated tobacco seed oil are lower than base line diesel operation.
Fig. 9.1 BSFC Vs Brake Power of all test fuels at respective best injection pressure and timing.

Fig. 9.2 Exhaust Gas Temperature Vs Brake Power of all test fuels at respective best injection pressure and timing.
9.3 BRAKE THERMAL EFFICIENCY

The variation of brake thermal efficiency with brake power of all the test fuels is shown in Fig.9.3. The highest brake thermal efficiency is obtained at around 4 kW with all the test fuels. Throughout the operating range the brake thermal efficiency is higher with diesel than all the other non-edible oils. The peak brake thermal efficiency with base line diesel, tobacco seed oil, pongamia oil, mahua oil, treated tobacco seed oil, treated pongamia oil, treated mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, pongamia oil + mahua oil blend and tobacco seed oil + pongamia oil + mahua oil blend are 28.05%, 24.92%, 24.85%, 25.36%, 25.04%, 25.81%, 24.86%, 25.53%, 25.42%, 26.93% and 24.98% respectively. When compared to tobacco seed oil, pongamia oil and mahua oil operation there is 8%, 8.3% and 6.19% increase in brake thermal efficiency with pongamia oil + mahua oil blend respectively. When compared to treated tobacco seed oil, treated pongamia oil and treated mahua oil there is 7.54%, 4.33% and 8.3% increase in brake thermal efficiency with pongamia oil + mahua oil blend respectively. When compared to tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, and tobacco seed oil + pongamia oil + mahua oil blend there is 5.48%, 5.94% and 7.8% increase in brake thermal efficiency with pongamia oil + mahua oil blend respectively. When compared to base line diesel operation 4.15% decrease in brake thermal efficiency is observed with pongamia oil + mahua oil operation. The decreased values of brake thermal efficiency with all the test fuels over diesel indicates lower heating value and poor combustion due to high viscosity of all the test fuels used. However there is 4 to 8% improvement in brake thermal efficiency with
pongamia oil + mahua oil blend operation is observed compared to other test fuels. The brake specific fuel consumption and exhaust gas temperature trends also support the improved brake thermal efficiency in case of pongamia oil + mahua oil blend operation. Hence pongamia oil + mahua oil blend operation can be adjudged as the best combination to achieve higher brake thermal efficiency, lower brake specific fuel consumption and lower exhaust gas temperatures. The reason for improved brake thermal efficiency can be attributed to the fuel compatibility leading to formation of better fuel mixture with enhanced calorific value and low carbon residue.

9.4 UNBURNT HYDROCARBONS

Unburnt hydrocarbon emission variation of all the test fuels with brake power is represented in Fig.9.4. Higher values of unburnt hydrocarbon with all the test fuels over diesel indicates improper combustion of the test fuels due to more heterogeneous mixture formation resulting from higher viscosity and low volatility. It is observed that there is reduction in unburnt hydrocarbon with pongamia oil + mahua oil operation indicating relatively better combustion compared to other test fuels. At the point of best brake thermal efficiency there is an increase of 11ppm unburnt hydrocarbon with pongamia oil + mahua oil operation when compared to base line diesel operation.
Fig. 9.3 Brake Thermal Efficiency Vs Brake Power of all test fuels at respective best injection pressure and timing.

Fig. 9.4 Un Burnt Hydro Carbon Vs Brake Power of all test fuels at respective best injection pressure and timing.
9.5 CARBON MONOXIDE

Emission of carbon monoxide variation with brake power of all the test fuels is indicated in Fig.9.5. The carbon monoxide emissions are very low in all the cases as expected in any of the compression ignition engines due to the presence of excess air. However there are lower values of carbon monoxide with pongamia oil + mahua oil blend over other test fuels indicating relatively better Combustion with pongamia oil + mahua oil blend.

9.6 OXIDES OF NITROGEN

The variation of Oxides of Nitrogen emissions of all the test fuels with brake power is shown in Fig.9.6. There is higher Oxides of Nitrogen concentration in the exhaust of all the test fuels when compared to base line diesel operation. This is obvious due to the availability of more oxygen with vegetable oils as the vegetable oils itself contains oxygen in its molecular structure.

9.7 SMOKE OPACITY

Fig.9.7. shows the variation of smoke opacity with brake power of all the test fuels. The smoke intensity is higher with all the test fuels when compared to diesel due to higher viscosity of vegetable oils leading to thermal cracking. More over the carbon residue values for all the vegetable oils are higher compared to diesel. The higher values of carbon residue are the indication of incomplete combustion which leads to higher levels of smoke opacity.
Fig. 9.5 Carbon Monoxide Vs Brake Power of all test fuels at respective best injection pressure and timing.

Fig. 9.6 Oxides of Nitrogen Vs Brake Power of all test fuels at respective best injection pressure and timing.
9.8 PRESSURE Vs CRANK ANGLE

The pressure versus Crank Angle data related to diesel and all test fuels at respective best injection pressure and timing at 80% load are given in fig. 9.8. The maximum pressure values of diesel, tobacco seed oil, pongamia oil, mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, Pongamia oil + mahua oil blend, tobacco seed oil + mahua oil + pongamia oil blend, tobacco seed oil + mahua oil + pongamia oil blend, treated tobacco seed oil, treated pongamia oil and treated mahua oil are 72.72 (368°Crank Angle), 74.9 (369°Crank Angle), 75.13 (370°Crank Angle), 75.53 (370°Crank Angle), 73.02 (372°Crank Angle), 66.58 (371°Crank Angle), 77.63 (369°Crank Angle), 73.02 (372°Crank Angle), 75.34 (371°Crank Angle), 68.16 (372°Crank Angle) and 55.34 (374°Crank Angle) bar respectively at respective Crank Angle as shown in parenthesis. The peak pressure value of 77.63 (369°Crank Angle) bar recorded by Pongamia oil + mahua oil blend further confirms the superiority as fuel over other test fuels.

9.9 RATE OF PRESSURE RISE Vs CRANK ANGLE

Fig 9.9 indicates rate of pressure rise versus Crank Angle of diesel and all test fuels at respective best injection pressure and timing at 80% load. The maximum rate of pressure rise values of diesel, tobacco seed oil, pongamia oil, mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, Pongamia oil + mahua oil blend, tobacco seed oil + mahua oil + pongamia oil blend, treated tobacco seed oil, treated pongamia oil and treated mahua oil are 7.37 (358°Crank Angle), 4.85 (357°Crank Angle), 4.58 (357°Crank Angle), 4.08 (358°Crank Angle), 3.73 (361°Crank Angle), 3.72 (360°Crank Angle), 4.48 (358°Crank Angle),
3.73 (361°Crank Angle), 4.08 (358°Crank Angle), 3.08 (362°Crank Angle) and 2.78 (364°Crank Angle) bar/°Crank Angle respectively.

**9.10 NET HEAT RELEASE Vs CRANK ANGLE**

Fig 9.10 gives the net heat release versus Crank Angle of diesel and all test fuels at respective best injection pressure and timing at 80% load. The highest net heat release values of diesel, tobacco seed oil, pongamia oil, mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + blend, pongamia oil + mahua oil blend, tobacco seed oil + mahua oil + pongamia blend, treated tobacco seed oil, treated pongamia oil and treated mahua oil are 68.85 (358°Crank Angle), 44.11 (358°Crank Angle), 40.54 (357°Crank Angle), 38.85 (359°Crank Angle), 41.35 (368°Crank Angle), 38.21 (361°Crank Angle), 40.49 (358°Crank Angle), 41.35 (368°Crank Angle), 38.85 (359°Crank Angle), 38.79 (370°Crank Angle) and 37.42 (365°Crank Angle) J/°Crank Angle respectively.

**9.11 CUMULATIVE HEAT RELEASE Vs CRANK ANGLE**

Fig 9.11 shows the cumulative heat release versus Crank Angle of diesel and all test fuels at respective best injection pressure and timings at 80% load. The highest cumulative heat release values of diesel, tobacco seed oil, pongamia oil, mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, pongamia oil + mahua oil blend, tobacco seed oil + mahua oil + pongamia oil blend, treated tobacco seed oil, treated pongamia oil and treated mahua oil are 0.91 (391°Crank Angle), 1.17 (423 °Crank Angle), 1.1 (398 °Crank Angle), 1.16 (406 °Crank Angle), 1.23 (416 °Crank Angle), 1.07 (504 °Crank Angle), 1.2 (414 °Crank Angle), 1.23 (416 °Crank Angle), 1.16 (406 °Crank Angle), 1.17 (412 °Crank Angle) and 0.9 (392 °Crank Angle) kJ respectively.
9.12 MASS FRACTION BURNT Vs CRANK ANGLE

Fig 9.12 explains the mass fraction burnt of diesel and all test fuels at respective best injection pressure and timings at 80% load. The °Crank Angle for 5% mass fraction burnt for diesel, tobacco seed oil, pongamia oil, mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, pongamia oil + mahua oil blend, tobacco seed oil + mahua oil + pongamia oil blend, treated tobacco seed oil, treated pongamia oil and treated mahua oil are 354, 354, 355, 354, 355, 354, 356, 354, 353 and 360 °Crank Angle respectively. The °Crank Angle for 5% mass fraction burnt for diesel, tobacco seed oil, pongamia oil, mahua oil, tobacco seed oil + mahua oil blend, tobacco seed oil + pongamia oil blend, pongamia oil + mahua oil blend, tobacco seed oil + mahua oil + pongamia oil blend, treated tobacco seed oil, treated pongamia oil and treated mahua oil are 375, 381, 381, 381, 383, 381, 381, 379, 378, 378 and 382 °Crank Angle respectively.
Fig. 9.7 Smoke Opacity Vs Brake Power of all test fuels at respective best injection pressure and timing.

Fig. 9.8 Pressure Vs Crank Angle of all test fuels at respective best injection pressure and timing at 80% load.
Fig. 9.9 Rate of Pressure Rise Vs Crank Angle of all test fuels at respective best injection pressure and timing at 80% load.

Fig. 9.10 Net Heat Release Vs Crank Angle of all test fuels at respective best injection pressure and timing at 80% load.
Fig. 9.11 Cumulative Heat Release Vs Crank Angle of all test fuels at respective best injection pressure and timing at 80% load.

Fig. 9.12 Mass Fraction Burnt Vs Crank Angle of all test fuels at respective best injection pressure and timing at 80% load.