CHAPTER 5

CONCLUSION

The experimental study is accomplished on a four stroke, single cylinder Kirloskar diesel engine using Polanga biodiesel and its blends with diesel. The thermal performance and emissions characteristics are evaluated by running the engine at different combinations of preset injection timings of 15, 19, 23, 27 and 31°bTDC and injection pressures of 160 bar, 180, 200, 220 bar and 240 bar and varying loads from no load to full load at a percentage increase of 20% in each step. The thermal performance parameters evaluated are BTE, BSFC and EGT while the emission constituents measured are CO, UHC, NOx, CO₂ and Smoke. Further, for the optimization, genetic algorithm (GA) analysis is carried out selecting only BTE, BSFC and EGT as thermal performance parameters and CO, UHC, NOx, CO₂ as emissions constituents. It should be noted that the two different studies conducted on thermal performance and emission constituents leads to prediction of each of them in isolation, although a unification of thermal performance and emission constituents is a possibility. However, it is difficult to strike an optimum combination of the possible maximum thermal performance and minimum emission constituents with respect to a combination of injection timing, injection pressure, bio-diesel blend when the engine operates at a preset load (at full load) using only the experimental data. Hence, a suitable technique of optimization is to be chosen to strike an optimum balance between the chosen four input parameters to predict the output parameters.
Thus, a computational study consisting of multi-objective optimization of thermal performance and emission characteristics using GA technique and modelling using ANN for the engine is carried out. The combination of optimization and modelling is intended to find the optimum combination of the three input parameters, viz, injection timing, injection pressure, load and blend and subsequently to predict the output parameters, viz. BTE, BSFC and EGT for thermal performance and CO, UHC, NOx, CO$_2$ for emission constituents for the optimum combination of input parameters. The GA toolbox of MATLAB is used for the purpose of optimization. The ANN is modelled by using the selected results of the experimental study using MATLAB. The accuracy with which this neural network works is judged by comparing the outputs from the network with the experimental data. The output parameters can be determined from the optimized input parameters. Based on the experimental and computational studies, following are the important observations made and the conclusions drawn thereon.

1. A single cylinder, four stroke CI engine originally designed to operate on diesel as fuel may be operated on Polanga biodiesel blends without any system hardware modifications. Based on the experimental study, it can be concluded that with the increase in injection timing, the performance of diesel engine operated using a Polanga biodiesel blends approach to that operated using diesel oil. At higher injection timing and injection pressure, the thermal performance of Polanga biodiesel blend is closest to that of diesel oil compared to that operated at other injection timings. Higher injection pressure is preferable for Polanga biodiesel due to its higher viscosity.

2. The thermal performance evaluation, in isolation, indicates that the blend B20 operates closest to that of diesel oil whereas, the engine operated with any
higher injection timing, ranging from 27 to 31° bTDC, the emission constituents of CO, UHC, CO₂ and Smoke are the least and remains constant in the injection timing range of 27 to 31°bTDC. Both the above observations are made when the engine is operated with IP at 200 bar and at full load.

3. Polanga biodiesel blends give minimum harmful emissions as compared to all other blends. Further, at a higher injection timing of 31°bTDC and injection pressure of 240bar, the fairly reduced exhaust emissions are observed irrespective of the fuel blend used. Therefore, operating the diesel engine with Polanga biodiesel at a injection timings of 31°bTDC and injection pressure of 240 bar results in minimum emissions except NOx emissions. If NOx is also to be minimised, then the engine should be operated at the injection timing of 23°bTDC, which will result in a decrease in BTE of about 10% and an increase in BSFC of 11% which are not affordable just for the sake of reduced NOx emissions.

4. ANN models have been developed to predict the performance and emission parameters. For training, different algorithms such as LM, GDM, SCG are tested. Multilayer feed forward network with back propagation training algorithm was found most suitable to predict the performance, emission and combustion features of a diesel engine at various injection timings and pressures. Logistic sigmoid, tangent sigmoid and linear transfer functions were used in the different network architectures. It was found that log sigmoid gives better results. The number of neurons in network layers is varied along with the layers. For performance model, two layer structure was sufficient to predict the results, whereas a three layer structure was found suitable for emission model.
5. The predicted R values were found to be very close to unity while the MSE error was less than 0.0004 for BSFC, BTE, EGT, CO, NOx, CO2 and UBHC and revealed that there was good correlation between the predicted and measured data. Analysis of the experimental data by the ANN revealed that there was good correlation between the predicted data resulted from the ANN and measured ones.

6. The percentage error for all the parameters lies in the range of 0.47 to 4.58%. The mean percentage error of Engine performance parameters BTE, BSFC and EGT are ±1.85, ±2.35 and ±2.57 %, respectively, also mean percentage error for Engine emission parameters UHC, NOx, CO2 and CO are ±1.78, ±2.57, ±2.79 and ±2.56 % respectively which is acceptable. The mean percentage error for variable injection timing is 2.39% and for variable injection pressure is 2.17%. The developed model thus reduces the experimental efforts and hence can serve as an effective tool for predicting the performance of the engine and emission characteristics under various operating conditions with different biodiesel blends.

7. From the large number of experimental data for thermal performance and emission constituents obtained for various input parameters such as load, injection timing, injection pressure and blends, picking up an optimum combination of the input parameters manually is not possible. The optimal solution for performance parameters is obtained by 24°bTDC, 233 bar fuel injection pressure and B27 biodiesel blend. For emission constituents, the optimal solution is obtained by 19°bTDC, 231 bar injection pressure and B19 biodiesel blend. The optimal solution when different weightages to
performance and emission parameters is assigned is given by 25°bTDC, 235 bar injection pressure and B31 biodiesel blend.

5.1 FUTURE SCOPE OF WORK

In the present work, ANN models have been developed for the performance and emission evaluation of the single cylinder CI engine using Polanga based biodiesel and its blends. The input parameters selected in the present work are; injection timing, injection pressure, and Polanga biodiesel blend. However, compression ratio of the engine may be an important parameter that influences the performance and emission evaluation. A study under varying compression ratio may be done to assess the performance and emission evaluation also multi-cylinder engine can be used for further investigation purpose. Further, an optimization of parameters viz., compression ratio, injection timing, injection pressure and Polanga biodiesel blend may be done.