CHAPTER - 7

CONCLUSIONS AND FUTURE SCOPE
A lot of Research Work is in progress on the usage of Bio-Diesel Fuels as a replacement to the Diesel. Further, the Globalisation made the industry to go for automation/mechanization, leading to sophistication of goods and services to compete at the global level. As such, many of the machines involved in the automation/mechanisation are run with IC Engines. Due to the economic reasons, the DI Diesel engines are being preferred over Petrol Engine. Further, the depletion of petroleum fuel resources and their continuous rise in the prices, made the researchers, academia and manufacturers of IC Engines explored the possibilities to invest and invent on alternative fuels. In the process, it is an established fact that the blends of Bio-Diesel can be used to run a DI Diesel Engine. Moreover, the blends of edible oils are also costly and hence the blends of non-edible oils are considered. The Literature shows that the experiments have been conducted on DI Diesel with non-edible oils, choosing either the Bio-fuel available in a particular geographical area at a specified Injection Pressure; or two/three Bio-fuels at a particular Injection Pressure and then established the usage of blends of Bio-Diesel in place of Diesel. But a lacuna has been observed in not finding the best blend and the best Injection Pressure among the various blends of different oils, such as Deccanhemp, Jatraopha, Mahua, Neem and Pongamia and also the better Bio-Diesel among the available Bio-Diesels. Therefore, the author has taken up the present research work and conducted experiments as explained in the earlier six chapters. Based on the Experimental Investigations, Results and Discussions, the Conclusions drawn are mentioned as follows.

7.1 CONCLUSIONS

1. The properties like density, viscosity, flash and fire points of all kinds of vegetable oils tested in this research are higher than that of diesel and only calorific value is lesser in the range of 85 – 95 % of Diesel.
2. Transesterification resulted in reduced density (by around 5%), reduced Viscosity (by approximately 8 to 10 times), reduced Flash and Fire points (by around 40%), slightly increased Calorific Value (by 1 to 3%) and thus enhancing the improvement in ignition characteristics of the oils.

3. The best blend and the injection pressure are found to be B30 DH and 200 bar among all the five Bio-diesel blends of all the non-edible oils followed by JP, MH and NM respectively, whereas for the Pongamia it is B20PN at 180 bar.

4. Though the Pongamia oil exhibits lower efficiencies when compared to other blends and Diesel, the variation is not that considerable. Perhaps better methods of esterification or combustion process may help improve their effectiveness and can be suitably used for Bio-diesel blends.

5. The experimental results with all the bends of B30DH, B30JP and B30MH at 180 bar on both Conventional Engine and LHR Engine reveal that the Brake Thermal Efficiency and Specific Energy Consumption are in good comparison with the Diesel Fuel except the blends of Pongamia.

6. Brake thermal efficiency of the LHR Engine in case of Deccanhemp, Jatropha and Mahua is higher than that of Diesel and slightly lower in case of Neem and Pongamia.

7. Among all the oils, Deccanhemp oil is found to be the best, with an increase in the overall Brake Thermal Efficiency of 10.81 % from the LHR Engine run with the best combination of the blend (B30DH and 200 bar) over conventional engine run with Diesel( i.e., the increase from 25.83 % with Diesel to 28.62 % on LHR engine with the best combination)

8. Similarly, the performance in terms of Brake Thermal Efficiency of the LHR Engine with the combination of the best blend is found to be 28.62 % as against 27.02 % of the conventional engine with the same combination of the best blend, i.e., an increase of 5.92 %.
9. Among all the oils, LHR Engine run with Deccanhemp oil (with the best combination of the blend) delivers the maximum with Brake Thermal Efficiency of Efficiency of 28.62 %

10. Further, reduction in specific energy is minimum for the best combination (of B30DH and 200 bar), when compared to all other Bio-diesels. (i) SEC with respect LHR Diesel Engine is 13420 KJ/KWh, whereas for B30DH it is 12577 KJ/KW-hr. Thus, resulting in the savings of heat value of 840 KJ/KWh. When compared to the conventional engine run with diesel, the saving in SEC is (13937 - 12577) = 1560 KJ/KW-hr, i.e., 10.81%. In both the cases, (Brake Power vs Brake Thermal Efficiency and Brake Power vs Specific Energy Consumption) the result is the same. Thus, confirming the combination of the blend B30DH and Injection Pressure of 200 bar being the best.

11. The best combination of the blend B20 PN at 180 Bar is observed to be the best indicating that the DI Diesel Engine can be run with blends of Pongarnia Oil at lower level of Injection Pressure, in which case it is only replacement for Diesel, where the efficiency is not the criterion.

12. Brake Thermal Efficiency got increased by around 4.5% to 6% for different Bio-diesels, maximum of 10.81 % in case of Deccanhemp oil.

**Exhaust Gases**

1. The performance curves of Load Vs HC, CO2, NOx and O2, show that as the load increases, the O2 content available in the blend is decreasing. Therefore, it can be concluded that the CO content is formed into CO2, which is an indication of better combustion of Bio-diesel with less emission of pollutants.

2. The performance curves Temperature vs the Exhaust Emissions O2, CO2 and NOx drawn at the best combination of the blend, it is said that the CO2 and the NOx emission are increasing as against the decrease in O2 with reference to Temperature. This is an indication of the proper utilization of O2. However, in the present research analysis is limited to estimate the percentage of exhaust gases and NOx.
3. The estimation of the temperature at which the gases form is an important factor to control the NOX formation. If the NOx released becomes NO3, the phenomenon dangerous as it leads to acid rain. Therefore, beyond NO2 formation, the exhaust Temperature also has to be controlled. The exhaust pollution was less in case of almost all the Bio-diesels.

4. Maximum CO got reduced from 68% to 28% in case of different Bio-diesels (minimum reduction being in Pongamia and maximum being in Deccanhemp).

5. Unburnt HC got reduced by from 34% to 4% (again minimum in Pongamia and maximum in Deccanhemp).

6. Smoke intensity got reduced in case of all oils (Varied between 10% to 43%, minimum being for Neem and Maximum being for Deccanhemp), except in case of Pongamia where increase was 8%.

7. NOx got reduced in case of all the oils (varied between 10 to 28.6%, minimum being in Jatropha and maximum in Deccanhemp).

8. Exhaust gas temperature rise is observed with LHR Engine in case of all Bio-diesels (varied between 2.4% and 13.6%, again minimum being in Jatropha and maximum in Deccanhemp). This is due to the fact that the development of higher thermal energy inside the cylinder of LHR Engine.

9. CO emission got reduced substantially (varied between 24.5% to 48.3%), maximum reduction being in Deccanhemp.

10. Unburnt HC got reduced by around 8% to 20%, maximum being in Jatropha closely followed by Deccanhemp.

11. Smoke intensity got reduced by around 14.8% to 26.2%, maximum being in Mahua oil closely followed by Deccanhemp.

12. NOx got increased by around 76% to 90% maximum being in Mahua oil.

13. Exhaust gas temperature got increased by around 29% to 44%, maximum being in Mahua oil, which is an indication that the need of further investigation on Mahua Oil at higher temperature of operating condition. But at higher
temperatures, the formation of NO$_3$ leads to acid rain, that requires better control of exhaust gas temperature as already mentioned.

14. Amongst the five oils tested in this Research Work, Deccanhemp is proved to be the best with highest Brake Thermal Efficiency and Least Specific Energy Consumption. This is closely followed by Jatropha, Mahua, Neem and whereas Pongamia standing far behind.

7.3 SCOPE FOR FUTURE WORK

The following suggestions are given for Future Research Work.

(i) The Analysis is based on the experimental results to establish the best combination of the blend and the Injection Pressure. The Combustion Analysis inside the cylinder requires detailed study as it is being done for Diesel Fuel with CFD Analysis. The detailed CFD Analysis, may further improve the blend preparation and also better utilisation of Oxygen, since the Bio-Diesel blends are of Oxy-rich fuels.

(ii) The volumetric efficiency is another parameter which can be tried along with Brake Thermal Efficiency. However, the main objective of the present Research is limited to identify the combination of the best blend and the Injection Pressure for better utilisation of the Thermal Energy, out of the available non-edible oils.

(iii) The CFD Analysis may be carried-out with Bio-diesel blends for combustion analysis leading to better Exhaust Gas Analysis.