CHAPTER 11

CONCLUSION AND SCOPE OF FUTURE WORK

11.1 Conclusions

In the present investigation, the direct injection diesel engine was tested in four modes namely i) COME and Diesel blends ii) Hydrogen and COME20 iii) Hydrogen, EGR and COME20 iv) Hydrogen, Nitrogen, EGR and COME20. The following conclusions are arrived from present investigation.

11.1.1 Corn oil methyl ester and Diesel Blends

- Compared to the neat diesel operation, the COME20 – diesel blends resulted in lower BTE for all load condition.
- The EGT increases with the higher blends of COME and Diesel compared to neat diesel.
- The CO emission of COME100 is 25.65 % lower than the diesel at full load. The CO emission of COME20 is 4.1087 g/kw-hr and it is very close to CO emission of neat diesel operation.
- The NOx emissions with COME100 increase approximately 14.04% as compared to diesel fuel at full load.
- The HC emission of COME100 decreased 24 % at the maximum load of the engine in comparison with diesel fuel.
• The Peak pressure and heat release rate of neat diesel is higher than COME20.

• The Ignition delay increases for all COME blends compared to diesel.

11.1.2 Effects of Hydrogen Addition with COME20

• Hydrogen addition with COME20 blends also helps to improve the BTE. The 26.64% hydrogen addition with COME20 gives the highest brake thermal efficiency (40.77%) compared to diesel (34.30 %) at full load.

• The BSFC is decreased for the increase of percentage of H\textsubscript{2} with COME20 fuel compared to diesel fuel.

• The CO emission was decreased when increase the percentage of hydrogen addition with COME20. The value of CO emission is 4.783 g/kW-hr for 26.6% hydrogen COME20 and it is 13.4 % lower than the diesel operation.

• The NOx emission also increased with increase in the percentage of H\textsubscript{2} with COME20. The percentage of NOx emissions for 26.64% H\textsubscript{2} addition is 21.78% at full load when compared to neat diesel.

• The lowest HC emission is 0.074 g/kWh with a hydrogen proportion of 26.64% compared to 0.108 g/kWh for diesel operation.

• The peak cylinder pressure 71.63bar is obtained for 26.6% hydrogen operation with COME20 when compared to neat diesel operation 63.89 bar.
• The HRR for 26.64% hydrogen enrichment is higher than that of neat diesel operation.

• The ignition delay is lower for Hydrogen enrichment compared to that of neat diesel.

11.1.3 Effect of hydrogen and EGR addition with COME20

• The BSFC increased for the hydrogen, EGR and COME20 blends compared to diesel fuel. The BSFC for hydrogen, 20% EGR and COME20 is 0.27 g/kW-hr. This value higher than that of the diesel fuel at full load.

• The BTE decreased with increasing concentration of EGR. The BTE for 10% EGR with COME20 and 20% EGR with C0ME 20 are 32.52% and 30.41% respectively. These values are lower than that of diesel at full load.

• The exhaust gas temperatures (EGT) for 10% and 20% EGR with hydrogen and COME20 blends are higher than that of diesel fuel and their corresponding values are 368ºC and 360ºC respectively, at full load.

• The HC emission increased for 10% and 20% EGR with hydrogen and COME20 blends compared to diesel fuel operation.

• The CO emission of EGR, hydrogen and COME20 combustion increases with increase in percentage of EGR. The value of CO for 20% and 10% EGR is 4.446 g/kw-hr and 4.231 g/kw-hr respectively.
• The NOx formation decrease for higher percentage of EGR. The NOx value for 20 % EGR and 10% EGR is 4.658 g/kW-hr and 4.857 g/kW-hr respectively.

• The peak cylinder pressure is lower for higher percentage of EGR compared to neat diesel.

• The HRR for 10% EGR and 20% EGR is 60.49 J/deg and 58.98 J/deg.

• The ignition delay period is increased with increase in EGR, compared with diesel fuel.

In general the Hydrogen with EGR and diesel fuel can be used as alternative fuels in conventional diesel engines without any major modification in the engine. CO and HC emissions increased with increase in EGR, when compared to diesel.

11.1.4 Effect of simultaneous addition of hydrogen, EGR and nitrogen withCOME20

• The BTE decreased with increase in percentage of N₂ with 26.64% H₂ and 20% EGR rate. The N₂ addition is varied for 6.66%, 9.99% and 13.32% respectively with constant addition of 26.64% H₂ and 20% EGR.

• The BSFC decreased with an increase in proportion of N₂ addition with 26.64% H₂ and 20% EGR. The BSFC of 0.2297kg/kW-hr is obtained for diesel and 0.28 kg/kW-hr is for 13.22% N₂ with 26.64% H₂ and 20% EGR at full load condition.
• The HC emission increases by 20% with the addition of 13.32% N\textsubscript{2} in with 26.64% H\textsubscript{2} and 20% EGR compared to the 0% N\textsubscript{2} addition.

• The CO emission increase with increase in percentage of N\textsubscript{2} addition with H\textsubscript{2} and EGR. The maximum CO emission obtained is 4.804 g/ kW-hr at 13.32% N\textsubscript{2} addition at full load condition.

• The NOx formation is reduced with increase in N\textsubscript{2} addition. The NOx formation is lower with 13.32% N\textsubscript{2} addition compared to 6.66% and 9.99% correspondingly. The proportion of NOx decrease is 21.4% lower for 13.32% N\textsubscript{2} enrichment compared to 0% N\textsubscript{2} addition with 26.64%H\textsubscript{2} and 20% EGR.

• The cylinder pressure and heat release rate decreased for nitrogen addition with EGR and hydrogen fuel in comparison with that of COME20 and diesel.

• The Ignition delay period is increase with increase in nitrogen addition.

In general the nitrogen addition with hydrogen, EGR and COME20 decrease the NOx emission and increase HC, CO emission. The BTE and BSFC decreased for addition of nitrogen fuel with hydrogen, EGR and COME20.
11.2 Scope for Future Work

The following suggestions are proposed as future work for the investigations on the use of hydrogen in a DI diesel engine.

- The alcohol fuel may be used to decrease the emission level with hydrogen, nitrogen and COME20.
- The manifold injection of hydrogen, nitrogen may be used with an other fuels to control the emission.
- The injection pressure and injection timing may be varied to improve the performance and reduce the emission of the above used fuels.
- The high pressure H$_2$ direct injection in to the cylinder may be used to improve the performance and reduce the emission of used fuel.