CHAPTER 7

CONCLUSIONS

From the investigations of the use of hydrogen fuel as an alternative fuel and to overcome the problems associated with hydrogen fuel, the following conclusions are arrived at:

- Hydrogen usage in engine is found to be justifiable.
- Spark timing has to be retarded for stable operation.
- Minimum equivalence ratio for stable operation was 0.25 and maximum is 0.8.
- Maximum power output was found to be 2.3 kW while beyond that the increase leads to back firing.
- Hydrogen engine operates on wide throttle at all loads because of the wide flammability limits.
- Brake thermal efficiency at maximum power output of 2.3 kW was around 22 % whereas for the same power output for gasoline it is 18.5 %.
- Brake specific energy consumption for hydrogen is lower due to the entire region due to its higher calorific value.
- Due to wide range of mixture formation in hydrogen the exhaust gas temperature variations are high.
• UBHC emissions are found to be almost zero because of the absence of hydrocarbons. Some traces of hydrocarbon are seen at maximum power because of evaporation of lubricating oil.

• NOx emission is negligible till equivalence ratio of about 0.56 and beyond that it increases drastically

• Inlet Air Treatment:
  - Heat release is found to be reducing while there was increase in the water flow.
  - Due to the air treatment there was only marginal drop in the brake thermal efficiency.
  - NOx reduction was identified after the treatment of the inlet air.

• Catalytic Converter
  - Drastic reduction in the NOx was identified of about 46%.
  - Reduction in NOx is maximum for the combination of inlet air treated and catalytic converter one

• Lubricating Oil
  - Kinematic viscosity is found to be good for the nanomaterials based lubricating oil which avoids evaporative losses

• Hydrogen storage
  - A new hydrogen storage device was developed and it was analysed with the CFD. For the operating pressure of around 60 bar, the maximum pressure does not raise beyond 65 bar and so it is within the safe limit.
- Hydrogen is stored in different nanomaterials using the newly developed storage apparatus.
- Among all the nanomaterials carbon nanoparticles and carbon-CNT combination offer a good hydrogen storage capability.

7.1 SCOPE FOR FUTURE WORK

Based on the difficulties experienced during the present investigations and to improve the investigations, the following are suggested for future work.

- The power output of the engine could also be improved by boosting up the intake pressure by the way of supercharging or turbo charging.
- In cylinder injection could be tried to improve the volumetric efficiency and power output.
- EGR can be tried for controlling the NOx emissions.
- Hydrogen storage system can be incorporated in a vehicle and tested for its capability.
- More number of nanomaterials can be tried for hydrogen storage in order to get more efficiency.
- Work on identifying the changes in the properties of nanomaterials of lubricating oil with long-term usage of hydrogen can be done.