CHAPTER 8

CONCLUSION

The in-cylinder coated catalysts performances, emission and combustion parameters have been extensively studied under varied load, speed and different EGR flow rate. The flame quenching model is also discussed. The following are the major conclusions and summary drawn based on these works.

8.1 EXPERIMENTAL INVESTIGATION

In the present work, a four stroke single cylinder S.I engine having a rated output of 2.28 kW loaded by an eddy current dynamometer was tested. The engine was operated with varying load at constant speed of 2500 rpm with exhaust gas recirculation (0%, 5% and 10% on volume basis) and also with maximum load at speeds of 2200 rpm, 2400 rpm, 2600 rpm, 2800 rpm and 3000 rpm. The results of engine performance, emission and combustion characteristics were analysed and compared with standard engine.

8.1.1 Engine Performance

The brake thermal efficiency for copper coated engine is about 5% higher than standard engine at full load. The catalytic coated engines showed better fuel consumption compared to the base engine at higher loads. Among the catalysts, the best specific fuel consumption by 0.074 kg/kW-hr is achieved for copper coating than base engine. Catalytic coatings increases pre-flame reactions which lead to better and faster combustion. When compared to the standard engine, all the catalytic coated engines showed better performance.
8.1.2 Engine Emission

NOx emission for catalytic coated engine is 7% to 20% higher than standard engine at full load. This higher NOx emission may be due to higher temperature of combustion chamber. CO emission of standard engine is higher than catalytic coated engine at higher loads which may be attributed to reduced in-cylinder temperatures. The amount of CO\textsubscript{2} produced while using standard surface is 1% to 10% higher than the catalytic coated engine. Copper coated engine has the lowest HC emission when compared to standard and other catalysts. The higher temperatures enhance the combustion, and stimulate oxidation reactions throughout compression and combustion process. As a result, unburned hydrocarbons are more completely oxidized.

8.1.3 Engine Combustion

Catalytic coated engines showed 6% to 12% higher pressure compared to the standard engine. Higher values of $P_{\text{max}}$ indicate a faster combustion for catalysts. Higher heat release rate for catalytic coated engines compared to standard engine is due to higher cylinder pressure for catalytic coated engine and also efficient combustion with catalytic activity. The catalytic surface activates the air fuel charge and increases the pre-flame reaction leading to stable and better combustion process.

8.3.4 Exhaust gas recirculation

Exhaust gas recirculation (EGR) technique has been used in recent years to reduce NOx emissions in petrol engine. To decrease the NOx, the exhaust gas recirculation method is done on 5% and 10% EGR by volume are investigated. The brake thermal efficiency decreases marginally with increase in EGR flow rate that result in larger replacement of air for all the catalytic coating. It is observed that SFC decreases with increased load and increases
with increase in EGR flow rate. The NOx emission reduces with increase in EGR flow rate, due to the presence of higher heat capacity gases that reduces the peak combustion temperature and exhaust gas temperature. Among the catalysts, 46% NOx emission reduction is achieved for copper coating with 10% EGR than standard engine. Hydrocarbon increases with increase in EGR flow rate due to the reduction of oxygen in the inlet charge by the EGR into the cylinder. Due to the instability in combustion and deficiency in oxygen, it makes the CO concentration to increase and CO$_2$ concentration to decrease with an increase in EGR rate. Decrease in peak pressure and heat release with increasing EGR is due to the reduction in oxygen concentration by the presence of CO$_2$. A SI engine can be run successfully with various catalytic coatings. The NOx emission can be reduced significantly by adopting EGR techniques.

8.2 PRE-FLAME CATALYTIC REACTION

To evaluate the pre flame catalytic reaction over various catalytic coated surfaces like copper, nickel and chromium are discussed. Catalytic reaction is controlled by the equivalent ratio, surface temperature and catalytic coating materials. Based on the experimental results, the catalytic ignition temperature of different catalyst materials are measured with the help of a fabricated test chamber using LPG as fuel. With the available activation energies and catalytic ignition temperature of base and copper materials, the catalytic activation energies of nickel and chromium are found. And also the activation energy of platinum for stoichiometric air-fuel ratio is used to find the catalytic ignition temperature of platinum.

8.3 THE FLAME QUENCHING MODEL

Based on the present investigations on flame quenching, the following conclusions were arrived. The thermal boundary layer thickness is
less than the laminar boundary layer thickness for most of the crank angle period, except near TDC. The squish motion near TDC suddenly reduces the boundary layer thickness and increases the Reynolds number. The diffusion rate of fuel into boundary sublayer limits the reaction rate during combustion. The results of the present flame quench model indicate that the flame quenches due to the heat loss to walls. The depletion of fuel due to the catalyst coated on the combustion chamber walls does not affect flame quenching.

Based on the present work the performance of various catalysts can be ranked in the order of Copper, Chromium, Nickel and Standard (Base).

8.4 SUGGESTIONS FOR FUTURE RESEARCH

The following are suggested as future work for the investigation on the use of catalyst

- Experimental measurements of flame quenching phenomena may be made by parallel plate method.

- Endurance tests can be conducted for studying the coating life.

- Microprocessor controlled system to control the engine emission by EGR to have better metering of EGR.

- Coating thickness can be optimized.