ABSTRACT

Internal combustion engines (IC engines) have found to have widespread use in industries, stationary power plants, automobiles, marine and aircraft applications. The success of the internal combustion engines is due to their compactness, reliability, ease of usage and efficiency. Especially in the automotive sector, IC engines are highly preferred as they offer good drivability. Spark ignition (SI) engines are preferred for their smooth operation, high power to weight ratio and good transient response. Petroleum based fuels are widely used throughout the world for automotive applications. The demand is increasing day-by-day and the availability of petroleum-based energy is limited. From the current availability of energy resources, it is impossible to meet the energy demand, which is going to arise in the near future. Another major problem associated with the use of petroleum-based fuels is air pollution. Major cities in developing countries like India suffer from air pollution, which has reached alarming levels. Therefore, there is an urgent need for alternative fuels, which are renewable in nature. The best way is to change over to alternative fuels that give good engine combustion characteristics and hence lead to low emissions and high thermal efficiency. Hence there is lot amount of research undergoing on gaseous fuels such as LPG, natural gas, biogas, producer gas and hydrogen, and on liquid fuel such as alcohols and vegetable oils.
Among the different alternative fuels, hydrogen fuel has many good factors like wide flammability, clean burning capability, low ignition energy, small quenching distance, high autoignition temperature, etc for being a successful internal combustion engines fuel. Even though hydrogen fuel was a good internal combustion engine fuel, it has some problems associated with it. The important problems such as knocking, nitrogen oxides (NOx) emissions and hydrogen storage, have restricted hydrogen from being a good fuel. Therefore an attempt has been made in this investigation to overcome the problems associated with hydrogen fuel.

The main focus is on the effective utilization of hydrogen as an alternative fuel in a SI engine. Initially the engine was made to run on gasoline fuel and the combustion, performance and emission parameters were obtained, Later the engine was modified to run on hydrogen fuel and experiments were conducted in the hydrogen fueled SI engine. A mathematical model has been generated for predicting the combustion characteristics of the hydrogen fueled engine. The simulated values were compared with the experimental values for its accuracy.

A new inlet air treatment device was developed for controlling the NOx emissions from the hydrogen fueled engine. The air inlet treatment device works on the principle of evaporative cooling. Evaporative cooling was selected because of its low energy consumption and less maintenance characteristics. It was found that there was reduction in the NOx emissions. A catalytic converter was developed in this study. The conventional catalysts
were replaced with the nanomaterials as catalyst. There was a significant reduction in the NOx emissions.

In order to overcome the problem of hydrogen storage, an attempt was made to develop a hydrogen storage apparatus. Nanomaterials were used to store the hydrogen in the solid form. Different nanomaterials such as carbon nanotubes, titanium nanoparticles, titanium dioxide nanoparticles, carbon nanoparticles, and their combinations have been tried in this investigation. The performance of the nanomaterials for hydrogen storage is found to have slighter advantage than the conventional metal hydrides. This may overcome the major hindrance of the hydrogen storage problem associated with the hydrogen fueled engine.

In this investigation, an attempt has been made to maintain the lubricating oil properties during hydrogen fuel operation. It was observed that the lubricating oil property was lost due to the blow by in the hydrogen fueled engine. So, the nanomaterials of copper and molybdenum were mixed with the lubricating oil. It was found that the lubricating oil properties were improved due to the addition of the nanomaterials.

This thesis has been organized in to seven chapters. The first chapter is an introduction which focuses on the potential of hydrogen fuel. The second chapter deals with literature survey covering mainly the methods of production, storage and usage of hydrogen in IC engines and the performance and emission characteristics. Third chapter deals with the overview of the work. The fourth chapter deals with the simulation of
hydrogen fueled engines. The fifth chapter deals with the experimental setup, covering the engine setup, instrumentation and measurements. This chapter also contains the details of the nanomaterials, synthesis and characterization. The sixth chapter presents the results obtained and discusses the same. The seventh chapter is focused to bring out the important results related to this work to draw conclusions.