CHAPTER I

INTRODUCTION

In our everyday life we usually see homogeneous combustion in the gas phase, i.e. burning natural gas, fuel oil, gaseous fuel, etc. One major problem with homogeneous combustion is the presence of hot pockets of reaction that are responsible for the generation of all nitrogen oxides (NO_x). Nitrogen oxides are the components of acid rain, when mixed with water vapor in the clouds, will form nitric acid. Nitric acid (HNO_3) is a strong acid and more dangerous than carbonic acid (HCO_3), a weak acid, that is formed by carbon dioxide (CO_2) and water (H_2O). Otherwise it participates in petrochemical smog generation by reacting with hydrocarbons in air.

Another major problem is that the homogeneous combustion that occurs in flames may appear complete but in fact there are some heterogenieties in it that result in carbon monoxide (CO) generating and hydrocarbons remaining in the exhaust gas. Carbon monoxide has direct effect on human because it has an affinity with haemoglobin in the blood which is 210 times greater than that of oxygen. It will form a carboxyhaemoglobin in the bloodstream that affects the transportation of O_2 to the body cells. Prolonged exposure at levels above 9 ppm. can lead to reduce mental acuity for some individuals. Unburned hydrocarbon gases lead to petrochemical smog when react with NO_x and give the petrochemical oxidants, for example ozone(O_3), nitrogen dioxide, peroxyacryl nitrates (PAN's) as the products. The effects of the oxidants are eye irritation and impairment of lung function when present at levels higher than 0.08 ppm. (Sell , 1992).

The best possible way to reduce NO_x formation is to reduce the combustion flame temperature because selectivity to NO_x formation reaction tends to increase with temperature (Nevers , 1995). Another way is to increase the amount of fuel (reduce air-fuel ratio) to under stoichiometric ratio operation (rich mixture) [see Fig 1.1] (Heck , 1995) because there would not be enough oxygen to react with fuel forming NO_x and the flame temperature is also low. On the other hand, if we reduce the combustion flame temperature, or operate at under stoichiometric ratio, hydrocarbon and CO will be present in high levels. The best way to solve this problem is to change homogeneous phase combustion to total catalytic combustion (heterogeneous phase) by using a catalyst that gives non-toxic gases as a product e.g. carbon dioxide and water.

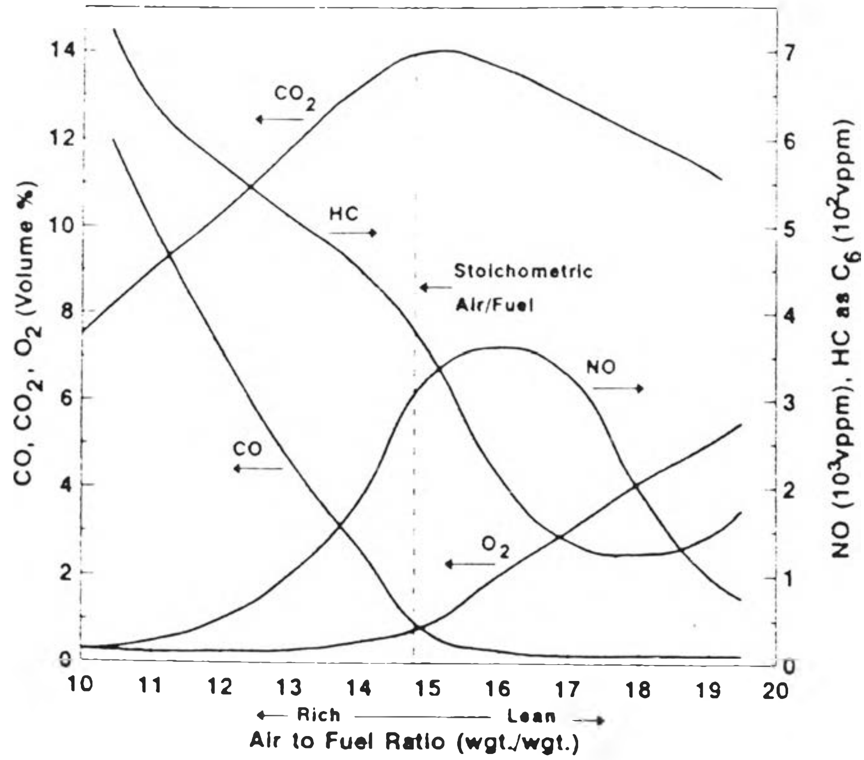

Figure 1 Spark ignition gasoline engine emission as a function of an air-fuel ratio [3]

Methane is the principle component of natural gas and itself is a potential environment problem as it contributes to the greenhouse effect. Although most of the attention is focused on carbon dioxide, methane is also a significant contributor because it is 21 times more effective than carbon dioxide as a greenhouse gas. So it is still of importance to study how to eliminate it from our exhaust gas emission by converting it into other valuable petrochemical feedstocks and non-toxic gases.

Methane is the most difficult hydrocarbon to oxidize, it requires high temperature to ignite them so the catalyst must survive high temperature and still be effective at low temperature.

Noble metals in the platinum(Pt) group, are known as effective metal catalysts for oxidation processes such as oxidation of methanol to formaldehyde and oxidation of volatile organic compounds. Palladium(Pd) metal shows significant efficiency in methane catalytic combustion (Heck , 1995) and still survives at high temperature because of its high melting point (1828 K) (Budavari , 1989).

Another important point to consider is to have a high temperature support for the catalyst, in order to prevent sintering of pore structure for maintaining surface area and catalyst active site. Ceramic, i.e. alumina, is usually the support choice for its high temperature operation, because of high melting point and high surface area.

The research objectives are (i) to study the effect of temperature on methane catalytic combustion reaction (ii) to study of the effect of concentration (air-fuel ratio) at rich and lean mixture operating conditions on the combustion reaction.