CHAPTER I
INTRODUCTION

Because the uncertainty of the petroleum energy situation in this decade while the demand of energy consumption is increasing. These are the reason why crude oil price was broadly fluctuated. Last two years, crude oil prices were in the range of US$ 25 to US$ 35 a barrel, but since the first quarter of this year the price dramatically increased to an all-time high of almost US$ 70. Therefore, the utilization of an alternative energy with practical use has been studied more intensively now than in the past. The fuel cell system is a great potential alternative energy device. Unlike others, its efficient conversion of fuel to energy is at least twice as efficient as internal combustion engines, has comparatively low or zero emissions of local or greenhouse gases (dependent on fuel), is very scalable and quiet, and has fuel flexibility (can use hydrocarbons or renewable fuels). With these effective advantages, fuel cell research is more attractive than other alternative energy technology research.

A fuel cell is an electrochemical device that produces electricity and heat without combustion. Hydrogen fuel (which now can be obtained from methanol, natural gas, water, biogas or petroleum products) is combined with oxygen (from air) to produce electrical energy. Natural gas is the major source of hydrogen production, which is mostly done by steam reforming. This method is well developed and accounts for over 95% of all hydrogen produced in the U.S. and 48% globally. Although steam reforming is currently the cheapest way for hydrogen production, the production stream of the reforming process typically contains undesired products such as carbon monoxide (CO), carbon dioxide (CO_2), and steam. The CO in the gas has to be reduced below 20 ppm to avoid poisoning of the catalyst on the fuel cell electrodes. As a result, the reduction of CO to a level acceptable to a fuel cell must be achieved. A promising solution to the problem of CO reduction is Water-Gas Shift Reaction (WGSR).

WGSR is a process whereby water, in the form of steam, and the undesirable gas, CO, are catalytically shifted to CO_2 and H_2. WGSR has been employed for 40 years in the industrial process for hydrogen production. The major role of the

WGSR is to reduce the CO concentration while the other benefit is the hydrogen yield. WGSR is normally added after the steam reforming. Trace amounts of CO remaining after WGSR can be removed by a further step, selective oxidation. The WGSR traditionally carried out in two fixed base adiabatic reactors; first, the high temperature shift (HTS) operates at temperature ranging from 300 to 500 °C and usually employs a Fe/Cr catalyst. Second, the low temperature shift (LTS) operates at lower temperature range ~100-350 °C (normally with commercial $CuO/ZnO/Al_2O_3$ catalyst) in order to displace the equilibrium, since the WGSR reaction is exothermic.

The literature of metal over oxide support catalyst for LTS has focused on gold over ceria catalyst with studying of fine gold particle size and their properties. However, it is possible that the reactant gas feed containing mixture of H_2, CO_2, and other traces from natural gas feed influence to the WGSR.

In this research, the experimental were performed in two parts, lab-scale and bench-scale experiments. The main objective of lab-scale experiment was to study the catalytic activity of LTS over Au/CeO_2 catalyst. Catalysts of 1-5 % by weight of gold loading on two types of ceria support, low surface area and high surface area, and commercial $CuO/ZnO/Al_2O_3$ catalyst were studied. The influences of gas hour space velocity at 4,000, 8,000 and 12,000 $ml \cdot h^{-1} \cdot g^{-1}$, H_2-pretreatment, H_2O/CO ratio, and H_2 mixing in reactant were studied. The stability of prepared catalyst was also studied. Finally, the influence of the mixing reactant gas with H_2, CO_2 gas, which is close to the composition of steam reforming product, was studied. The objective of bench-scale is to eliminate CO from the product of steam reforming unit which used compressed natural gas as a feed. A commercial Fe based oxide catalyst was used in HTS and a commercial $CuO/ZnO/Al_2O_3$ catalyst was also used in LT-WGS. The optimum condition from lab-scale will be applied to bench-scale unit.