CHAPTER I

INTRODUCTION

1.1. Background of the Utilization of Natural Gas

The natural resources are important factor for development in both agriculture and industry. The natural resources in Thailand can be discovered that their amounts are enough to use. Especially the natural gas on the ground can be used from the Sirikrit and Nampong sources and also in the Gulf of Thailand from the Bunprod, Arawan, Kapong, Nangnaun, Pratong, Bongkroch, and Satoon sources. Since 1981, the natural gas in the Gulf of Thailand could be used. Moreover, its production in 1991 was equal to 698 million cubic feet per day, but crude oil could be produced about 126,340 barrel per day. At present, the overall standby natural gas in Thailand is equal to 13 million cubic feet. Owing to the total amount of natural gas in each day 698 million cubic feet can be used as raw material for the separation-gas plant being 98 million cubic feet per day, fuel for the electric plant being 560 million cubic feet per day, and raw material in other industry being 40 million cubic feet per day. As the natural gas is non-reversible natural resource then learning of science and technology should be used for the utilization of natural gas at most to the public. In the beginning of the utilization of natural gas in Thailand, no separation-gas plant could be used only as fuel for the electric plant. When there was the separation-gas plant, the natural gas could be used increasingly by gas separation method. The natural gas could be separated as methane, ethane, propane, butane, and heavier hydrocarbons for the utilization in petrochemical industry. The natural gas in Thailand is composed mainly of methane that it can be used only as fuel for the electric plant and the ceramic furnace. As a result, these natural resources cannot be used effectively since the utilization of methane is less than the amount of methane. Furthermore, one of the causes of greenhouse effect problem is the methane combustion [1-3].

For this reason, the utilization of methane for more increasing value is studied by methane reforming to synthesis gas.

The synthesis gas (or syngas) is a mixture of carbon monoxide and hydrogen that it may also contain nitrogen. It can use both mixed gas and pure gas as the raw material in producing methanol, ammonia, liquefied petroleum gas (LPG), dimethyl ether (DME), fuel cell and other derivative chemicals as the important feedstocks in petrochemical industry, which is shown in Table 1.1 [4-5].

Table 1.1. The utilization of synthesis gas.

Synthesis gas ratio	Uses
Pure H_2	The manufacture of ammonia, dimethyl ether, and fuel cell. Moreover, using for the hydrocracking and hydrotreating processes.
$1H_2 : 1CO$	Aldehyde and alcohol synthesis.
$2H_2 : 1CO$	Methanol and hydrocarbon synthesis.
$3H_2 : 1CO$	Methane synthesis.
Pure CO	Acid synthesis e.g. formic acid and acetic acid etc.

The manufacture of synthesis gas may be made by a variety of processes, either catalytic or non-catalytic. The synthesis gas is generally produced from coal and hydrocarbon feedstocks ranging from natural gas to naphtha or a light gas oil by several processes, such as catalytic reforming processes, both steam reforming and carbon dioxide reforming, partial oxidation, autothermal system and gasification [6-7]. Especially, the catalytic steam reforming of methane and light hydrocarbons is the major industrial process for the manufacture of synthesis gas and hydrogen because the capital cost of this process is less expensive than other processes [8-11].

This research was to study the steam reforming of methane on $Ni_{0.03}Mg_{0.97}O$ solid solution catalyst since this process can be used to produce synthesis gas at high hydrogen for the utilization as raw material in the manufacture of fuel cell. In addition, the ability of this catalyst is the control of coke formation during steam reforming because small nickel particles formed on this catalyst are effective for the inhibition of carbon deposition.

1.2. Objectives

1. To study the steam reforming of methane on $Ni_{0.03}Mg_{0.97}O$ solid solution catalyst to synthesis gas at high hydrogen-carbon monoxide ratio.
2. To study the effect of $Ni_{0.03}Mg_{0.97}O$ solid solution catalyst and various process parameters, such as temperature, steam to methane ratio, methane feed rate, steam feed rate and catalyst weight on the performance in the steam reforming of methane to synthesis gas.
3. To study the kinetics of methane reforming with steam on $Ni_{0.03}Mg_{0.97}O$ solid solution catalyst to determine rate of reaction.

1.3. Scope of the Research

This research was to study the steam reforming of methane on $Ni_{0.03}Mg_{0.97}O$ solid solution catalyst that showed excellent activity, stability and resistance to carbon deposition. The influence of this catalyst and operating parameters, i.e. temperature, steam to methane ratio, methane feed rate, steam feed rate and catalyst weight on the performance in the steam reforming of methane were carried out. Moreover, rate of reaction, which showed the best result, was determined. The research procedures were carried out as follows:

1. Literature survey and in depth study of this research work.
2. Design and installation of the steam reforming apparatus in laboratory scale and also preparation of the chemicals and raw materials for the experiment.
3. Test of the prepared apparatus for the experiment.
4. Preparation of the $Ni_{0.03}Mg_{0.97}O$ solid solution catalyst and the catalyst characterization by spectroscopic techniques.
5. Study of the influence of $Ni_{0.03}Mg_{0.97}O$ solid solution catalyst and operating parameters on the performance in the steam reforming of methane at atmospheric pressure :

5.1 Temperature (700-850 °C)

5.2 Steam to methane ratio (2.0, 4.0, 6.0, 8.0 and excess)

5.3 Methane feed rate (6.0×10^{-5} to 1.25×10^{-3} mole/min)

5.4 Steam feed rate (1.0×10^{-4} to 0.15 mole/min)

5.5 Catalyst weight (2, 5, 8 and 10 g)

6. Summarization of the results.

1.4. Expected Results

The steam reforming of methane on $Ni_{0.03}Mg_{0.97}O$ solid solution catalyst to synthesis gas at high hydrogen-carbon monoxide ratio and determination of rate equation of reaction can be carried out.