CHAPTER I
INTRODUCTION

Nowadays, the energy consumption all around the world has been rapidly increased, but the amount of available fuels tends to decrease sharply because of its limitation resource. Therefore, many countries have concerned about the unbalance of fossil fuels in the future and have tried to find the new sustainable energy resources with developing the use of alternative energy in order to extend the life of fossil fuels. There are three catagories of fossil fuels: oil, coal, and natural gas. Oil is of the first priority use among those types of fossil fuels, however, the drawback is the strong impact to climate change because of its combustion and spill, while coal is mainly used to produce electricity and also has a huge effect to environment from gas emission, especially CO_2 and SO_2. Although natural gas has not been used such high amount comparing with the first and second types, it is more efficiency than the others, as well as good in economical, cleanest energy, and environmentally friendly aspect. That is why many petrochemical industries are interesting in natural gas to be used as feedstock to produce many products, such as synthesis gas and methanol.

Natural gas is a flammable mixture of hydrocarbons, which is mainly composed of methane 70-90%, ethane, propane and butane 0-20%, carbon dioxide 0-20%, and the remaining are other compositions, such as O_2, N_2, and H_2S (www.naturalgas.org). The composition of natural gas depends on geology and condition in the reservoir. The most important route of natural gas utilization is to convert into more valuable product called synthesis gas (H_2 and CO) by using methane as a reactant.

There are three conventional methods to produce synthesis gas from methane. The first method is the steam reforming of methane (Equation 1). The reaction is strongly endothermic that consumes high energy. Generally, the reactor is operated over Ni catalyst with high H_2O/CH_4 ratio to prevent coke formation on catalyst. This results in having high H_2/CO ratio and less selectivity for CO.

$$CH_4 + H_2O \longrightarrow CO + 3H_2 \quad \Delta H_{298K} = 206 \text{ kJ/mol} \qquad (1)$$

Next method is the partial oxidation of methane, which is mildly exothermic, consumes low energy, and produces H_2/CO ratio equal to 2 (Equation 2).

Moreover, this method can use air instead of pure O_2 in order to make partial oxidation. Therefore, the variable cost is decreased (Supat, 2003). Mainly used catalyst in this method is Ni, which gives high activity and selectivity, however, coke can deposit easily due to the generation of hot spot of catalyst.

$$CH_4 + 1/2O_2 \longrightarrow CO + 2H_2 \qquad \Delta H_{298K} = -38 \text{ kJ/mol} \qquad (2)$$

The last method is CO_2 reforming of methane that is similar to steam reforming process. The reaction is strongly endothermic, requires high energy, uses conventional catalyst resulting to catalyst deactivation due to coke formation, and produces low H_2/CO ratio (Equation 3). Because CO_2 is a component of greenhouse gas and found in many natural gas resources, especially in Asia (Rueangjitt, 2007), the reaction should directly use carbon dioxide-containing natural gas in order to reduce operation cost and CO_2 emission.

$$CH_4 + CO_2 \longrightarrow 2CO + 2H_2 \qquad \Delta H_{298K} = 247 \text{ kJ/mol} \qquad (3)$$

As many drawbacks are found in those three conventional methods, recently new technology known as non-thermal plasma is introduced. Non-thermal plasma is one type of the electrical gas discharge that occurs when sufficient voltage is applied across electrodes. In non-thermal plasma, quite high energy free electrons are generated, and they further activate various radicals to initiate and enhance the plasma chemical reactions. Moreover, the advantages of plasma reforming process are low power requirement and using mild condition. Gliding arc discharge is one kind of non-thermal plasma, which has been introduced to be another option in reforming natural gas process. Gliding arc discharge can occur when the plasma is generated after applying voltage across a pair of knife-shaped electrodes. Its advantages are high-energy efficiency and environmental friendliness. Therefore, it has been selected for producing synthesis gas in this research.

The main objective of this research is to determine the possibility for using a multistage gliding arc plasma system in combination with reforming and partial oxidation of CO_2-containing natural gas to improve the natural gas reforming performance. The experiments will be carried out to investigate the effect of stage number of plasma reactors with fixed feed flow rate and fixed residence time on reactant conversions, product selectivities and yields, and power consumptions in the

presence of both steam and oxygen addition in natural gas feed. Moreover, the optimum conditions for a maximum synthesis gas production will be examined.