CHAPTER I
INTRODUCTION

During the past decades, there has been increasing concern over the emission of many greenhouse gases (carbon dioxide, methane, nitrous oxide, and halogenated hydrocarbons) that contribute to global warming. More than half of the warming is caused by the increased concentration of carbon dioxide which comes from fossil fuel combustion. Another greenhouse gas, methane, comes from coal mines, oil and gas operations. Moreover, carbon dioxide and methane can produced from anaerobic digestion processes is called biogas that contains 60-70 vol. % of methane, 30-40 vol. % of carbon dioxide, and some hydrogen sulfide. So that decreases of emission and environmental friendly utilization of carbon dioxide and methane have become areas of great interest to the world.

Biogas can be used as potential feed in methane reforming with carbon dioxide for the production of synthesis gas or syngas, a mixture of carbon monoxide and hydrogen, is used in various petrochemical processes such as methanol or via the so-called Fischer-Tropsch synthesis to liquid hydrocarbon. It has raised interest in its use as an alternative energy source because have the two advantages are produce the hydrogen and reduce the greenhouse effects simultaneously.

Methane reforming with carbon dioxide using conventional catalytic methods, however, often has two problems. It is a strongly endothermic reaction consuming much energy and the deactivation of catalysts used due to coke deposition on the catalysts surface under the reaction conditions (Li *et al.*, 2004).

Carbon dioxide reforming

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

A second route for methane conversion to syngas include the steam reforming. This reaction is strongly endothermic same as carbon dioxide reforming resulting in high energy consumption. Steam reactors generally run with excessive amounts of water in order to prevent the deposition of carbon on the catalyst (Hwang *et al.*, 2003). Steam reforming has poor selectivity for CO and produces syngas with a high H_2/CO ratio, while carbon dioxide reforming of natural gas gives a high CO selectivity (Xu *et al.*, 1999).

Steam reforming

$$CH_4 + H_2O \longrightarrow CO + 3H_2 \qquad \Delta H_{298K} = 206.2 \text{ kJ/mol}$$

Another way to produce syngas is catalytic partial oxidation (POX) of methane. The catalysts investigated are mainly the Ni metal and the noble metal supported catalysts. The latter are more active but high cost and limited availability of noble metals, while nickel-based catalysts show high activity and selectivity with low cost but coke deposition on nickel is much faster than on noble metals (Juan-Juan *et al.*, 2004). This process has high activity and selectivity but cannot be easily controlled because of the generation of hot spots in the catalytic bed (Xu *et al.*, 1999).

Partial oxidation (POX)

$$CH_4 + 0.5O_2 \longrightarrow CO + 2H_2 \qquad \Delta H_{298K} = -38 \text{ kJ/mol}$$

The combination of these reaction can get the good result such as a combination of carbon dioxide reforming and steam reforming can be reduce the carbon formation because the C/H ratio in the feed decreases and the C/O ratio decreases as well resulting in controlled and limited carbon formation (Effendi *et al.*, 2002). And a combination of carbon dioxide reforming and partial oxidation has benefit in terms of balancing the heat load (Supat *et al.*, 2003).

One attractive method for reforming hydrocarbons is to use plasma. The plasma contains highly active species, such as electrons, ions and radicals, which can catalyse conversions of feeds into more valuable products. Therefore, the plasma reforming processes can operate at mild conditions and in the absence of catalysts.

The purpose of this study was to apply the plasma to biogas reforming with/without added air for hydrogen production. The effects of electrical parameters, flow rate, gap width and residence time were studied.