CHAPTER VII
CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Generally, natural gas mainly contains methane with a very high carbon dioxide content up to 20 %. Synthesis gas (a mixture of hydrogen and carbon monoxide) is produced commercially by using the conventional catalytic reforming processes of methane separated from natural gas with steam reforming. However, the catalytic processes have to be operated under high temperatures and pressures, resulting in both high energy consumption and deactivity problems of catalysts. Therefore, in this study, non-thermal plasma was proposed to be a new promising alternative for the reforming of natural gas at ambient temperature and atmospheric pressure without catalysts. A low-temperature gliding arc discharge system was preliminary employed to investigate the effects of steam content and operational parameters, i.e. total feed flow rate, input voltage, and input frequency, on the reforming performance of CO_2-containing natural gas. The results reveal that the reactant conversions and yields of hydrogen and carbon monoxide were found to reach maximum values at a steam content of 10 mol%, a total feed flow rate of 100 cm^3/min, an input voltage 13.5 kV, and an input frequency 300 Hz. Under these optimum conditions, the power consumptions were as low as 2.26×10^{-18} Ws (14.10 eV) per reactant molecule converted and 1.58×10^{-18} Ws (9.85 eV) per molecule of produced hydrogen.

A technique of combining steam reforming and partial oxidation of CO_2-containing natural gas in a gliding arc discharge plasma was further investigated. The effects of several operating parameters including: hydrocarbons (HCs)/O_2 feed molar ratio, input voltage, input frequency, and electrode gap distance on reactant conversions, product selectivities and yields, and power consumptions were examined. The results showed either methane (CH_4) conversion or synthesis gas yield increased with increasing input voltage or electrode gap distance whereas the opposite trends were observed with increasing HCs/O_2 feed molar ratio or input frequency. The optimum conditions were found at a HCs/O_2 feed molar ratio of 2/1, an input voltage of 14.5 kV, an input frequency of 300 Hz, and an electrode gap distance of 6 mm, providing high CH_4 and O_2 conversions with high synthesis gas selectivity and relatively low power consumptions, as compared with the other processes (sole natural gas reforming, natural gas reforming with steam, and combined natural gas reforming with partial oxidation).

The combined steam reforming and partial oxidation of CO_2-containing natural gas was finally investigated under two series of systems with a constant feed flow rate and a constant residence time by using non-thermal multistage gliding arc discharge. The major products were mainly hydrogen and carbon monoxide. From the results, the stage number of plasma reactors for both system operated at a constant total feed flow rate and a constant residence time shows significant effect on reactant conversions, product yields, product selectivities, and power consumption. Under the operating conditions of a HCs-to-O_2 feed molar ratio of 2/1, an applied voltage of 15 kV, an input frequency of 300 Hz, and an electrode gap distance of 6 mm, the lowest power consumption of 3.49×10^{-17} Ws per mole of reactants converted or 2.04×10^{-17} Ws per mole of hydrogen produced was obtained from 3 stages of plasma reactors at a residence time and feed flow rate of 4.11 s and 100 cm^3/min, respectively.

7.2 Recommendations

The recommendations for future work are as follows:

1. To investigate the effects of catalyst on combined steam reforming and partial oxidation of CO_2-containing natural gas in a multistage gliding arc discharge system

2. To compare the process performance of other types of plasma reactors (dielectric barrier discharge, corona discharge) for combined steam reforming and partial oxidation of CO_2-containing natural gas in the presence of catalyst.