CHAPTER I

INTRODUCTION

The rapid growth of economy leads to a high demand of energy especially electrical power in order to support its expansion. Nevertheless, power generation systems at present are mainly based on low-efficiency combustion heat engines which have substantial losses of energy during many energy conversion stages (Douvartzides et al., 2003). According to this reason, one choice of interest is fuel cell technology because it can fulfill the requirement of both effective and clean power generation unit. It converts the chemical energy of hydrogen fuel directly into electrical power and releases steam as a harmless product. Solid oxide fuel cell (SOFC), one type of fuel cells, has offered many advantages, for examples, flexibility of various fuels usage, heat recovery cogeneration, fast kinetic rate and internal reforming. In addition, SOFC can reduce emissions of greenhouse gas and air pollutants causing serious environmental impacts.

Selection of appropriate fuels for fuel cell is a crucial issue. Fuels should be ecological friendly and derived from sustainable energy resources. In contrast, non-renewable fossil fuels should be avoided. Renewable biofuel is available from agricultural products and suitable for countries which have strong agriculture sector. Several renewable fuels have been used for fuel cell such as methane, methanol, biogas, ethanol and ammonia. All of these fuels can be reformed into hydrogen-containing gas. Methane is an attractive choice for fuel cell because of its high hydrogen to carbon ratio (Naidja et al., 2003). Ammonia is another choice since it releases zero-carbon emission (Zhang and Yang, 2008). Biogas has been widely used because it consists of 40-65 mol% methane (Dayton, 2001) high enough to be directly used as a fuel but biogas is based on source scales, normally small-scale, it may be an inconsistent resource. However, it is inevitable that using these fuels may face the problem of carbon deposition when SOFC is operated. Plenty of solutions have been undergone to solve this problem. A simple method is to adjust proper ratio of related compositions or operating conditions to avoid boundary of carbon formation.

Among the various biofuels, bioethanol is a particularly promising fuel due to a number of benefits: high hydrogen content, availability, non-toxicity, ease of handling and storage (Meng Ni et al., 2007). Moreover, bioethanol can be derived from various biomass sources such as sugar cane molasses, lignocelluloses and agroindustrial wastes (Comas et al., 2004) by fermentation processes. The net carbon dioxide emission from bioethanol utilization is lower than fossils (Arteaga-Perez., 2009) because of its carbon-closed cycle. However, bioethanol contains mainly water and dilute ethanol. In order to be an effective fuel for a fuel cell, water must be removed from bioethanol by purification to obtain a higher ethanol concentration which is later reformed into hydrogen rich gas for feeding into SOFCs.

There are several choices for purification processes such as distillation, adsorption, membrane etc. In previous work, the SOFC systems integrated with distillation was examined (Jamsak et al., 2007). It was found that the systems have somewhat low electrical efficiency due to limitation of high reboiler heat duty consumption. Adsorption unit seems to be a low energy consumption system but this unit faces the problem in using plenty of adsorption agents when it operates at large scale. It is difficult to regenerate adsorption agents and to achieve high recovery yield of ethanol (Chang et al., 1998). Pervaporation membrane separation is an interesting choice. As the pervaporation does not depend on thermodynamic equilibrium, it can avoid the azeotropic problem occurred with ethanol/water system. It also requires lower energy consumption compared with a distillation because pervaporation relies on the different ability of each substance which adsorbs and diffuses through membrane material. Although some problems may occur with pervaporation such as high capital cost, thermal instability and short life time, in the energy point of view, SOFC systems produce both electricity and thermal energy. Installing a pervaporation can reduce burden of SOFC unit in case of distributing much thermal energy supplied to purification unit. Instead of heating the separation unit, excess thermal energy can be taken to another added power cogeneraton (combined heat and power, CHP) units like turbine and recuperator to increase the overall efficiency of SOFC systems.

From the reasons mentioned above, this research is emphasized on efficiency analysis of solid oxide fuel cell system fed by bioethanol incorporated with pervaporation unit. Firstly, Selection of appropriate pervaporation membrane type for the overall system is investigated. After obtaining a suitable membrane type of pervaporation, a performance of the overall system is further improved by installing vapor permeation as an extra separation unit after pervaporation. The appropriate membrane type for vapor permeation is also investigated to serve an optimal efficiency of the system. The electrical efficiencies of the system before and after installing vapor permeation are compared. Finally, SOFC system integrated with the proposed purification process is compared with the use of ordinary distillation column to clearly show its performance improvement.