CHAPTER 1 INTRODUCTION

1.1 Background

Nowadays, the energy consumption increases continuously, while the energy resources decrease. Therefore, people motivate to find out the new resources to handle this problem. One of them is fuel cell because of its advantages such as high efficiency, low aggressive to the environment and low emission of oxides of nitrogen and sulfur. However, there are difference fuel cell technologies that have been successfully used. Proton exchange membrane fuel cell (PEMFC) is the most popular type of them due to its high power density, low weight and volume, low operating temperature about 70-100°C, quick startup capability compared with the other fuel cells [1].

Proton exchange membrane fuel cell is an electrochemical device that converts the chemical energy of hydrogen (anode side) and oxygen (cathode side) to electrical power and heat. It can candidate for powering the next generation of electric vehicles such as the power for cell phone or laptop. The PEMFC basic structure is composed of the anode and cathode channel, the gas diffusion layer, the catalyst layer and the membrane as shown in Figure 1.1. Normally, PEMFC is divided into three sections for three control volumes namely the anode channel, the cathode channel, and the fuel cell body. In fuel cell body, there are the gas diffusion layer, the catalyst layer and the membrane. Typically of PEMFC is connected with auxiliary equipment in order to supply the energy. There are the air supply system for feeding oxygen to fuel cell, fuel supply system for feeding hydrogen to fuel cell, and thermal management for cooling the fuel cell body [1].

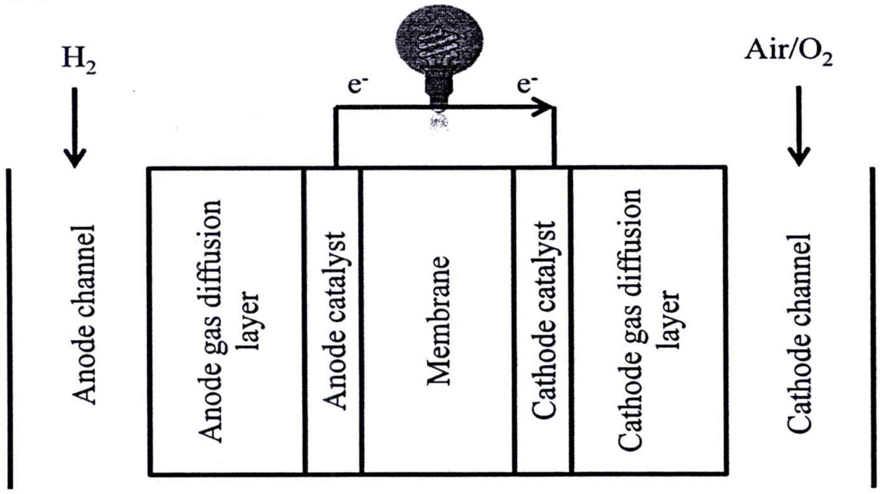

Figure 1.1 A simple model of PEMFC

The fuel cell performance is examined by the net output voltage. Therefore, the high fuel cell voltage indicates the high performance of fuel cell. Generally, the operating conditions of PEMFC significantly affect the fuel cell voltage. These parameters are the current drawn from fuel cell, the partial pressure of the reactants (hydrogen and oxygen partial pressure) in anode and cathode channel, and the stack temperature [2]. Since, the fuel cell is used to produce the current for using in an electrochemical device, in view of high current demands, an excess heat produced from the higher electrochemical reaction will cause of fuel cell overheating problem. This phenomenon will lead to drying out of membrane. Therefore, the proton transportation in membrane will become difficult. In case of low stack temperature, the heat produced from an electrochemical reaction does not enough for vaporizing the excess water out of membrane, therefore, the undesired liquid water formation leads to flooding of the membrane. All of the above will reduce the performance of fuel cell [3]. Therefore, the main emphasis in this work is to control the stability of fuel cell performance (the net output voltage) by considering to the stack temperature, relative humidity, and the cell voltage under the current load changed.

Recently, the new stability criterion is developed based on passivity concept [4]. It is attractive to apply passivity concept with proton exchange membrane fuel cell to achieve both stable and controllable process. Therefore, this is the main motivation in this work.

1.2 Objective

1. To study and design the passivity based controller for proton exchange membrane fuel cell

1.3 Scopes of work

1. Proton exchange membrane fuel cell is controlled by using the passivity theorem. There are three control variables under the current load change which are the stack temperature, the relative humidity and the cell voltage. For each loop, the passive controller is determined.
2. The cell voltage is controlled at the normal operating condition which is the maximum value.
3. The model of proton exchange membrane fuel cell is developed in MATLAB^{TM}-Simulink simulation.

1.4 Expected Results

1. The stack temperature, the relative humidity and the cell voltage of proton exchange membrane fuel cell system can be controlled within the optimal level, the membrane does not cause an overheating problem or flooding.
2. The PEMFC system stills stable even the system is disturbed or one loop fails by using the passive controller.