

Alternative Energy of the Future: A Technical Note of PEM Fuel Cell Water Management

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Abstract

This study that presents that proton exchange membrane fuel cell (PEMFC) models are interpreted in the light of the previous literature that demonstrates components and functions of PEMFC concisely. The objective of this study, a review of PEMFC's water can be controlled by the temperature, and a waste water of PEM fuel cell should be removed quickly to get the high efficiency and to ensure the water management. Protons (H⁺) from the anode which can be transmitted to the cathode well are required to have sufficient water membrane. In this review of the study, the water management of PEM fuel cell has been investigated and the importance of the subject's information is given from the similar studies. Therefore, the rate of water composition should be higher than the rate of water evaporation. According to the balance, a temperature of working should be small. The anode and cathode used in the reaction of hydrogen, and the reaction of oxygen (air). Anode and cathode are stored in a dry state, normally. The reaction of fuel cell gases should be moist for a good. Consequently, the efficiency of the PEM fuel cell can be increased at 80°C.

Keywords: HPEMFC; Water management; Fuel cell; Alternative energy; Membrane

Introduction

Nowadays, energy resources has been begun to run out. The global energy problems are increasing, rapidly. This cause refers to the various energy systems. The renewable energy sources are evolving with technology. Therefore, alternative energies must be used, immediately. One of the important energy is fuel cell that uses the hydrogen energy. Fuel cells that will be studied extensively will be used in the future widely. Proton Exchange Membrane Fuel Cell (PEMFC) will become one of the alternative energy. A working principle of PEMFC; the chemical energy is converted directly into electricity then heat.

PEMFC that are the most significant technology in fuel cell system has been occurred at least an anode, a cathode and a membrane [1].

PEMFC works as follow; the chemical energy is converted directly into electricity then heat. Reviews of the proton exchange membranes are investigated similar studies for fuel cell applications. PEMFC will be become as a clean energy and an efficient energy in the 2020s. The academic researchers have studied on the proton exchange membrane with high proton conductivity, a low electronic conductivity, and a low permeability to fuel, a low electro-osmotic drag coefficient, good chemical/thermal stability, a good mechanical properties and a low cost [2].

Proton exchange membrane fuel cells have a high power density, quiet operation, a high efficiency. PEMFC set out waste water is the most important features. The future of fuel cell power is the PEM fuel cell that demands at the automotive sector, especially [3,4].

The aim of this paper, PEMFC's water can be managed by the temperature. PEM fuel cell's waste water should be removed quickly to get high efficiency. This paper is a review of previous studies.

A Working Principle of PEM Fuel Cell

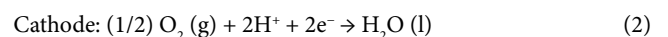
Hydrogen that is activated to form proton ion by catalyst eject electron at the anode in PEMFC. The proton passes through the membrane while electron is forced to flow to the external circuit, and

generate electricity. When the electron flows back to the cathode the electron will interact with oxygen. Proton ion forms to the water. The chemical reactions are occurring at each electrode. It is given in Eq. 1, 2 and 3. The PEMFC is shown in Figure 1 [5].

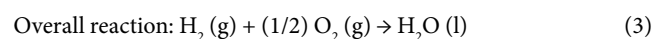
Anode reaction can be seen in equation 1 as follows:



Cathode reaction can be seen in equation 2 as follows:



Overall reaction can be seen in equation as follows:



In Figure 1 (drawn by AutoCAD 2015), PEM fuel cell's manner of work can be seen clearly. An air and fuel should pass to their own catalyst layers of the PEM fuel cell, and the PEM is in the middle of the PEMFC. A layer oxidant flow is located left side. A layer of fuel flow is right side of the PEM membrane. Exhaust of water vapour has got no pollution. Fuel passes according to recirculate in the membrane. This electrochemical process has got low temperature at 90°C. Also, heat water can cool at 90°C.

PEMFC consist bipolar plates and membrane electrode assembly (MEA). The MEA is composed of dispersed catalyst layer, carbon cloth or gas diffusion layer and the membrane. Membrane transports

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protons from anode to cathode. Gas diffusion layer accesses to the fuel in uniform way. Electrons pass through the external circuit for generate electricity at the anode [5].

PEMFC has been a low temperature in the fuel cell. Its process temperature is 60°C - 100°C. Their weight is light. PEMFC that is compact systems its startup process is very fast. The sealing of PEMFC electrode is easier than other types of fuel cells. Material specifications of PEMFC electrodes are solid and substantial. In addition, PEMFC has longer lifetime than the other fuel cell. PEMFC is cheaper for the manufacture [6,7].

Advantages and Disadvantages of PEM Fuel Cell

There are many advantages and disadvantages of the PEM fuel cell. Advantages of PEMFC [4,8-12] are electrode reaction kinetics, heat and water management, alternative catalysts, high power density, and low working temperature [13].

Disadvantage of PEMFC [3,4,8,14-17] are high sensitive, expensive of materials, membrane and materials (Nafion 117), catalyst problem, gas diffusion layer and flow field layers, degradation, production's difficulties (Production of Membran Electrode Assembly: MEA).

PEM fuel cell process phase can be seen in Figure 2 (drawn by AutoCAD 2015). This Figure 3 shows the cognitive of fuel cell diagramming processes that are as follows, respectively. Firstly, convective and diffusive gas flows pass through anode gas channel to cathode gas channel. Anode gas should transport the area of the anode channel, gas diffuser and catalyst layer, and cathode gas passes the cathode channel, gas diffuser and catalyst layer. Electrochemical

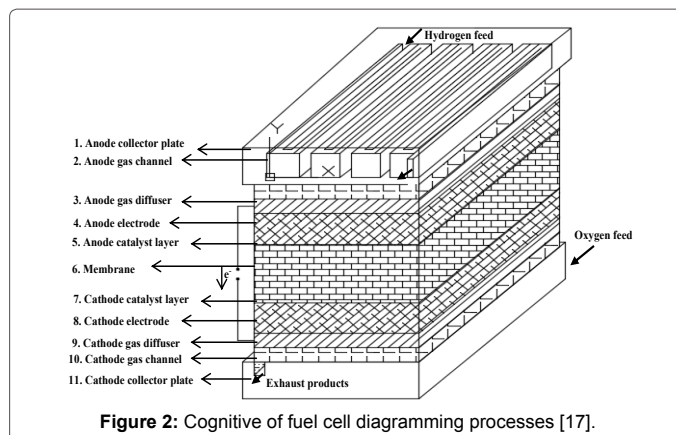


Figure 2: Cognitive of fuel cell diagramming processes [17].

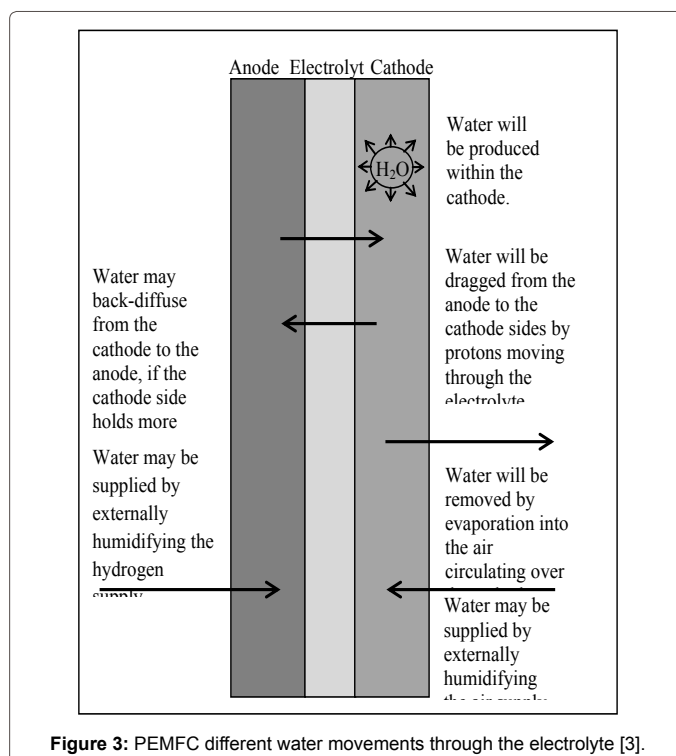


Figure 3: PEMFC different water movements through the electrolyte [3].

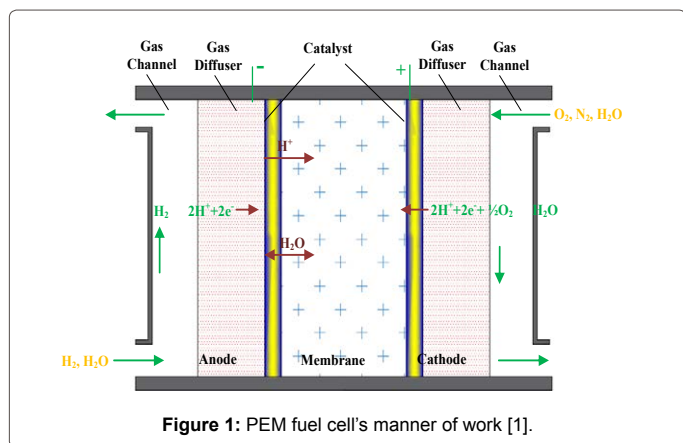


Figure 1: PEM fuel cell's manner of work [1].

reaction reacts to the anode and cathode catalyst layer. By this way, proton has been transported anode catalyst layer to cathode catalyst layer by the membrane. Electron conduction gets shape from the anode collector plate, anode gas diffuser, anode electrode, anode catalyst layer, cathode catalyst layer, cathode electrode, cathode gas diffuser, and cathode collector plate. Water transports to the membrane, cathode catalyst layer, electrode, and gas diffuser. Two-phase flow accumulates through cathode catalyst layer, cathode electrode, cathode gas diffuser. Convection and conduction of heat transfer occur in the anode collector plate, anode gas channel, anode gas diffuser, anode electrode, anode catalyst layer, membrane, cathode catalyst layer, cathode electrode, cathode gas diffuser, cathode collector plate, cathode gas channel.

PEM Fuel Cell Water Management

A performance and lifetime of PEMFC depend on water management. PEMFC can be determined a model of the water distribution in a process of fuel cell. MEA has been made by a membrane that has got two active layers, and gas diffusion layers (GDLs) on both sides. Methods of various studies are developed in using magnetic resonance imaging (MRI), neutron radiography, confocal Raman microscopy and Small-Angle Neutron Scattering (SANS) [3,18,19].

Another previous study [20] used Nafion 117 that's water uptake was found 18.6 wt%. This result is more efficient than the other material.

Numerous recent experimental and numerical studies conclude that water management in PEMFCs is critical to reliable and efficient operation. Over the last 15 years several different methods of water management have been proposed. Humidification of the reactant gases is typically employed to eliminate membrane dry out but humidification alone does not address cathode flooding [3,21].

Developing the proton exchange membrane fuel cells (PEMFCs) are with integrated planar electroosmotic (EO) pumping structures that actively remove liquid water from cathode flow channels. EO pumps can relieve cathode design barriers and facilitate efficient water management in fuel cells. Removing water from the cathode using integrated EO pumping structures improves fuel cell performance and stability. The application of EO pumps for liquid water removal from PEMFC cathodes extends their operational range and reduces air flow rates [3,19].

PEM fuel cell's different water movements to, within, and from the electrolyte can be seen in Figure 3 (drawn by Word 2010).

Water will be produced within the cathode that will be dragged from the anode to the cathode sides by protons moving through the electrolyte. Water might back-diffuse from the cathode to the anode, if the cathode side holds more water [3].

The other movements, water may be supplied by externally humidifying the hydrogen supply. Water will be removed by evaporation into the air circulating over the cathode. Another transport can be like as water may be supplied by externally humidifying the air supply [3].

Results and Discussion

Another study have determined that the total cost of car with the PEMFC system is 500–600 \$/kW which is 10 folded compare with cars using Internal Combustion Engine (ICE). Total cost of the PEMFCs includes the costs of assembly process, bipolar plate, platinum electrode, membrane and peripherals. From efficiency point of view, the higher the working temperature the higher efficiency can be gained. This is due to the higher reaction rate. Nevertheless, working temperature above 100 °C will vaporize the water causing dehydration to the membrane which leads to the reduction in the proton conductivity of the membrane. Electrical efficiency of PEMFCs is between 40 and 50% and the output power can be as high as 250 kW [5].

As a result, PEMFC's water can be controlled by the temperature and PEM fuel cell's waste water should be removed quickly to get high efficiency and to control water management. Protons (H⁺) from the anode which can be transmitted to the cathode well are required to have sufficient water membrane. Therefore, the formation rate of water shouldn't be lower than the evaporation rate of water. High temperature of PEMFC has got the durability problem [22]. This durability progress is one of the important problems for PEMFC. If water management is ensured, durability of PEMFC problem can be solved. Thus, PEMFC can become as tractive usual power sources [23]. PEMFC power systems can be solved by low humidity conditions to enhance the efficiency [24]. In addition, Pt (Platin) and catalyst was demonstrated enhanced electrolytic activity with cycle stability for fuel cells by Choi et al. [25]. But, Pt cost is very high [26]. This cost should be decreased to down. Otherwise, PEMFC has a high efficiency and zero emissions [27].

To achieve this balance, the working temperature should be small. The anode and cathode used in the reaction of hydrogen and oxygen (air) are normally stored dry. Fuel cell reaction gases should be moist for a good performance that some studies of the literature have been compared. Consequently, to increase the efficiency of the PEM fuel cell temperature kept at about 80°C, water of the surface area must be expanded. So, removing water from the systems by using electroosmotic pressure with pump is very necessary for the PEM fuel cells.

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