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Experimental investigation of the temperature effect on a PEMFC Performance under constant pressure Conditions

F. Mostofi, Ms. Student, Dept. of Chemistry, Ardabil Branch, Islamic Azad University
K. abbaspoursani. Ass. Prof., Dept. of Energy Conversion, Mech. Eng., TIAU
A. Shamel, Ass. Prof., Dept. of Chemistry, Ardabil Branch, Islamic Azad University

E-mail: mostofi@ardabilcity.ir

Abstract: PEM fuel cells are known as low-temperature fuel cells. In comparison with other types, for a certain weight and volume, pem fuel cells are more efficient and can produce high power energy. In addition, because of low operating temperature the start-up time for these fuel cells are very short. This characteristic is very important, especially for transport applications which provide an appropriate option in substitution the internal combustion engines with fuel cells. The effect of operating factors and as a result their optimum values are essential in the performance of PEM fuel cells. In this study, data are reported for a 1cm^2 laboratory-scale PEM fuel cell. The membrane electrode assembly, (MEA) exposed to relatively low concentrations hydrogen at 5, 15, and 25 psi and at 60, 70 and 80°C. The steady-state and transient measurements obtained in this study at low reactant stoichiometry for atmospheric conditions to show the effect of pressure and temperature. The results show that for a 300cc/min of Hydrogen flow the performance at 15 psi and and 1V provides a steady-state current density of 870 A/cm^2 at 80 °C but only 600 A/cm2 at 60 °C.

Keywords: PEM fuel cell, Naphion, MEA, Teperature and Pressure.

بررسی تجربی تاثیر دما در فشار ثابت بر کارکرد پیل سوختی پلیمری

فروزان مستوفی- دانشجوی کارشناسی ارشد شیمی دانشگاه آزاد اسلامی واحد اردبیل
کمال عباسپورثانی- استادیار گروه تبدیل انرژی، دانشکده مهندسی مکانیک، دانشگاه آزاد اسلامی واحد تاکستان
علی شامل– استادیار گروه شیمی دانشگاه آزاد اسلامی واحد اردبیل

چکیده: پیل سوختی پلیمری از نوع پیل‌های سوختی دما پایین شناخته می‌شوند. که در مقایسه با انواع دیگر پیل‌سوختی، برای یک حجم و وزن معین توان بیشتری تولید می‌کند. علاوه براین پیل‌سوختی پلیمری بعلت دمای کارکرد پائین به زمان کمتری برای راه‌اندازی نیاز دارند که همین ویژگی آن را گزینه مناسبی در کاربردهای حمل و نقل بعنوان جایگزین برای موتور احتراق دیزلی و بنزینی معرفی می‌نماید. بررسی تاثیر عوامل مختلف و در نتیجه تعیین مقادیر بهینه پارامترها جهت رسیدن به حداکثر توان خروجی در پیل‌های سوختی پلیمری (PEM) امری ضروری می‌باشد. در این مطالعه به روش تجربی تاثیر دما بر عملکرد یک پیل سوختی با استفاده از غشاء نافیون ۲۱۲ در سه حالت فشار کارکرد psi ۲۵، ۱۵ و ۵ مورد بررسی قرار گرفته است. نتایج نشان می دهد که در قبال جریان هیدروژن به اندازه cc/min ۳۰۰ و فشار psi ۱۵ وجریان یک ولت یک چگالی جریان ثابت A/cm2 ۸۷۰ در درجه حرارت C ° ۸۰ تولید میشود.اما این مقدار در در C ° ۶۰ فقط A/cm2 ۶۰۰ می باشد.

واژه های کلیدی: پیل سوختی پلیمری، نفیون، MEA، دما و فشار.

1. Introduction

Polymeric fuel cells (proton membrane fuel cells) firstly were used for a NASA program which called Gemini in the 1960s.This kind of fuel cell is one of the interesting kinds of fuel cells, from the design and functional point of view[1]. In the figure 1,aschematic of a polymeric fuel cell which containing a polymeric electrolyte, is illustrated. This polymeric electrolyte is located between two porous electrodes. For higher efficiency, it's required that use from saturated water as electrolyte. Nefion is one of the best electrolytes that used in fuel cells.

In this fuel cell, we used from hydrogen as fuel. The electrode reactions included:

Anodic reaction:

$$2H_2 \rightarrow 4H^+ + 4e^-$$

Cathodic reaction:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

Total reaction:

$$2H_2 + O_2 \rightarrow 2H_2O$$

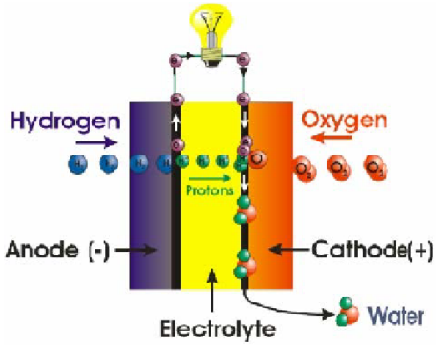


Fig 1.A schematic of a fuel cell

The properties of Nefion which used in this fuel cell as a electrolyte, are very influenced by molecular arrangements. So that manufacturing of this fuel cell needs to high technical knowledge. A high level of contact between catalyzer and membrane is necessary for fine functionality of catalyzer. In fact, the catalyser must be match with the membrane and electrodes also must have a good contact with the membrane. This fine collection needs to mass and electrical current transfer with its environment for continuing its function. This collection which used in integrated manner, is called MEA1. In totally, the electrochemical process of the cell is done in this part. The collecting plates are used for suitable contact between MEA and reactants and conduction of electrons. This set of navigating plates (graphite plates) and MEA must to be assembled so that isolating completely from external environment. This collection is called fuel cell.

The main output of the cell is electrical behavior of it which generally illustrated by volt-Amperediagram of polarity. This parameter defines per surface unit of a cell. This diagram extremely depends on the kinds of MEA, chemical equilibrium, anodic - cathodic current patterns, physical situation (such as temperature, pressure and the type and concentration of reactants). A group of fuel cells often was used because a single cell could not have enough current and voltage.

2. MEA membrane

In this study, the MEA membrane was used which containing Nefion 212 (effective surface 1*1 cm and five layers with load applying of 4.0 mg/ cm^2). In figure 2, an image of MEA could be seen.

3. Experimental instrument

An instrument is used for investigating of the behavior of fuel cell (figure 3). This instrument manufactured by Sribner, 850e

Model. The total time for test is about half of an hour.

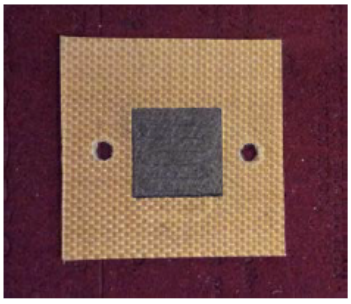


Fig 2.A MEA which provided for experience

Fig 3.instrument for testing of fuel cells

4. Experimental manner

An electrical load is applied on the fuel cell and then the properties of it, is recorded by controlling circuit. In the other world, with doing this work, we could examine the electrical properties of the cell. The parameters like temperature, voltage and current were measured by controlling of variable component (like pumps, heaters and electrical valves). The recorded data is stored in the memory of apparatus as an Excel file. This raw data then could be used by users. Users also could change this data to favorable format and edit them.

5. Experimental results

The experiences show that the function of a fuel cell is depended on the construction method and the working situations of the cell. There are a lot of observations in the research reports that show an increase in the function of the cell at the temperature above 60 ℃. On the other word, at the temperature above 60℃, the power density reaches to 200 mW/ cm^2. In this experience, a set of membrane- electrode (MEA)was used that the properties of it are summarized in Table (1).

Table1. The properties of MEA that was used in our experience

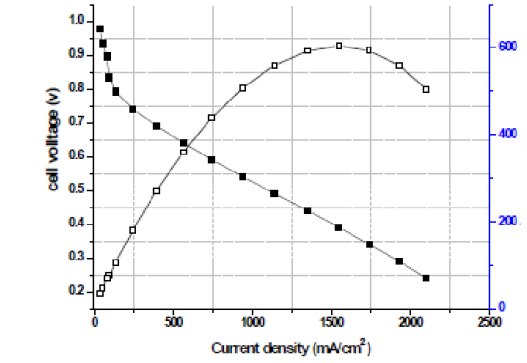
MEA	
4.0 mg/cm2 Pt-Ru	آند
4.0 mg/cm2 Pt	کاتد
شرکت دانش نوین هیدروژن آسیا	سازنده
نفیون 212	نوع غشاء

6. The effect of temperature on the behavior of fuel cell

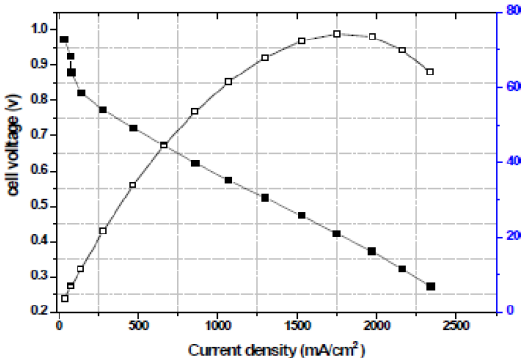
Figure 4 shows the change of voltage and output power in the different temperatures (between 60℃. and 80℃). According to figure 4, the function of fuel cell was improved in the higher temperatures so that the maximum density of power equaled 870 mW/cm^2.

In this practical research, a fuel cell has been studied. The results show that the function of the fuel cell is depends on the type of MEA. With increase in temperature, the functionality of cell is increase because of increase in the rate of electrochemical reactions. But according to the temperature limit, the practical use of this type of polymeric membrane is impossible in the temperature above 75 ℃. But creating of power density 870 mW/ cm^2 is an acceptable result that help us to design a fuel cell stack.

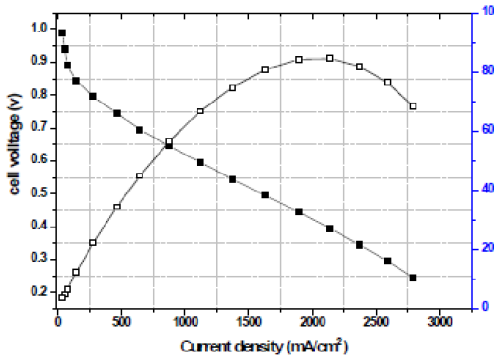
This result also help us to construct bigger cells.



Cell temperature = 60 °C



Cell temperature = 70 °C



Cell temperature = 80 °C

Fig4. The diagrams of voltage and output power changes in the fuel cell at pressure 15 psi (the relative humidity equaled 40 % in cathode and 100 % in anode.

7. References

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