

HYDROGEN USAGE IN A PEM FUEL CELL

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Abstract: - This work in progress paper presents a method of utilizing the unused hydrogen gas in a PEM fuel cell. The design of a closed loop circuit that will return the unused fuel to the fuel cell is then proposed. Experimental results are used to support the analysis.

Index Terms - PEM fuel cell, optimization of hydrogen gas, fuel wastage and volume flow.

I. INTRODUCTION

There is a continuing need to adopt environmentally sustainable methods for energy production, storage and conversion in order to move towards a sustainable existence in our critically energy dependent society. The fuel cell is a device that produces electricity through a chemical reaction between a source fuel and an oxidant [4]. They consist of an electrolyte medium sandwiched in a membrane electrode assembly (MEA), where the anode facilitates electrochemical oxidation of fuel, and the cathode receives input reactant gas. Research has shown that 10 to 20 percent of hydrogen gas that is fed to a fuel cell is not fully used and serves as excess gas which comes out of the anodes exhaust in a fuel cell system [6]. A variety of designs to the control of fuel wastage have been proposed to improve the performance of proton exchange membrane (PEM) fuel cell systems. However temporary faults in such systems still occur during operations due to the complexity of the physical process and the functional limitations of some components.

II. FUEL CELL

Most fuel cells have the same basic operating principle. Input fuel passes over to the anode compartment as shown in Figure 1, which comprises of two layers, the gas diffusion layer and the catalyst layer [7]. The gas diffusion layer distributes the input hydrogen gas evenly to the catalyst layer, which could be (platinum, nano iron powders or palladium). This result in an electrochemical reaction, where anions (protons) and cations (electrons) are formed [3]. The electrons flow through an external circuit supplying power while the protons are conducted through the membrane to the cathode. On the cathode catalyst, oxygen molecules react with the electrons (which have traveled through the external circuit) and protons to form water which is a by-product of the system [5].

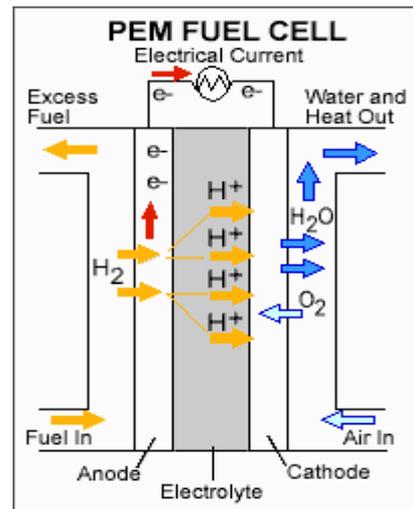


Figure 1: Schematic representation of a PEM fuel cell

III. RESEARCH OBJECTIVE

This research will address the problem of hydrogen gas wastage while safeguarding the membrane and supporting the power supply in a fuel cell. This will involve the following:

- Determine the concentration of hydrogen gas at the anode outlet by calculating the volume flow of the recirculated gas through a fuel cell stack.
- Properly control the pressure of the anode gas discharged at the anode outlet of the fuel cell.
- Improve the closed loop circuit that will return the unused fuel to the fuel cell stack.
- Implementing an anodic gas closed loop circuit for optimal utilization of fuel in a fuel cell stack.

IV. WORK DONE AND FUTURE RESEARCH WORK

Experiments were carried out with a PEM fuel cell stack and a Nexa™ power module (Ballard Power Systems, 310-0027) in a laboratory. The Nexa™ power module is an automated proton exchange fuel cell (PEFC) system, providing unregulated dc power through the use of an external hydrogen fuel supply. Its operation is limited only by the fuel purity requiring no more than 0.01% of total inert gases at a rated power of 1.2 kW. The operating pressure at the fuel supply inlet was chosen to be 10 psig. The fuel supply pressure to the stack was 5.0 psig, and the pressure of air oxidant was set to 2.2 psig. It was observed that as the

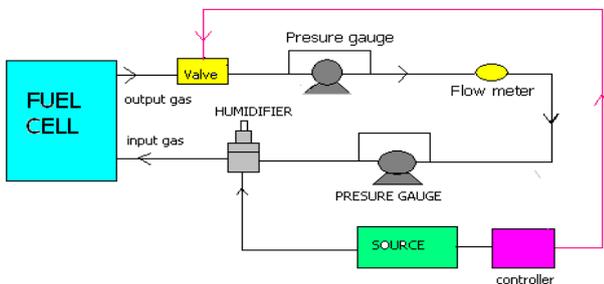
output load (W) increases, the stack voltage (V) decreases and the stack current (A) increases. The hydrogen gas consumption increases accordingly as shown in Table 1. In a fuel cell the inlet gas at the anode compartment is not fully used by the fuel cell unit and the unused gas is discharged at the anode outlet. (also known as anode exhaust gases). The anode exhaust gases are mainly composed of pure hydrogen gas, which have not been utilized.

Conclusion: The unused gas could be recirculated back to the anode gas inlet of the fuel cell stack, resulting in optimal efficiency as long as fuel starvation does not occur.

Table 1: Fuel gas and its exhaust gas compositions as well as different flow rates

Output load (W)	Stack T (°C)	Stack V (V)	Stack I (A)	Fuel P (bar)	Fuel Cons. (L)	O ₂ %
20	22.69	40.69	1.42	2.2	7.36	20.86
30	22.49	40.09	1.68	2.2	7.86	20.86
40	22.49	37.73	3.33	2.17	8.46	20.86
50	23.07	37.83	3.69	2.08	9.68	20.86
100	23.65	37.97	3.76	2.08	10.9	20.86
120	23.98	37.97	3.67	2.08	12.12	20.86
150	24.38	37.53	4.36	2.04	13.46	20.86
170	24.8	37.43	4.33	2.04	14.89	20.86

Figure 2: The proposed design for the recirculation of the hydrogen gas in the fuel cell will ensure that the entire research objective is attained



Future research work will consider the calculation of volume flow of hydrogen gas at the anode outlet, pressure control of the anode gas discharge and the design of hydrogen gas recirculation.

V. BRIEF CONCLUSION

The outcome of this research is to design a close loop circuit that will optimise the fuel usage in a fuel cell stack.

VI. REFERENCE

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