The Mechanization and Analysis of a Proton Exchange Membrane Hydrogen Fuel Cell Stack

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Research Experience for Undergraduates – 2015

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Introduction and Broader Impact

Hydrogen fuel cells

- Promising: clean alternative energy
- Problematic: cells are bulky, materials are costly, hydrogen is explosive so systems are complex
- Basic hydrogen fuel cell process shown in Figure 1

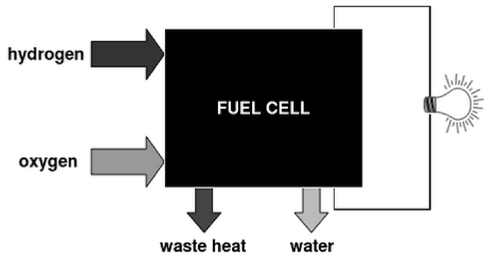

Figure 1: Hydrogen fuel cells utilize electrochemical processes to produce DC power *

Proton Exchange Membrane fuel cells (PEMFC)

- Distinctive proton conductive polymer membrane used to produce power, shown in Figure 2, used for this project

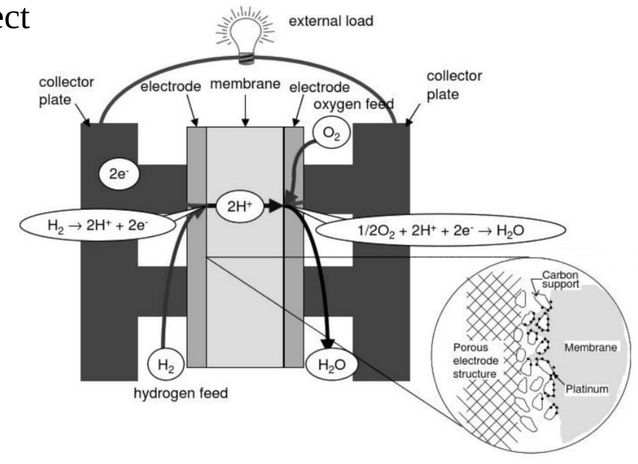

Figure 2: Detailed chemical processes of PEM fuel cell*

Why do fuel cells matter?

- Despite their complexities, hydrogen fuel cells are predicted to be the future of clean renewable energy. In order to see fuel cells implemented in cars, homes, and other applications, researchers, students, and industries must continue to research and develop the field.

Procedure

Objectives

- Complete the mechanization of a PEMFC stack, a continuation of a senior design project from May 2015 (stack shown in Figure 3)
- Analyze voltage, current, and power outputs to determine efficiency of this stack

Figure 3: Ballard® FCGen-1020ACS 5117418 stack, 18 cells **

Developmental Plan

- Confirm that over 460 requirements and specifications from stack manufacturer are met
- Implement external gas monitor for safety
- Run the fuel cell stack and gather data regarding its voltage, current, and power outputs

Results

Many small-scale adjustments and contributions were made to stack system development.

- Circuitry labelled, documented, reorganized, and made more mobile shown in Figure 4
- External gas monitoring system wired (calibration kit purchased and ordered), shown in Figure 5

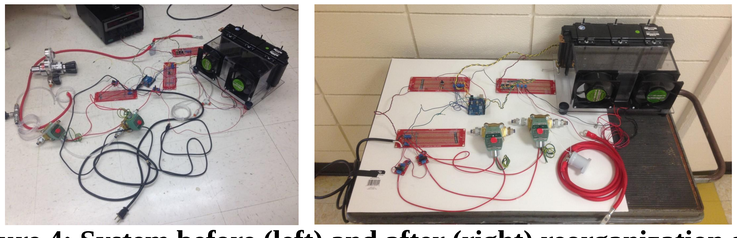

Figure 4: System before (left) and after (right) reorganization and adjustments

Figure 5: GasScanner 2C with hydrogen LEL and oxygen detector heads

Results continued

- Microcontroller updated
- New pressure sensor integrated into sensing circuit
- Multiple fixes and replacements due to storage/travel damage

Conclusions

While efficient in producing clean energy (average PEMFC stacks are ~50% efficient), fuel cells require complex control circuitry in order to be successfully developed in a commercial application, such as an electric vehicle, and need development before advancing to provide wide-scale energy.

Future Work

For future SDSM&T students and faculty:

Necessary developments

- Design PCB to replace soldered breadboard circuits
- Design and implement Teflon or PVDF tubing system
- Complete stack enclosure to protect stack
- Implement power electronics to safely manage power output from stack

Long-term goals

- Use stack to power golf cart or small ATV
- Continue to improve stack operating system

* Image courtesy of Frano Barbir's *PEM Fuel Cells Theory and Practice* at http://site.ebrary.com/lib/sdsmt/detail.action?docID=10138196

** Image courtesy of Ballard® Power Systems' FCgen ®-1020ACS Fuel Cell Stack/ FCvelocity ®-1020ACS Fuel Cell Stack Product Manual and Integration Guide

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