Restated Project Definition and Project Plan for an Alkaline Membrane Fuel Cell Educational Kit for High School and College Level Laboratory Demonstration

Team Number: 10

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Deliverable Name: Restated Project Definition and Project Plan

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Abstract

This paper will elaborate on any project changes such as definition, objective, or design that have been made since the last report. Since the project members working in Brazil have returned the team dynamic has changed, facilitating the completion of the project through increased communication and ease of ability to share ideas. Moving forward, we plan on creating an Alkaline Membrane Fuel Cell educational kit that proves the practicality of this device and showcases the organic membrane developed by Dr. Ordonez and Dr. Vargas. A proof of concept such as this should prove that AMFC technology is a viable, sustainable solution to power generation and could possibly increase further funding and research in the field.

The team plans on doing this by making some design changes to the existing prototype that was used at the university in Brazil (UFPR), such as reducing the overall size and creating different flow patterns by use of different channel geometry. The case that allows for the safe portability of this product is also being considered and the design is in its final stages, awaiting fabrication after the fuel cell component has been completed.

1 Introduction

This section of the report introduces the background research in order to gain an understanding of the AMFC and some of its advantages over other cells. Also, the needs statement that is explained as well as the goals and objectives the team has set for the project. Finally, the constraints for the design are discussed.

1.1 Background research

Fuel cell technology has been increasingly recognized in the field of alternative energy as a clean option for future power generation. For this reason, an educational kit using an alkaline membrane fuel cell is to be created to demonstrate the technology and spread interest in the concept.

This project aims to build on the research previously conducted on alkaline membrane fuel cells (AMFC) by the engineering departments of both Florida State University and Universidade Federal do Paraná. Professors Juan Ordonez (FSU) and Jose Vargas (UFPR) were able to produce and validate a dynamic model to predict the response of a single AMFC according to the variation of physical properties, as well as design and operating parameters. Based off some of the data that was gathered the team has determined some of the advantages and disadvantages of using this kind of cell and have displayed the results below in table 1. Using this model, the fuel cell of the educational kit will be optimized to lower overhead costs and increase functionality.

Advantages	Disadvantages
• No expensive polymer membrane is necessary – liquid alkaline solution as electrolyte • Liquid electrolyte may enable a simple cooling of the stack • Activation overvoltage is less than with an acid electrolyte	• High corrosivity of the electrolyte • Electrolyte must be reconcentrated during long time • Intolerance to CO_2 $CO_2 + 2OH^- \rightarrow CO_3^{2-} + H_2O$ • Must use pure H_2 and O_2

Table 1. Advantages and Disadvantages of Alkaline Membrane Fuel Cells[1]

Though similar kits already exist in today's market involving other types of fuel cells, this kit will be the first to use an AMFC to power the system. Alkaline membrane technology has shown promising characteristics when compared to other forms of fuel cells, such as a higher current density, lower cost electrolyte and higher operating temperatures, which should allow for the production of a more accessible and affordable educational kit. There are also some disadvantages that will bring some different challenges to the design as seen in the table below. First, the reaction taking place in the fuel cell has an intolerance to CO_2 which will hurt the efficiency overall. Also, pure H_2 and O_2 must be used as fuel for the chemical reaction to take place within the fuel cell. These problems have been addressed previously in larger scale designs and will soon be addressed for smaller scale design as well.

2 Project Definition

This semester the team will be approaching the project differently than in the Fall. This section will be discussing some of the changes that result from this new approach.

2.1 Need Statement

The sponsor for FIPSE Team 10 is Florida State University, however the needs are being conveyed through Florida State University Associate Professor Dr. Juan Ordonez. Currently the alkaline membrane fuel cell is set up in a laboratory in the CAPS building, the size of the setup is in the neighborhood of 70 ft^2. Florida State and Dr. Ordonez would like for the entire setup to be inside of a portable case. This means shrinking the setup roughly 30 times its current size. By making the alkaline membrane fuel cell fit into a suitcase Florida State University hopes to create a prototype of an educational alkaline membrane fuel cell kit that students can use to learn more about the technology. The team plans to deliver a fully operational alkaline membrane fuel cell prototype kit smaller than a standard suitcase by March 22, 2015.

"The current AMFC setup is too large and immobile to be a portable educational kit alkaline membrane fuel cell."

2.2 Goal Statement & Objectives

"Deliver a fully functional alkaline membrane fuel cell in a portable case to Florida State University by the end of the spring 2015 semester."

With the start of the spring 2015 semester Team 10 has decided to take a look at previous objectives and update them based on the progress made in the fall. The first main objective for the spring will be to have a fully functioning fuel cell. This means that the fuel cell will have all of the necessary components and machining completed and can safely generate power. Also, along with this kit a safety procedures and an operations manual will be formed in order to instruct the operator on all of the steps needed in order for the fuel cell to function at optimum efficiency while maintaining safe operating conditions.

Once the fuel cell is machined to necessary specifications, the team will perform numerous tests in order to determine the optimal ratios of gasses and their pressures, which will be used to calculate exact amount of gas that the cell uses. This data is crucial because it will help achieve the maximum output from a fuel cell of this size. This output will be used to power an observable display in order to attract interest of the students, and demonstrate the possibilities of the technology. Possible student experiments will also be created to help develop a sense of fuel cell function and power generation, such as forming a polarization curve using a series of increasing resistances. We will be constructing polarization curves to easily demonstrate the output that our fuel cell is achieving during operation. Also, in order to prove that the size of the fuel cell is beneficial, representations will be made comparing the pros and cons of both smaller and larger options.

The next main goal is to obtain the necessary materials needed to construct a protective case and find a way to store the cell and the components within the case safely. This will be done last due to the many different variables that need to be determined beforehand such as tank size.

2.3 Constraints

Before the use of fuel cells can be considered a practical means of energy production it must meet some specific constraints that are put in place for the design to succeed. First, the case must weigh under 20 lbs. to ensure its portability. Also, all of the components of the alkaline membrane fuel cell should be contained within a standard sized suitcase (1.4 ft^2 – 2.0 ft^2). Also, the design must meet the strict budget requirements by using all of the components as efficiently as possible. Finally, the design should meet all of the safety requirements needed to transport the gasses used in the reaction.

3 Project Plan

With the new semester Team 10 have decided to update the schedule and methodology based off the progress made in the fall. This section discusses those changes and why they were made.

3.1 Scheduling

The Gantt chart shown in Figure 1 is designed to keep the team on pace to finish successfully, a large component of staying on pace is visualizing the steps needed to get to success.

Now the team is finalizing the design of the fuel cell, which holds as a continually changing process. The reason for this change is that there are many variables to consider based on the parts that we have available to us within our budget. After meeting with our sponsors and Dr. Gupta it was decided that the fuel cell should be ready for demonstration in the open house taken place in four weeks. This fuel cells will not be the final version but will be able to demonstrate the overall concept trying to be achieved. Also, this will not change the future timeline because after the open house many tests will still have to be performed to obtain a polarization curve and determine the ideal conditions of operation.

Currently the team is researching the ideal electrode sheets needed for a fuel cell of this size. This is a very important step because these are without a doubt the most costly part of the project. The team is also making a more detailed design in order to machine the necessary parts with as little error as possible. Project members will also be placing purchase orders within the week on pressure valves and other important components that we will need to be ready to present in the open house. Since making a fully functioning fuel cell is currently the top priority the finalization of the case will not be the primary focus until this step is complete.

GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		◢ **Background Research**	**33 days**	**Mon 9/1/14**	**Wed 10/15/14**	
2		Obtain Design Ideas	14 days	Wed 9/3/14	Mon 9/22/14	
4		Commercial Research	23 days	Wed 9/3/14	Fri 10/3/14	
5		QFD Diagram	5 days	Mon 10/6/14	Fri 10/10/14	
6		◢ **Collect Data**	**29 days**	**Wed 10/15/1**	**Mon 11/24/1**	
7		Run Trials With Existing Prototype (UFPR)	19 days	Wed 10/15/14	Mon 11/10/14	
8		◢ **Mathematical Modeling and Optimization**	**21 days**	**Mon 10/27/14**	**Mon 11/24/14**	
9		Use Fortran Code to Run Trials	21 days	Mon 10/27/14	Mon 11/24/14	
10		Variation of Parameters	18 days	Thu 10/30/14	Mon 11/24/14	
11		◢ **Design of Fuel Cell**	**65 days**	**Mon 11/3/1**	**Fri 1/30/15**	**8**
12		Component Specifications	53 days	Thu 11/6/14	Mon 1/19/15	
13		Component Design	48 days	Wed 11/19/1	Fri 1/23/15	
14		Formulate ProE Drawings	48 days	Wed 11/26/14	Fri 1/30/15	
15		◢ **Construction of Prototype Budget**	**35 days**	**Tue 12/2/14**	**Mon 1/19/15**	**11**
16		Follow-up Sponsor Meeting	4 days	Tue 12/2/14	Fri 12/5/14	
17		Market Research	9 days	Tue 12/2/14	Fri 12/12/14	
18		Communicate With Vendors	27 days	Fri 12/12/14	Mon 1/19/15	
19		◢ **Manufacturing**	**37 days**	**Tue 1/20/15**	**Wed 3/11/1**	**15**
20		Compilation of ProE Drawings	6 days	Tue 1/20/15	Tue 1/27/15	
21		Obtain Materials	31 days	Tue 1/20/15	Tue 3/3/15	
22		Schedule with Machine Shop	28 days	Mon 2/2/15	Wed 3/11/15	
23		◢ **Physical Testing and Validation of Mathematical Model**	**21 days**	**Thu 3/12/15**	**Thu 4/9/15**	**19**
24		Testing of Prototype Under Ideal Conditions	12 days	Thu 3/12/15	Fri 3/27/15	
25		Variation of Parameters and Optimization	10 days	Fri 3/27/15	Thu 4/9/15	
26		Analysis of Results	15 days	Tue 3/31/15	Mon 4/20/15	
27		Presentation Of Results	6 days	Mon 4/13/15	Mon 4/20/15	
28		Delivery of Final Semester Report	5 days	Tue 4/14/15	Mon 4/20/15	

GANTT CHART

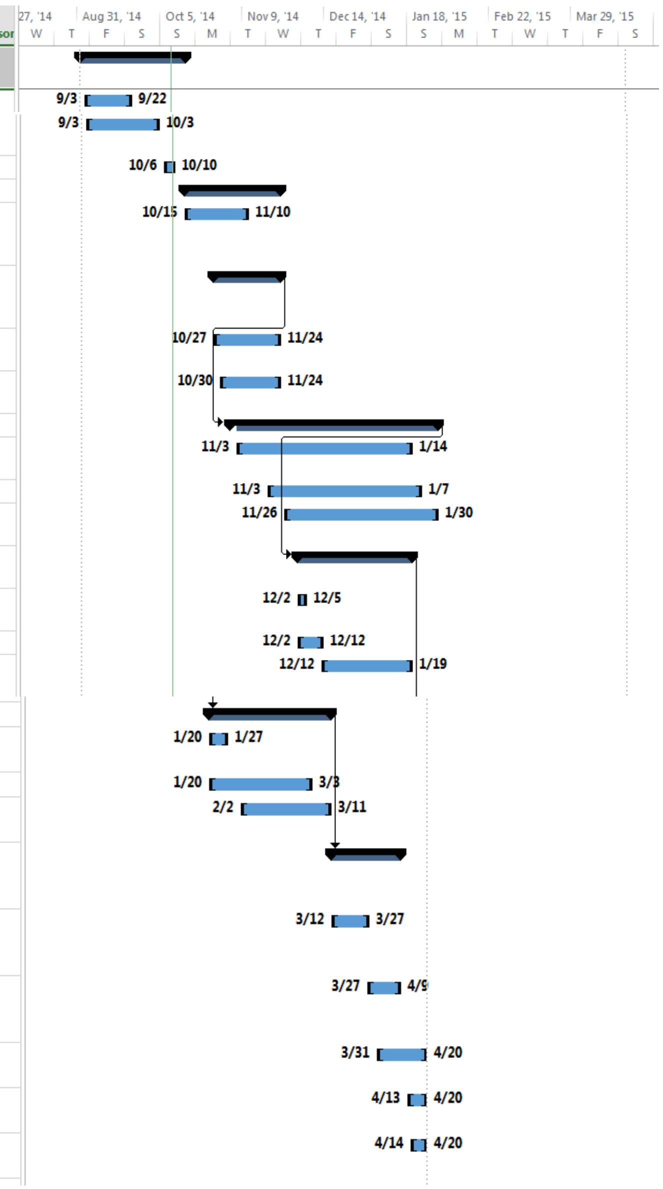

Table 1. Gantt Chart

3.2 Methodology

The coming months will be used by the team to culminate everything learned so far through experience and research into forming a final AMFC educational kit. As the raw materials needed for the fuel cell construction continue to arrive, final dimensions of the AMFC will be decided upon and formal drawings will be created in Creo Elements. From this point, we can begin fabrication in the COE's Machine Shop and, upon completion, begin testing to determine the upper and lower bounds of operation.

The Alkaline Membrane Fuel Cell will be tested in a controlled environment prior to the kit's final construction to determine the possible power output, durability of materials, and necessary fuel requirements needed for operation. A marathon test will be run using new cathode and anode sheets with a 40% KOH solution to determine the length of time a single batch of potassium hydroxide solution will react for, as well as map the voltage and current response of the fuel cell over sustained use. The mass flow rates of the Hydrogen and Oxygen gases entering the AMFC will also be varied using pressure valves to determine the rate at which maximum efficiency occurs in the cell, which will result in lower consumption of fuel.

The case that will make up a majority of the kit will be constructed once the necessary volumes of the gas storage tanks are determined in order to properly size the outer casing. The fabrication of the case is relatively simple, consisting of a sturdy foam for storage, and two-bar linkages on either side of the case walls to form the support beam that the AMFC hangs from. Safety precautions and a detailed operation manual will be created after reviewing notes and observations taken during the testing and fabrication stages.

3.3 Changes Made

In the previous fall semester, working with teammates in Brazil posed as a challenge when trying to communicate and work on our design. However, this experience has made us properly plan and schedule meetings that benefited the team across the border. Now that those teammates have left Brazil and are back at FSU, the entire team is actively involved with completing the goals of the project.

In addition, some of the other aspects of the project that involved the focus of the design of the kit were changed. With all members of Team 10 present, the cost benefits for designing different size fuel cells and the effectiveness of each size are being determined. Once that is accomplished, the team aims to set the focus to obtain all the necessary materials and data to build the AMFC fuel cell based on appropriate size for the kit components.

3.4 Design Changes

After some preliminary research however, the group has determined that a serpentine channel geometry in the fuel cell would be more effective than the parallel flow geometry used in the prototype at UFPR. The overall size will be limited to 4 in^2 due to limitations in the size of the electrode sheets sold by the chosen vendor, however there is still flexibility below this maximum point. Another major challenge experienced with the fuel cell in Brazil was the assembly of the AMFC. In order to improve on this, mounting brackets have been designed in order to facilitate easier use of the fuel cell, while still evenly distributing the mounting pressure across the fuel cell to ensure proper sealing and operation. The brackets were chosen to be fashioned from a polycarbonate since this material is both easily machined and rated to withstand the maximum operating conditions of the Alkaline Membrane Fuel Cell, as well as remaining relatively cheap.

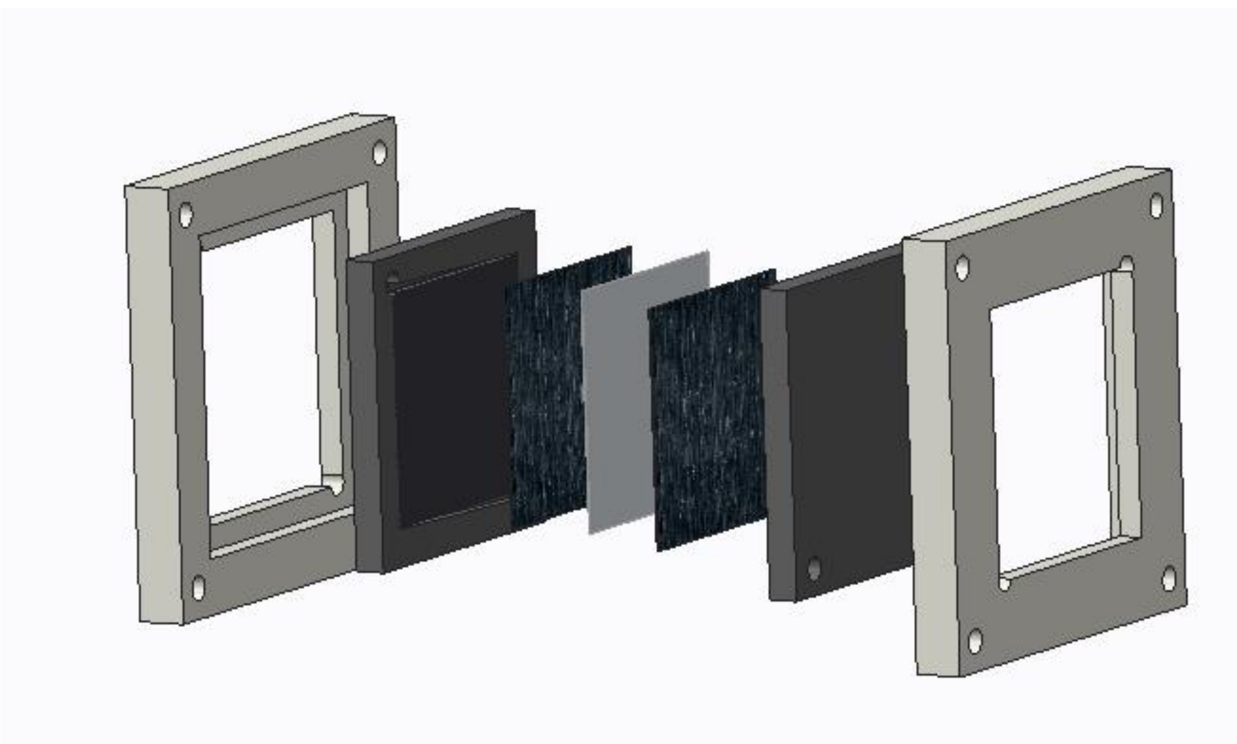

Figure 2. Exploded view of current Alkaline Membrane Fuel Cell design.

4 Conclusion

This semester we have decided to shift some of our project goals based off of what we have learned previously. One of the main changes that will be made this semester is that the fuel cell itself will be the primary focus. This is important because there is an open house approaching that we hope to have a functioning fuel cell ready to demonstrate. Also, this semester we have determined that there are some extra data points that are very important to show. First, we are hoping to have a relationship between size of fuel cell and overall cost and efficiency. This may prove to be difficult though due to the fact that budget restraints will most likely limit our ability to test fuel cells of different sizes. Also, we will be showing polarization curves that will demonstrate the power used by the cell. By the end of the semester we will have a fully functioning fuel cell with the ability to power a device for demonstrative purposes. Also, we plan on having the case ready to support the storage of all necessary components. Finally, we will have enough data gathered to show the fuel cells marketability as an educating tool.