Group 16

Design and Development of Optimized Flow Channels for an Alkaline Membrane Fuel Cell Educational Kit

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Re-Introduction to AMFC Operation

- Converts chemical energy into electric potential energy
- Requires an electrolyte solution, hydrogen gas, and oxygen gas or air for operation
- Generates electricity with no harmful Bi-products
- Most electrically efficient of all the fuel cells (60% efficiency)
- Safe operating temperature for educational kit (70-100 Celsius)

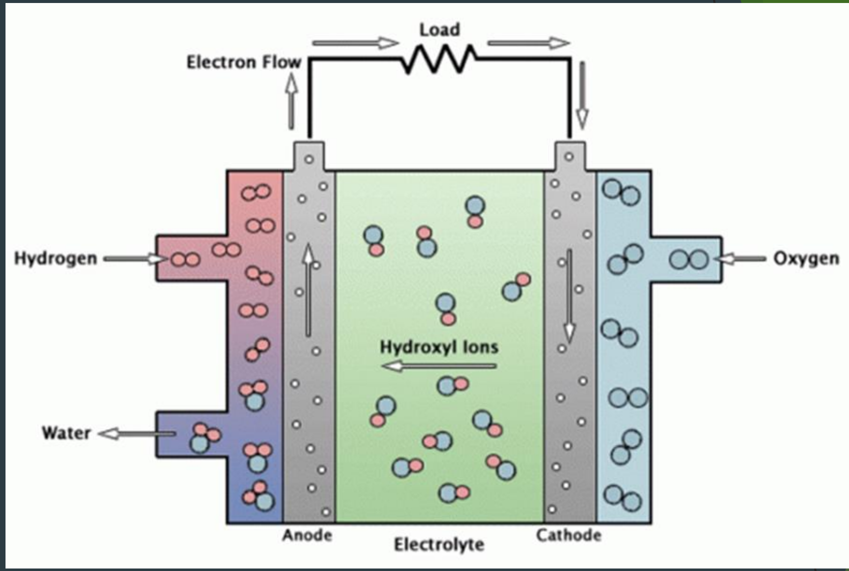

Fig. 1: Fuel Cell Operation

Table 1: Operation of various fuel cell types

Fuel Cell Type	Operating Temperature (°C)	Electrical Efficiency
Alkaline (AFC)	70 – 100	60%
Polymer Electrode Membrane (PEM)	50 – 100	25 – 58%
Phosphoric Acid (PAFC)	150 – 200	>40%
Molten Carbonate (MCFC)	600 – 700	45 – 47%
Solid Oxide (SOFC)	600 – 1000	35 – 43%

Project Summary and Purpose

- Research and test the effects of different flow configurations on a fuel cell’s performance
- Create an educational kit that demonstrates these results
- Design hands on experiments for different levels of education
- Kit must be self sufficient and portable
- Integrate the fuel cell with other forms of sustainable energy

Break Down of Updates

- New components
- Current experimental setup
- Testing and Results
- Experimental designs for future use
- Overview of assembled kit
- Future plans

New Components

- HydroFILL PRO
  - Produces pure Hydrogen through electrolysis
- HydroSTIK PRO
  - Safe Hydrogen Storage Solution
    - Binds Hydrogen with a metal alloy to form solid metal Hydride
- Pressure Regulator
  - Regulates outlet pressure from HydroSTIK to 6.5 psi
- Air pump
- Measurement Set
  - Load Box
  - Multimeters
- Rubber Gaskets
  - Prevents leaks

Fig. 2: New Components in Kit

Configuration Updates

- New plates finished being machined
- Banana plug enabled
- Need to be sanded for housing fitting

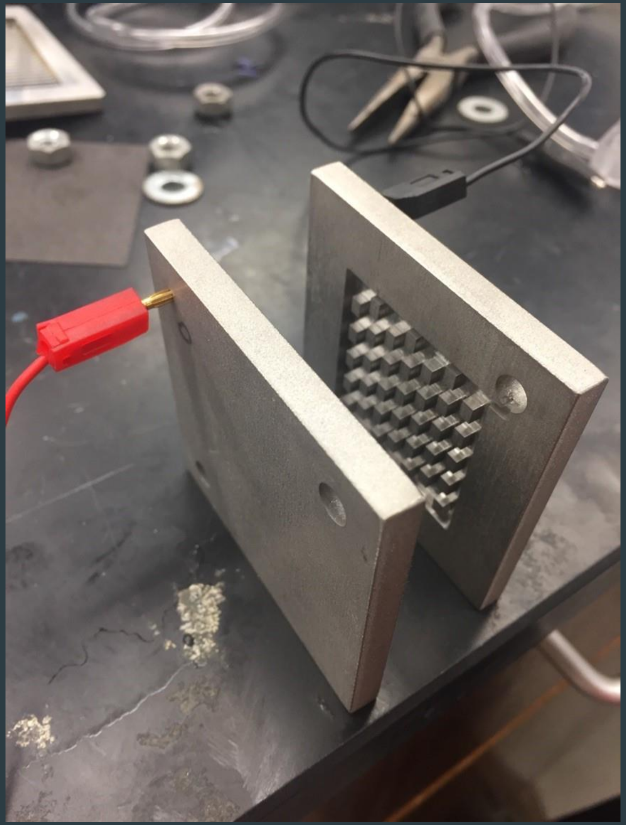

Fig. 3: Banana Plug Inserts

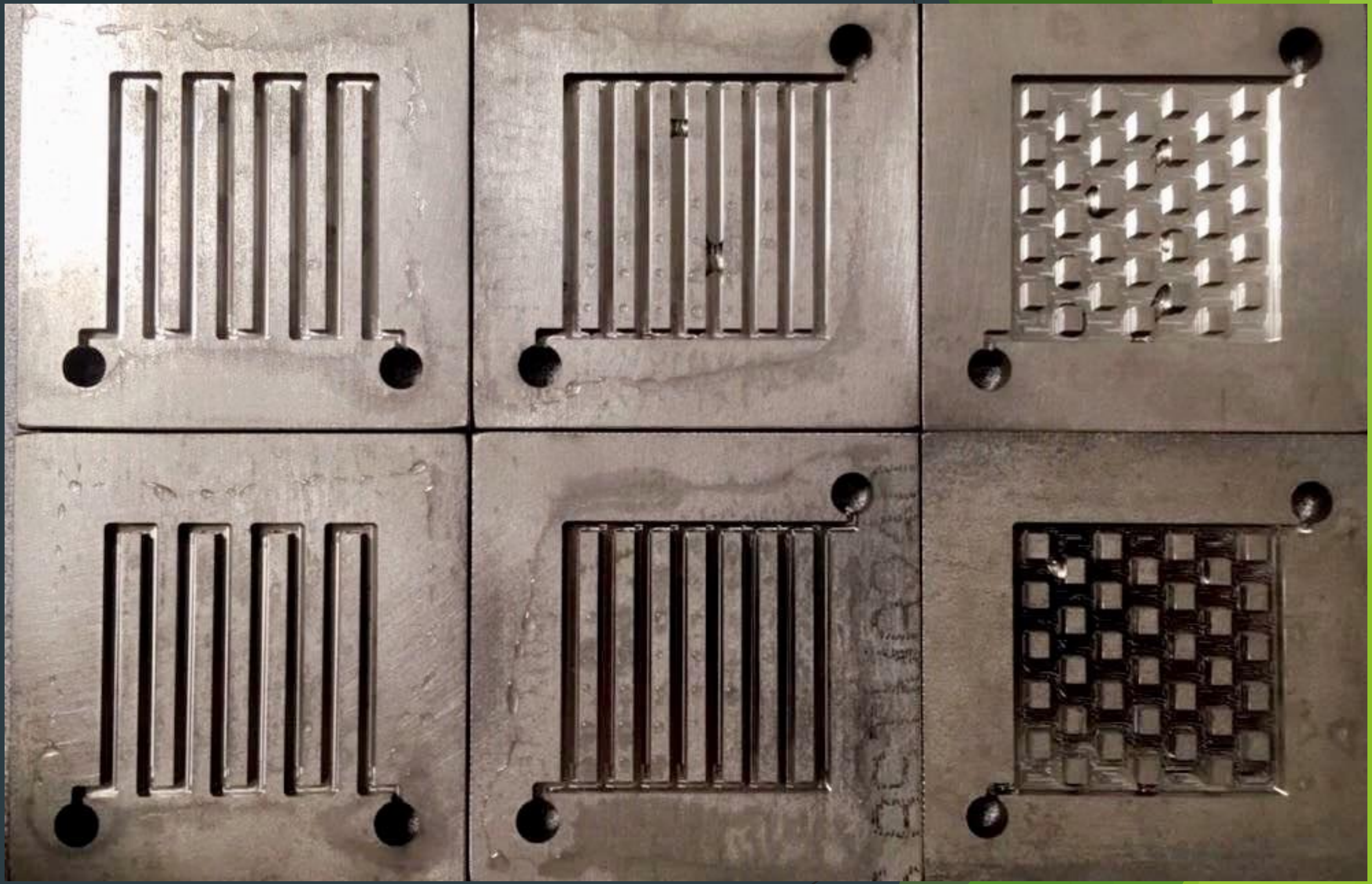

Fig. 4: New Cell Configurations

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Experimental Setup

- Charge Hydrostik pro
- Soak membrane in KOH solution
- Assemble fuel cell
- Connect air pump to cathode
- Connect Hydrostik to regulator and connect to anode
- Run banana plugs from cell to port 1
- Connect multimeter 1 in voltage port
- Connect multimeter 2 in current port
- Connect water waste tubes from cell to cylinders

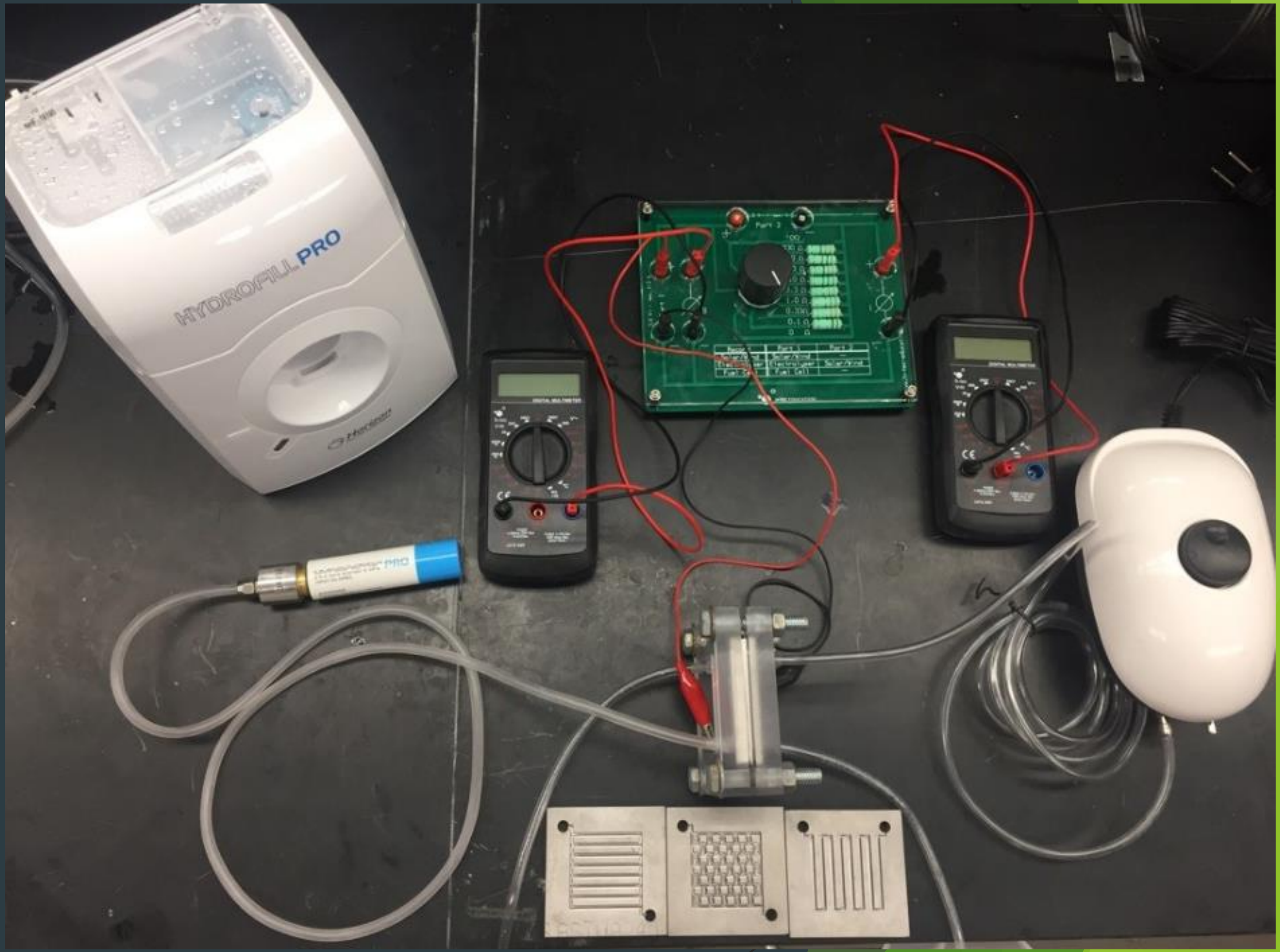

Fig. 5: Experimental Setup

Testing

- Measure voltage
- Vary resistance to produce different voltages and currents
- Run test after 5 min of fuel cell operation
- Run test after 15 min of fuel cell operation
- Construct I-V curve and plot power
    - Power is calculated from P=IV

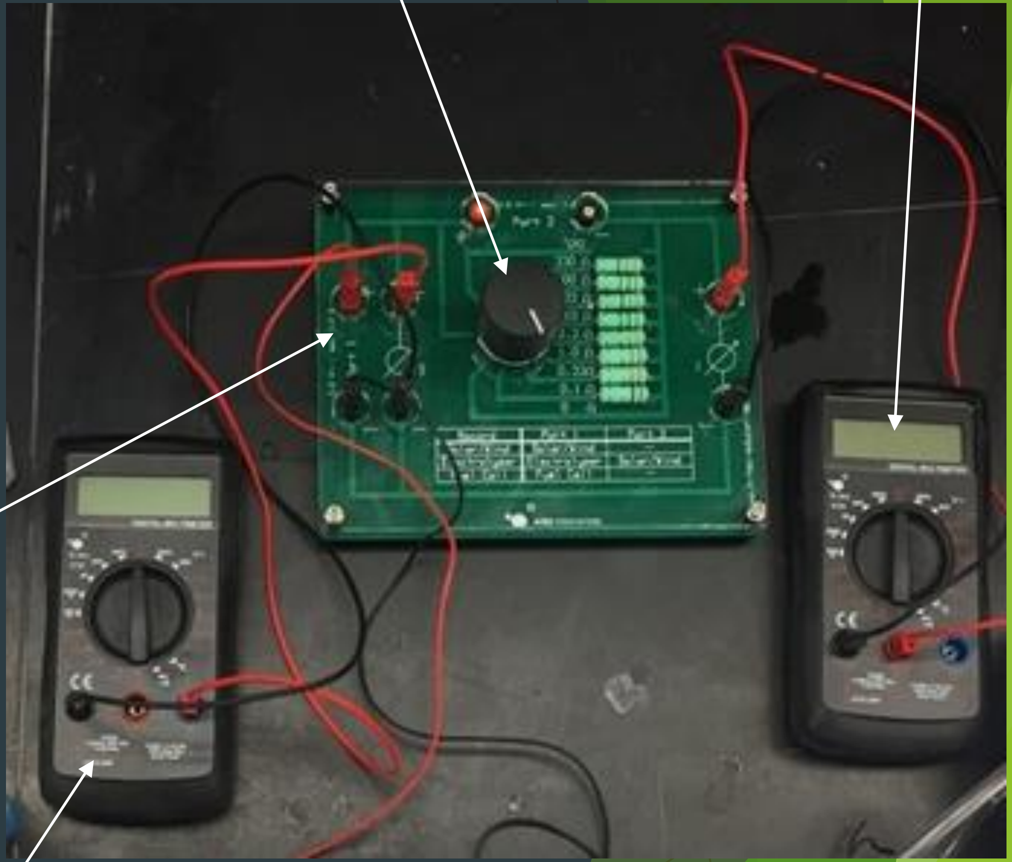

Fig. 6: Measurement Tools

Results

- Performance Curve of Current Design
  - Voltage decreases with increasing current due to losses
  - Drastic decrease in voltage drop results in lower efficiency
  - Want to minimize voltage drop
    - Activation Losses - Temperature, material, carbon dioxide poisoning
    - Fuel Crossover - Contact area is affected by current density
    - Ohmic Losses - Built in resistances
    - Concentration Losses - High pressure drop results in poor water removal hence less Hydrogen consumption

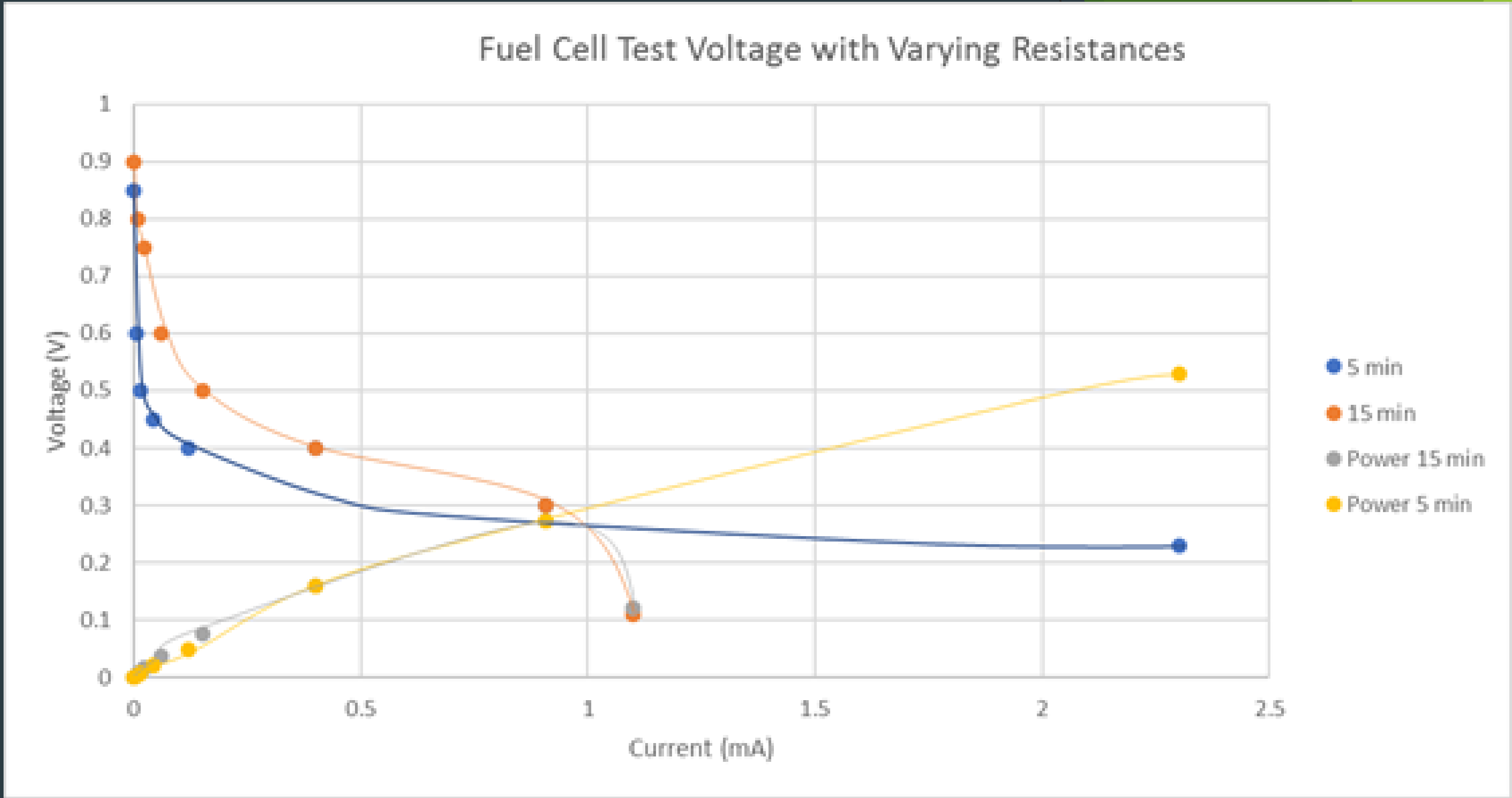

Fig. 7: Performance Curve

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Results Cont.

- 15 min after operation less efficient
  - Fuel cell overheated
  - Burning electrolyte membrane
    - Not enough KOH
      - Soak for longer period
    - Membrane reused
      - Use new sheet

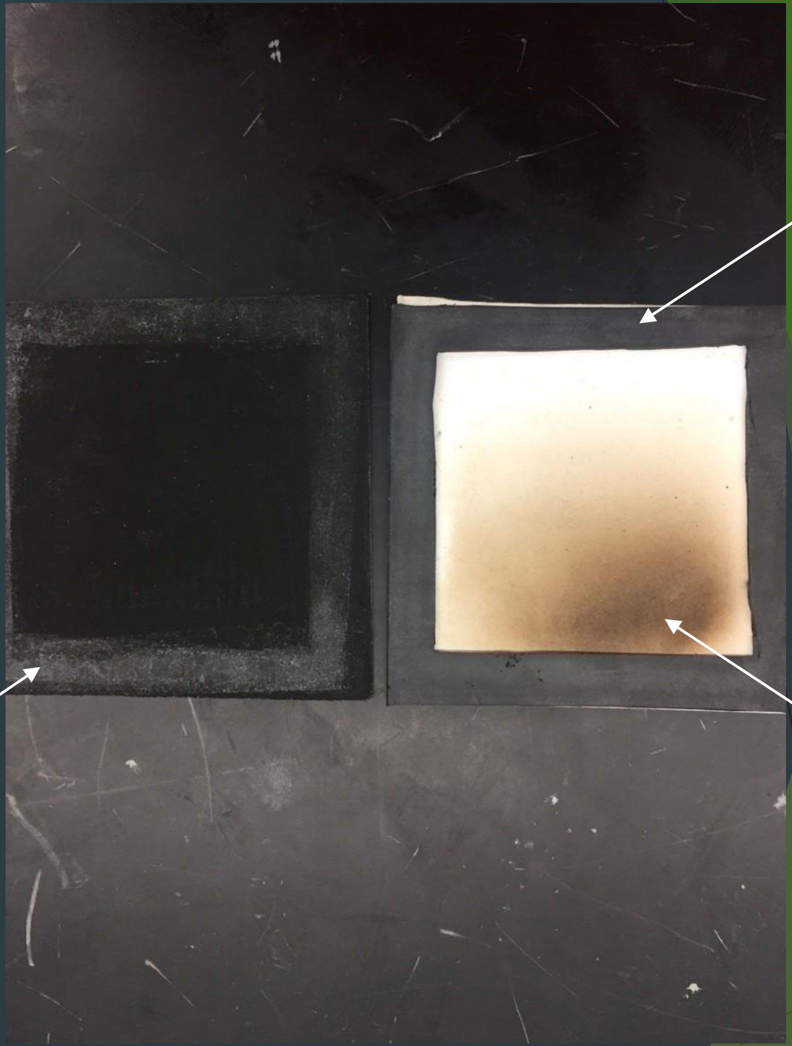


Fig. 8: Burnt Membrane

Educational Experiments

- Designing experiments to be included in final kit
- Experiments meant for different educational levels
  - Junior High school
  - High school
  - College

Fig 9: Students conducting an experiment

Educational Experiments – Jr High

- Experiment will be completed by a teacher
- Students will help assemble fuel cell
- A simple LED light can be attached to the cell to display power output
- Students will learn basic fuel cell concepts
- Provides an introduction to sustainable energy

Educational Experiments – High School

- Experiment more hands on for students
- Students allowed to assemble fuel cell
- Students can operate fuel cell and take voltage measurements under adult supervision
- Students can plot results
- Will provide insight to basic chemistry and physics concepts

Educational Experiments – College

- Students can operate fuel cell in laboratory with TA
- Students can learn and understand the significance of different fuel cell components
  - Electrolysis
  - Stoichiometry
  - Thermodynamic Properties
  - Fuel cell properties
- Run fuel cell with different flow configurations and record/plot results
- Calculate fuel cell efficiency

Educational Experiments – College cont.

- Fuel cell will be integrated into the operation of a microalgae bioreactor
  - Closed systems for sustainable energy
- Fueled by a byproduct of algae growth (hydrogen gas)
- Students can study overall efficiency of the system while working to increase efficiency

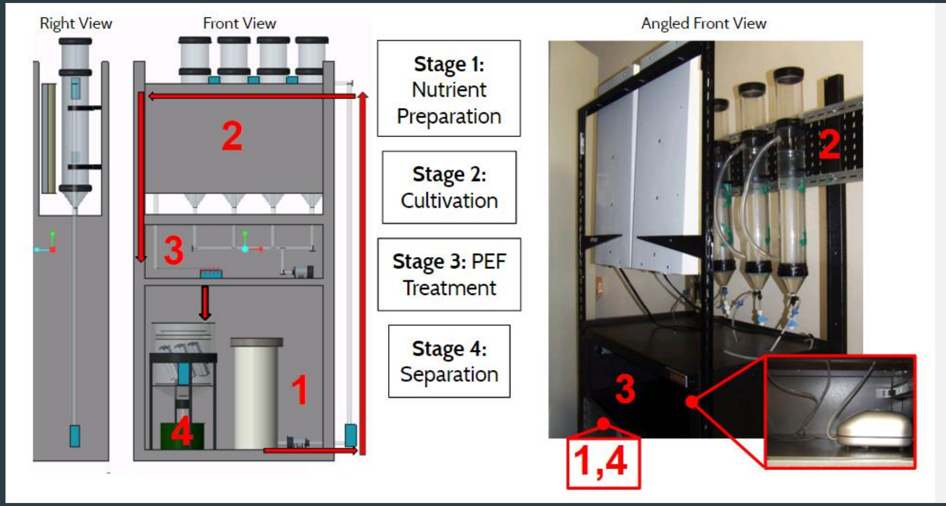


Fig 10: CAD Design and Picture of Bioreactor

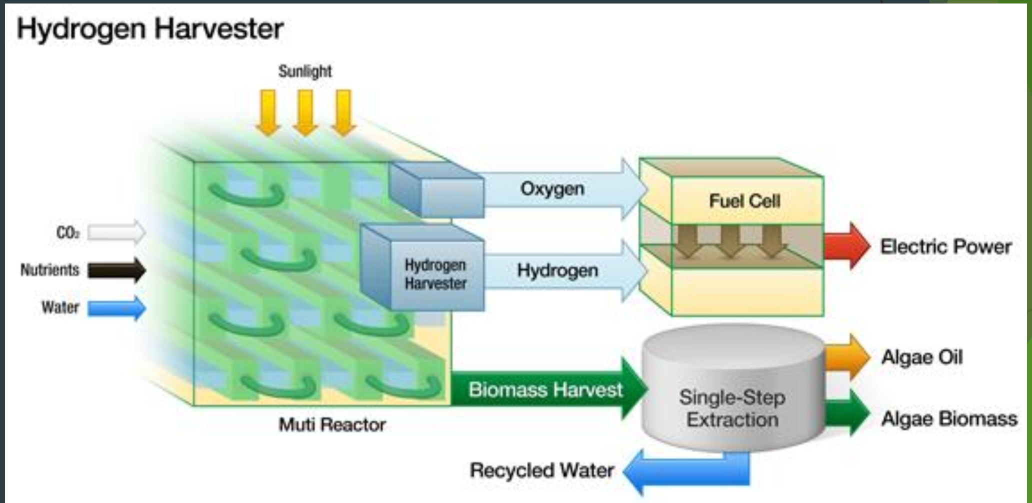


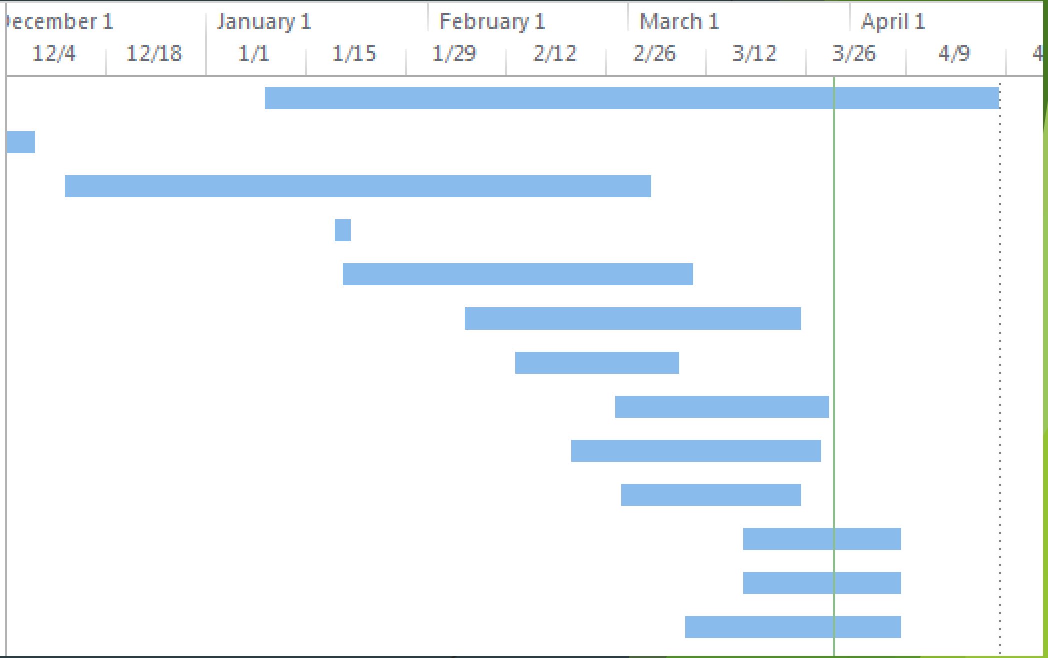
Fig 11: Flow Diagram Integrating Fuel Cell

Current Standings and Future Plans

- All parts ordered and machined
- New plates need sanding and to be tested
- Kit being organized and consolidated
- Experiments and kit manual being written

Table 2: Gantt Chart

Task Name	Duratio	Start	Finish	Pr
Web Design	75 days	Mon 1/9/17	Fri 4/21/17	
Begin Testing of Existing Design	13 days	Mon 11/21/16	Wed 12/7/16	
Communication with Brazilian Team	60 days	Mon 12/12/16	Fri 3/3/17	
Meet with Advisor/Sponsor	2 days	Thu 1/19/17	Fri 1/20/17	
Communicate with Machine Shop	35 days	Fri 1/20/17	Thu 3/9/17	
Purchase Components	35 days	Mon 2/6/17	Fri 3/24/17	
Simulation of Fluid Flow Using Comsol	17 days	Mon 2/13/17	Tue 3/7/17	
Machine New Flow Channels	22 days	Mon 2/27/17	Tue 3/28/17	
Optimize Gas Delivery System	25 days	Tue 2/21/17	Mon 3/27/17	
Optimize Electrolyte Membrane	19 days	Tue 2/28/17	Fri 3/24/17	
Test Flow Configurations	16 days	Fri 3/17/17	Fri 4/7/17	
Conduct Mathematical Analysis	16 days	Fri 3/17/17	Fri 4/7/17	
Finalize Kit	22 days	Thu 3/9/17	Fri 4/7/17	



Summary

- Background
- Project overview
- New plates and components
- Experimental setup and testing
- Results of current parallel plate
- Experiments for different levels
- Plans for future

Questions