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Thermal Management of a Proton Exchange Membrane Fuel Cell by air cooling of the external surface.

to produce *economical* $ cooling system

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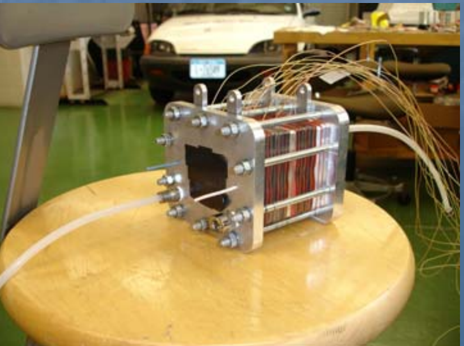

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Thermal Management of a Fuel Cell by Air Cooling of the External Surface

Abstract

The use of fossil fuel has become a major problem that has national security implications. The emission of green house gasses and the need for clean renewable energy has led to the research into alternative energy sources. One of the major options being considered for this critical situation is a hydrogen fuel cell, also called proton exchange membrane fuel cell. It has been established that a proton exchange membrane fuel cell (PEMFC) shows optimum performance at an ideal operating temperature of about 80ºC. The PEMFC produces heat energy as a byproduct of the chemical reaction needed to produce electrical energy. The production of heat by the fuel cell is closely related to the current density. The removal of the excess heat produced has to be performed at a rate that keeps the internal temperature constant at about 80ºC. Monitoring and controlling the external temperature of the active area of the flow field plate or end plate can be an economic way to keep the fuel cell within an ideal temperature range. Two fans with variable air flow will be used to introduce a stream of regulated air to cool the external surface of the fuel cell stack. Fifteen thermocouples will be equally dispersed across three bipolar plates of a fuel cell to monitor the internal temperature and the rate of heat production. An infrared heat sensing camera will be used to display the external surface temperature of an operating fuel cell. The sixteen sensors will be connected to a computer with temperature data collecting software. Real-time temperature monitoring is automatically done at predetermined time intervals. Two other sensors will be used to measure the upstream and downstream temperatures of the fuel cell cooling air flow. Data was collected with the fuel cell stack operating at different power output, while trying to establish the required air flow to keep the temperature constant at a safe level. It can be inferred from the results that an economical air cooling system can be designed for any fuel cell power stack set to run at its maximum capacity. The current work has established a relationship between the active area, the heat produced, and the air flow required to remove the excess heat, can supply the parameters needed to recreate a cooling system for any size fuel cell.

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Objective

- The objective of this experiment is to study the internal temperature of a fuel cell in relation to the power output.
- To find a relationship between the cooling load and the power produced.

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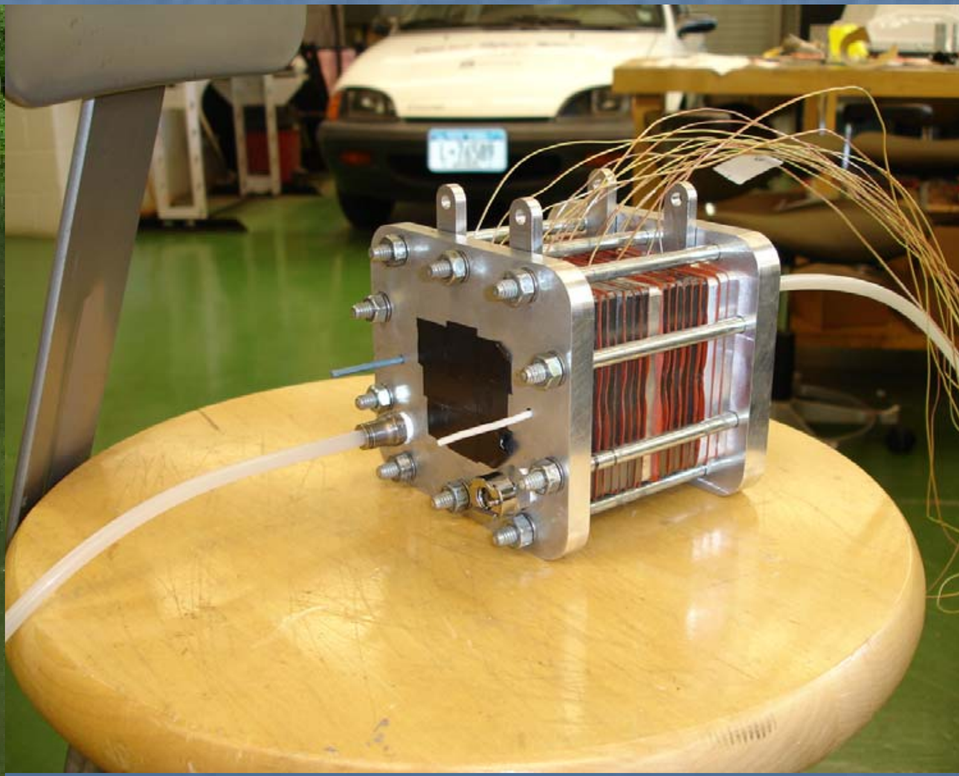
Clean Alternative Energy



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The Equipment

2 Data cards with 8 terminal as an attachment to any ordinary PC

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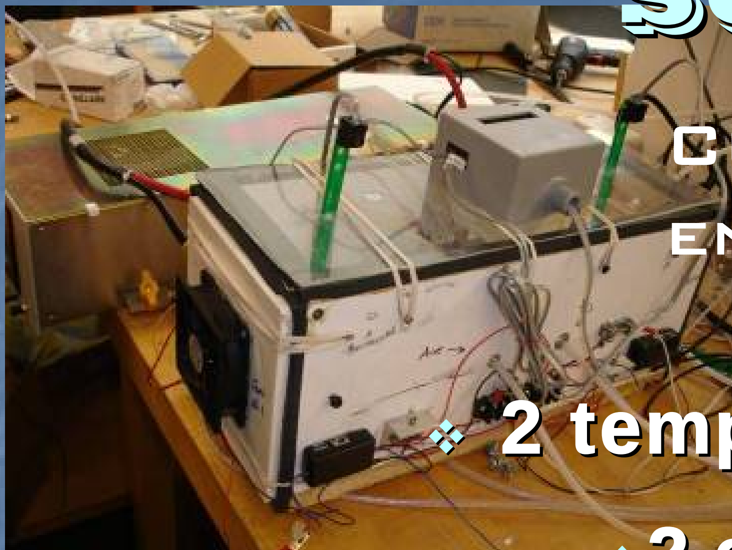
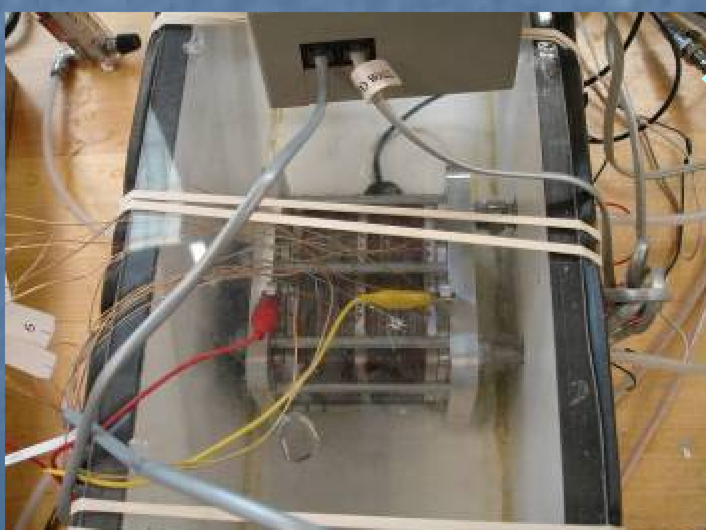
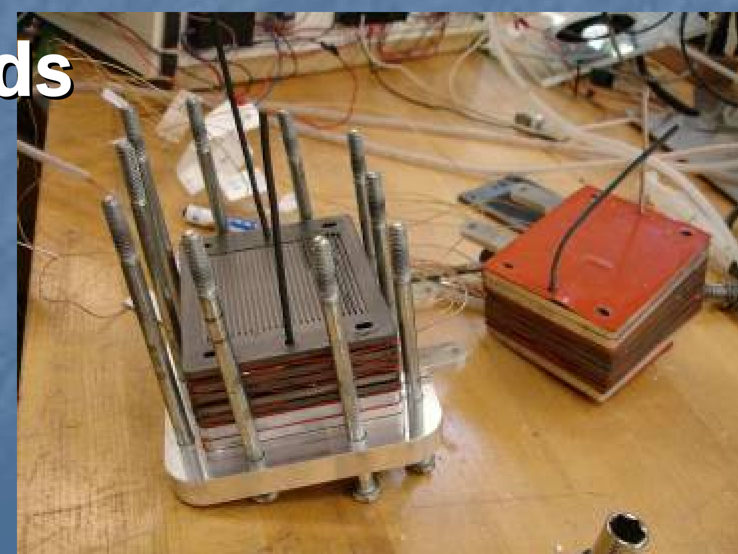
The experimental set up



Custom made enclosure

- 2 temp sensors by AMP
- 2 cooling fans
- 3 speeds

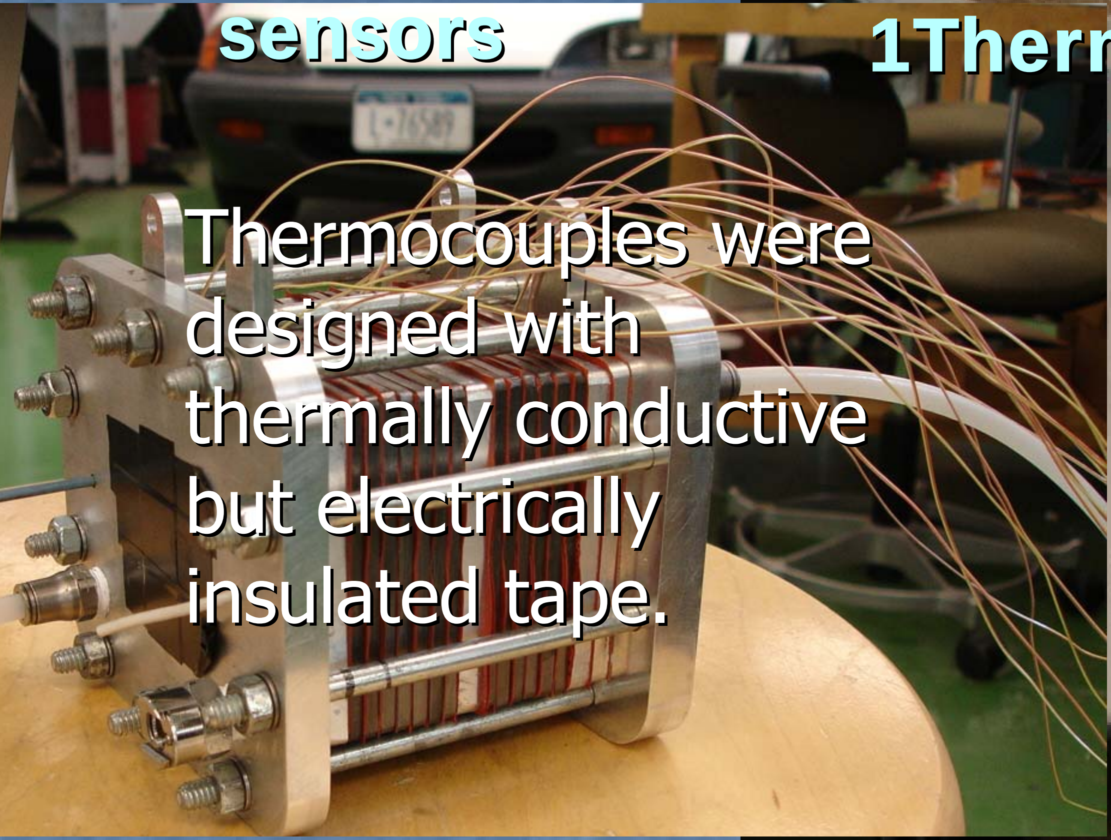




2 Electronic temperature sensors

15 thermocouples

1Thermal Imaging Camera



Thermocouples were designed with thermally conductive but electrically insulated tape.

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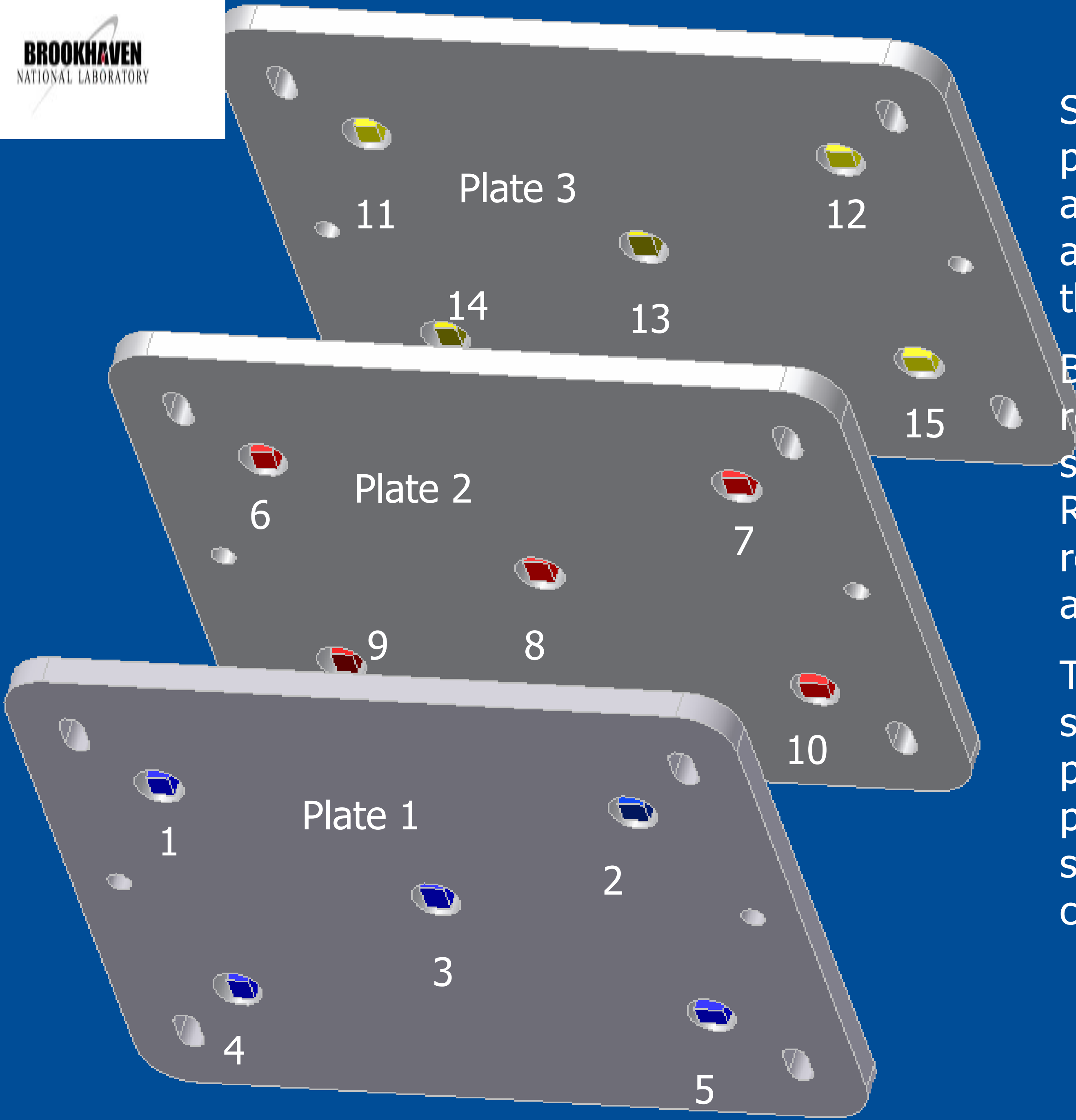
State of the Art Analysis

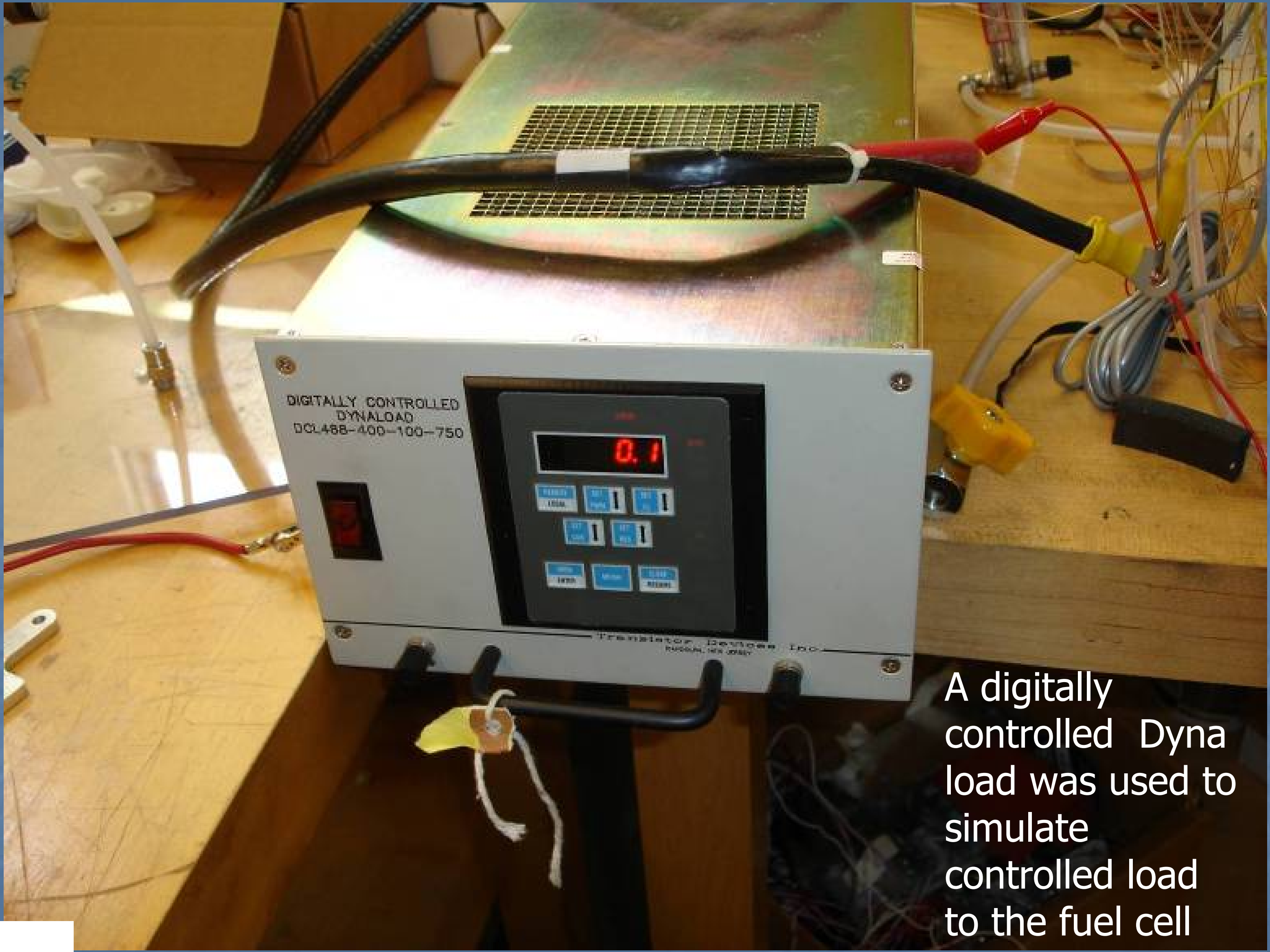
The software and equipment is supplied by PSC Inc. provides real time temperature information



Special in-house bipolar plates were designed and manufactured to allow for the insertion of thermocouples.

Blue sensors on plate 1 represent the areas showing the least heat. Red sensors on plate 2 represents the hottest areas

The yellow on plate 3 shows it is hotter than plate1 but cooler than plate 2. This is significant and consistent in all tests



A digitally controlled Dyna load was used to simulate controlled load to the fuel cell

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Results

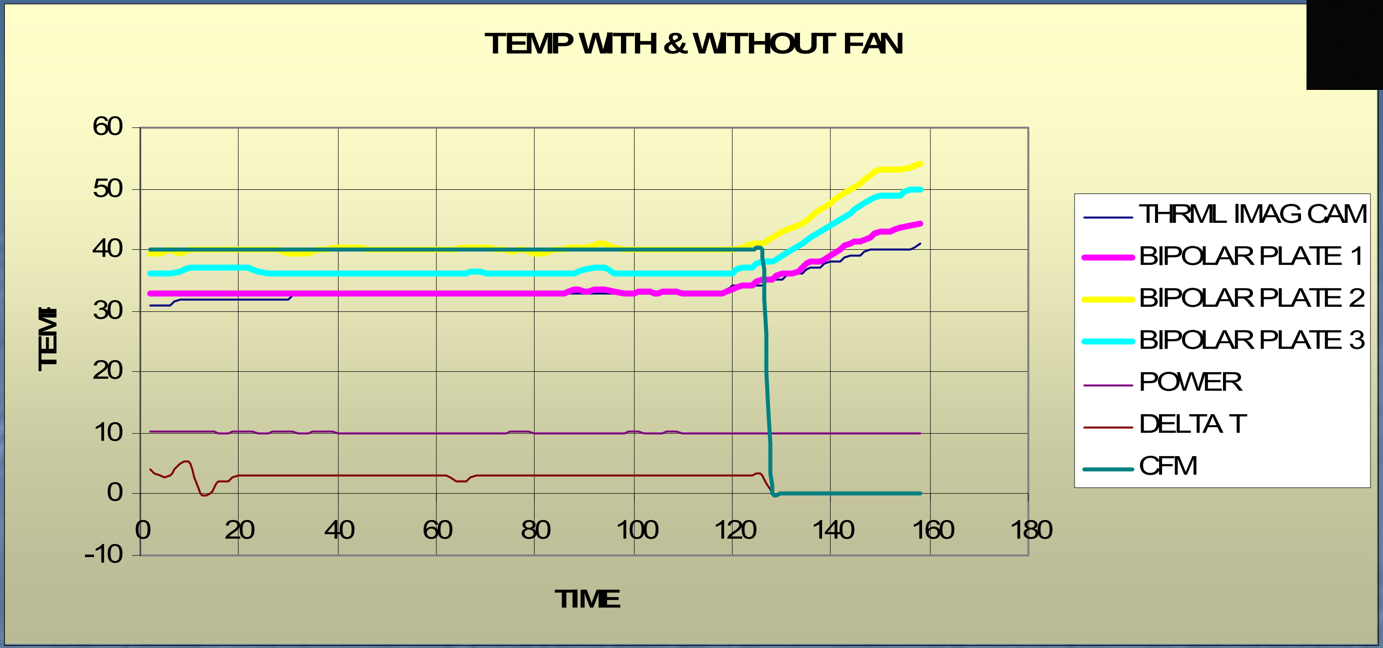
- At sea level, the density remains fairly constant and we calculate the CFM using a heat transfer equation: Cooling load =
- A mass flow rate was calculated using CFM*r (density) of air. The total active area of the fuel cell was used to find the cooling required per area

$\dot{M}$*cp(AIR) ΔT Where:

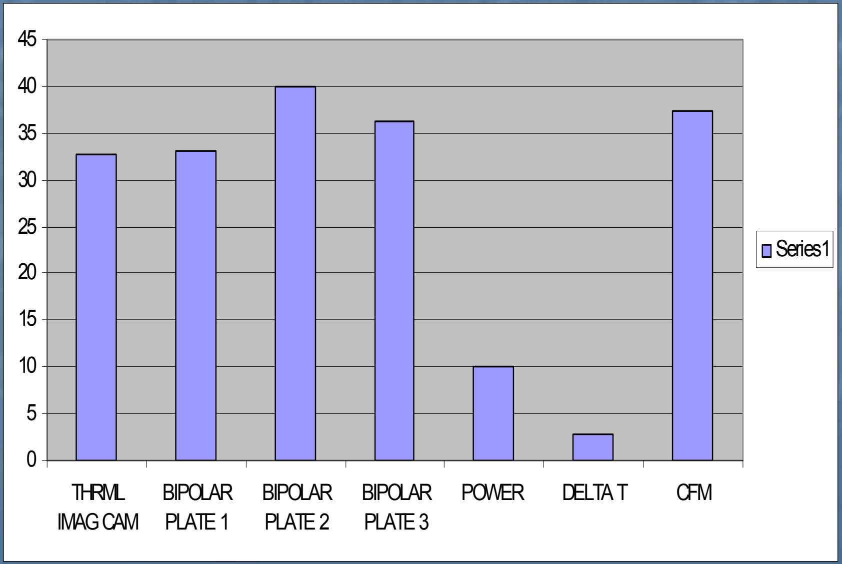
CFM = Cubic Feet per Minute
Q = Cooling load (Btu)
Cp = Specific Heat of Air
r = Density
DT = Change in Temperature

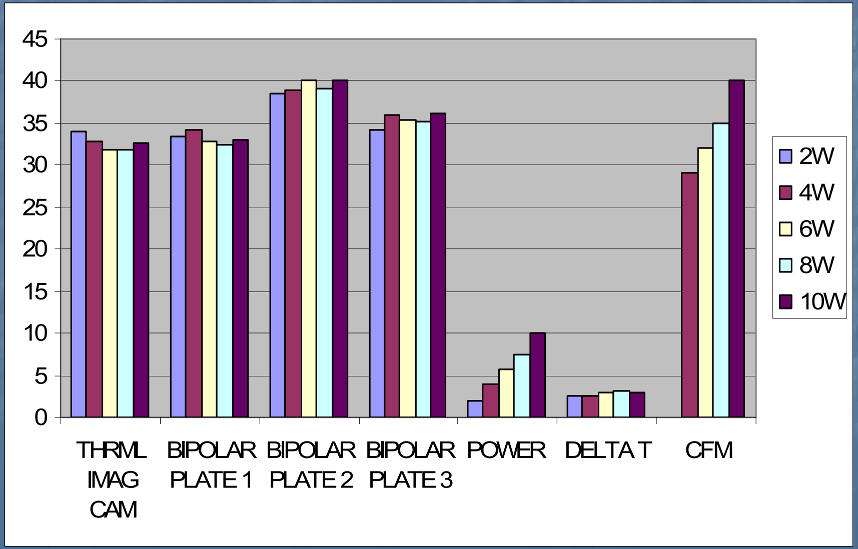
If the specific heat of air and the density are held constant (eg. sea level), the equation then becomes simplified:
Q = CFM*r *DT

	D	E	F	G	H	I	J	K
1	BIPOLAR PLATE 2	BIPOLAR PLATE 3	POWER	DELTA T	CFM	RATE OF COOLING BTU/HR	RATE OF COOLING PERSQ FT BTU/HR/SQFT	
2	38.53	34.28	2	2.5	0	0		
3	38.86	35.99	4	2.6	29	147.0368765	367.5921912	
4	40	35.46	5.64	2.9	32	180.9684634	452.4211584	
5	39.14	35.25	7.49	3.1	35	211.5848952	528.962238	
6	39.99	36.21	10.07	3	40	234.010944	585.02736	
7								

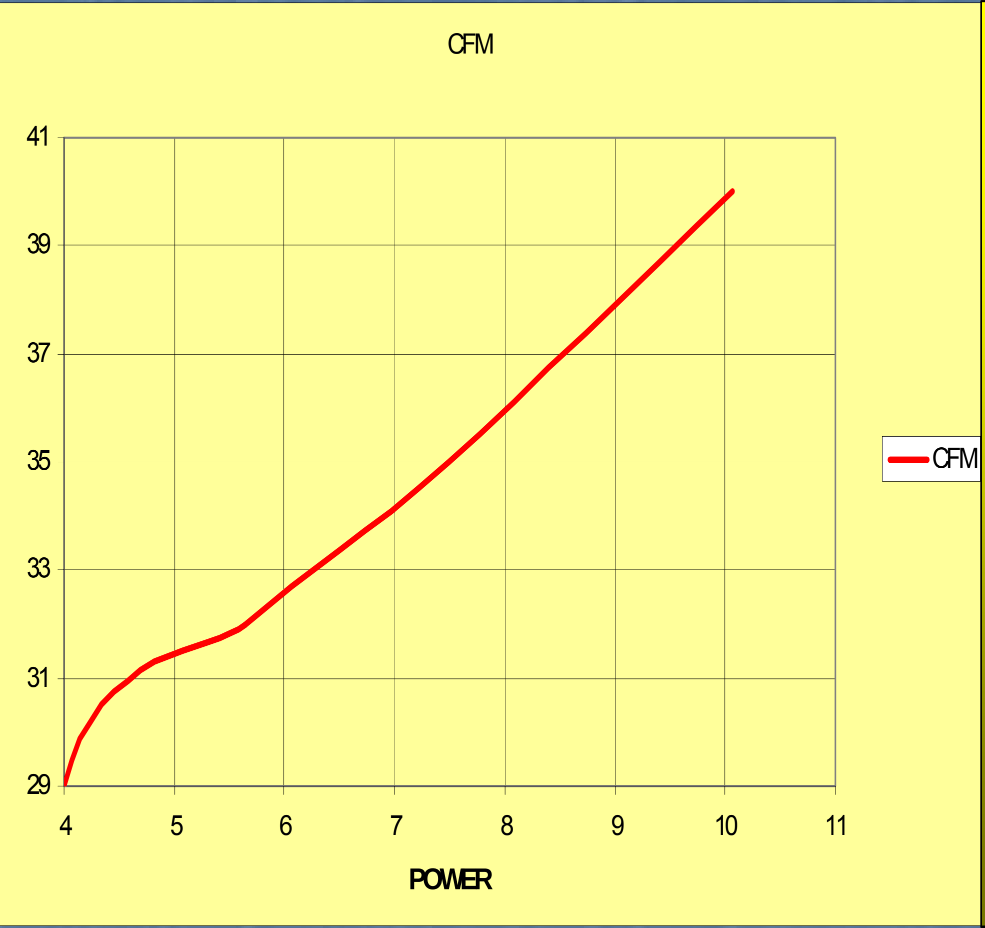


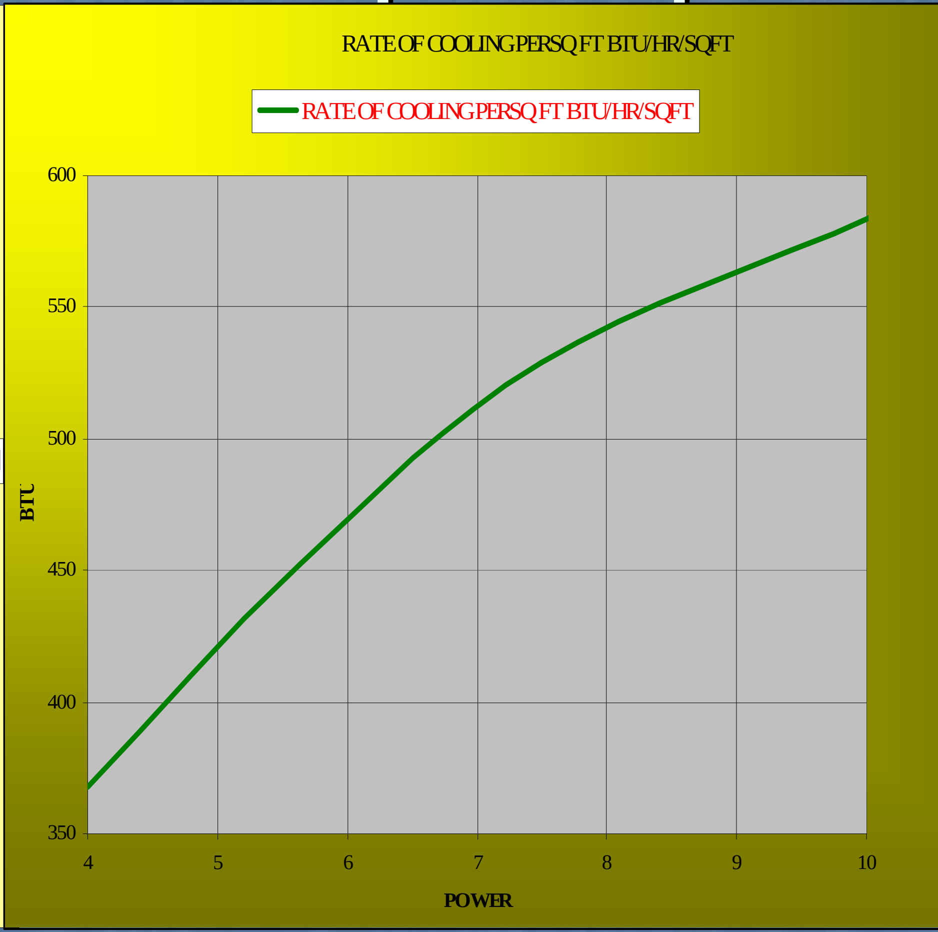
COOLING LOAD = $\dot{M}$*cp(AIR)ΔT





CFM Vs POWER & BTU per sq ft





CONCLUSION

- This research was able to monitor the internal temperature change of a hydrogen fuel cell power stack with external air cooling.
- The outside surface of the fuel cell power stack was monitored by infrared camera during external air cooling process.
- The cooling load per unit of the active area has been determined in relation to power output.
- This furnishes a viable design tool for fuel cell cooling systems.

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