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

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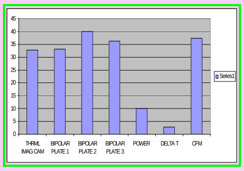
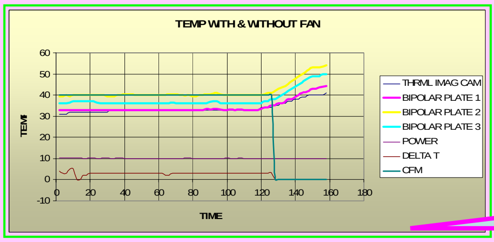
Abstract

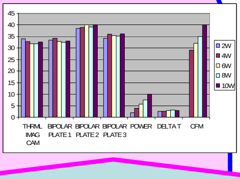
The use of fossil fuel has become a major problem that has national security implications. The emission of green house gasses and the need for clean renewable energy has led to the research into alternative energy sources. One of the major options being considered for this critical situation is a hydrogen 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.



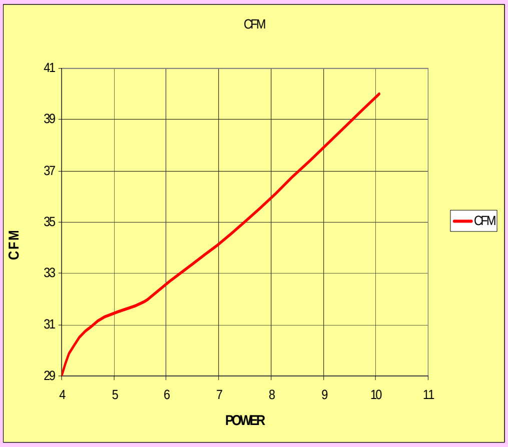
This is a graph of power versus CFM

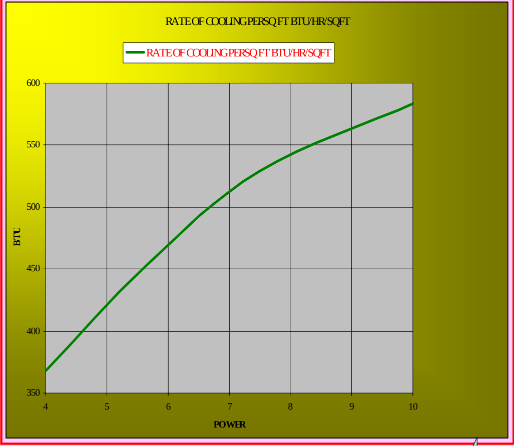


This graph shows the co relation between power produced and Btu/hr per sq ft



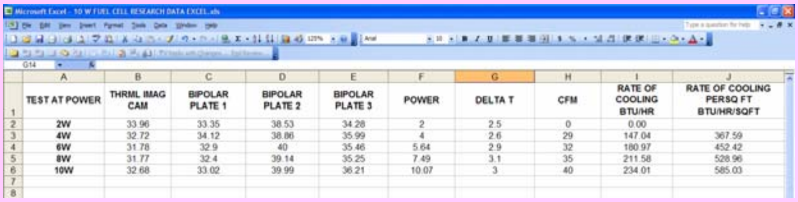
A comparison of the temperature on al three bipolar plates and the thermal imaging camera.





Graph of CFM and Power

The Fuel cell stack

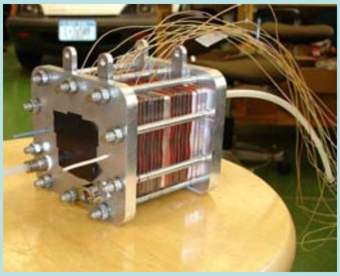


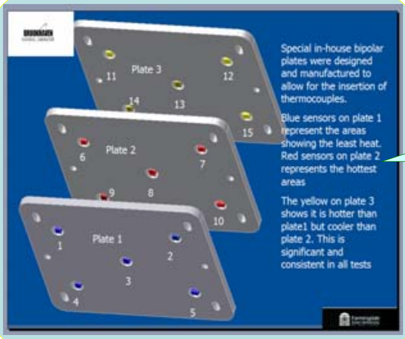
	A	B	C	D	E	F	G	H	I	J
1	TEST AT POWER	THRML IMAG CAM	BIPOLAR PLATE 1	BIPOLAR PLATE 2	BIPOLAR PLATE 3	POWER	DELTA T	CFM	RATE OF COOLING BTU/HR	RATE OF COOLING PERSQ FT BTU/HR/SQFT
2	2W	33.96	33.35	38.53	34.28	2	2.5	0	0.00	
3	4W	32.72	34.12	38.86	35.99	4	2.6	29	147.04	367.59
4	6W	31.78	32.9	40	35.46	5.64	2.9	32	180.97	452.42
5	8W	31.77	32.4	39.14	35.25	7.49	3.1	35	211.58	528.96
6	10W	32.68	33.02	39.99	36.21	10.07	3	40	234.01	585.03
7										
8										

The Excel summary chart

The heart of the analysis system is this data acquisition system on loan from Power Service Concepts. Thermocouples embedded in the specially designed bipolar plates were attached to two data cards that automatically reads and records the temperature in real time.

Display screen of data acquisition system





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

Air flow tube

Fuel cell in construction

CONCLUSIONS

The real time analysis of the temperature in the PEMFC generated information that was used to predict the required air flow necessary to maintain constant temperature. The temperature change due to change in power demand was monitored in real time, and controlled by external cooling. The temperature distribution across the entire fuel cell stack was seen as the cell reacted to power demand changes. The phenomenon that shows the middle plate (plate #2) being the hottest plate in all experimental runs was analyzed with a supporting explanation provided. The external cooling effects of the air stream provided by the fans were isolated and quantified. A graph of the cooling load versus the power produced was generated. The graph of cooling load per square feet versus power produced can supply the parameters needed to design a cooling system to cool the external surface of a fuel cell stack.

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