

Tech Brief

PEM Fuel Cell Integration With a Hydrogen Generator on a Bench

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BACKGROUND

In 1999 the New Jersey Department of Transportation successfully completed a mobile prototype fuel cell system fueled by compressed hydrogen in cylinders. A second, more advanced system, was designed in 2001 that operated as a Proton Exchange Membrane (PEM) with a Hydrogen On Demand Fuel Source. This system required the following elements to run: a fuel cell stack, fuel source, humidifier, compressor, electronic controller, cooling pump, and motor(s).

HERE'S THE PROBLEM...

Bench-testing was needed to determine the improvements of the 2nd version Proton Exchange Membrane over the original mobile prototype fuel cell system.

AND, HERE'S THE SOLUTION...

To explore the design and performance of the 2nd generation Proton Exchange Membrane.

BUT HOW CAN IT BE DONE?

Through exploring the abilities of the Proton Exchange Membrane by conducting a bench test as a fuel cell with a hydrogen generator. This will establish its overall efficiency, projected output, and consumption rates and times.

THESE ARE OBJECTIVES:

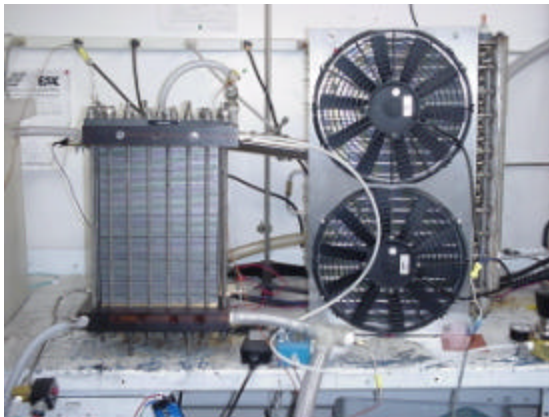
- To develop an easy to use, easy to storage, safe chemical.
- To determine the gas quality and provide information on pressure and temperature.

- To match the generator output with the fuel cell output.
- To bench test the next generation PEM fuel cell with a hydrogen generator and identify potential improvements.

HERE IS WHAT WE DID...

To begin, a Next Generation Fuel Cell was developed at H-Power, Incorporated. The fuel cell stacks were developed using graphite stacks with plastic end caps, making them have a lowered fuel cell weight by nearly half of the previous fuel cell system. The graphite will not corrode or react to de-iodized water. Unfortunately, the graphite is more brittle and more expensive, though it is more viable in strength and thickness than its steel counterparts. The end caps of the fuel cell were designed this time around in plastic so they would be lighter, less expensive, and easier to machine than the steel used in the first fuel cell.

The upgrades resulted in approximately 50 pounds weight savings of the second generation fuel cell. The resulting upgrades produced a fuel cell stack measuring 10" x 12" x 24" and weighing only 75 pounds.

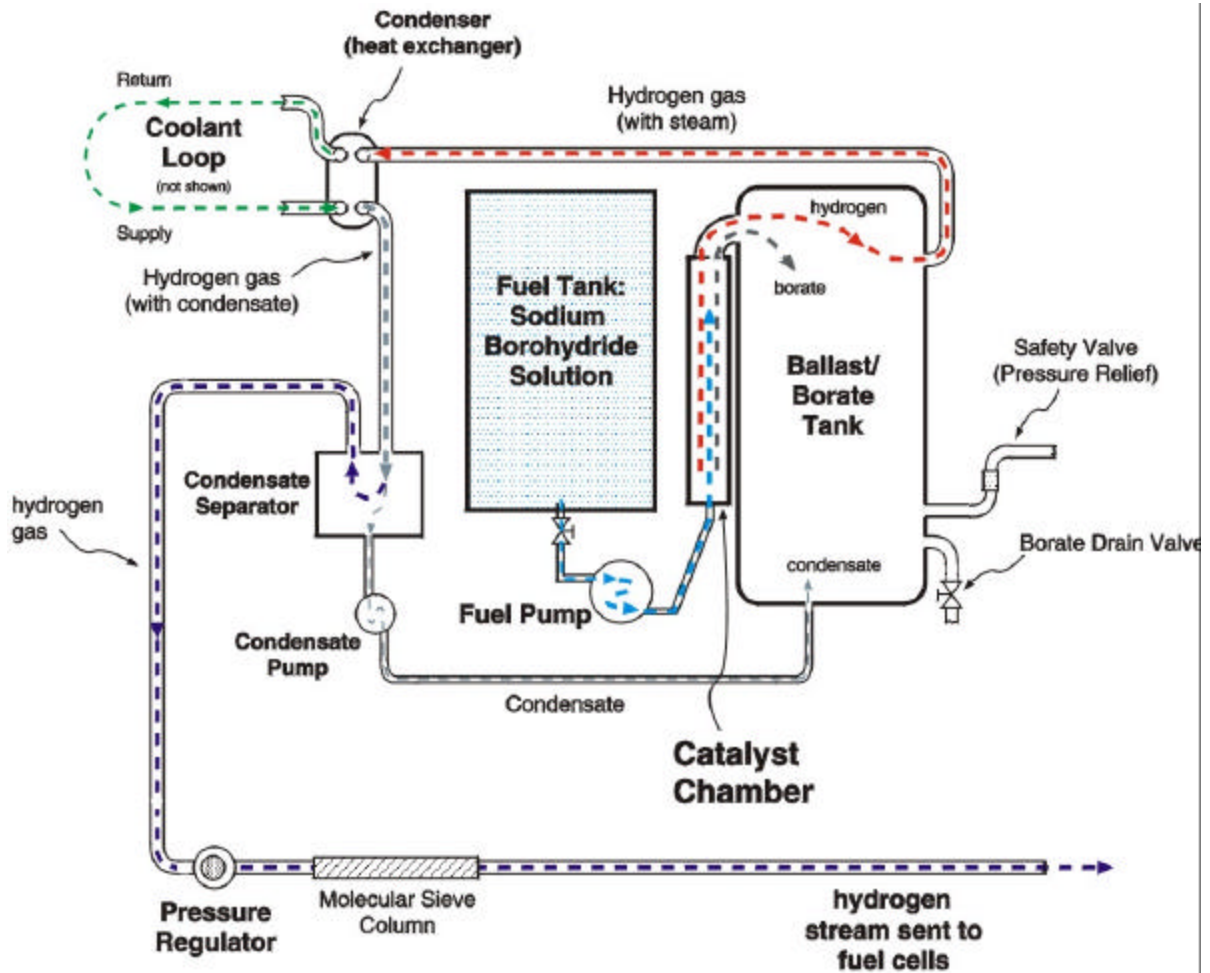


The new fuel cell was engineered to have an overall electrical efficiency surpassing that of the old fuel cell.

The next step was to establish the air flow and thermal management of the fuel cell stacks. The byproducts of the PEM fuel cell were water, electricity, and heat. The heat posed a potential problem; the operational temperature is approximately 60 degrees Celsius. During the bench testing, the temperature had to be regulated by using a blower to cool the fuel cell. An improvement was made during this second round-one blower was able to be used to cool two fuel cell stacks, while the old system required one blower per stack.

Ball valves were used to modulate both the airflow rate and the pressure. The air pressure was found to be able to be varied depending on the pressure.

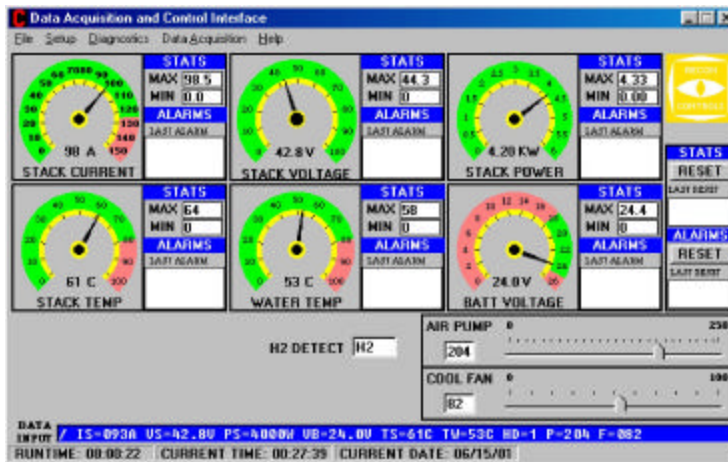
Lower power consumption resulted from the use of larger pipes; however, this experiment used a $\frac{3}{4}$ " instead of the suggested $1 \frac{1}{2}$ ". The air for each fuel cell was humidified by a shell in the tube membrane humidifier.



An advanced fuel cell and hydrogen generator were developed. This meant that the cell will be provided with energy output through a continuous supply of fuel input the Hydrogen-On-Demand System. This system used sodium borohydride as a storage medium for the hydrogen, resulting in a system that could potentially be capable of use in the heating, power generation, mobile communications, and other stationary applications.

The Hydrogen On Demand System was created at Millennium Cell, Incorporated as a result of the need for a catalyst enhanced storage process. A sodium borohydride system was proposed for the storage, transportation, and generation of the hydrogen gas. The resulting system uses a generator requiring a 20 percent by weight solution of sodium borohydride stabilized by 1 percent by weight sodium hydroxide.

The fuel cell control and data acquisition system was designed and manufactured by Recon Industrial Controls Corporation for testing a high power fuel cell stack. The fuel cell tested consisted of cells connected electrically in a series. A humidified air stream and dry hydrogen were used. Temperature management was best achieved through water cooling.



The Recon test system consisted of a Recon single stack controller and a Recon Data Acquisition Module. The Recon Controller Interface Software used provided a graphical operator interface to monitor fuel cell stack operating variables and to set up operating parameters to optimize performance. In addition, it provided manual control of system devices for diagnostic purposes. A continuous logging

of date/time stamped data was later able to be downloaded with Recon's Controller Interface Software.

Estimated ability calculations are possible through estimating the overall efficiencies of other systems and substituting them for actual value. This practice was used until the initial bench tests were performed. The efficiency was measured in the lab using several system characteristics.

AND, HERE IS WHAT WE FOUND...

The two fuel cells used in this research were larger than those from the previous generation. However, several subsystems were able to be combined to reduce redundancy, rather than have true parallel system components such as air blowers, controllers, humidifiers, and heat exchangers. A new, custom built, fully automated controller is able to monitor all of the fuel cell functions, as well as optimizing flow rates and purge cycles. This has increased the overall efficiency of the system. The control board exists as a critical component responsible for varying the speed of the air compressor and continuously performing safety checks on the voltage and temperature of the fuel stacks.

Light weight materials could be used to reduce the weight of the fuel cell stacks and to reduce their size. The original design of the fuel cells used many stainless steel components. The fuel cell stainless steel rods and end plates were replaced with titanium rods and plastic end plates. The stainless steel plates used inside the previous generation fuel cell were 50 pounds heavier in net weight. The result of the upgrades is that each fuel cell stack now has dimensions of 10" x 12" x 24" and weighs only 75 pounds.

The solution of sodium borohydride in water is capable of achieving hydrogen production rates of 120 to 150 L/min at about 100 psi. The products of power production will be pure water, hydrogen gas, and sodium borate.

WHAT IS THE NEXT STEP?

It is also possible to recycle the spent fuel sodium borate back into sodium borohydride, but this process was beyond the scope of the project. Future research may indicate that there is an inexpensive process to regenerate sodium borohydride from sodium borate. This would be significant in establishing this fuel as a renewable resource.

Potential refinements of the system include possibly lowering the weight of the entire system further of applying the system to a technology that would reasonably benefit from its use.

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