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Development of a 400 W High Temperature PEM Fuel Cell Power Pack : Fuel Cell Stack Test

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Motivation

The use of a liquid reformed hydro-carbon as fuel for fuel cells can reduce fuel storage volume considerably. The PBI membrane technology used in high temperature PEM (HTPEM) fuel cells has great advantages when using reformate fuel gas compared to low temperature PEM fuel cells (LTPEM).

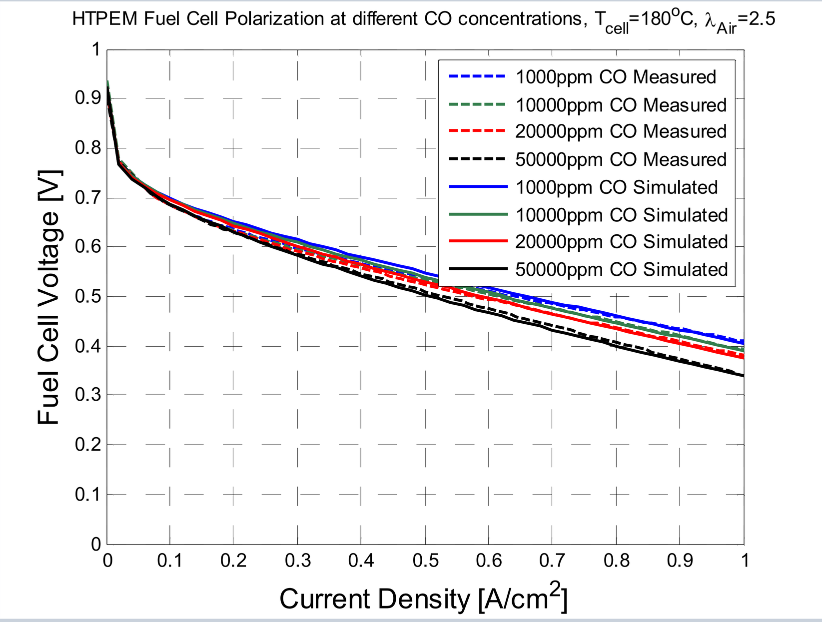

Figure 1: Simulation and measurements of a single HTPEM fuel cell at different CO concentration levels.

The PBI membrane technology also simplifies the PEM fuel cell system de-sign greatly, which makes it an ideal choice where reliable systems are needed. A low air pressure loss stack has been designed using cathode air cooling.

Figure 2: 30 cell HTPEM prototype stack designed at the Institute of Energy Technology, at Aalborg University.

When using HTPEM fuel cells, no membrane hydration problems occur, and the CO tolerance is high. This makes these types of fuel cells preferable for reliable, robust fuel cell systems running on reformate gas.

Fuel Cell Stack Test

A simple system has been designed consisting of a prototype 30 cell HTPEM fuel cell stack, a pressure reduction valve and an axial blower. The stack is for initial tests supplied with pure hydrogen and is designed for cathode air cooling, which simplifies the system significantly.

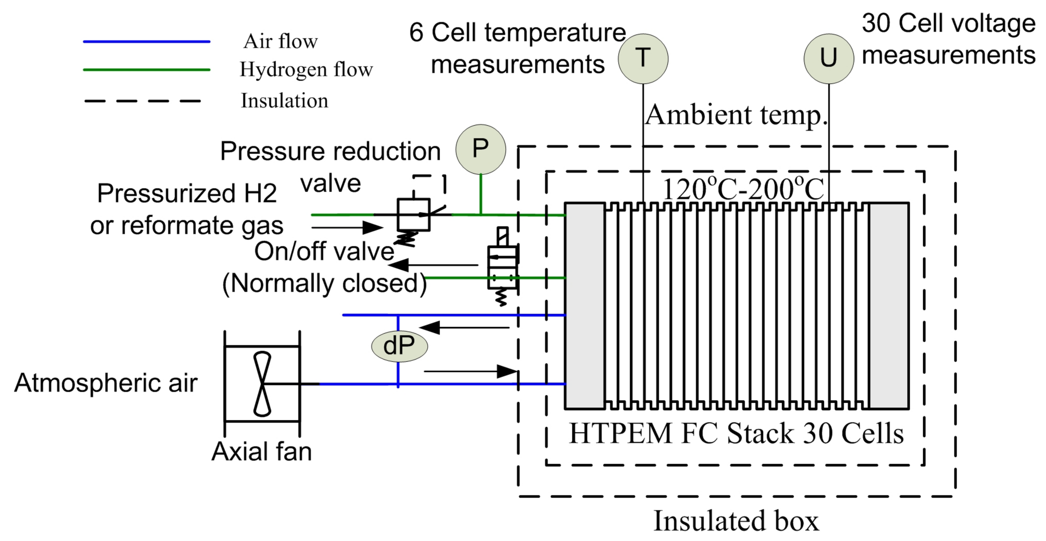

Figure 3: System diagram of a simple HTPEM fuel cell system for testing a 30 cell prototype stack.

"Simple and reliable HTPEM fuel cell system with cathode air cooling"

The experiences obtained operating the system are, that the cathode air cooling efficiently cools the stack, but the temperature profile of the stack changes with the airflow. Situations can occur at the inlet of the stack, where temperatures are quite low at high airflows. This results in a fuel cell voltage drop, and hereby a power loss because of the lower temperature.

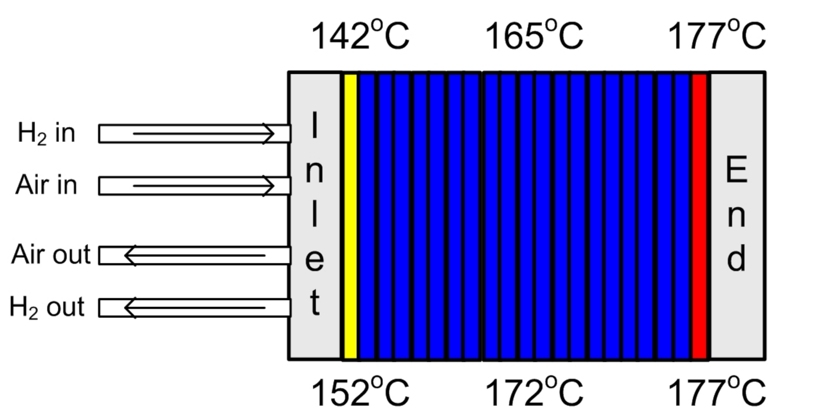

Figure 4: Stack temperatures at low load, 0.2 A/cm². The front of the stack is severely cooled by the incoming air.

"Temperature differences introduce problems for cathode air cooled stacks"

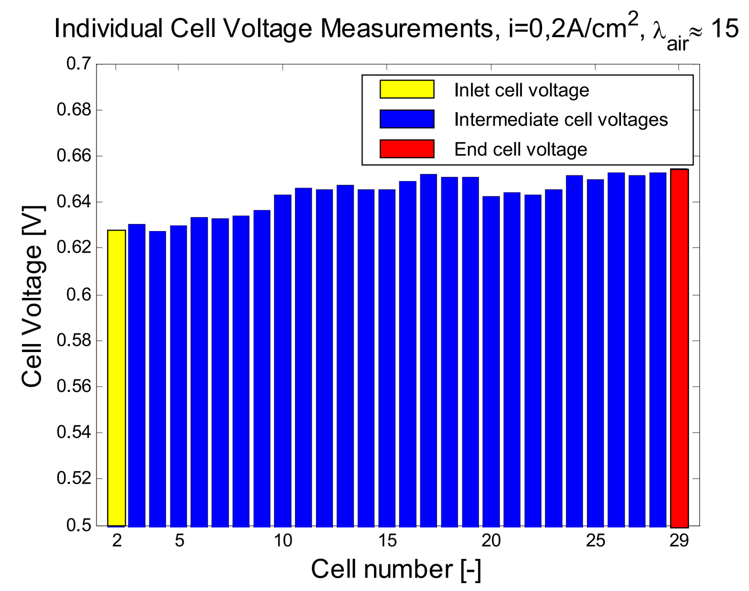

Figure 5: Stack voltage differences measured in each cell. The differences is primarily due to the temperature differences.

The design of the gas channels in the bipolar plates offer a very low pressure loss, which makes it possible to use small low power consuming blowers for cathode air supply and cooling.

"Low pressure loss through stack makes it possible to use small blowers for air supply"

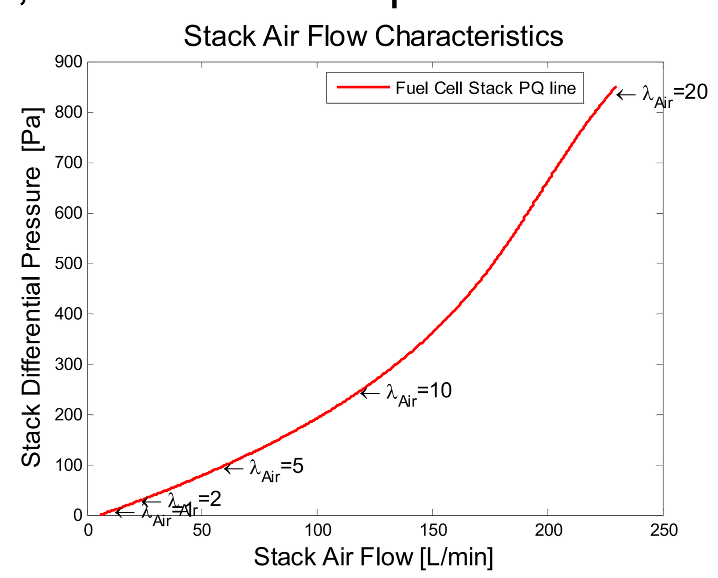

Figure 7: Stack pressure-flow characteristics, with stoichiometries at a constant load of 0.5 A/cm^2.

The general experience of running the HTPEM fuel cell system was positive. he primary drawback being the temperature gradient in the stack and a long start-up time because the system operates at 120°C-200°C to avoid liquid water. The first of these problems has been dealt with in the 2nd generation HTPEM fuel cell stack design.

Conclusions

The construction of the HTPEM fuel cell system illustrated in figure 3, has resulted in a very simple and reliable HTPEM fuel cell system.

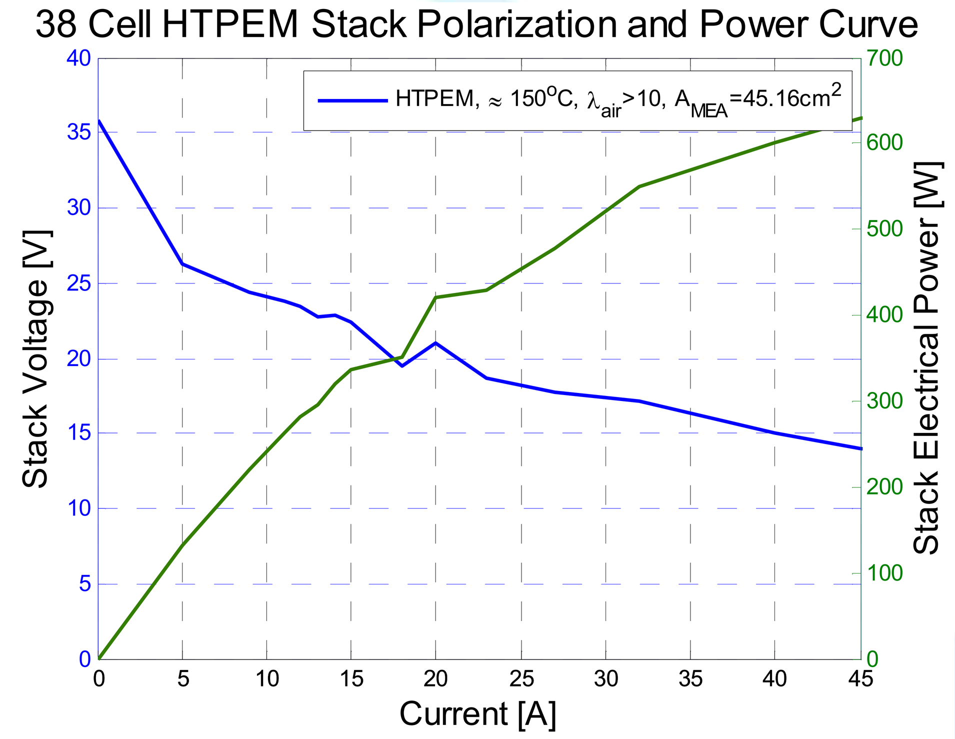

Figure 8: Polarization curve of 38 cell HTPEM fuel cell stack at approximately 150°C.

The following conclusions were made while experimenting with the stack, and loading it in different ways:

- Very stable operation, stable fuel cell voltages, slowly changing temperatures.
- Fast fuel cell dynamics, the fuel cells can quickly respond to load steps.
- Long start-up time.

Figure 9: Picture of fuel cell stack in insulated box with axial blower mounted on the outside.

The conclusions and experiences made during these experi-ments, have given much knowledge for improvement of the cathode air cooled HTPEM fuel cell stack design, and demon-strates the potential of using HTPEM fuel cells to make simple, and reliable fuel cell systems. Furthermore, the experi-mental results have given inputs to the further development and test of different controllers and control strategies.