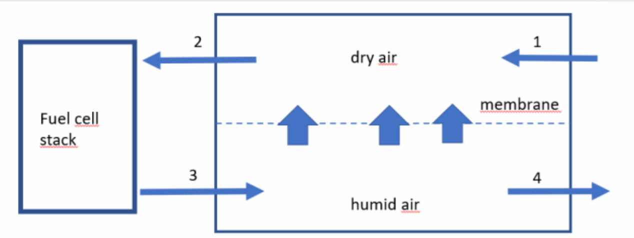
Modelling of an Air Humidifier at the Cathode Inlet

A model for an air humidifier was developed to get an understanding and to determine the important characteristics of that product. Based on this model simulations were performed. Additionally, experiments were done to determine characteristics of different available membranes. From the results a concept for the humidifier will be further developed in a prototype.

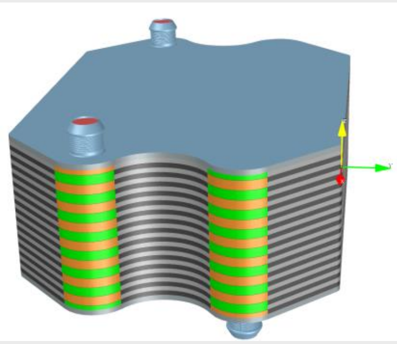
THE CONTEXT

The Fuel Cell Electric Vehicle (FCEV) uses electricity to generate enough power to drive a vehicle. On the cathode side of the fuel cell, the membrane might dry out depending on the water content of the air supplied to the system. Thus, placing a humidifier before the cathode inlet provides water vapour to the air and protects the fuel cell membrane. Different types of humidifiers (flat or hollow fibre membranes) are used in automotive applications. However, little is known about the implementation of humidifiers in vehicles.

Thus, A. Kayser Automotive Systems reached out the Innomem OITB, to build up a model for the humidifier to get a better understanding of the parameters like the air flow configuration, surface size area of the membrane, pressures, and temperatures.



Scheme of an air humidifier for the PEM fuel cell.



Develop 3D model of a concept for the humidifier.

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THE CHALLENGE

To get an optimised concept for the air humidifier it is necessary to clarify the following points:

- Optimal direction of air flow (counter or cross flow)
- Influence of parameters like temperature, flow rate pressure
- Needed surface area of the membrane

University of Twente created a model in 1 & 3D of the humidifier and EMI Twente did experimental investigations with commercially available membranes to find answers to those questions.

Experimental set up for characterisation of the membrane (left) and tested membrane (right).

THE RESULTS

The simulations carried out by the University of Twente with the 1D model showed clearly that a counter flow of the air streams is more efficient than other considered flow concepts.

Furthermore, the necessary surface membrane area was determined using the 1D model which was later specified using a more sophisticated 3D model. With the later model the efficiency of different concepts of the humidifier could be compared.

The experiments done by EMI Twente could determine the water transfer rate of the different membranes.

CONCLUSION

The project was successful in increasing the knowledge about important parameters like water transfer rate, membrane surface area, temperature & pressure to construct an air humidifier for the PEM fuel cell.

From the gained data in the project A. Kayser Automotive Systems was able to decide which concept should be further developed. Thus, of the tested membrane the one with the best performance characteristic was chosen to be used further.

By using knowledge obtained from simulations and experiments done by the Innomem partners, University of Twente and EMI Twente, it was possible to determine the main characteristics for the humidifier and the concept to be further considered for the prototype manufacturing.

TECHNIQUES USED

The University of Twente and the EMI Twente used an experimental setup and simulation tools to better design the air humidification system at the cathode inlet. In the experimental system, the water vapour permeability through a specific membrane was analysed, which further is essential for the simulations performed.

Two approaches were used for the simulation, basic and finer models. In the basic model, mass balances around the humidifier and wet/dry side were analysed and the approximate membrane surface area was determined. In the more detailed simulation (finer model), the concepts given by Kayser were specifically analysed by solving the Navier-Stokes and convection-diffusion equations in 3D.

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