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Heat Pipe Assisted Thermal Management of a HT PEMFC Stack

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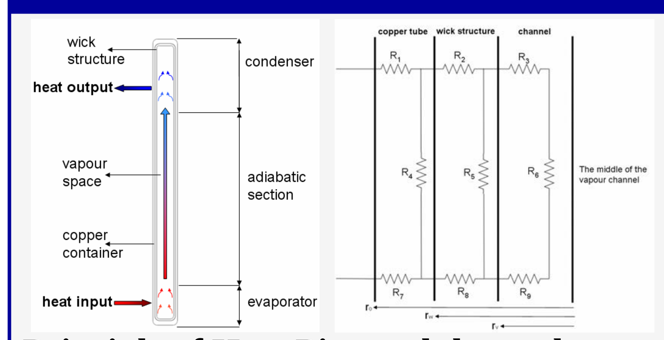
Introduction

The thermal management of HT-PEM fuel cells plays an important role in getting higher performance and stable operating conditions.

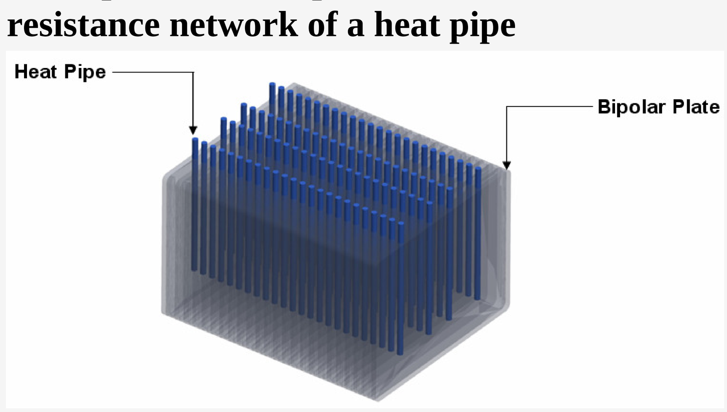
Heat pipes are known to be thermal superconductors operating on the principles of high convective heat transfer and phase transition and can transfer large amounts of heat at high speeds in both heating and cooling applications with a higher thermal conductivity.

Current work investigates the use of heat pipes in a HT PEMFC stack consisting of 24 cells, each with an active area of 300 cm².

Model Set-Up



Principle of Heat Pipe and thermal resistance network of a heat pipe



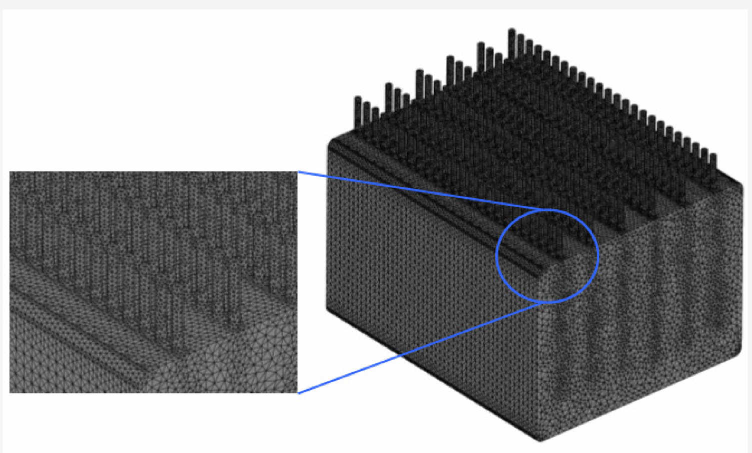
Simplified model of a HT-PEM fuel cell stack assembled with heat pipes

The efficient heat removal with small temperature gradients is performed by the heat transfer from the evaporator to condenser section. The easy structure and cost-effective manufacturing are significant advantages of heat pipes. The equivalent model of a heat pipe is obtained using the thermal resistance network and implemented in the model.

Use of COMSOL Multiphysics®

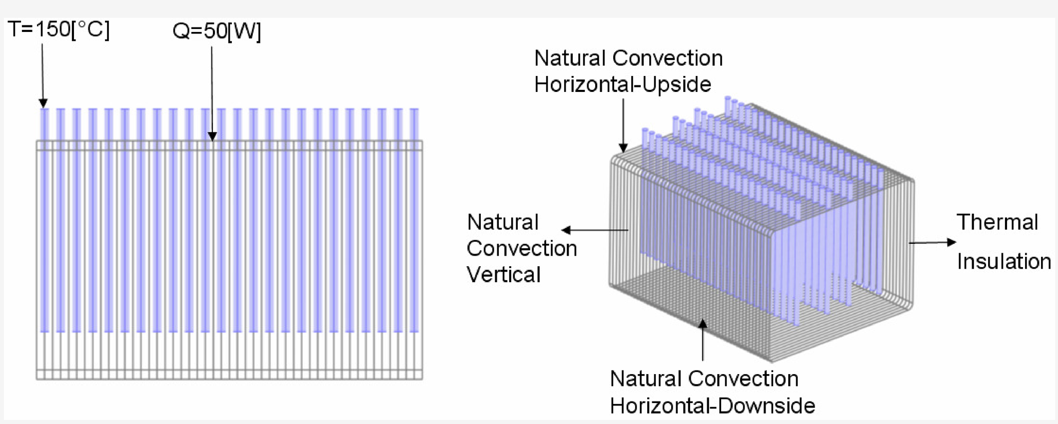
Transporting and meshing the model geometry

The model geometry is imported in SAT format with the help of CAD import module of COMSOL Multiphysics®.



Mesh model of the geometry

The model consists of 116,958 degrees of freedom.



Boundary conditions

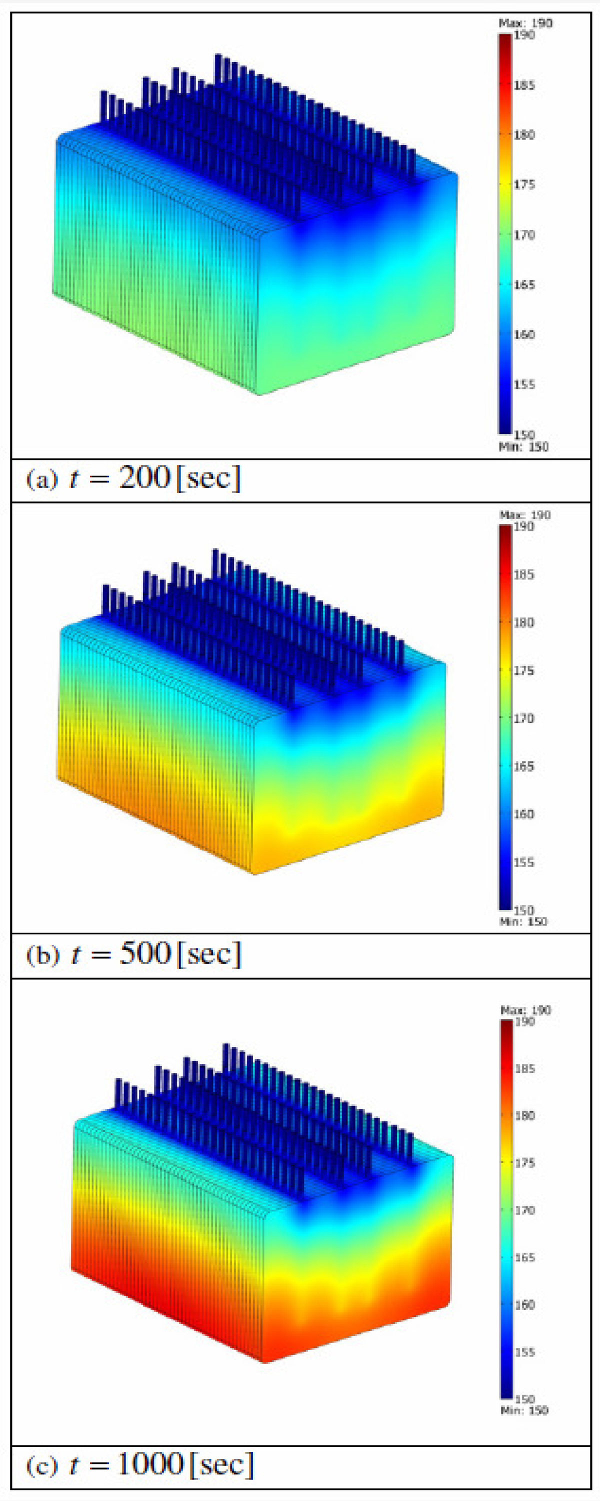
The natural heat convection on the sides of the fuel cell stack is defined using convection functions of COMSOL reference library. The initial temperature is selected as 160[°C].

Solver Settings

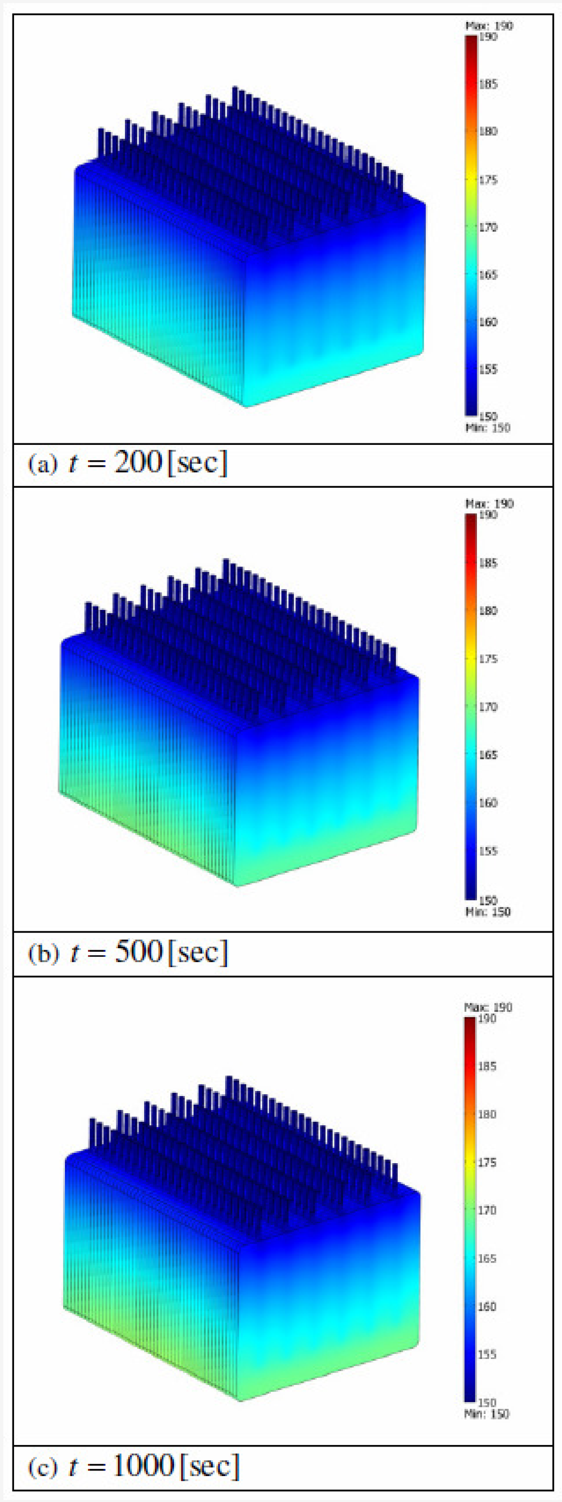
Direct solver (SPOOLES) is chosen for transient analysis.

Results

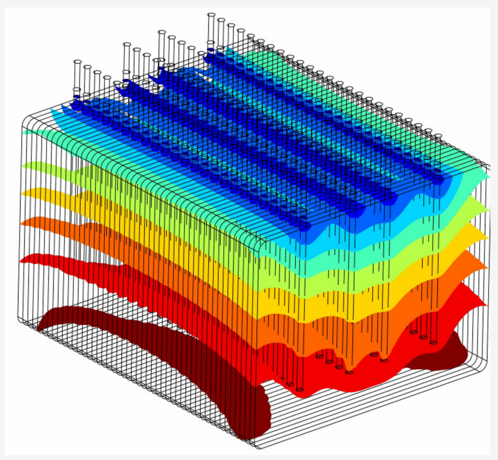
Two types of heat pipe assembly concepts are studied. Four heat pipes for each fuel cell are used in the first one. The second concept has six heat pipes assembled for each fuel cell.



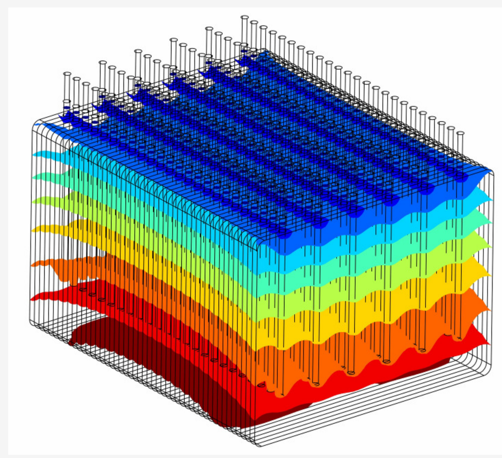
Thermal distribution [°C] of the first concept with 4 heat pipes for each fuel cell at the time (t= 200, 500, 1000[sec])



Thermal distribution [°C] of the second concept with 6 heat pipes for each fuel cell at the time (t= 200, 500, 1000[sec])



Isothermal surfaces for the first concept at time (t=1000[sec])



Isothermal surfaces for the second concept at time (t=1000[sec])

The temperature peaks occurring in the middle of the fuel cell stack can be seen in Figure 6 and Figure 7.

The second concept with 6 heat pipes for each cell shows better thermal distribution and lower temperature profile. The first concept can lead to exceeding the allowable temperature interval during the stack operation.

Use of COMSOL Multiphysics®

- 3D model geometry was used in COMSOL Multiphysics® v3.5a.
- Transient heat transfer module is used.
- The equivalent model for a single heat pipe is implemented.
- Simulations for two concepts are performed to analyze the heat pipe application in HT-PEM fuel cell stacks.

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