# Climate Chamber with Fast Humidity and Temperature Response for Small-Angle Neutron Scattering

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## Abstract

We have developed a small environmental chamber (see also Figure 1 and 2) to expose a sample to adjustable climate conditions. This climate chamber will be used as sample environment for small-angle neutron scattering (SANS) experiments. SANS is a favorable measuring method, to explore structural changes on the length scale between 1 and 500 nanometer during water intake or dissipation, for example in fuel cell membranes. The climate condition is determined by temperature, pressure und humidity.
In contrast to conventional humidity chambers, our device is geared to dynamic climate changes. This is necessary to inspect structural transformations in the sample with good time resolution. We used COMSOL Multiphysics® for many tasks. First of all, we calculated the stationary temperature distribution (see also Figure 3) in the sample chamber, to verify our design decisions.
The next task was, to equalize heating up and cooling down processes, to improve a dynamic temperature control. In this respect, COMSOL Multiphysics was used to optimize the temperature response by means of chamber geometry adjustments. As the climate chamber is a double-walled vessel with insulating vacuum, we also computed the mechanical stress and displacements (see also Figure 4).
With COMSOL Multiphysics we investigated the fluid flow around the sample and the humidity sensor, and especially the pressure distribution. Finally, we are simulating the humidity distribution in the gas stream inside the chamber, to prove that there is no water condensation in any used climate condition. To date, the humidity chamber is in the commissioning phase.
We have experienced almost equal temperature response while heating up and cooling down processes, and a good agreement between calculated and measured results. A further improvement in thermodynamic behavior could be achieved by better thermal contacts. Our environmental chamber is almost ready to study and improve new materials, for example membranes for fuel cells, recently developed at PSI: How do they change their structure in humid environment?

## Figures used in the abstract

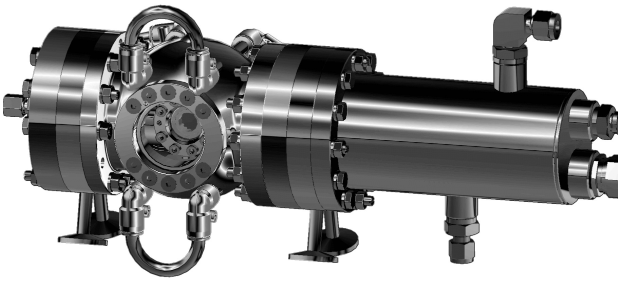

Figure 1: 3D design model (CATIA®).

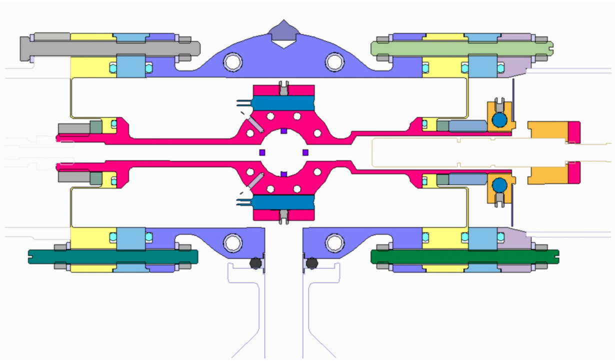

Figure 2: Cut from 3D CATIA® model.

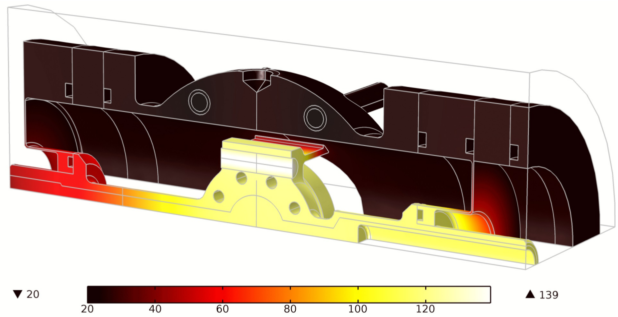


Figure 3: Stationary temperature [°C], here without fluid flow.

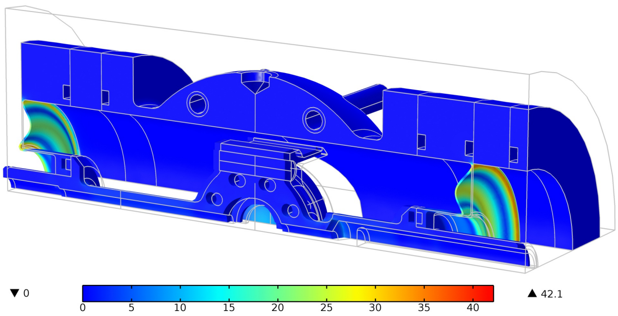


Figure 4: V. Mises stress [MPa] under insulating vacuum and process pressure (deformation scaling factor = 300).