# MODELING SUPPORT FOR SOLID OXIDE FUEL CELL-COMPONENT DEVELOPMENT

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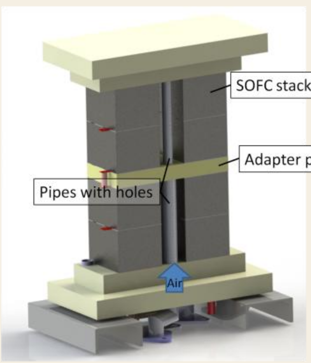
## MOTIVATION

The modeling group at Fraunhofer IKTS is dealing with different aspects of SOFC stack and component simulation. To demonstrate our modeling strategies (partially based on homogenisation methods), two examples for both SOFC stacks and components are given.

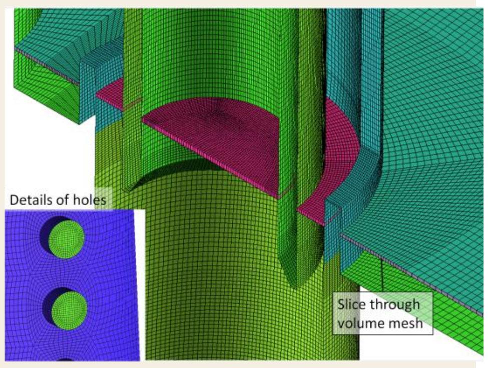
- A detailed Hotbox model is presented
- A catalytic afterburner- and reformer model will be introduced
- A 3D thermo-fluid Hotbox model will be presented

## HOTBOX MODEL

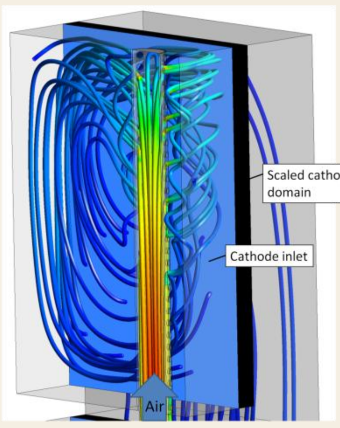
- Three-dimensional CFD model (ANSYS FLUENT) of hotbox, comprising eight SOFC stacks, air/fuel supply and collection
- Hexahedral, block-structured mesh performed in ANSYS ICEM-CFD 12, in total 16 Mio. control volumes
- k-Epsilon-type turbulence model used
- Analysis of fuel and air distribution, stack treated as hydraulic resistance (porous medium)
- Pressure drop across cathode domain (trapezoidal channels) dominates, leading to an equal mass flow distribution at the cathode inlet



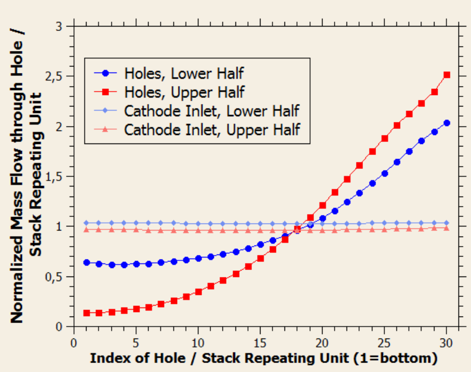

Geometry of hotbox with 8 SOFC stacks.




Detail of mesh (16 Mio. control volumes).



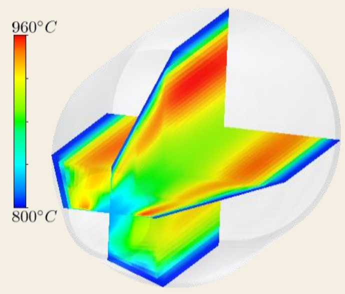

Streamlines (coloured by flow velocity) in the upper half of the hotbox.



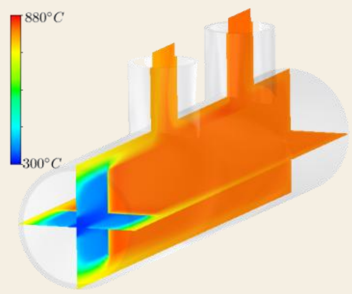

Mass flow distribution per hole / stack repeating unit.

## AFTERBURNER AND REFORMER MODEL

- 3D afterburner model with gas-phase and catalytic oxidation of hydrogen and carbon-monoxide within ANSYS FLUENT
- Afterburner model shows hotspots due to insufficient fuel/air mixture quality
- 3D reformer model with catalytic oxidation, reforming and shift reactions within ANSYS FLUENT
- k-Epsilon-type turbulence model outside and Darcy flow within the porous (homogenized) honeycomb



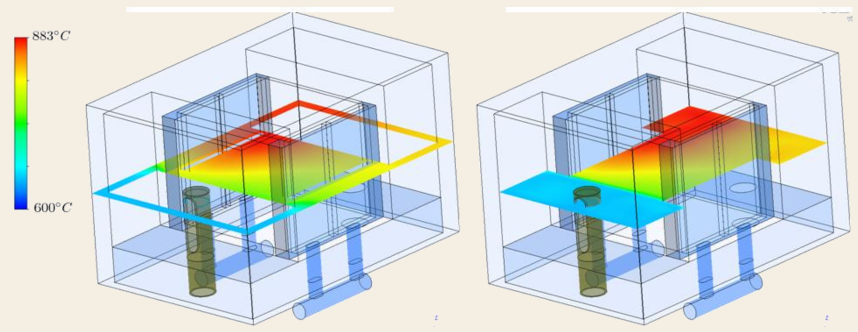

Afterburner temperature distribution.




Reformer temperature distribution.

## THERMO-FLUID HOTBOX MODEL

- 3D thermo-fluid model for an 30 repeating unit cells stack within FLUENT
- Fixed heat power distribution across active stack area
- 3 overlapping meshes in active stack region (distinction between fuel, air and solid temperature)




Hotbox temperature distribution (left solid parts and right air).

## CONCLUSION AND OUTLOOK

At the Fraunhofer IKTS modeling group, different SOFC stack and component models for several system designs have been developed. Because of the wide variety of length scales, ranging from decimeters for the hotbox up to micrometers of fuel cell electrolyte height, a detailed numerical modeling is computationally expensive. Therefore, a homogenization approach (e.g. for the active domain of a stack, catalytic honeycomb) is used, coupled with detailed models for the surrounding.