Institute for Applied Materials
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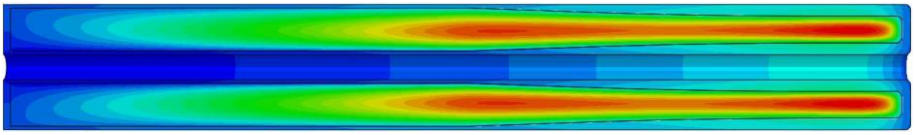
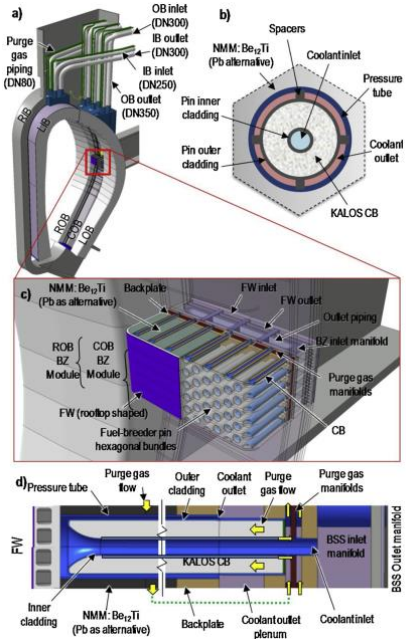
Institute for Applied Materials

Master thesis: Thermomechanical Finite-Element-Analysis of Ceramic Breeder Blanket Design for Fusion Reactors

Motivation and Objective:

The European fusion reactor DEMO (https://www.euro-fusion.org/programme/demo/) is based on the fusion of the Hydrogen isotopes Deuterium and Tritium. While Deuterium is abundantly available, Tritium needs to be “bred” by the power plant itself. At KIT, the Helium Cooled Pebble Bed (HCPB) concept is under consideration where neutrons from the fusion plasma react with Lithium based ceramics in the so-called breeding blanket to yield the needed Tritium fuel. For the purpose of short diffusion paths and good accessibility to Helium purge gas, the Lithium ceramic is present in the form of highly packed pebble beds surrounded by stiff cooled steel housings. The deceleration of neutrons from the plasma causes volumetric heating of the ceramic particles in the pebble bed, which in turn leads to thermal expansion and stresses in the pebble bed. The thermomechanical constitutive behavior of ceramic pebble beds is quite complex and involves non-linear elasticity, volumetric plasticity, and creep.





Fus. Eng. Des, 2019

It is the objective of this master thesis, to investigate by non-linear Finite Element Analysis the thermomechanical states (temperature, strain, stress) of recent HCPB breeding blanket designs.

Work Program:

- Literature study of previous works on modeling thermomechanical constitutive behavior of ceramic breeder pebble beds and Finite Element Analysis of breeder blanket sections
- Training on the commercial Finite Element code ABAQUS with special emphasis on user defined subroutines at IAM-MMI for non-linear thermomechanical constitutive behavior of ceramic breeder pebble beds: non-linear elasticity, volumetric plasticity and creep, single element test simulations
- Training on breeder blanket component simulation by recalculation of previously developed models, study of the impact of ABAQUS settings on convergence behavior and stability of results
- Parameter studies for component design and material properties in view of their effect on thermomechanical stresses

We offer:

- A workplace at IAM-MMI (KIT-CN, Building No. 696), including a computer
- Access to commercial and in house software, as well as simulation models as developed in previous projects

Prerequisites:

- Studies in the master program of mechanical engineering, materials science, physics, technomathematics
- Knowledge in continuum mechanics, constitutive modeling, Finite Element Method

Contact in case of interest in the topic:

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