Institute for Applied Materials
Mechanics of Materials and Interfaces (IAM-MMI)
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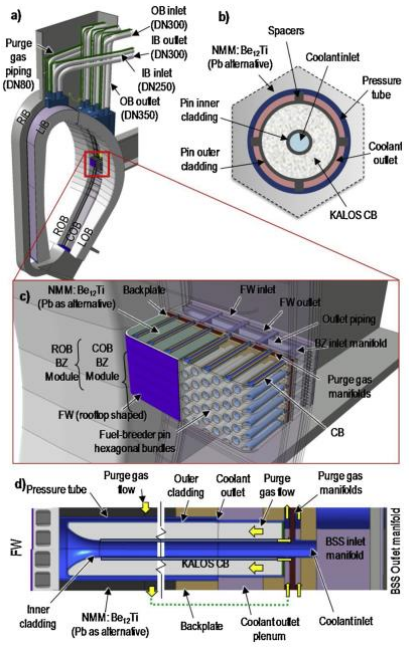
https://www.iam.kit.edu/mmi/

Institute for Applied Materials

Master thesis: Thermomechanical Finite-Element-Analysis of Beryllide Neutron Multipliers for Fusion Reactors

Motivation:

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) breeding blanket concept is under development where neutrons from the fusion plasma react with Lithium-based ceramics to yield the needed Tritium fuel. To ensure a breeding ratio above 1 for sustainable operation, the number of neutrons for the breeding reaction needs to be multiplied by reaction of neutrons with neutron multiplier materials. For the future DEMO fusion power plant, blocks of titanium beryllide ($TiBe_{12}$) are under consideration. The deceleration of neutrons from the plasma causes volumetric heating of the beryllide blocks, which leads to thermal expansion and stresses. In long-term thermal cycling experiments, simulating the operation of beryllides in DEMO, one of the blocks has cracked after about 300 cycles..



Fus. Eng. Des, 2019

Research objectives:

The objectives of this master thesis are twofold:
1.) To understand the cracking observed during thermal cycling experiments with fast inductive heating carried out at the manufacturer
2.) To estimate the stresses in the beryllide blocks under DEMO conditions of neutronic heating

KIT-IAM-AWP

Work Program:

You will address these research questions by thermo-mechanical Finite-Element-Analysis in cooperation with KIT research partners at INR and IAM-AWP

- Training on the analysis software (most likely Ansys) and building the Finite-Element model of the berrylide block
- Definition of the thermo-mechanical boundary conditions for (1) the experiments at the manufacturer and (2) under DEMO conditions based on input from KIT project partners at IAM-AWP and INR
- Collecting all material parameters from KIT project partners at IAM-AWP and INR
- Importing power densities for volumetric heating for (1) inductive heating provided by the manufacturer and (2) for neutronic heating according to DEMO conditions from INR
- Carrying out the analysis in a first step for inductive heating and in a second step for neutronic heating

We offer:

- A workplace at IAM-MMI (KIT-CN, Building No. 696), including hardware and software
- An inspiring research environment with careful supervision

Your profile:

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

Contact in case of interest in the topic:

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