INTEGRAL APPROACH FOR NEUTRONICS ANALYSES OF THE EUROPEAN TBMS IN ITER

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The European Fusion Technology Programme considers two different blanket concepts for tests in ITER: the Helium-Cooled Pebble Bed (HCPB) blanket with Lithium ceramics pebbles as breeder material and beryllium pebbles as neutron multiplier, and the Helium-Cooled Lithium-Lead (HCLL) blanket with the Pb-Li eutectic alloy as breeder and neutron multiplier. The related Test Blanket Module (TBM) development work is performed by the European TBM Consortium of Associates (CA). The objectives of the TBM tests in ITER are, among others, to demonstrate the integral performance and structural integrity of the blanket systems under fusion-relevant loads. Accordingly, TBMs of the HCPB and HCLL type are designed for irradiation and performance tests in a dedicated ITER test blanket port using DEMO relevant materials and technologies.

Detailed nuclear analyses are required to ensure, first of all, that all objectives of the planned irradiation tests in ITER can be met, and, second, to provide the neutronic data needed for the engineering layout of the TBMs and the associated systems. This necessitates to employ in the neutronics calculations a suitable 3D ITER model with the HCPB and HCLL TBM systems properly included in the test blanket port.

The underlying 3D neutronics model of ITER, named “A-lite”, was developed by ITER in co-operation with other research institutions for calculations with the Monte Carlo code MCNP. This model represents a 40° ITER torus sector including various dummy ports for the integration of diagnostic tools, test objects, etc. There is one dummy test blanket port included in the “A-lite” model which can be modified to allow the integration of a test blanket inset.

The approach employed for the neutronic analyses of the TBM CA is based on the use of the “A-lite” ITER model and TBM insets integrated into the test blanket port. The model for the test blanket inset with a water-cooled steel frame and the HCPB TBM system was developed at KIT employing the conversion tool McCad for the generation of MCNP geometry models from CAD data. The underlying engineering CAD model was provided by the TBM CA and adapted to the specific neutronics requirements using CATIA V5. The model for the HCLL TBM system was developed at ENEA Frascati and integrated into the reserved compartment of the test blanket inset. Thereby a unique MCNP model of ITER was created with HCPB and HCLL TBM systems properly included in the test blanket port.

The neutronic analyses performed with this model by means of MCNP-5 calculations include performance analyses of the HCPB and HCLL TBMs and of their respective shielding systems. Detailed results of the analyses are presented and discussed in the paper.