Proceedings of the 2nd IAEA Technical Meeting on First Generation of Fusion Power Plants: Design & Technology

US DCLL Test Blanket Module Design and Relevance to DEMO*

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In the design of Test Blanket Modules (TBMs) for ITER, it is required to provide a design concept that is demonstration power reactor (DEMO) relevant. It should be noted that in the US, DEMO is defined to be a good representation of the first generation fusion power reactor. In order to evaluate the potential of the US TBM design for DEMO, a system evaluation of DEMO design was performed with an improved GA system code, and the physics results were benchmarked to ITER. With the selection of ferritic steel as the structural material, the maximum neutron wall loading is limited to 3 MW/m^2. When designed to a 3 GW fusion device the optimum aspect ratio is found to be in the range of 2.5 to 3. Results show that the US dual coolant lead-lithium (DCLL) blanket can satisfy all the DEMO design requirements. On the chamber wall material, for the ITER-TBM design, the design guidance is to apply a 2 mm Be layer onto the plasma facing surface. When extrapolated to the DEMO design, the Be layer will not be suitable due to radiation damage. Similarly, a carbon surface will not be suitable due to high physical and chemical sputtering rates, radiation damage of the material and potential large retention of tritium. Unfortunately, the remaining commonly proposed material, tungsten (W), would suffer radiation damage from alpha particle implantation and, with blistering, W transport to the plasma core could severely limit the core performance. To resolve this potential impasse, different innovative options were evaluated. All high performance tokamak experiments presently use boron or silicon to condition the first wall. To use boron in DEMO, it is found that in-situ boronization will be required in order to maintain a boronized layer on the chamber wall. This boronized layer could also protect the W substrate, while retaining low-Z wall characteristics. Further innovative ideas are being evaluated to handle transient events like ELMs and disruptions.

TOPICS: (PPCA) Power Plant Concepts and Systems Analysis

*Work supported by the U.S. Department of Energy under DE-FC02-04ER54698.