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Nuclear Performance Analysis and Optimization Study of Indian Solid Breeder Blanket for DEMO

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The tritium breeding blanket is the essential part of a fusion reactor which provides the tritium fuel self-sufficiency to the reactor. India under its breeding blanket R&D program for DEMO is focusing on the development of two breeding blanket concepts viz. Lead–Lithium cooled Ceramic Breeder (LLCB) and Helium Cooled Ceramic Breeder (HCCB). The study presented in this paper focuses on the neutronic design analysis and optimization of HCCB blanket which is having an edge on configuration and is one of the variants of helium cooled solid breeder blanket concepts proposed by several other countries. Indian HCCB blanket aims at utilizing the low energy neutrons at the rear part of the blanket and has RAFMS as the structural material, Lithium Titanate (Li2TiO3) as tritium breeder with Beryllium (Be) as neutron multiplier. The aim of the optimization is to minimize the radial blanket thickness, while ensuring tritium self-sufficiency and provide data for further neutronic design and thermal-hydraulic layout of HCCB blanket. Several parametric studies have been performed considering, different 6Li enrichment, varying composition of Be & Li2TiO3 in the breeder blanket and radial length of the breeder zone, as well as different arrangements of Be & Li2TiO3 layers in the blanket. The cases provided tritium self-sufficiency and sufficient shielding of the TF-coils have been identified.

Neutronic calculations are performed using the 1-D discrete ordinate code ANISN with FENDL-2.1 nuclear cross section data library to assess the overall nuclear performance of HCSB blanket. The inboard and outboard blanket thicknesses of 40 cm and 60 cm respectively can give TBR > 1.3, with 60% 6Li enrichment which is assumed to be sufficient to cover potential tritium losses and uncertainties. It is found that optimal multiplier to breeder material volume fraction ratio obtained is around 3:1. The results also demonstrated that Be packing fraction has more profound impact on the TBR as compared 6Li enrichment and packing fraction of Li2TiO3. Other improvements on the TBR are seen by introducing a 10 mm breeder layer before multiplier layer behind the first wall.

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