Seminar

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Institute for Plasma Research

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Title: Helium cooled solid breeder blanket concepts studies for Indian fusion pilot plant

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Date: 18th September 2025 (Thursday)

Time: 02:00 PM

Venue: Seminar Hall, IPR

Abstract

A gross electricity producing compact fusion pilot plant is crucial element of the proposed fur staged approach to the Indian DEMO program [1]. One of the most important technical challenges of delivering a DEMO-scale device from ITER is the demonstration of an effective heat extraction, power conversion and self-sufficient tritium cycle through breeding blankets. The pilot plant design aims to address these issues on a smaller scale, thereby ensuring the technology readiness required for a credible extrapolation to DEMO and, eventually, to commercial power plants [2]. India's ITER Test Blanket Module (TBM) program is progressively developing breeding blanket considering solid as well as liquid concepts. Among these, the helium-cooled solid breeder (HCSB) blanket has been identified as one of the key design choices [3, 4].
In this context, studies on helium-cooled solid breeder (HCSB) blanket concepts are being carried out for the Indian fusion pilot plant of 300 MW fusion power, 3.6 m major radius and a neutron wall load of 0.75 MW/m^2. In my work, neutronic analyses of three blanket configurations were performed: (i) poloidal stacking with a similar arrangement [5], (ii) radial stacking of alternating breeder and multiplier layers with interleaved cooling plates [6], and (iii) a mixed-bed $Be_{12}Ti$ breeder-multiplier concept [4]. Neutronic responses of all the three cases has been presented. The results show that the radial stacking concept provides a higher tritium breeding ratio (TBR) compared to the other two designs, however other two concepts haver their own advantages [7]. In addition, two-dimensional thermal simulations and flow analyses have been conducted for the radial stacking case, while three-dimensional thermal, thermal-hydraulic, and structural analyses are currently in progress. These results highlight the potential of the radial stacking HCSB concept as a promising candidate for ensuring tritium self-sufficiency and efficient heat management in the Indian fusion pilot plant. Apart from this study, a neutronic simulation has been performed to evaluate tritium production in lithium ceramic samples (Li_2TiO_3 and Li_2CO_3 powder), a candidate material for fusion reactor breeder blankets. Tritium is bred via neutron-induced reactions, involving the isotope Li-6 and Li-7. The calculation estimates the activity (Bq), specific activity (μCi/g) and tritium production rates using Monte Carlo N-Particle (MCNP) simulations, along with experimental inputs. The sample irradiation experiment has been performed using a 14 MeV neutron environment at Institute for Plasma Research [8].

References:

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