An overview of STEP Breeder Blanket nuclear analysis using OpenMC

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The Spherical Tokamak for Energy Production (STEP) Fusion programme is an ambitious UK initiative to design and build a prototype fusion energy plant, aiming to demonstrate the ability to generate net energy, fuel self-sufficiency and a route to the commercialisation of nuclear fusion.

The compact radial design of a spherical tokamak limits tritium breeding volume and thus presents a significant neutronic design challenge for fuel self-sufficiency. Following a comprehensive assessment of all breeder, coolant, and structural material options, solid ceramic lithium oxide (Li_2O) has been selected together with a Ti-modified austenitic stainless steel structural material, CO_2 coolant, and beryllium-based multiplier. This combination is considered to give the highest confidence in successfully meeting the powerplant requirements.

Nuclear performance such as tritium breeding ratio, nuclear heating and shielding were key factors in the choice of architecture for the powerplant breeder blanket using these materials. This talk presents the workflow used to perform nuclear analysis on various breeder designs and the challenges of an optimization process that must be integrated with design, thermal and structural analysis.

A Constructive Solid Geometry (CSG) reactor model incorporating parameterised CAD in Direct Accelerated Geometry Monte Carlo (DAGMC) universes was used to rapidly explore the design space of high-fidelity blanket architectures, allowing quantitative comparison between configurations. The selection of an architecture and progression from concept to detailed design has led to an increase in design complexity, requiring improved workflows that can incorporate key features of the design for timely neutronics analysis to support integrated design choices. This talk presents some of the updates to the workflow required to manage this complexity, and plans for further improvement.

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