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PROCEEDINGS

Design and Fabrication of Porous Lithium-Containing Ceramic Tritium Breeders for Fusion Reactors

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ABSTRACT

Effectively obtaining tritium is one of the essential issues to realize commercial and controlled nuclear fusion [1]. Conventional lithium-containing ceramic tritium breeders with pebble bed configurations in fusion reactors have shown insurmountable structural drawbacks weakening tritium extraction, including inherently low packing fractions, extensive stress concentrations, and low thermal conductivity. Therefore, extensive efforts have been devoted to enhancing tritium extraction by improving the design of tritium breeders and addressing structural drawbacks [2-4]. In this study, porous block configurations were proposed to replace conventional pebble bed configurations for the ceramic tritium breeder. Utilizing fluid-solid coupled heat transfer simulation, the feasibility of the porous block configuration was evaluated by comparing it with a pebble bed configuration regarding thermo-hydraulic performances. The flow behavior of the porous block configuration was superior to that of the pebble bed configuration. At the same inlet velocity of 0.1-0.2 m/s, the porous block configuration had a ~56% higher average flow velocity and only half the pressure drop. The convective heat transfer coefficient and effective thermal conductivity of the porous block configuration increased by ~56% and ~35%, respectively. Additionally, a Gyroid lithium titanite block breeder with an attractive dimension of ~18.8 × 18.8 × 18.8 mm^3 and a high packing fraction of ~78.8% as a proof-of-concept was prepared by the hybrid process of stereolithography (SLA) and gelcasting [5]. The SLA/gelcasting hybrid process demonstrated enormous advantages over the reported digital light processing additive manufacturing for the preparation of porous block breeders with low shrinkage and large-sized dimensions. This study not only verifies porous block configurations are a promising alternative for tritium breeders but also offers an effective avenue for the manufacture of porous block breeders with tunable tritium-releasing channels and large-sized configurations.

KEYWORDS

Ceramic tritium breeders; numerical simulations; stereolithography/gelcasting; fusion reactors

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