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Nuclear analyses of solid breeder blanket options for DEMO: status challenges and outlook

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Within the Power Plant Physics and Technology (PPPT) programme of EUROfusion, an intensive development effort is devoted to the detailed design of a solid breeder blanket for a demonstration fusion reactor (DEMO) with the inherent capability of a highly efficient tritium breeding. A novel design of the Helium Cooled Pebble Bed (HCPB) breeding blanket based on a Single Module Segment (SMS) and an enhanced, near term configuration has been developed for the EU DEMO reactor, having high flexibility with regard to tritium generation and global reactor performances. The key part of the analyses is the development of the geometry model of the breeder blanket with enough detail to perform high fidelity nuclear simulations. To this end a generic geometry model of a DEMO 2017 baseline was adopted to arrange the newly developed SMS HCPB layout using a novel modelling technique. Separate models were developed using detailed CAD designs and the McCad conversion tool: the SMS blanket module, a breeder unit and a highly detailed First Wall (FW) with cooling channels and a roof-top shape. In this way, the model includes a detailed representation of the breeder zone, the back supporting structure and the FW of the blanket.

This model has been applied for the study of this new generation of HCPB blanket, as well as for the investigation of an alternative concept based on liquid lead neutron multiplier, replacing the Be/beryllide one. The simulations include assessment of the main required nuclear responses: TBR, nuclear power generation and shielding performances. A special technique has been also applied to find the optimal geometry configuration of the different concepts. The study concludes with sophisticated activation analyses of the in-vessel components and with the discussion of different effects coming from the detailed modelling and affecting engineering solutions, current design highlights, challenges and outlook.

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