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Material optimization technique to minimize radiological responses in fusion reactors

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High-energy, high-intensity neutrons emitted from the fusion plasma present a stringent environment for the structural materials present in the fusion device. This has significant life-limiting effects on the reactor components. The neutrons interact with the material initiating nuclear reaction leading to the production of radioactive isotopes, gas molecules and material defects. These gases, particularly helium, can cause swelling and embrittlement of the material. Furthermore, the radioactive isotopes produce would cause heating in the material. Some of these isotopes may have long lives which would contribute towards the radwaste produced in the fusion devices. Hence designing of low activation materials for fusion devices is warranted.
At Iter-India, Institute for Plasma Research a number of computational tools are being developed to estimate the nuclear response of the materials. ACTYS-1-GO, a multipoint neutron activation code which can calculate radiological responses of materials located at various positions in a fusion reactor efficiently, is developed. Along with it, a mathematical framework is developed for accessing the relationship of radiological quantity with the initial elements present in the material. Such framework helps in identifying and thus minimizing the elements/isotopes from the initial material composition.
In the present study both the methodologies are efficiently coupled for a complete material optimization. Quantities responsible for various radiological effects (like activity, dose, heat, and radwaste) and related defects in the material are at all irradiation times considered and their contributing elements are sorted and minimized accordingly. Also, since a single material faces a gradient of neutron flux over its entire volume, all such optimization is carried out over the entire range of neutron flux faced by that material. This would provide the best material composition in accordance with the neutron environment faced by the material and its functionality, minimizing the radiological effects like activity, dose, gas production and radwaste.

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