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Fusion chamber dynamics and first wall response in a Z-pinch driven fusion-fission hybrid power reactor (Z-FFR)

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The Z-Pinch driven fusion-fission hybrid reactor (Z-FFR) concept utilizes energetic neutrons produced by D-T fusion to drive a sub-critical fission blanket for energy production. Benefiting from an innovative local-holistic-ignition Z-pinch fusion target and advanced sub-critical fission blanket made of natural or depleted uranium, the Z-FFR has significant advantages in safety, economy and environment, and has great potential to be a millennial energy that could address the main issues of long-term sustainability related to nuclear power: fuel supply, energy production, and waste management. In Z-FFR, the fusion target will produce enormous energy of ˜1.5 GJ per pulse at a frequency of 0.1 Hz. Almost 20% of the fusion energy yield, approximately 300 MJ, is released in forms of pulsed X-rays. Radiation hydrodynamics in the fusion chamber were investigated by MULTI-1D simulations. To evaluate the influence on thermal and mechanical loads on the first wall brought by the uncertainties of calculated radiation opacities, as well as limitations from employing a single-group treatment in chamber radiation transport, artificial adjustments of opacities by multiplying a coefficient were adopted in the simulations to increase the design reliability. The thermo-mechanical response in a tungsten-coated Zr-alloy first wall was performed by FWDR1D calculations using the derived thermal and mechanical loads as inputs. The temperature and stress fields were analyzed, and the corresponding elastic strains were conducted for primary lifetime estimations. Both pure tungsten and W-Re alloy were tested on an intense pulsed Z-pinch X-ray source to find the safety thresholds of certain materials for designing requirements, as well as to verify and validate the FWDR1D code.

Eligible for student paper award?

No

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