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Fatigue analysis of spallation target beam window for baseline beam trip parameters at ESS

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Abstract

The spallation target at ESS must withstand the very high intensity proton beam with timeaveraged power of up to 5 MW. The 2.5 GeV proton beam carries approximately 0.36 MJ of the particle kinetic energy to the tungsten target at the pulse rate of 14 Hz. For the proposed pulse length of 2.86 ms, the periodic application of intense beam load of 0.125 GW poses a significant challenge to the designing of a robust spallation target that must satisfy the lifetime criterion of 5 years. One of particular concerns is the fatigue failure of the target beam window that will be made of stainless steel. In this paper, we study the correlation between the impinging beam profile with different peak power densities and the thermomechanical fatigue failure limit of several ESS beam window options with chosen geometric and operational parameters. Advanced simulation technologies are used. The FLUKA is used for calculating thermal loads in the target beam window, and the associated thermomechanical fatigue loads are calculated by ANSYS Multiphysics. The simulated amplitudes and frequencies of the thermomechanical loads are compared with the experimental data from literatures, and the fatigue lifetimes of the studied target beam window models are analyzed.