THERMAL FEATURES OF SPALLATION WINDOW TARGETS

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ABSTRACT

Subcritical nuclear reactors have been proposed for a number of applications, from energy production to fertile-to-fissile conversion, and to transmutation of long-lived radionuclei into stable or much shorter-lived nuclei. The main advantage of subcritical reactors is their large reactivity margin for not to attain prompt-supercritical power surges. On the contrary, subcritical reactors present some economic drawbacks and technical complexities that deserve suitable attention in the R&D phase. Namely, they need a very intense neutron source in order to keep the neutron flux and the reactor power at the required level. The most intense neutron source seems to be based on the proton-induced (or deuteron-induced) spallation reaction in heavy nuclei targets, which present very demanding thermal features that must be properly limited. Those limits pose upper bounds to the neutron yield of the target. In turn, the limits depend on the features of the impinging particle beam and the material composition and geometry of the target. Although the potential design window for spallation targets is rather wide, the analysis presented in this paper identifies specific topics that must properly be covered in the detailed project of a spallation source, in order to avoid unacceptable temperatures and mechanical stresses in the most critical parts of the source.

In this paper, some calculations are reported on solid targets (water cooled or helium cooled) and molten metals targets. It is seen that thermal-hydraulic and mechanical calculations of spallation targets are fundamental elements in the coherent design of this type of very intense neutron sources. This coherence implies the need of a suitable trade-off among the relevant beam parameters (proton energy, total intensity and cross-section shape) and the features of the target (structural materials, coolant characteristics and target geometry). The goal of maximizing the neutron yield has to be checked against the safety criteria regarding the source integrity, notably those depending on the thermal performance of the system.