Contribution ID: **6** Type: **Poster**

Hydrodynamics of a liquid Pb-Bi target for high-power ISOL facilities

Tuesday, 9 June 2015 18:30 (1h 30m)

In the context of the forthcoming next generation of Radioactive Ion Beams (RIBs) facilities based on the Isotope Separation On Line (ISOL) method, the development of production targets capable of dissipating the high power deposited by the primary beam is a major challenge. EURISOL and ISOL@MYRRHA are examples of such facilities. Within this framework, the concept of a high-power target based on a liquid Pb-Bi loop incorporating a heat-exchanger, a pump and a release chamber was proposed and is currently being developed within the LIEBE project. In this target the irradiated Pb-Bi containing short-lived isotopes is promptly spread into a shower of droplets, thereby reducing by two orders of magnitude the diffusion length of isotopes.
Yet, ensuring an efficient release of isotopes is still of crucial importance and several delay-inducing processes have to be optimized. This requires design-optimization of both the irradiation volume and the release chamber. LBE evacuation from the irradiation volume of this target is one such process that needs to be carefully studied. The optimization of the flow of liquid Pb-Bi in the compact and complex geometry of the irradiation volume will be discussed in this presentation. The full target geometry and its dimensions have been set as design variables. Among other aspects, this includes optimizing the number and positions of the target inlets and outlets. The following quality criteria were considered: a residence time of LBE inside the irradiation volume bellow 100 ms, a uniform distribution of velocity vectors through the few thousands outlet apertures and a reduced cavitation risk. Several constraints were taken into account, such as a maximum pressure-drop limit and maximum limits on target dimensions.
Three-dimensional computer simulations of the LBE flow have been used for the evaluation of design modifications. Results pertaining to the initial design geometries have revealed issues such as long residence time due to irradiated LBE recirculation, non-uniform distribution of LBE-velocity vectors at outlet apertures and regions with pressure dropping below the vapor pressure of LBE. Thorough analysis of the results led to successively-improved target-design options. Among other improvements, the design of a feeder volume equipped with a feeder grid was required in order to uniformly distribute the high-momentum inlet jet over the irradiation volume. Two different optimized target geometries were eventually obtained. Each of them showcases a different way to deal with the jet effect initially observed due to the high-momentum inlet liquid stream.
Calculations of the thermo-mechanical effects of the impact of a proton pulse will be presented for the optimized geometries. Under the assumptions of a rigid irradiation-volume-container and not accounting for potential cavitation effects, temperature and pressure fields inside the irradiation volume have been determined.

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Session Classification: Poster session

Track Classification: Production and manipulation of RIB