High power spallation target using a heavy liquid metal free surface flow.

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Abstract

A lead-bismuth cooled accelerator driven system (ADS) is considered as a promising option for the transmutation of long lived nuclear waste into short lived or stable isotopes. In this type of reactor a subcritical core is used. It receives the required neutrons for the nuclear reaction by spallation, using a high power proton beam from an accelerator. At the entry point of the reactor pool, where the beam impinges on the surface of the liquid metal, which simultaneously acts as the target material, special construction effort is indispensable to handle the high heat production.

In order to demonstrate the ADS concept, the Multi-purpose hybrid Research Reactor for High-tech Applications (MYRRHA) is currently under design at Mol/Belgium. One of the proposed targets for this reactor is a free surface target, based on a ring-like liquid metal curtain, converging into a liquid metal jet by surface tension effects, and thus forming an inner and an outer free surface. The inner surface is then subjected to the 2.4MW proton beam, while the curtain maintains the separation between beam line and reactor pool.

A near full scale prototype of this target design with a nozzle diameter of 88 mm, allowing a LBE mass flow rate up to 300 tons per hour, has been set up and experimentally investigated at the Karlsruhe Liquid Metal Laboratory (KALLA) of the Karlsruhe Institute of Technology (KIT). Measurements show a stable operation of the free surface in a wide range of operating conditions. In addition, the exact inner and outer shape of the jet were detected using high speed image processing and surface reconstruction by depth of field information. Comparison with numerical pre-calculations employing commercial CFD code Star-CD and Star-CCM+ show a very good agreement of experimental and numerical data with a difference between predicted and measured surface shape of less than 5%.