INVESTIGATION OF LBE COOLED MULTI-LAYER TUNGSTEN SPALLATION TARGET

Kazuma Kobayashi, Ph.D. student
Missouri University of Science and Technology
301 W 14th St, Rolla, MO 65409, USA
Email: kk55f@umsystem.edu

Due to the development of accelerator technology, high-intensity protons with beam powers of several MW are now available. Accordingly, the design of spallation targets, especially heat removal, has become a particularly important issue. In order to solve this problem, the feasibility of a lead-bismuth eutectic (LBE) cooled tungsten target was investigated. The target schematic is composed of tungsten plates and LBE coolant flowing between the plates, as shown in Fig. 1.

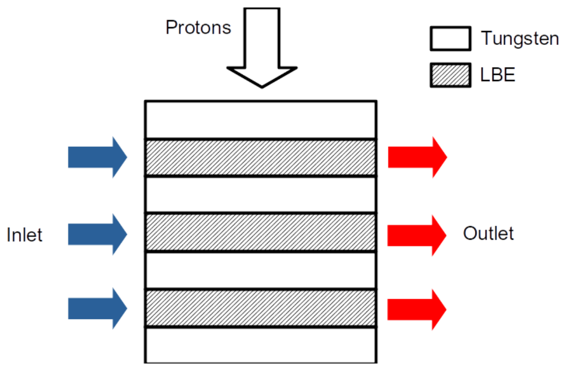

FIG. 1. Schematic diagram of LBE-cooled tungsten target.

Tungsten has been studied as a solid spallation target material from the early stage because of its density (19.3 g/cm^3 at r.t.), melting point (3422 °C), and thermal conductivity (175 W/mK at r.t.), and it has been used in actual research facilities [1], [2]. Water and heavy water are candidates as coolants, but experience has shown that tungsten is corroded by water under irradiation condition [3]. To overcome this problem, ISIS Neutron and Muon Source employ tantalum-coated tungsten plates cooled by heavy water as the target [1].

An alternative solution is to employ LBE as a coolant. LBE is also being studied as a coolant for fast reactors, and there are concerns about corrosion damage to the construction components. However, previous research has revealed that tungsten is highly corrosion resistant to high-temperature LBE [4]. Therefore, there is a possibility to construct a target system with a combination of tungsten and LBE coolant.

For target design simulation, a coupling analysis of particle transport code and computational fluid dynamics code (CFD) was employed. The dose induced by particles was calculated using Particle and Heavy Ion Transport code System [5]. ANSYS Fluent 2021 R2 was used as the CFD code to apply the obtained dose as a heat source in a system. Fig. 2. shows a temperature distribution at steady-state obtained from the coupling calculation of which a LBE-cooled tungsten target irradiated with 600 MeV of protons at a beam current of 4 mA. When the inlet temperature of the LBE was 500 K, and the inlet velocity was 0.1 m/s, the maximum temperature of the tungsten plate was about 2000 K, and the maximum temperature of the LBE outlet was 1740 K. In the case of tungsten plates with a thickness of

2 mm, the escaped neutrons are 1.9 neutrons/proton, which is only about 20% of the bulk tungsten target.

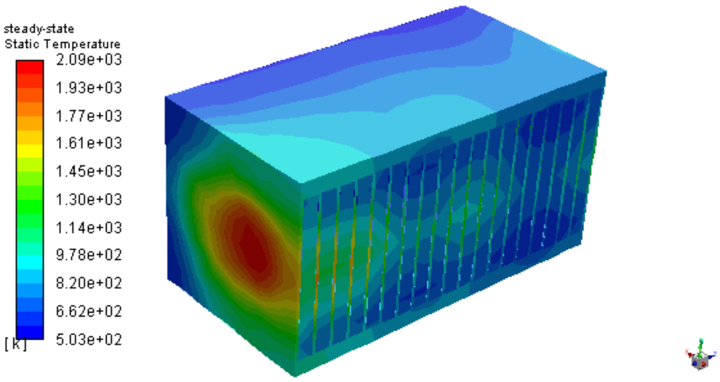

FIG. 2. Temperature distribution in the LBE-cooled tungsten plates obtained with Fluent. The LBE flowing velocity is 0.1 m/s.

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