Seminar

Institute for Plasma Research

Title: Moderator Assembly Design for Multi-isotope Production using high-yield D-T Neutron Generator

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Abstract

Accelerator-based neutron generators are emerging tools that are advancing research on fusion, neutron interaction, material testing, and medical radioisotope production. Medical radioisotopes are generally produced by neutron irradiation in thermal nuclear reactors, where slow neutrons are used. However, fast neutrons can also be used to target specific nuclear reactions and thereby produce radioisotopes in demand or enhance research on emerging ones. These reaction channels have a high neutron absorption threshold and can only be targeted by accelerator-based neutron generators. Generally, this method allows for the production of limited isotopes. To overcome this limitation, a moderator assembly can be used to ensure that neutrons of different energies are available for radioisotope production. An accelerator-based D-T neutron generator has been developed for the Institute for Plasma Research (IPR), Gandhinagar, India. It accelerates deuterium ions that bombard a tritium target, resulting in a fusion reaction. In this way, it can provide a high neutron yield of 1E12 neutrons per second. A medical radioisotope production unit was designed to test the feasibility of the neutron generator facility. The Particle and Heavy Ion Transport Code System (PHITS) was used to develop simulation models for the isotope irradiation assembly. This assembly consists of lead as a neutron multiplier, High-Density Polyethylene (HDPE) as a neutron moderator, and stainless steel (SS-304) to provide support to the system.

The neutron generator produced 14 MeV neutrons, which were multiplied and moderated to develop neutrons across all energy bins. In this study, the nuclear reactions were divided into 3 common groups, depending on the optimized neutron energy bin for high reaction cross section. These energy bins are 0 to 5 eV (thermal), 0.2 to 100 keV (keV), and above 3 MeV (fast). The simulation study is designed to optimize and increase the percentage flux in these energy bins, while also considering the overall neutron flux in the region. The assembly was further divided into sections to deliver the neutron flux percentage favored for the reaction channel. In this way, several radioisotopes, such as Tc-99m, Mo-99, Cu-64, Lu-177, and Ir-192, can be produced simultaneously. The simulation study shows that a similar facility could be used to establish a new medical radioisotope production facility in remote locations.