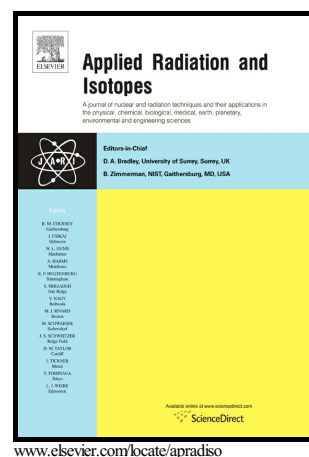


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Pressure control of a proton beam-irradiated water target through an internal flow channel-induced thermosyphon

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Abstract

A water target was designed to enhance cooling efficiency using a thermosyphon, which is a system that uses natural convection to induce heat exchange. Two water targets were fabricated: a square target without any flow channel and a target with a flow channel design to induce a thermosyphon mechanism. These two targets had the same internal volume of 8 ml. First, visualization experiments were performed to observe the internal flow by natural convection. Subsequently, an experiment was conducted to compare the cooling performance of both water targets by measuring the temperature and pressure. A 30-MeV proton beam with a beam current of 20 μ A was used to irradiate both targets. Consequently, the target with an internal flow channel had a lower mean temperature and a 50% pressure drop compared to the target without a flow channel during proton beam irradiation.

Keywords: Thermosyphon, water target, natural convection, flow channel, low pressure

1. Introduction

Radio-isotope water targeting is a system that is normally used to produce Fluorine-18 by irradiating [^{18}O]water with a proton beam. The proton beam originates from an accelerator, travels through a vacuum beam line, and hits the water target. This water target contains the H_2^{18}O during irradiation. The H_2^{18}O target has a thin foil beam entrance window that directly faces the vacuum. The incident proton beam passes through this thin foil before entering the H_2^{18}O . Mechanically, the H_2^{18}O is separated only by this thin foil window from the vacuum beam line. As soon as the proton beam irradiates the water target, the temperature and the pressure inside the target increase rapidly. The pressure inside the water target pushes the window foil toward the vacuum. Inevitably, the foil ruptures and this deformation of the foil changes the volume of the cavity where the H_2^{18}O water is contained. The change of the volume enhances the phase change of water by boiling, and the pressure and temperature increase owing to the generated steam. Because the nuclear reaction cross-section is proportional to the material density, boiling is undesirable as the generated steam has a much lower density than the water in the liquid state. The radio-isotope production yield can be increased by increasing the proton beam intensity, but the internal pressure of the water target increases when more power is transferred to the target. The increment of the internal pressure can damage the water target. Therefore, controlling the

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