High power rotating tube target for BNCT

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Introduction

There are two types of neutron generation reactions that can be considered for AB-BNCT.

$^{7}L(p, n)^{7}Be$, $^{9}Be(p, n)^{9}B$ [1]. Recently, generation of neutrons using deuteron has also become an issue. In this case, there are two neutron generation reactions that can be considered: ^{9}Be $(d, n)^{10}Be$ and $^{13}C(d, n)^{14}N$ [2]. In case of using (p, n) reaction lithium target has a better neutron flux and distribution but has a lower thermal conductivity and melting point. And the issues with ^{7}Be accumulation and environmental radiation by tritium must be consider when we use a lithium target. But the lithium has an advantage when fabricating a target because lithium is widely used material in many industrial applications, while beryllium is not easy to handle needs more higher proton energy for getting enough neutron flux than lithium target. For (d, n) reaction beryllium and carbon can be used at a lower energy of deuteron than the proton energy for Li(p, n) reaction.

For all case of reactions, considering beam energy and current to produce enough neutron flux from a target approximately 30 kW of power (heat load) must be removed from the target. There are several techniques to enhance the cooling performance. The main concept is increasing the heat transfer surface. To increase the heat transfer surface, we could wobble the beam, install the target at an angle, rotating the target and apply micro channels for cooling.

In Korea Institute of Radiological and Medical Sciences (KIRMAS), we are developing a rotating beryllium tube target for use at 13 MeV proton beam and 1.5 MeV deuteron beam.

Experimental conditions

A rotating beryllium Tube target was fabricated to investigate the cooling performance by experiments. The thickness of tube was 0.9 mm. The thickness of the beryllium was determined to allow the 13 MeV proton Bragg-peak to pass through the beryllium to reach the coolant. The reason for determining this thickness is to avoid blistering in beryllium in practical cases. Instead of proton beam we use a laser welder to simulate the heat power.

The beam size of the laser welder was 5 mm (2.5 mm of half maximum) in diameter. The tube was rotating with 15 RPM and the flow rate of the cooling water was 25 l/min. The inlet temperature of the cooling water was 25 ºC.

The cooling performance of the rotating Be tube target was test by two case with vary the beam power. The beam power were 1 kW and 1.5 kW.

The surface temperature was measured by IR camera and pyrometer. IR camera was used to measure the temperature distribution and the pyrometer was used to measure the local temperature and simultaneously compensate the measured temperature of IR camera.

Results

At the beam power of 1 kW the cooling performance was 5.1 kW/cm^2 and the surface temperature of the target was about 137 ºC

When the beam power was 1.5 kW the cooling performance was 7.6 kW/cm^2 with the temperature of 197 ºC on the beryllium tube surface.

Conclusion

The cooling performance of a rotating Be tube target is 7.6 kW/cm^2. The performance can be increased by RPM, flow rate and tube diameter. More experiment will be conducted to find a optimal condition for better cooling performance.

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