Design of a model for BSA to meet free beam parameters for BNCT based on multiplier system for D–T neutron source

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ABSTRACT

Extensive research has recently been carried out for the development of high-energy D–T neutron generators as neutron sources for BNCT. The energy of these high-energy neutrons must be reduced by designing a Beam Shaping Assembly (BSA) to make them usable for BNCT. However, the neutron flux decreases drastically as neutrons pass through different materials of BSA. Therefore, it is very important to find ways to treat the neutrons economically. In this paper, the possibility of using natural uranium as a neutron multiplier was investigated in order to increase the number of neutrons generated by the D–T neutron generator. The energy of fast neutrons that are generated by D–T fusion reaction and amplified by neutron multiplier system is decreased using proper materials as moderators and fast neutron filters in BSA. The gamma rays which are generated as a result of neutron interaction with moderators are removed from neutron spectrum using bismuth as the gamma filter. Also, a thermal neutron absorber omits undesired low-energy neutrons which lead to a high radiation dose for the skin and soft tissues. The results show that passing neutrons through such a BSA causes the establishment of free beam parameters yet the reduction of the output beam intensity is unavoidable. The neutron spectrum related to our BSA has a proper epithermal flux and the fast and thermal neutron fluxes are compatible with the IAEA recommended values.

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1. Introduction

As a prominent method for treating tumors, radiotherapy is classified into “direct” or “indirect” categories. In direct method, the tumor is influenced by proton or alpha radiation which directly leads to the destruction of cancer cells. However, the second method destroys cancer cells indirectly. As an example of indirect destruction of tumor cells, BNCT (Boron Neutron Capture Therapy) treats the tumors by particles which are generated in the process of a nuclear reaction such as the resultant particles of interaction between boron and low energy neutrons (Cerullo et al., 2004; Durisi et al., 2007). Neutron flux is one of the most important characteristics of the neutron source for BNCT. The flux must be large enough so that the therapy procedures can be established in a reasonable time. Initially, nuclear reactors have been the only neutron sources which are capable of providing the required neutron beam with high neutron flux (Autenrieth et al., 2004; Tahara et al., 2006). However, recently the use of other potential neutron sources has been investigated for BNCT method (Durisi et al., 2007; Cerullo et al., 2002; Rahman and Shahriari, 2010; Kononov et al., 2004; Ghasoun et al., 2009). Compact neutron generators based on D–T fusion reaction (H(d,n)He) seem to be much better for in-hospital treatments due to greater safety, lower energy for incident deuterons, smaller size and high social acceptability.

High energy neutrons of 14.1 MeV are emitted from this fusion reaction. As these neutrons cannot be used directly in BNCT, it is...