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Technical note

Optimization of ^{60}Co production using neutron flux trap in the Tehran research reactor

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Abstract

Radioisotope production is one of the most important applications of research reactors. ^{60}Co has a wide application in industry and medicine. In this paper the efficient production of ^{60}Co by enhancing radiation systems is studied and developed by using neutron flux trap concept in Tehran research reactor. Calculational methods were checked against experimental results.

1. Introduction

Tehran research reactor (TRR) is the only facility for production of long-lived radioisotopes needed for the country. The efficient utilization of this facility needs qualified system and optimization of methods for specimen irradiation.

Since TRR core has a limited size for irradiation purposes, and since maximum thermal neutron flux occurs within a limited space, it would be a significant engineering challenge to relax or override this problem.

Neutron flux intensity and spectrum is highly important in research reactors for radioisotope production purposes. One way to optimize the above-mentioned factors

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is to consider special places within the reactor core or its surrounding (Mele, 1990). With a correct choice of fuel element position and use of proper materials one can find appropriate positions inside the core to obtain maximum flux in thermal region. In this paper, feasibility study of production of ^{60}Co from natural cobalt (^{59}Co) was carried out using calculational and experimental techniques. Calculational methods are compared against experimental results.

2. Procedures

The existing TRR is a 5 MW pool-type research reactor with MTR type fuel elements of low enriched Uranium (LEU) with 20% enrichment. Detailed explanation of TRR core and its relavent irradiation facilities is described elsewhere (AEOI, 1989). The core is built upon an aluminium grid plate, on which there are $9 \times 6 = 54$ holes to accept either fuels or other tools such as irradiation boxes. A sample holder is designed and constructed in such a way to position over one of such irradiation boxes from which samples are suspended to receive maximum neutron flux.

2.1. Analytical basis

The production of radio nuclides is a function of total neutron flux intensity and its spectrum at each irradiation position in the core. The total neutron flux depends mainly on reactor power, while its spectrum depends on the type of material chosen and also geometry of reactor core around irradiation positions. Therefore, it is clear that neutron energy spectrum at each position inside the core is a function of number, burn up, type, and arrangement of the neighboring fuel elements and other materials (Mele and Ravnik, 1985).

For the purpose of radioisotope production, TRR core and its central neutron flux trap (FT) is configured as depicted in Fig. 1 (Khalafi and Gharib, 1999). The following criteria should be observed as a safety requirements for any core configuration and experimental setup (INVAP S.E., 1989):

- Temperature of the clad surface should be less than or equal 105 °C (water B.P).
- Total power peaking factor should be less than 3 when at maximum power.

According to our calculations reactor could operate safely up to 4.5 MW within the above-mentioned criteria having neutron flux trap positioned in core centre filled with water. This flux trap is simply an empty box of similar dimensions compared to fuel assemblies and easily positioned anywhere on grid plate. Clearly one wishes to operate at maximum power to obtain maximum flux intensity. To be within safe limits, maximum reactor power having central FT should not be more than 4.5 MW, (maximum power peaking factor = 2.92), at which maximum clad temperature is 97 °C. At this power the unperturbed thermal neutron flux is about 7.38×10^{13} n/cm^2 s in central FT in central region (Khalafi, 1999). It has been shown elsewhere