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Monte Carlo simulation for designing collimator of the neutron radiography facility in Malaysia

Rafhayudi Jamro[a]*, Nikolay Kardjilov[b], Mohamad HairieRabir[a], Mohamed Rawi Mohd Zain[a], Abdul Aziz Mohamed[c], NurSazwani Mohd Ali[d], Faridah Idris[a], Megat Harun Al Rashid Megat Ahmad[a], Khairiah Yazid[a],Hafizal Yazid[a], Azraf Azman[a], Mohd Rizal Mamat[a]

[a]*Malaysian Nuclear Agency, 43000 Kajang, Malaysia*
[b]*HZB, Berlin, Germany*
[c]*Center for Nuclear Energy, UNITEN, Kajang, Selangor, Malaysia*
[d]*University Technology Malaysia (UTM)*

Abstract

Neutron collimator is the most important component in a neutron radiography facility set-up, which defines the neutron beam characteristic at the object plane. The neutron radiography facility in Malaysia was built at one of the radial beam ports of TRIGA MARK II PUSPATI research reactor (RTP).At present, the facility has low thermal neutron intensity at the sample position, which leads to long irradiation times; it gives many limitations for the industrial applications. The collimator used for this facility is based on step divergent collimator type. The aim of this research is to design the best geometry and to choose materials for thermal neutron collimator so as to obtain a uniform beam, high L/D ratio and a maximum thermal neutron flux at the object plane. In order to achieve this aim new collimator geometry has been designed to improve the existing radiography facility by using Monte-Carlo simulation codes of SIMRES and MCNPX. The new design results are compared with those of the existing facility. Our simulation result may be of help in the design of new collimator for neutron radiography facility.

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*Keywords:*Monte Carlo Simulation, neutron and gamma flux, collimator, NUR II and neutron radiography

* Corresponding author. Tel.: +60389250510; fax: +60389250907.
E-mail address: rafhayudi@nuclearmalaysia.gov.my

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1. Introduction

Neutron radiography (NR) is an important tool in non-destructive testing which has been widely used especially in industrial, medical, metallurgical, nuclear and explosive inspection. In order to enlarge the range of applications of NR technique, it is necessary to design and optimized high thermal neutron intensity at least 10^5 $ncm^{-2}s^{-1}$. However, these systems must be properly shielded and the radiography rules and regulations must be fulfilled. In addition the size, weight and operational conditions of the system must be optimized.

Generally, the collimator is a beam forming assembly, which determines the geometric properties of the beam. In addition, it may contain filter to modify the energy spectrum or to reduce gamma contaminations of the beam. Various effective parameters on the image quality are needed to be studied to achieve a neutron radiography system with a good resolution. The geometry of collimator must be selected based on maximum intensity and uniformity of a neutron flux at the image plane at the end of collimator outlet. In practice, it is intended to have an experimental arrangement which is accomplishing neutron beam parameters as close as possible to the ideal ones. For that reason the neutron collimator should be optimized in respect to neutron and gamma radiation using MCNPX and SIMRES codes based on Monte Carlo Method.

2. Neutron Radiography Facility and Neutron Collimator

Since the 1MW Reactor TRIGA MARK II PUSPATI (RTP) was commissioned in June 1982, a lot of developmental work was performed in order to establish the neutron radiography facility as a tool for research and development purposes. The neutron radiographic facility system in Malaysian Nuclear Agency was ready for use in 1984. The imaging system was based on film as an image recorder. Many improvements have been made to the system since then including the installation of the step divergence collimator type at the radial piercing beam port, the installation of the beam catcher in front of the radiographic film holder and construction of the biological shielding surrounding the irradiation facility.

RTP is a swimming pool-type light water research reactor using enriched uranium-zirconium-hydride fuel with 8.5, 12 and 20wt% of 19.9% enrichment of U235 (SAR, 1985) and equipped with graphite reflector. There are four beam ports, three radial beam ports and one tangential beam port, and one thermal column as shown in Figure 1.

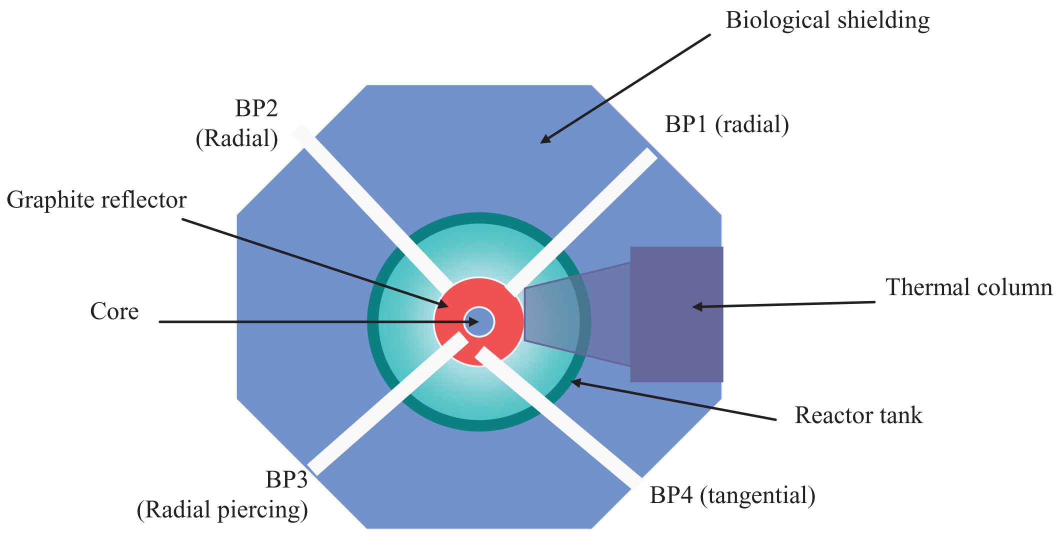

Figure 1: Cut-away view of the MINT TRIGA MARK II research reactor

In late 1983, neutron radiographic facility system known as NUR-1 was constructed and tested. The data collected from this test facility enabled the design and construction of the permanent facility, later known as NUR