Calculation of Energy Dependent Neutron Correction Coefficient Ratios of Natural Rhodium in Energy Region from 0.003 to 100 eV

Samyol Lee

Department of Radiology, Nambu University

Abstract

In the neutron capture experiment and calculation, the neutron absorption and scattering are very important. Especially these effects are conspicuous in the resonance energy region and below the thermal energy region. In the present study, we obtained energy dependent neutron absorption ratios of natural rhodium in energy region from 0.003 to 100 eV by MCNP−4B Code. The coefficients for neutron absorption was calculated for several types of thickness. In the lower energy region, neutron absorption is larger than higher region, because of large capture cross section (1/v). Furthermore it seems very different neutron absorption in the large resonance energy region. These results are very useful to decide the thickness of sample and shielding materials.

Ⅰ. Introduction

The neutron absorption and scattering are very important to calculate the thickness of shield and experimental sample. In the present study, the absorption ratios of natural Rhodium (^{103}Rh) were calculated by MCNP(A General Monte Carlo N-Particle Transport Code)-4B Code. Furthermore the accurate neutron capture cross-sections of fission products (FPs) is very important for designing the high burn-up core of a nuclear reactor, because the products, for which they are called a fission product poisons, decrease the neutron flux of a reactor. Rhodium (^{103}Rh) is a fission product with high fission yield (several percent in the fast reactor[1]) and a strong neutron absorbing nuclide. The accurate measurement of capture cross-section is of great importance for the characteristic calculation in a reactor. However the effects of neutron absorption and scattering in the sample were not to be ignored.[2] Since the capture cross-section is large in the lower energy region (thermal neutron capture cross-section: 1452 barn)[3].

Ⅱ. Method and calculation

In the neutron capture cross-section measurement and the study of the neutron shielding effects, the effect of single and multiple neutron scatterings in the capture sample are quite important in determining a thickness of material. This effect, which increases with the effective sample thickness relative to the geometrical thickness in the direction of incident neutrons, must be considered in the capture cross-section measurement in which the total number of capture events in a sample is measured. In the present study, we have made Monte Carlo calculations using the MCNP-4B code[4] to simulate the neutron capture and multiple scattering events in the sample and carry out the corrections of the effect of single and multiple neutron scatterings in the capture sample. The scheme of simulation shown in Fig. 1.

There are several type of neutron and photon reaction in the sample(material). We can assume that there are one and two reactions in the case of thin sample. However, there are several type of reactions in the case of thick sample. (18mm x 18mm and Thickness: 1, 2, 4, 10mm). The sampling(neutron generation number) is 10,000,000 times.

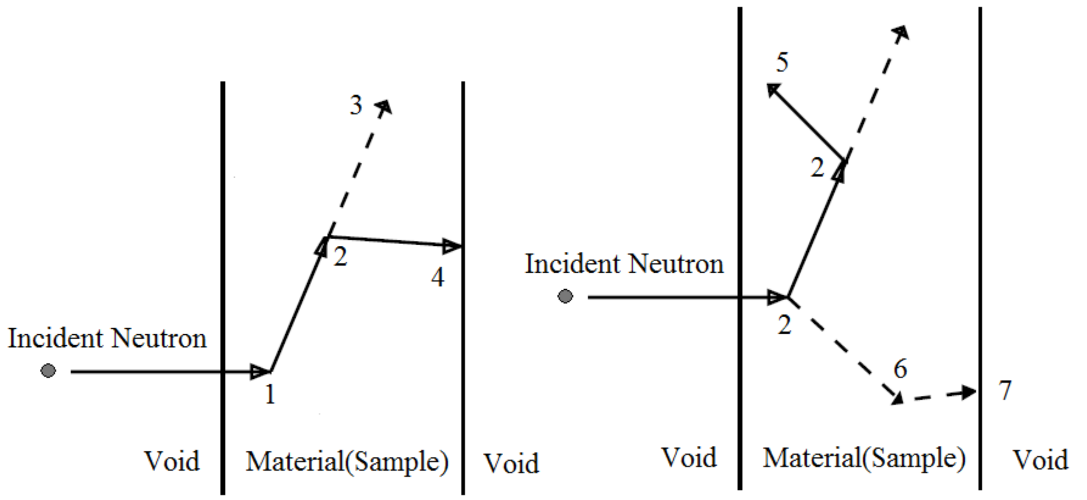

Figure 1. Incident neutrons have several type of reaction as follows
(1). Neutron elastic scattering
(2). Neutron inelastic scattering and photon production
(3). Photon absorption(capture)
(4). Neutron leakage
(5). Neutron capture
(6). Photon scattering
(7). Photon leakage

Ⅲ. Result

The correction factor of the Rhodium sample is shown in Fig. 2. In the thermal energy region, the correction factors were remarkably depend on the incident neutron energy. Furthermore it seems very different correction factor in the large neutron capture resonance and below the resonance. It correspond to the result from Breit-Wigner formular and 1/v thermal neutron capture cross section. However in small and sharp resonances above several neutron energy, the difference is small. It seems constant factor above 1 keV neutron energy because of low neutron capture cross section. From these results we have to consider the neutron capture effects in the thermal energy region and large neutron capture region.

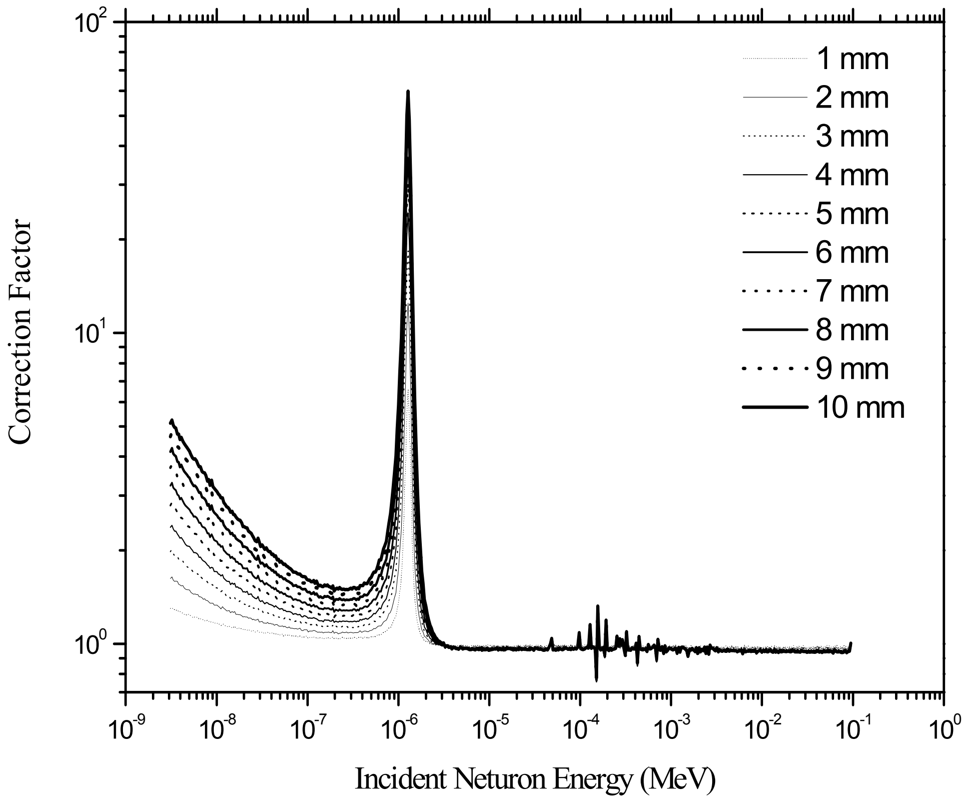

Figure 2. The correction factor of Rhodium sample for several thickness(1～10mm)

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