Monte Carlo Calculation for Landmine Detection using Prompt Gamma Neutron Activation Analysis

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1. Introduction

Identification and demining of landmines are a very important issue for the safety of the people and the economic development. To solve the issue, several methods have been proposed in the past [1, 2]. In Korea, National Fusion Research Institute (NFRI) is developing a landmine detector using prompt gamma neutron activation analysis (PGNAA) as a part of the complex sensor-based landmine detection system. In this paper, the Monte Carlo calculation results for this system are presented.

2. Configuration and Calculation

In this section, a configuration of landmine detector using PGNAA, soil effect on the radiation, and results of Monte Carlo calculation are described.

2.1 Configuration

The landmine detector consists of neutron source, moderator, controller, radiation detector, and signal processor. The neutron source of the landmine detector is the DD neutron generator due to the tritium security, pulse operation, and control of the neutron generation. The moderator for the thermal neutron will be the water or polyethylene. To determine the explosives material in the ground, a high energy gamma of 10.8 MeV will be used to separate the signal from the background. For this, the detector is designed based on a scintillator of BGO crystal and photomultiplier tube. Figure 1 shows the configuration of the landmine detector.

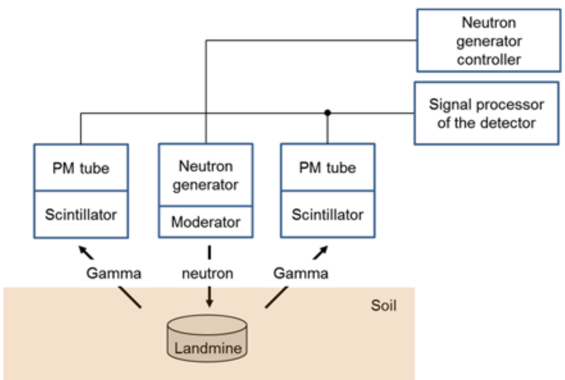

Fig. 1. A configuration of the landmine detection using PGNAA.

2.2 Soil Analysis

In the previous research for identification of explosive material using PGNAA, the effect of soil composition, moisture has been experimentally investigated [5]. And it is significantly affect the detection rate of buried landmines by neutron capture reactions. To consider the effect of Korea soil on the Monte Carlo calculation, average soil composition was analyzed by Korea Testing and Research Institute. Table I shows the result of the soil analysis.

Table I: Average soil composition in Korea

Element	Elemental weight fraction
H	0.015
C	0.038
O	0.4679
Na	0.0134
Mg	0.0023
Al	0.0863
Si	0.3211
K	0.0246
Ca	0.0033
Fe	0.0249
Ti	0.0025
Zn	0.0002
P	0.0003
Mn	0.0002
Density (g/cm3)	1.3896

2.3 Monte Carlo Calculation

The aim of Monte Carlo calculation for landmine detector is the determination of the specifications. The calculation was carried out with the following steps: energy attenuation of the neutron as a function of moderator thickness, the counts of the thermal neutron at the mine top surface, and the counts of the high energy gamma at the detector surface.

Firstly, the energy attenuation of the neutron and the conversion rate from the fast neutron (2.45 MeV) to the thermal neutron (0.025 eV) was calculated as a function of the thickness of moderator. And the counts of the neutron at the top surface of the landmine was calculated as a function of the burial depth of the landmine. In this calculation, input energy of the neutron is changed to maximize the number of the thermal neutron. The Figure 2 shows the calculation results.

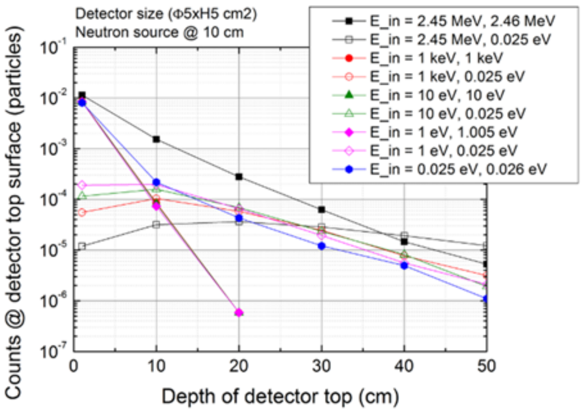

Fig. 2. The counts of the thermal neutron at the mine top surface.

Then, the count of the high energy gamma at the detector surface was calculated as a function of the depth of the source of the high energy gamma as shown in Fig. 3. Through this result, the variation of the signal level as a function of the depth is calculated and the maximum detection depth is estimated.

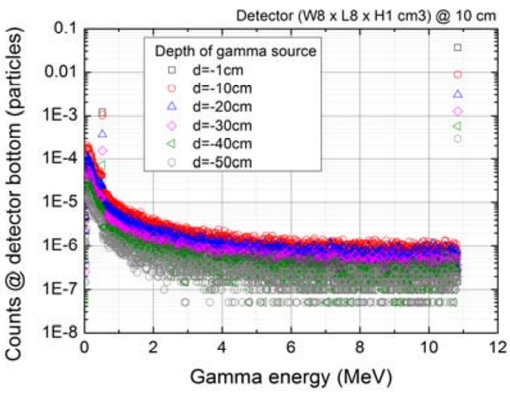

Fig. 3. The count of the high energy gamma at the detector surface.

3. Conclusions

Monte Carlo calculation was carried out for the design of the landmine detector using PGNAA. To consider the soil effect, average soil composition is analyzed and applied to the calculation. This results has been used to determine the specification of the landmine detector.

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