Potentiality of MCNP6 code in studies of neutron activation analysis technique applied on cement

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This report presents a study to evaluate the elemental concentration of Portland cement using the Neutron Activation Analysis (NAA). The determination of the mass fraction concentration of elements that form cement are very useful to ensure the quality control of the construction industry. A mathematical model of the NAA technique was used in this study to evaluate the amount of four major elements (Al, Ca, Fe and Si) in cement by identifying their characteristic gamma rays [1]. A neutron source was used to simulate the activation process using the MCNP6 code [2]. The Activation Control Card, or simply ACT Card is a feature in MCNP6 used to control delayed-gamma or delayed-neutron production. Using a simple geometry, a hollow sphere with a radius of 35 cm and a thickness of 5 cm was constructed as shown in Figure 1. The sphere was filled with air dry and centered at the origin. A 4 MeV neutron source was placed at the center of the sphere. The chemical composition of the sphere was altered, according to the material we wished to evaluate.

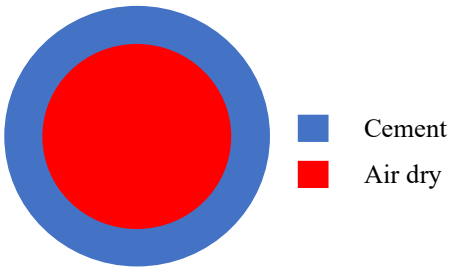

Figure 1. The 2D geometry proposed.

In the MCNP6, the tally card F2 to measure the flux averaged over a surface was used. Chemical composition of the simulated cement is described in Table 1 [3]. The radioisotopes produced due to β^- decay in the NAA and their energies are compared with the results from MCNP6 code. The most important result is to compare the energy with the relative frequency obtained by the MCNP6 code. The delayed gamma-rays spectrum due to decay from nuclear activation reactions generated by the MCNP6 code for the cement material is shown on Figure 2.

Table 1. Chemical compounds of cement.

Compound of Cement (wt %)	
Al_2O_3: 3.772	MnO: 0.127
SiO_2: 14.317	Fe_2O_3: 4.320
SO_3: 3.923	ZnO: 0.052
K_2O: 0.626	SrO: 0.307
CaO: 72.160	TiO_2: 0.324

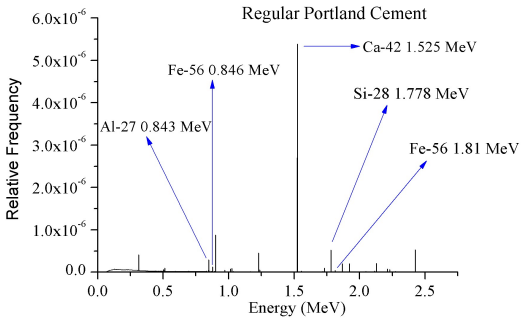

Figure 2. Delayed gamma spectrum generated by the MCNP6 code for cement.

It can observe a huge number of interactions for the ^{42}Ca peak, which is expected from Table 1, since calcium is the major element in Portland cement. Portland cement is rich in tricalcium and dicalcium silicates, which allows to observe the peak for major ^{42}Ca. The results show that the accuracy of the MCNP6 code was evaluated by the spectrum that agrees with the considered (n, p) nuclear reactions for the chemical elements present in the cement sample. A cement sample is being prepared and specified to validate this methodology experimentally using the Argonauta reactor, also considering (n, γ) nuclear reactions.

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