Study on Neutron Shield Concrete and Resin Based on Natural Minerals

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Neutron shielding is very important for construction of neutron facilities. Concrete is usually used for neutron shielding. Although concrete is inexpensive, massive thickness is required. In recent years, there has been a need for a compact shielding design such as self-shielding of PET cyclotron or upgrading of radiation machinery in existing facilities. In these cases, high-performance shielding materials are needed. Concrete or polyethylene has been used for neutron shields. However, for compact shielding, they fall short in terms of performance or durability. Therefore, a new type of neutron-shielding material based on epoxy resin and colemanite has been developed. Slab attenuation experiments up to 40 cm for the new shielding material were carried out using a ^{252}Cf neutron source. Measurement was carried out using a REM counter, and was compared with the calculation. The results show that the shielding performance is better than concrete and polyethylene mixed with 10 wt% boron oxide. From this result, we confirmed that the performance of the new material is suitable for practical use.

A novel neutron-shielding concrete using colemanite rock and peridotite rock was also developed. Its shielding performance was evaluated through transmission experiments using a ^{252}Cf spontaneous fission source and calculations with the MCNP5 code. The results show that a neutron 1/100 attenuation length of the neutron concrete shield with a typical colemanite content of 10 wt% is shorter by a factor of 1.7 than that of normal concrete. The results show that the shielding performance becomes better when the thickness is still thicker and the incident neutron spectrum is softer.

Trace element analysis using instrumental neutron activation analysis for neutron-shielding concrete made from colemanite and peridotite rocks is carried out. Also, an activation estimation for the concrete wall in the accelerator neutron source facility is made using the element data obtained. The results show that the amount of short-half-life nuclide production in the neutron-shielding concrete is 1/100 that of limestone concrete and also that the amount of ^{60}Co production is 1/5 to 1/8 that of limestone concrete. From these results, the activation property of the neutron-shielding concrete was found to be

much lower than that of limestone concrete, which has been previously reported as having low activation.

The main neutron shield for the neutron beam line and neutron spectrometer at the Japan Proton Accelerator Research Complex (J-PARC) consists of multilayers of iron and ordinary concrete or boric acid resin and ordinary concrete. However, the available space inside the shield will become limited since a multilayer shield must have sufficient thickness to guarantee radiation safety outside of the shield. A neutron-shielding concrete was developed and applied to the shield for the TAIKAN neutron-scattering instrument at J-PARC. Neutron transport calculations revealed that the shield's thickness could be reduced to about 70% of that of the original design, which used ordinary concrete. The resulting slim neutron-shielding structure could leave more space in the interior shielded areas.

［出典］奥野功一：天然岩石を用いたコンクリート系及び樹脂系中性子遮蔽材料に関する研究，北海道大学大学院工学院学位論文，2013.3