Investigation of the Properties of Aluminum Tube used in Thailand Research Reactor TRR-1/M1

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Thailand research reactor, TRR-1/M1, is a TRIGA Mark-III nuclear research reactor using UZrH fuels with 20% U-235 enrichment. The reactor operated approximately at 1,200 kWth, which produced neutrons maximum flux of $8 \times 10^{13}$ neutrons-cm$^{-2}$ per second and maximum temperature of 600°C at the hottest spot in the core. Exposure to such high neutron flux and temperature can cause property degradation to the core structural materials. In addition, corrosion is one of major degradation mechanisms for the pooled-type reactor. This paper presents the material degradation analyses of an aluminum (Al6061) tube for neutron irradiation that was detached from the TRR-1/M1 reactor core. The analyses consisted of oxide characterization and radiation hardening measurement. The oxide characterization was done using XRD grazing angle technique for phase identification, and SEM for surface morphology and cross-section investigation. The radiation hardening was evaluated through Vicker-hardness measurement. Preliminary results showed that oxide on the aluminum tube consisted of two layers. Oxide thicknesses on outer side were larger than those of inner side of the tube. Major oxides are Bayerite ($\text{Al(OH)}_3$), Gibbsite ($\text{Al}_2\text{O}_3\cdot3\text{H}_2\text{O}$) and Quartz ($\text{SiO}_2$). The results revealed that the neutron-captured reaction of Al produced Si. The formation of Si can cause changes in material properties from loss of Al content in bulk material, and by Si precipitation. Therefore the material would degrade after service in the reactor core. Results from the hardness test will be compared with the pre-limitary assessment of the radiation effects by Kinchen-Pease Model. Overall outcome of the study will explain the major degradation mechanisms of the structural materials in the TRR-1/M1, which will lead to suggestions on operation and maintenance for safe operation of the reactor.

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