§10. Irradiation Effect of 14 MeV Neutron on Interlaminar Shear Strength of Glass Fiber Reinforced Plastics

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Intense neutron streaming from ports for neutral beam injectors is clarified by design activities for fusion reactors. Also, there is some neutron penetration through blankets, though blankets can reduce the fast neutron by the order of 10^{-5} or 10^{-6} n/m². The streaming and penetration is very wide and 14 MeV neutron and gamma ray are the typical radiations. Epoxy resin type glass fiber reinforced plastics (GFRP) is used in a superconducting magnet system as an electric insulation material and a support structure. In this report, effects of 14 MeV neutron and gamma ray irradiation on interlaminar shear strength (ILSS) and fracture mode are investigated using G-10CR. A short beam test under three point bending was conducted at RT and 77 K.

The cryogenic target system for neutron irradiation was installed at Fusion Neutronics Sources (FNS) in Japan Atomic Energy Agency (JAEA). The small size specimens, which size was 2.5 mm thick, 10 mm wide and 15 mm long, were attached on the cryostat cap shown in Fig. 1. In the irradiation test, hall elements and superconducting wires were arranged at the same time. Neutron fluence of 3.91×10^{19} n/m² was irradiated. The irradiation test of gamma ray was carried out at Osaka University using Co⁶⁰ and up to 1 MGy of gamma ray was irradiated.

Two G-10CR plates were prepared. One is 2.5 mm thick plate and the specimen had original plate thickness. The other is 13 mm thick plate and the plate was sliced into two thinner plates of about 5 mm thick and 2.5 mm thick samples were machined out of these thinner plates.

After the irradiation, specimens were tested by three-point bending in air and in liquid nitrogen and the maximum bending load was recorded. The ILSS was obtained by the following equation:

$$\sigma_{ILSS} = (3 \times P_B) / (4 \times b \times h),$$

where P_B is the maximum bending load, b is specimen width (10 mm) and h is specimen thickness (2.5 mm).

Figure2 shows the ILSS test results after neutron irradiation. As far as the test results obtained here, there is no clear difference in the ILSS at RT and 77K. There is a report showing that neutron fluence of about 10^{21} n/m² is corresponding to 1 MGy gamma ray irradiation. Neutron fluence of less than 10^{20} n/m² would be too small irradiation to cause some degradation of strength.

Figure3 shows the effect of gamma ray on the ILSS. The results tested at 77 K present the degradation of the ILSS after 1 MGy radiation, and RT tests did not show such degradation because of the lower ILSS. Radiation of 10 MGy made the samples useless with delamination.

Most of the specimens showed both of interlaminar cracking and bending fracture, but some specimens were fractured with translaminar fracture which was the irregular shear occurred on the planes connecting the loading point and the supporting points. The translaminar shear fracture

Fig. 1 Set up of cryogenic target with arrangement of GFRPs and other samples in RT space. (June 20, 2005)

Fig. 2. Relation between interlaminar shear strength and 14 MeV neutron fluence.

Fig. 3 Relation between interlaminar shear strength and gamma ray dose.

would be caused by special stress distribution formed in the sample by irregular restraint at the loading and the supporting points.