§13. Fabrication of Electric Insulation Materials with Good Property against Neutron Irradiation

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An electric insulation material is very important for a large scale superconducting magnet with high break down voltage. Especially, under neutron and gamma ray irradiation environment, the degradation of the insulation ability must be investigated and piled up into database. Around twenty years ago, a small company in USA proposed to cyanate ester resin instead of epoxy resin to glass fiber reinforced plastics (GFRP). The researchers at Atomic Institute of the Austrian Universities in Vienna, Austria, have investigated the irradiation properties of cyanate ester GFRP using TRIGA fission reactor and the excellent property has been clarified. They reported that blended cyanate ester resin with epoxy resin also shows good property against neutron irradiation in the fission reactor.

In Japan, the cyanate ester resin is not popular for the insulation material of large scale superconducting magnet and the treatment of the resin is not clear even in research institute. Under the collaboration with Japan Atomic Energy Agency (JAEA), Universities and National institutes, the trial fabrication of the cyanate ester GFRP started. Since Toshiba began to deal with the cyanate ester resin GFRP, the polyimide film and glass cloth were supplied by JAEA through Toshiba.

A stainless steel mold of GFRP was machined with two shallow grooves of 80 mm wide, 120 mm long and 2.5 mm deep. The polyimide film and the glass cloth were cut into 77 mm wide and 120 mm long and the lamination was performed alternately as show in Fig. 1. 11 sheets of glass clothes and 10 sheets of polyimide films were used for one GFRP plate. The polyimide film was corona-discharged treated.

After the lamination, the cover plate was bolted and put in a box made of Teflon sheet. The mold was set vertically so that the resin goes up from the bottom to the top. The box was put in a vacuum device with a resin tank. The mold jig and resin box were heated up and kept at 50 degree C and the inside of the vacuum device was evacuated by a rotary pump. Then the resin was gradually transferred into the box with some transferring breaks to fill the clothes with resin. After the vacuum impregnation, the box was put in a drying machine with a fun and curing was performed.

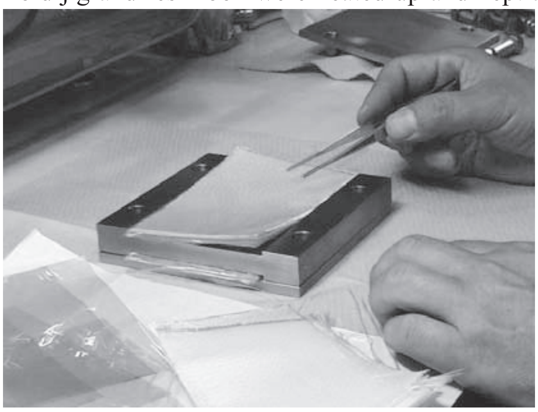

Fig. 1. Laminate process of polyimide film and glass cloth in the mold jig.

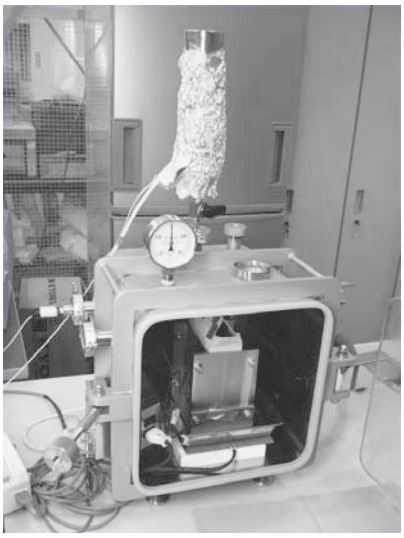

Fig. 2. Vacuum impregnation equipment.

The cyanate ester resin used was CTD403 and the epoxy resin was Epikote 828. The hardener for Epikote 828 was D230 (JEFFAMINER).

The external appearances after the neutron irradiation of 1 x 10^{22} n/m^2 at JRR-3 are shown in Fig. 3 (Epoxy resin GFRP) and Fig. 4 (Cyanate ester resin GFRP). In case of Epoxy resin GFRP, the swelling occurred and thickness increased to about 4 mm from 2.5 mm of original. The cyanate ester resin GFRP did not change the shape and showed good stability against neutron irradiation.

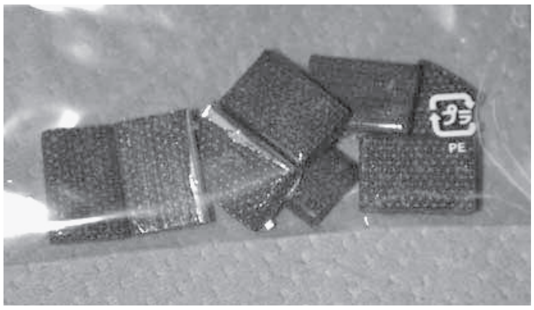

Fig. 3. Epoxy resin GFRP after neutron irradiation of 1 x 10^{22} n/m^2.

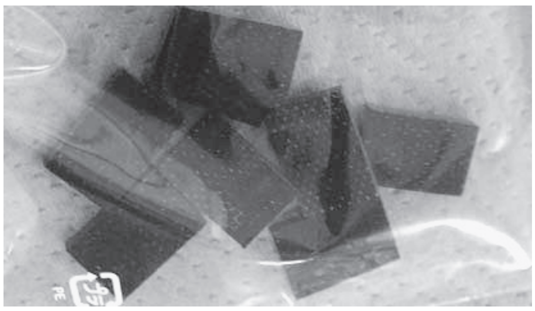

Fig. 4. Cyanate ester resin GFRP after neutron irradiation of 1 x 10^{22} n/m^2.