NEUTRON IRRADIATION EFFECT ON INTERLAMINAR SHEAR STRENGTH OF INSULATION MATERIALS WITH CYANATE ESTER - EPOXY BLENDED RESIN

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New large scale plasma devices will create D-D and D-T burning plasmas and generate lots of high energy neutrons. Some neutrons will stream out of large ports and penetrate through blanket and plasma vacuum vessel, and finally they will reach the superconducting magnets. Organic insulation materials are very popular and the insulation technology has been established during the fabrication of many superconducting and normal conducting magnets. Since breakdown must be prevented, the high performance organic insulation materials must be applied with excellent technology against neutron irradiation. Traditionally, an epoxy resin system has been used for the matrix resin of glass fiber reinforced plastics. However, the epoxy system does not have enough resistance against neutron, so a cyanate ester resin system and the blended system with epoxy resin has been proposed to apply to the fusion magnet system will be operated in neutron exposure environment.

The first trial to fabricate cyanate ester and epoxy blended resin and the insulation materials with polyimide film and glass cloth was performed in Toshiba and National Institute for Fusion Science in Japan. After machining the test specimens from the vacuum impregnated plates, the specimens were irradiated with fast neutrons of over 0.1 MeV up to 10^{22} n/m^2 at fission reactor (JRR-3) in Japan Atomic Energy Agency. The irradiated samples were tested at Oarai center of Tohoku University and the interlaminar shear strength (ILSS) was evaluated at RT and 77 K.

On the second trial fabrication, the blend ratio of cyanate ester to epoxy was varied at 2:8, 3:7 and 4:6. The small number shows the weight fraction of the cyanate ester. The cyanate ester forms a triazine ring when the cure treatment is carried out at over 200 degree C and the cyanate ester and the epoxy will cyclize and form oxazoline ring when the epoxy resin is added. Since the cure treatment was performed at 150 degree C in this study, an imperfect reaction would occur and some imperfect triazine rings and imperfect oxazoline rings would be performed together with epoxy polymers. The glass transition temperatures (Tg) of the fabricated insulation materials were measured by deferential scanning calorimetry and it was clarified that Tg increased with an increase of the amount of cyanate ester. Also, the ILSS of these insulation materials were evaluated after neutron irradiation of up to 10^{22} n/m^2 and a gamma ray irradiation of up to 10 MGy.

Based on these results, the molecular structure of the blended resin system will be discussed. The ILSS of irradiated insulation materials will be presented and the degradation mechanism will be discussed.