Contribution ID: **148** Type: **Invited Oral**

M3Or1B-01: [Invited] Study on Irradiation Effect of Insulating Materials for Fusion Superconducting Magnets: Temperature Dependence of Mechanical Strength

Wednesday 12 July 2023 09:30 (20 minutes)

1. Introduction
   Insulating materials used in superconducting magnets for fusion reactors are exposed to radiation at the cryogenic temperature of liquid helium temperature. ITER, an experimental nuclear fusion reactor, uses glass fiber reinforced plastic (GFRP), which is a 3:2 mixture of epoxy resin (EP) and cyanate ester (CE) (40 wt.% in CE content) with excellent radiation resistance, as an insulating material that can maintain mechanical strength and insulation performance under such an environment. However, this composition was determined through strength tests at room temperature and liquid nitrogen temperature. In this study, four types of insulating materials with different resin compositions were prepared, and the interlaminar shear strength (ILSS) was measured at room temperature, liquid nitrogen temperature, and liquid helium temperature before and after γ-ray irradiation to evaluate the effect of resin composition on the absorbed dose dependence and temperature dependence of ILSS, in order to determine the optimal resin composition in consideration of mechanical strength at liquid helium temperature.
2. Experimental methods
   Four types of GFRP were prepared by vacuum-impregnating a mixture of EP and CE resins with CE content of 0, 20, 40, and 60 wt.%, and then heating and curing the laminated glass cloth. For resins with 0 wt.% CE, polyetheramine was used as the curing agent. These GFRPs were fabricated into the double-notched shapes, and then irradiated with 60Co γ-rays at room temperature and in the air atmosphere, and then subjected to ILSS test at room temperature, liquid nitrogen temperature, and liquid helium temperature.
3. Results and discussion
   Regarding the absorbed dose dependence, the ILSS of GFRP with 0 wt% CE decreased by γ-ray irradiation, but the ILSS of GFRP with more than 20 wt% CE did not decrease after irradiation. This indicates that the addition of CE enhances radiation resistance. As for the temperature dependence, the ILSS of irradiated GFRP with 0 wt% CE increased with decreasing temperature, whereas the ILSS of GFRP with 20 wt% CE increased with decreasing temperature from room temperature to liquid nitrogen temperature, whereas decreased when cooled to liquid helium temperature. This is considered to be due to the formation of a rigid molecular structure in the resin by the addition of CE, which leads to embrittlement at cryogenic temperatures.
4. Conclusion
   The temperature dependence of ILSS of specimens after room temperature irradiation was found to be different between EP without CE and those with CE. It was also found that the temperature dependence was changed with the CE content. In order to clarify the optimal composition for practical use, it is necessary to examine the effects of low-temperature irradiation and temperature history in the future.

Acknowledgments: This study was supported by QST Research Collaboration for Fusion DEMO, and the NIFS Collaboration Research Program (NIFS22KIEA006) of the National Institute for Fusion Science. Materials for testing were provided by Arisawa Manufacturing Co., Ltd, Shouritu Kogyo Co., Ltd., and Risho Kogyo Co., Ltd.

Keywords: insulating materials, γ-ray, glass fiber reinforced plastic (GFRP), interlaminar shear strength (ILSS), liquid helium temperature, cyanate ester, embrittlement

Author: AKIYAMA, Yoko (Osaka University)

Co-authors: Mr OHTA, Asato (Osaka University); Dr MANABE, Yuichiro (Osaka University); Prof. SATO, Fuminobu (Osaka University); Dr IWAMOTO, Akifumi (National Institute for Fusion Science); IMAGAWA, Shinsaku (National Institute for Fusion Science); UTOH, Hiroyasu (National Institute for Quantum Science and Technology); Dr SAKAMOTO, Yoshiteru (National Institute for Quantum Science and Technology); Prof. NISHIJIMA, Shigehiro (Fukui University of Technology)

Presenter: AKIYAMA, Yoko (Osaka University)

Session Classification: M3Or1B: Thermal, Electrical and Magnetic Properties, Radiation, and Degradation