§23. Development of Non-Metalic Insulator for Superconducting Magnet of LHD

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Introduction

Glass fiber reinforced plastic(GFRP) have been applied for the insulation of LHD superconducting magnet as an insulating spacer.The spacer is ought to show high modulus, high strength to compression and low thermal contraction in the laminated direction. To achieve these properties in GFRP, high density GFRP laminates were newly developed and the laminate properties were examined at cryogenic temperatures.

In this year, the mechanical properties of the GFRP provided for the practical use, that is, the interlaminar shear strength (ILSS) are tested and the resulte are reported.

ILSS

Such properties required for insulators of LHD as low thermal contraction and high modulus were confirmed to be obtained by increasing glass content of GFRP. The ILSS, ie. one of the primary mechanical properties of GFRP is measured in this work. The ILSS is the strength which resists to the relative displacement between the laminates yielded by shear stress. Bending stress on the laminate also produces such shear displacement in GFRP.

As the adhesive strength of resin controles the interlaminar strength, high glass content of GFRP might reduce the ILSS. Macroscopic mechanical strength of GFRP has been reported to be decreased with the decrease of the ILSS when the GFRP is irradiated.

Experiments and results

Samples are high density glass cloth reinforced composites in which the glass content of plain fabric cloth is 71.5 vol %. The specimens for the shear test are cut to the shape of 5x5x40 mm^3 (thickness x wideness x length) from the plate sample. The testing method of ILSS was the short beam shear method.

The test results of the ILSS for high density laminates at room temperature (RT) and at liquid nitrogen temperature (LNT) are shown in Fig. 1. The test results for usual GFRP, ie. G11 and G10 are also included in the figure. The strength for the developed high density GFRP shows almost the same values as those of G11 and G10 at RT and some higher values at LNT than those of G11 and G10. This result indicates that the increment of glass content in GFRP produces no degradation of the ILSS in the laminates.

The degradation behavior of ILSS induced by electron beam irradiation of LINAC (20MeV) is shown in Fig. 2. The specimens were irradiated in liquid nitrogen and after that they were warmed up to RT. The shearing test is performed in liquid nitrogen. The decrease of 40 % strength is observed at 30 Mrad irradiation. Considering the LHD irradiation condition, the degradation of ILSS for the GFRP is proved to be small.

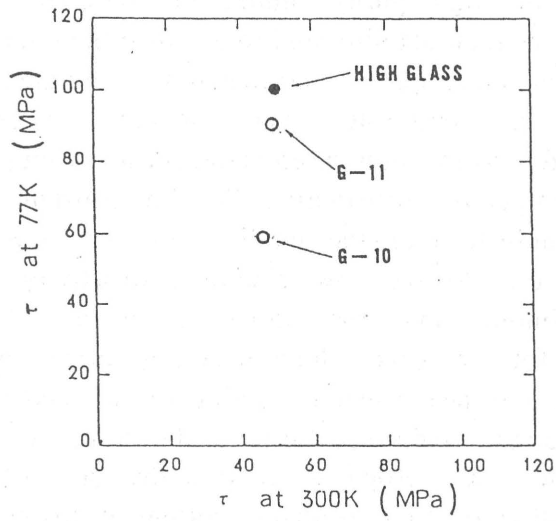

Fig. 1. Comparison of ILSS between the developed GFRP and the usual ones.

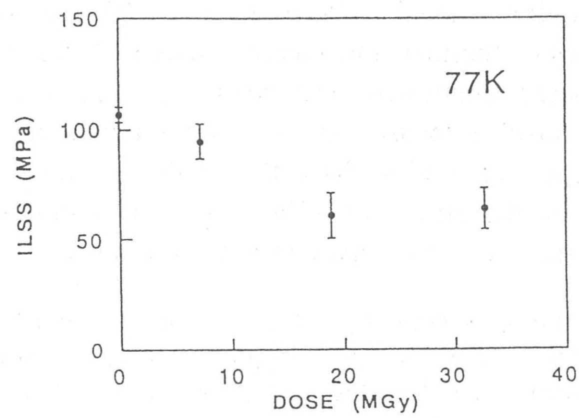

Fig. 2. The degradation of ILSS of the developed GFRP.