§33. Cryomechanics of Electromagnetic Materials for Superconducting Magnets

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i) Mechanical Behavior of Woven Glass-Epoxy Laminates

(a) We discuss the low temperature interlaminar shear behavior of G-10CR glass-epoxy laminates. Interlaminar shear tests were carried out with guillotine shear specimens at room temperature and 77K. The effects of temperature, notch separation S and specimen thickness T on the interlaminar shear strength (ILSS) are demonstrated. Fig. 1 shows the influence of notch separation variations for varying specimen thickness on ILSS values at room temperature and 77K. At room temperature, ILSS is independent of notch separation and specimen thickness. However, ILSS at 77K increases with increasing specimen thickness, and decreases with increasing notch separation.

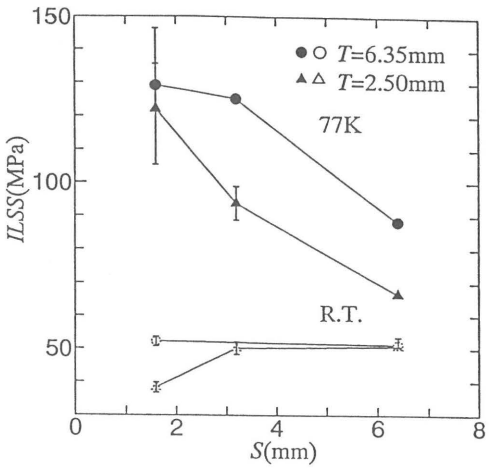

Fig. 1. Variation of ILSS with distance between grooves.

(b) We study the nonlinear fracture behavior of G-10 woven glass-epoxy laminates. Elastic-plastic fracture toughness (J_{IC}) tests were performed with compact tension specimens (width to thickness ratio W/B=2.5) at 77K. The effect of individual damage events on the determination of J-integral resistance curves and J_Q values is discussed. The method proposed dose not allow a determination of fracture toughness J_{IC} for G-10. The results presented here indicate that the damage zone created in the notch tip, analogous to the plastic zone that exists in the case of metallic materials, represent an appreciable error in the physical measurement of crack extension value.

ii) Fracture Toughness Evaluation of SUS316 Type Austenitic Stainless Steel Electron-Beam Weld at 4K

We evaluate the fracture toughness of SUS316 type austenitic stainless steel electron-beam weld for the helical coils in the Large Helical Device at 4K. Elastic-plastic fracture toughness tests were performed with 12.5-mm-thick compact tension specimens in liquid helium. The SUS316 type stainless steel weld was tested and analyzed at three locations through the depth of a 75-mm-thick welding. The effect of specimen location on the fracture toughness parameter is investigated. Fracture surfaces are also examined by a optical microscope and a SEM to verify the failure mechanisms. The crack fronts were found to be somewhat irregular and bordered on unacceptability, according to the criteria established by ASTM E813-89. The J_Q values for the center specimen and the bottom specimen are 285.1kJ/m^2 and 280.1kJ/m^2, respectively. The J_Q value for the top specimen is however lower(192.8kJ/m^2).

iii) Mechanical Behavior of Structural Materials in a Strong Magnetic Field

We discuss the effect of magnetic field on the fracture behavior of a cracked soft ferromagnetic beam plate. The fixed-end beam plate of length l and thickness $2h$ containing a single edge crack or two symmetric edge cracks of length $2a$ is bent by a normal point force at the center of the plate and is permeated by a static uniform magnetic field normal to the plate surface. The experiments show the predicted increase in the moment intensity factor with increasing magnetic field. The effect of the magnetic field on the moment intensity factor is more pronounced with increasing the ratio a/h.