§32. Cryomechanics of Electromagnetic Materials for Superconducting Magnets

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i) Mechanical Behavior of the conduit of Superconductor for the Poloidal Coils

On the development of the superconducting poloidal coil, it is important to examine the mechanical behavior of the conduit of cable-in-conduit conductor. Compression tests were performed using 15mm and 20mm length SUS316L conduits at room temperature. Finite element method is used for the numerical analysis of the conduit. The numerical results of displacements and strains are obtained and compared with the experimental results. Fig. 1 shows the compressive load versus displacement for the SUS316L conduit at room temperature.

![Fig. 1. Compressive load versus displacement for SUS316L conduit (3D analysis).](image)

ii) Cryomechanics of G-10 Woven Glass-Epoxy Laminates at Low Temperatures

Design and development of superconducting magnets require basic research on cryogenic fracture mechanics. Nonmetallic woven composites are used as structural support, and electrical and thermal insulations in superconducting magnets at low temperatures. We discuss the cryomechanics of G-10 woven glass-epoxy laminates \(^1\). Plane-strain fracture toughness testing was carried out with compact specimens (width to thickness ratio \(W/B=2.5\)) at room temperature, 77K and 4.2K to evaluate the fracture toughness and the temperature rise of G-10 woven glass-epoxy laminates. Au-Chromel thermocouples were used to measure the temperature rise. Testing was conducted in accordance with ASTM standards E399. The influence of the crack length and loading rate on the low temperature fracture behavior is shown graphically. The temperature rise near the crack tip is correlated with the amount of crack extension and loading rate. SEM fractograph shows the complicated structure of the damage zone near the crack tip (broken and delamination fibers, fiber pull-out, broken epoxy resin).

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

We discuss the deflection of a soft ferromagnetic beam plate under a uniform magnetic field \(^2\). The cantilevered plate of length \(l\) and thickness \(2h\) is bent by a normal point force at the end and is permeated by a static uniform magnetic field normal to the plate surface. Numerical calculations are carried out and the deflection is obtained for several values of magnetic field and geometrical parameter. The experiments show the predicted increase in the deflection with increasing magnetic field. The effect of the magnetic field on the deflection is more pronounced with increasing the ratio \(l/2h\). A comparison of the deflection is made between theory and experiment and the agreement is good for the magnetic field considered.

References