§23. Cryomechanics of Electromagnetic Materials for Superconducting Magnets

Shindo, Y., Horiguchi, K., Takagi, Y., Kobori, T.
(Dept. of Mater. Processing, Tohoku Univ.)
Ueda, S. (Dept. of Technology, Shizuoka Univ.)
Yamamoto, J., Nishimura, A., Tamura, H.

i) Mechanical Behavior of Superconductig Coils

On the development of the superconducting helical coil, it is important to examine the mechanical behavior of the coil and the evaluation of the coil rigidity at liquid helium temperature. The helical coils in the Large Helical Device are subjected to high electromagnetic force of about 10MN/m. First, we consider the mechanical behavior and the compressive rigidity of the superconducting helical coil pack under compressive load at liquid helium temperature [1]. Finite element method is used for the numerical analysis of the composite structure of the coil pack. 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 superconducting helical coil pack.

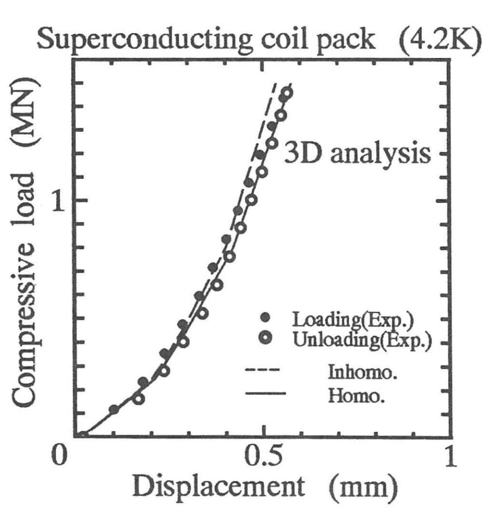

Fig. 1. Compressive load versus displacement for superconducting helical coil pack (3D analysis).

The superconducting poloidal coils are subjected to the compressive stress of about 20 ~ 35MPa. Next, we also consider the displacement and strain analysis of the superconducting poloidal coil pack under compressive load at liquid helium temperature [2]. The validity of numerical techniques for evaluating the rigidity of the coil pack is examined.

ii) Dissipated Energy and Low Temperature Fracture in Cracked Glass-Epoxy Composite Materials

In order to evaluate the dissipated energy and the low temperature fracture of glass-epoxy composite materials, which are used in magnetic fusion energy structures as thermal insulation, electrical insulation and structural support at low temperatures, we performed fracture toughness testing at 77K and 4.2K. We use 0.4T compact test specimens for the test. Testing was conducted in accordance with ASTM standerd E399-83. The effect of the crack length and the loading rate on the dissipated energy and the fracture toughness is examined.

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

We present experimental evidence and theoretical analysis for the bending of a soft ferromagnetic beam plate in a strong magnetic field. The experiments were conducted in the bore of a superconducting magnet at room temperature. Ferritic stainless steel SUS430 is here used as the contilever specimen for the bending test. The experiments show the predicted increase in the deflection with increasing magnetic field. The theoretical analysis is based on a classical plate bending theory for magneto-elastic interactions in a soft ferromagnetic bodies. The effect of the magnetic field on the deflection is discussed in detailed. The theoretical results agree very well with the experimental data.

References

1) Shindo, Y. et al. : Cryogenic Engineering 29(1994) 58.
2) Shindo, Y. et al. : Cryogenic Engineering (in press).