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Investigation of the influence of residual strain of epoxy resin on critical current of HTS tape by using fiber Bragg grating sensors

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Epoxy resin is used to improve the mechanical properties, insulation properties and thermal conductivity of superconducting magnets. The second-generation high temperature superconducting (HTS) tapes have significant mechanical strength anisotropy due to their multi-layer structure. In the cooling process, stress concentration occurs between the layers due to the different cooling shrinkage rate of each layer of materials, and the cooling shrinkage of epoxy resin is much larger than that of the HTS tape, making this situation more serious, resulting in strong stress on the conductor. It may cause the crack, spalling, or even fracture of the superconducting layer, and then result in the decline of the critical current. Therefore, it is necessary to study the influence of the curing residual strain of the epoxy resin and of the cooling shrinkage on the attenuation of the electrical properties of the HTS tape, so as to avoid the performance degradation of superconducting magnets to a certain extent. In the present work, the fiber Bragg grating (FBG) sensors were used to monitor the strain of the YBCO tape during curing and cooling process, and the critical current before and after the epoxy resin curing was measured. It was found that brought about 12,000 με strain to the tape upon the pure epoxy resin cured and cooled to 77 K, whereas the critical current was reduced by about 5 A. In addition, we studied the impregnation of epoxy resin with glass fiber cloth on the tape, and found that the residual strain was greatly reduced to less than 3000 με, and the critical current did not degrade at all. In this way, by embedding the FBG sensors, the degradation of the critical current can be corresponded to the curing and cooling process, which further guides the performance improvement of the epoxy resin and curing process.

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