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STABILITY ANALYSIS OF HIGH TEMPERATURE SUPERCONDUCTING ENERGY STORAGE MAGNET BASED ON MULTI-PHYSICAL FIELDS COUPLING

Abstract

With the discovery and application of YBCO, the second generation (2G) high temperature superconducting (HTS) material, superconducting technology and modern power technology have been combined to produce advanced power equipment such as cables, transformers, and energy storage magnets. Compared with other conventional energy storage devices, it has obvious advantages in terms of power density, energy conversion efficiency, and response speed. Due to the high current carrying capacity of the superconducting tapes, the energy storage magnet is subject to greater stress and the temperature rise may also cause quench of superconducting tapes, so the stability is a major consideration in the design of HTS energy storage magnets. In this study to avoid the circular dependency of the resistivity and current density, The *E-J* power-law relation is described by the relationship between the resistivity and the electric field strength, and the AC loss and electromagnetic and thermal stress are analyzed in 3D model of superconducting coil. The results show the maximum electromagnetic stress is 3.95×10^4Pa and the stress causes the stretching of superconducting coil. After impregnating the epoxy resin, the maximum stress of superconducting tape is 2.16×10^4Pa. Combined with the stress value and distribution of superconducting tape, it can be seen that the impregnated epoxy resin can effectively reduce the electromagnetic stress on the superconducting tape. In this study we combined with electromagnetic theory, solid heat transfer theory and thermal expansion theory to analyze the thermal stress caused by the AC loss of superconducting coil. The results show the AC loss at the middle of the superconducting coil is greater than the both sides of the superconducting coil, and the maximum AC loss density is $5.96 \times 10^5 \mathrm{W/m^3}$; the maximum thermal stress lied at the inner radius of the coil and the maximum thermal stress is 0.01 MPa. Non-uniformity in thermal stress and strain distribution caused by AC loss may result the separation of superconducting coils and insulating epoxy layers. This work can help to design and operate stability of HTS energy storage magnets.