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Research on the dynamic multi-heat load coupling calculation method for fusion superconducting magnets

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The superconducting magnet system is a key component of the tokamak fusion reactor for confining high-temperature plasma. High-temperature superconducting magnets are favored by various countries due to their larger critical temperature and critical magnetic field. When high-temperature superconducting magnets are applied to fusion devices, they will be subject to various steady-state and transient thermal disturbances, which will lead to the degradation of their critical performance. Based on a compact tokamak device currently being designed in China, we have conducted research on the impact of transient thermal disturbances, including AC loss, nuclear heat, and coil case conduction heat, on the temperature margin of the superconducting magnet system. For AC loss, we considered coupling loss and hysteresis loss, and calculated their time distribution and spatial distribution using empirical formulas. For nuclear heat, we established a detailed winding pack neutronics model and evaluated the spatial distribution of the nuclear heat power of each component based on the Monte Carlo method. For coil case conduction heat, we used a quasi-three-dimensional method and analyzed it using thermal-hydraulic software. Furthermore, based on the cooling circuit design, we developed a multi-heat load time-space coupling loading program to realize dynamic thermal load coupling analysis of fusion superconducting magnets, and finally completed the temperature margin analysis of the toroidal field superconducting magnet and the poloidal field superconducting magnet.

Topic

Innovative methods and tools for modelling large-scale HTS systems

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