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Strain response of superconducting magnets during excitation and quench training based on FBG and cryogenic strain gauge measurements

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ABSTRACT: The mechanical characteristics and behaviors of two superconducting magnets with different low temperature superconducting materials and configurations during excitation and quench training processes are investigated experimentally and numerically in the present work. One is a racetrack magnet made of NbTi/Cu with the maximum magnetic field of 4 T. Another is hybrid superconducting magnet with field up to 10.5 T, which is fabricated with Nb₃Sn/Cu and NbTi/Cu concentric solenoids. Since the high field in the superconducting magnets provides a huge Lorentz forces, the maximum stress in the coils is significant even up to 180 MPa. To measure the stress-strain responds in the two SC magnets, a serial of Fiber Bragg Grating (FBG) sensors and cryogenic strain gauges (CSG) are utilized and attached onto the NbTi/Cu racetrack magnet and Nb₃Sn/Cu solenoid. It is found that both the FBG and CSG can record the strain responds for the SC magnets during excitation and quench training processes with high precise and repeatability. Compared to the CSG with compensation bridge, the FBG exhibit more attractions like smaller size, immunity to electromagnetic interferences, non circuits compensation and sensing performance of internal strain. We further analyze the electromagnetic and deformation fields in the two SC magnets based on FEM to show good predictions on their multi-field behaviors in comparison with the measurements.

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