Contribution ID: **711** Type: **Poster**

Sat-Mo-Po.05-04: Precise solder shunt area control for improved quench protection in HTS magnets

Saturday 5 July 2025 09:30 (1h 45m)

High-temperature superconducting (HTS) magnets are essential for advanced applications such as particle accelerators and fusion reactors, requiring effective quench management to ensure safety and performance. No-insulation (NI) coils, which allow current to move between turns during quench events, are commonly used in HTS magnet design. However, the contact conditions between turns in NI coils need further study, especially when combined with other insulation methods like metal insulation. This research presents a soldered surface shunt method that precisely controls the solder shunt height within 200 μm, enabling better tuning of contact resistance and charging delay. We fabricated two 50-turn coils with a 50 mm inner diameter using 4 mm-wide Shanghai Superconductor tape. One coil was co-wound with Kapton tape as insulation (INS), and the other was wound without insulation (NI). The soldered surface shunt was applied to different portions of the coil's top surface (12.5%, 25%, 50%, 75%, and 100% for INS; 33%, 66%, and 100% for NI) using a controlled soldering process. Experiments were conducted in liquid nitrogen at 77 K. Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) were used to analyze the solder interfaces. Additionally, a localized heater structure was integrated to induce controlled quenches in specific coil areas. Results showed that increasing the soldered area reduced contact resistance by up to one order of magnitude and increased time constants by two orders of magnitude, enhancing quench stability. The critical current increased by about 9% for NI coils and 10% for INS coils with larger solder areas. The soldered shunt method remained stable over 50 thermal cycles, demonstrating its reliability. Furthermore, resistance estimation models based on SEM and EDS data confirmed the relationship between soldered area and time constant. This study could contribute to future designs of HTS magnets using the solder shunt method.
Keywords: HTS magnets, Contact resistance, Insulation techniques, Thermal stability
Funding: This work was supported in part by the National Natural Science Foundation of China (NSFC) under Grant 52277026, in part by the Strategic Priority Research Program of Chinese Academy of Sciences under Grant XDB25000000.

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Session Classification: Sat-Mo-Po.05 - Quench Detection and Protection IV