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Wed-Af-Po.04-04: Thermal and soldering effects on REBCO HTS tapes: optimizing joint reliability for high-field magnets

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High-Temperature Superconducting (HTS) magnets, composed of multiple pancake coils made from Second Generation (2G) HTS tapes, offer significant advantages due to their superior performance in elevated magnetic fields and temperatures compared to traditional low-temperature superconductors. A critical aspect of manufacturing these magnets is creating reliable joints, which transfer current between pancake coils and connect short tape lengths. The quality of these joints directly influences the magnet's overall performance and operational stability. Among the various joint techniques, non-superconducting soldered joints are considered the most cost-effective and practical. However, thorough testing is essential to ensure these joints do not compromise the superconducting properties of the tapes due to heat and solder application.

This study introduces a comprehensive approach to test and characterize HTS tapes for better joint reliability in magnet applications. The samples were subjected to controlled heating at temperatures ranging from 170 ℃ to 250 ℃ for varying durations. This step aimed to simulate the thermal exposure typically encountered during soldering processes and magnet operations. Another set of samples underwent pre-tinning with Sn60Pb40 solder at selected temperatures. This process involved applying melted solder to the tape to evaluate its impact on the tape's surface and overall superconducting quality. After each treatment (heating or pre-tinning), critical current measurements were conducted at 77 K (self-field). This approach allowed us to isolate the effects of direct heat exposure from the impact of melted solder on the tape surface, offering a deeper understanding of how different thermal processes influence the tape's integrity. Notably, critical current degradation following pre-tinning could be attributed to the delamination of the tape's top layer, driven by thermal-induced contraction.

Practical challenges in joint preparation, such as repetitive heating during soldering, were simulated to assess potential damage under realistic conditions. Statistical reliability was ensured by testing a large number of samples under identical conditions, allowing us to identify consistent trends across multiple datasets.

The Rare-Earth Barium Copper Oxide (REBCO) tapes tested were sourced from world-leading manufacturers. Variations between tapes from different manufacturers and batches are currently being analyzed. These outcomes are expected to provide insights into acceptable thermal limits for soldering without compromising superconducting integrity. The obtained parameters will be crucial into optimizing HTS magnet coil design for tapes from different manufacturers, ensuring enhanced reliability and performance.

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