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Mon-Af-Po1.15-07 [39]: Numerical investigation on the thermo-electro-mechanical behavior of HTS tapes

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High temperature superconducting (HTS) materials are nowadays considered as possible candidates for high field magnets, e.g. for fusion and high-energy physics, and for AC or DC power applications. The development of HTS conductors requires extensive information about the impact of the main characteristics of the cable architecture on the electrical performances of the superconducting tapes or wires. In particular, for a proper conductor design, it is important to characterize the bending behavior of the tape.
In this work, a detailed finite element (FE) model is used to investigate the thermo-electro-mechanical behavior of a commercial (Re)BCO tape from Superpower. A measurement procedure to determine the critical current of the tape when wound helically around cylindrical mandrels of different diameters is simulated. This tape configuration can be found in conductor on round core (CORC®) cables as well as in many types of conductors for power applications.
As a first step, the cooldown to cryogenic operating conditions is fully analyzed, thus computing the strain field corresponding to the first critical current measurements performed on the straight sample. After that, the heating up to room temperature, the helical winding and the following new cooldown is modeled to obtain the final strain map in the tape. This complete analysis is repeated for different mandrel diameters and helix pitches. The numerical results are finally compared to the outcomes of experimental tests performed at 77 K. The combination of thermal contraction effects and bending/twisting loads due to helical winding is simulated with a fully coupled approach and temperature dependent mechanical properties for HTS tapes. The experimental and numerical results presented in the paper give a better insight to the distribution of 3D thermo-mechanical strain components inside the tapes and their impact on the conductor electrical performance.

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