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Fri-Mo-Or2-02: Screening current induced stress and strain analysis considering thickness variation along the width of REBCO tape

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Consideration of screening current induced stress (SCIS) is crucial for management of stress and strain in the design of ultra-high field REBCO magnets. We developed a numerical simulation tool that utilizes COMSOL and studied the effects of including reinforcement in REBCO coils such as co-winding or over-banding steel tapes [1]. The model employs the penalty method as a boundary condition between neighboring tapes and assumes a "hard contact", meaning the effective Young's modulus in the radial direction of the coil winding (Er,eff) is the same as that of the REBCO tape. However, it is found that this Er,eff is significantly smaller than that of the bulk REBCO tape and changes nonlinearly depending on the magnitude of radial compression [2, 3]. This is due to a reduced tape-to-tape contact area caused by microscopic roughness on the tape surface and macroscopic (μm level) thickness variation in the REBCO tape's width direction. In this case, the stress and strain distribution in the winding and effectiveness of reinforcement that was discussed in the previous study [1] changes significantly. The effects of this low and nonlinear Er,eff on structural analysis is studied further here.

In [4], modeling of a low and nonlinear Er,eff was represented by changing the penalty factor in COMSOL's penalty method. However, the relationship between actual gaps between tapes and the applied penalty factor is unclear.

In this study, the developed numerical simulation model has been improved to perform SCIS analysis that accounts for thickness distribution along the REBCO tape's width. We will present details of the simulation model, simulation results on both small and practical-scale coils, and discuss the effects of the profile of REBCO tape's thickness and the magnitude of turn-to-turn gap length on the simulated results.

[1] Y. Suetomi et al., "Screening Current Induced Stress/Strain Analysis of High Field REBCO Coils With Co-Winding or Over-Banding Reinforcement," IEEE TAS, 34, 5, 8400206 (2024).

[2] S. Xue et al., "Compressive Stress-Strain Behavior of REBCO Coated Conductors and Cables," IEEE TAS, 33, 5, 4800706 (2023).

[3] Y. Yan et al., "Measurement and analysis of winding stresses in dry-wound pancake coils considering nonlinear compressive behaviors"SuST, 36, 115019 (2023)

[4] J. Park, "A Numerical Study on Mechanical Boundary Conditions for Screening Current Induced Stress Analysis of REBCO Magnets", ASC 2024, 5Lor1C (2024)

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