Contribution ID: **669** Contribution code: **WED-OR2-703-03** Type: **Oral**

Non-uniform screening-current-induced mechanical strains in small-scale REBCO insert coils

Wednesday, November 17, 2021 9:00 AM (15 minutes)

In recent years, remarkable progresses have been made in the R&D efforts for HTS high-field magnets. The screening-current-induced magnetic field (SCIF) and mechanical stress/strain (SCIS) in REBCO coils are raising growing concerns. This study presents experimental and theoretical analyses on the SCIS in two REBCO coils, with and without over-banding structures, as inserts in an LTS background field magnet.
The coupled electromagnetic-mechanical model, which takes into account the tilting angles of the superconducting tapes and the strain dependency of the critical currents, were developed. Three modelling strategies, the discrete-coupled model with turn-to-turn contacts, the discrete-sequential model and the block model, are implemented and compared against measured data. The block model, which presumes strong turn-to-turn interaction, underestimates the deformation of a dry-wound coil. Simulations with the discrete-coupled model are in better agreement with the experiments in most cases, in comparison with overestimation using the sequential model. It is demonstrated that the coupling of the electromagnetic field and the displacement field through the tilting angle and ε-J_c relationship can significantly influence the magnetization process, especially with a large B_z/B_r ratio.
In order to mechanically protect dry-wound REBCO coils against the concentrated Lorentz force, studies on the effects of over-banding and edge-bonding are carried out. The method of over-banding is proven efficacious in mitigating the SCIS, although it shows a different pattern compared to conclusions with uniform current distribution assumption. Edge-bonding with Stycast 2850 can reduce the hoop strains along the axially outer side of the pancake coil, but with increasing applied forces, it was no longer effective as the bonding materials eventually failed in our experiment.
This work could be useful for the design and analyses of future high-field REBCO magnets.

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Session Classification: WED-OR2-703 Mechanical Behavior and Coil Tests