Estimation of AC Losses in the REBCO Insert of the NHMFL 32T All-Superconducting User Magnet

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Introduction

To ensure reliable operation of the NHMFL 32T user magnet, it is important to estimate the hysteresis losses in its HTS pancake-wound insert [1]. Such an estimate allows implementing safe operational procedures to avoid premature quenching and, in the worst case scenario, the insert failure. The insert coils have thousands of turns with notable variations in the critical current (current carrying capacity). Therefore, estimating the losses in such a large superconducting magnet presents a significant challenge. A new approach relying on a multiscale scheme to achieve a high computational efficiency was suggested. This new method is flexible enough to simulate different sections of the entire insert with the right level of detail while providing a larger computational speed than other approaches using the finite element method. The hysteresis losses in the insert coils for a ramping operation sequence were computed.

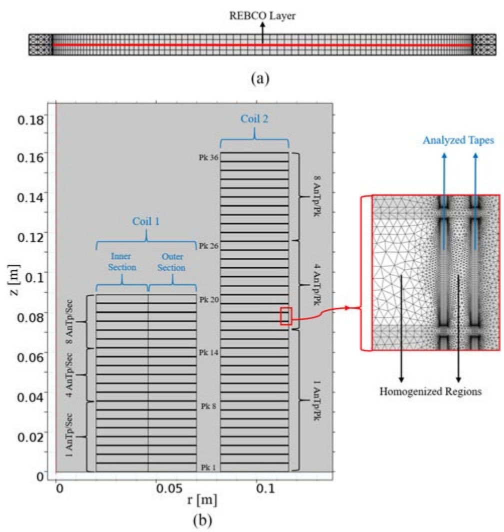

Fig. 1. (a) Mesh of the single-tape submodel. (b) The insert submodel. Each pancake of Coil 1 has two sections. The zoomed fragment shows the local mesh in the outer part of pancake 18 of Coil 2. The mesh of both the analyzed tapes and the homogenized regions are shown. The notation “AnTp/Pk” stands for Analyzed Tapes per Pancake.

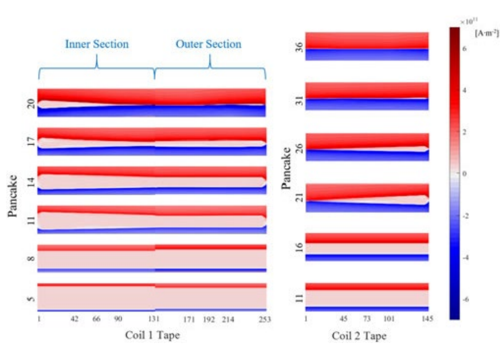

Fig. 2. Current density distribution within the selected pancakes at 60 s, the ramping cycle peak.

Modelling and predictions

The 17 T HTS insert is composed of two nested coils assembled from double pancakes/modules co-wound with sol-gel plated stainless steel strips and REBCO tapes. The sol-gel plated stainless steel strips increase the mechanical strength of the winding to handle the extreme Lorentz’s forces. The model of a REBCO tape, shown in Fig. 1(a), includes a single 1 μm thick layer of REBCO surrounded by a non-electric and non-magnetic region, which lumps the stabilizer, substrate and other layers of the tape, and the stainless-steel strip as well. The REBCO layer is properly meshed with rectangular elements: 1 across its thickness and 100 along the width. The mesh is graded with increasing number of elements at the extremities. Fig. 1(b) shows the axisymmetric insert submodel. The approach enables one to calculate rather precisely the instantaneous distributions of current density (Fig. 2), magnetic field, and thus the hysteresis losses within the insert. The work continues with a view to analyzing the profound shielding current effect.

Acknowledgement

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Reference

[1] Berrospe-Juarez, E. et al., IEEE Trans. Appl. Supercond., 28, 3, 4602005, 2018.