Hysteresis Loss of REBCO Conductor up to 35 T

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Introduction

The hysteresis loss (Q_{hyst}) of superconducting wires during a superconducting magnet field ramp is a very important parameter for magnet design. High Q_{hyst} will significantly limit the ramp rate, especially if the effective thermal conductivity of the magnet coil is low. In addition, high Q_{hyst} causes high liquid helium consumption, therefore high magnet operation costs. Therefore for the engineering design of a superconducting magnet, it is necessary to measure the Q_{hyst} of the conductor. Due to the strongly anisotropic nature of REBCO coated conductor, its Q_{hyst} is also strongly angular dependent. Our previous work [1] established the relationship between Q_{hyst} and magnetic field, field angle and temperature up to 9 T. In this work, we extend our Q_{hyst}(B, □, T) measurement to 35 T taking advantage of a 35 T resistive magnet at the NHMFL.

Experimental

A 1 x 1 mm^2 sample is made from SuperPower SCS4050 REBCO tape by the photolithography process. The hysteresis losses were measured in a 35 T resistive magnet at the NHFML (cell 8) by a Lakeshore vibrating sample magnetometer (VSM) with a homebuilt pickup coil. Sensitivity of this VSM system is about 10^{-4} emu below 15 T, which decreases to about 10^{-3} emu with increasing field to 35 T. The sample is glued to the sample holder at different angles.

Results and Discussion

The hysteresis loss is the integrated loop area of M-H curves which are shown in Fig. 1.

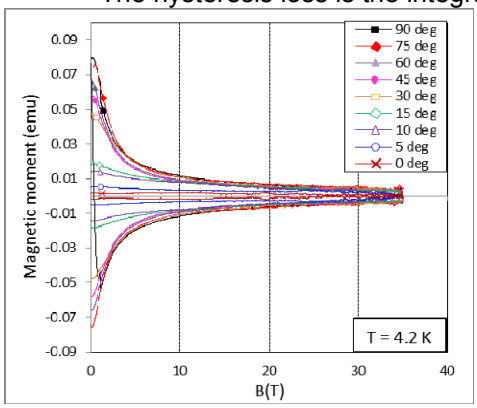

Fig. 1. The hysteresis loops of 0-35-0 T at different field angles.

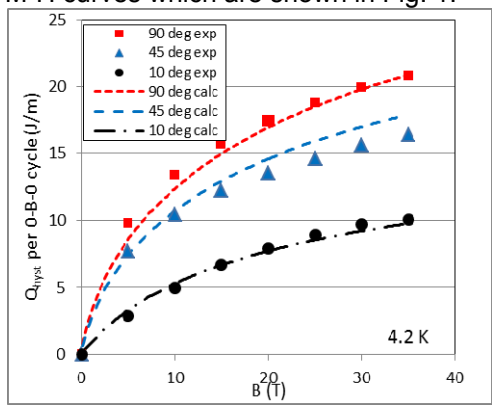

Fig. 2. Q_{hyst} of 0 – B – 0 T cycle vs. B at 10°, 30°, and 90° field angles. The calculated curves are also plotted for comparison.

A simulation of hysteresis loss using

$$Q_{hyst}(B,\theta,T,I) = \frac{1}{2}Kw\sin\theta\left(1-\frac{T}{T_c}\right)^{2.2} \times \int_0^B I_c(B',\theta,4.2K)\left(1+\left(\frac{I}{I_c(B',\theta,4.2K)}\right)^2\right)dB' \qquad [1]$$

is compared with the experimental Q_{hyst} data as shown in Fig. 2. Here w is the conductor width, $K = 0.88$, I_c(B, □, 4.2 K) is obtained from previous work [1]. The simulation agrees reasonably well with the experimental data.

Conclusions

Our 0-35-0 T, 4.22 K Q_{hyst} vs. angle data is consistent with a simulation using a previously formulated I_c(B, □, 4.2 K) expression. We also measured the Q_{hyst} temperature dependence which can be fitted with a function of $Q_{hyst0}(1 - T/T_c)^{2.2}$.

Acknowledgements

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Reference

[1] J. Lu, D.V. Abraimov, A.A. Polyanskii, A.V. Gavrilin, D.K. Hilton, W.D. Markiewicz, and H.W. Weijers, IEEE Transactions on Applied Superconductivity, v 23, no. 3, pp 8200804, June 2013.