Field Angular Dependence of Hysteresis Losses of Coated Conductor for High Field Magnets

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Introduction

Hysteresis loss (Q_{hyst}) of REBCO coated conductors strongly depends on magnetic field orientation. This is mostly due to the shape and critical current (I_c) anisotropy of the coated conductors. The heat generated by Q_{hyst} at different field angles will significantly affect the magnet design temperature-margin at different locations of a REBCO magnet coil. Therefore, it is very important to characterize and understand the field-angle dependence of Q_{hyst}.

Experimental

A 1 x 1 mm^2 sample is made from SuperPower SCS4050 REBCO tape by the photolithography process. The hysteresis losses were measured by a vibrating sample magnetometer (VSM) in a Quantum Design physical property measurement system (PPMS) with up to 9 T magnetic fields. 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 curve. **Figure 1** shows the ± 9 T Q_{hyst} vs. magnetic field angle. **Figure 2** is the ± 9 T hysteresis losses measured at 90º field angle versus temperature. The data can be fitted reasonably well with $Q_{hyst} = Q_{hyst0}(1 - T/T_c)^{2.2}$ as shown in the figure.

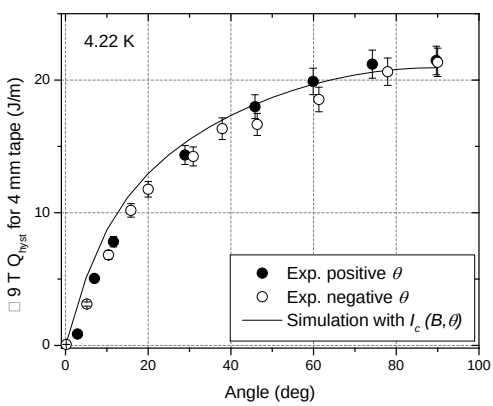

Figure 1. Q_{hyst} of 4 mm wide tape in a ± 9 T cycle at 4.22 K as a function of field angle from - 90º to + 90º.

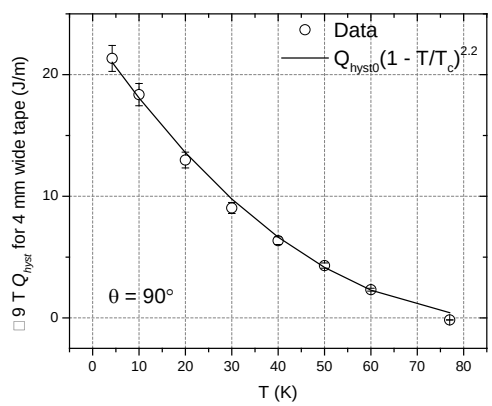

Figure 2. Hysteresis losses of ± 9 T cycle measured at different temperatures. The data is fitted with a temperature function $Q_{hyst0}(1 - T/T_c)^{2.2}$.

A simulation using

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

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

Conclusions

Our ± 9 T, 4.22 K Q_{hyst} vs. angle data is consistent with a simulation using a previously formulated $I_c(B,\theta,4.2K)$ 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] D.K. Hilton, *et al.*, Presentation 1IO2-1, MT 22, Marseille, France, Sept. 2011.