Characterization Of (Re)BCO Conductor for the 32T All Superconducting Magnet

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Introduction

High I_c values together with excellent mechanical properties made (Re)BCO 4 mm wide tape the choice for the all-superconducting 32T user magnet. In order to use the conductor successfully in high-field magnets, a variety of its properties should be predictable within specific tolerances. Because of the large anisotropy of J_c, I_c(4.2K) of 4 mm wide tapes is specified at 17 T and at 18° angle between the tape plane and B, since this appears to be the critical orientation imposed by the large radial fields in the end pancakes. Because the tape is being delivered in ~100 m lengths, many joints are needed, making their resistance critical. In addition, the RRR of the Cu stabilizer, the tape dimensional tolerances, and general property variability along the length are all of great importance to the magnet designer and builders.

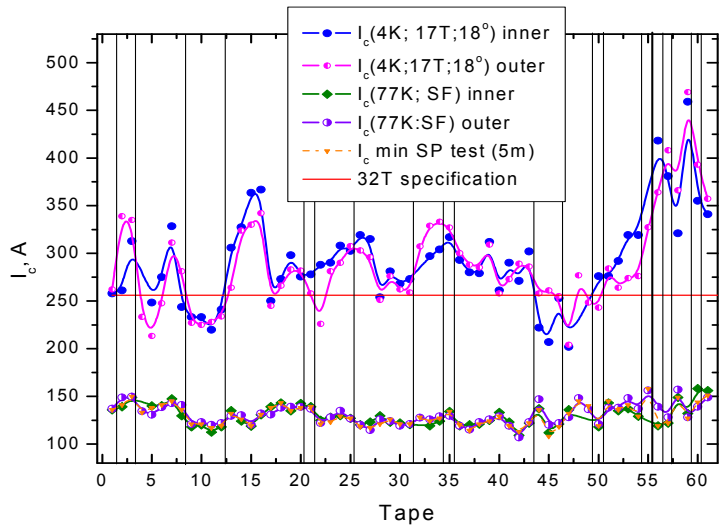

FIGURE 1. Extrapolated to 17T I_c (4K, 18°) data of short samples from each end of the piece length plotted with I_c(77K; SF). Data arranged by SuperPower's process number. Vertical lines separate SP processes. I_c(4K, 17T, 18°) values vary smoothly from process to process.

Experimental

QA procedures have been applied to verify compliance with our 32T conductor specification using 61 piece lengths (60m or 110m each) of 2G HTS product recently purchased from SuperPower Inc. We measured I_c(4K,B,18°) dependencies for magnetic fields up to 13.5T and calculate extrapolated I_c (4K,17T,18°) (see Fig.1).

Results and Discussion

Contact resistance has a small spread within each run, but large differences between runs. Several runs were out of specification. I_c values for samples from inner and outer peace lengths of almost all tapes correlate well at 77K and 4K (see Fig.1) . From tape to tape I_c(4K, 17T, 18°) has a large spread with standard deviation σ_{4K}=17%, but I_c(77K, SF) has twice smaller spread: σ_{77K}=8.4%. Relative difference between I_c from inner and outer parts of tapes is small (σ_{r77K}=4.8%) at 77K, SF. Relative difference between I_c from inner and outer parts of tapes is within the specification for 4K, 17T, 18° (σ_{r4K}=9.3%). We observe weak correlation between I_c at 77K,SF and at 4K, 17T, 18°.(see Fig.1). We found ≈28% of tapes show I_c (4K, 17T, 18°) below 256A.

Conclusions

I_c(4K, 17T, 18°) is important for predicting coil performance, not just testing at 77 K; SF. The highest values and lowest spread of I_c(4K, 17T, 18°) occurs for tapes with the smallest spread of bulk T_c, smaller angle between ab-planes and tape plane, and lower CuO grain density. It is not the in-field I_c(4K), RRR or joint resistance that needs improvement, but Cu stabilizer layer uniformity through tape width. A conservative choice of tape for top and bottom coil pancakes: min I_c>358 A (≈5σ_{r4K}) at 4K, 18°, 17T. Transport and geometrical properties of commercially available (Re)BCO conductor are sufficient for making our 32 T user magnet.

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