Validation of COMSOL®-Based Performance Predictions of Bi-2212 Round Wire Prototype Coils

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Abstract

A prominent technological goal at the National High Magnetic Field Laboratory (NHMFL) involves developing high temperature superconductors (HTS) for use in nuclear magnetic resonance (NMR) at fields above 31 T. Work presented here demonstrates the extensive use of finite element analysis (FEA), predominantly used to design a series of $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212) round wire prototype coils. The required operating conditions for these coils approach the material performance limits of the HTS conductor. At high fields and large transport currents, the generated Lorentz forces result in a mechanical load on the coils that translate to azimuthal strain on the conductor level. Strain management schemes have been built into a series of prototype coils to systematically investigate the reinforcement techniques. Design constraints range from the size of the furnace, in which the Bi-2212 coils are reacted, to the available size and field strength of the outsert magnet system in which experimental tests are performed. Construction of the models, particularities of individual coils within the prototype series, and predicted operating-limit curves for each of the coils are discussed, and followed by experimental results. The modeling results have been a very useful tool during experimental tests and have proven to match experimental results exceptionally well. More importantly, the prototype successes further support Bi-2212 as a viable conductor for high field, high homogeneity magnet technology.

Figures used in the abstract

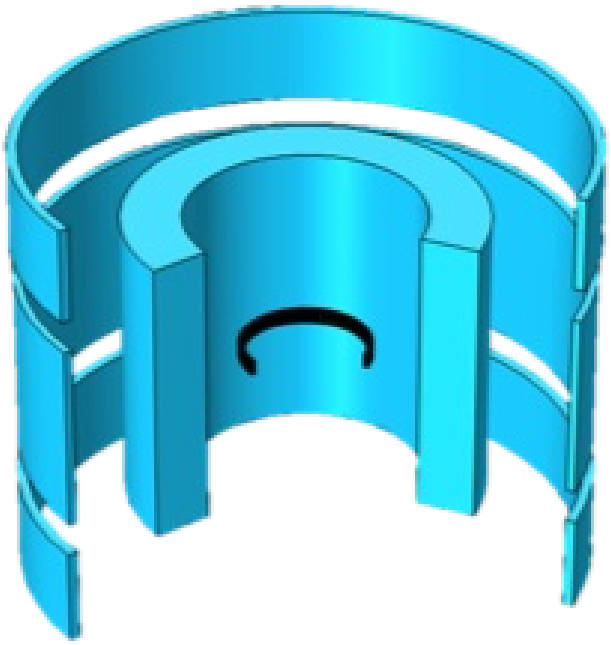

Figure 1: A prototype HTS coil tested within an LTS outsert magnet