Numerical models of HTS coated conductors are now ready for realistic applications

Francesco Grilli[1], Víctor M. R. Zermeño[1], Loïc Queval[2]

[1]*Karlsruhe Institute of Technology, Hermann-von-Helmholtz Platz 1, 76344 Eggenstein-Leopoldshafen, Germany*

Phone: +49-72160828528 e-mail address: francesco.grilli@kit.edu

Phone: +49-72160828582 e-mail address: victor.zermeno@kit.edu

[2]*University of Applied Sciences, Josef-Gockeln-Strasse 9, 40474 Düsseldorf, Germany*

Phone: +49-2114351318 e-mail address: loic.queval@gmail.com

Abstract:

Numerical models are powerful tools to predict the electromagnetic behavior of superconductors. In recent years, a variety of methods and models have been successfully proposed and utilized by several research groups around the world to simulate high-temperature-superconductor (HTS) coated conductors. While the models work well for the simulation of individual tapes or relatively small tape assemblies, their direct applicability to applications involving hundreds or thousands of tapes, as for example coils used in electrical machines, is questionable. This is especially the case for time-dependent and optimization problems, where the simulation time and memory requirement can quickly become prohibitive.

In this contribution, we present an overview of different solutions we have devised for simulating realistic HTS coated conductor applications. First, we present two techniques for the simulation of HTS devices composed of a large number of tapes: 1) the homogenization technique simulates the coil using an equivalent anisotropic homogeneous bulk with specifically developed current constraints used to account for the fact that each turn carries the same current; 2) the multi-scale technique parallelizes and reduces the computational problem by simulating individual tapes at significant positions of the coil's cross-section using appropriate boundary conditions to account for the field generated by the neighboring turns. Both approaches allow speeding-up simulations of large number of HTS tapes by 1-2 orders of magnitude, while keeping a very good accuracy of the results. Second, we present a series of models of different complexity and accuracy that can take contact resistances of HTS cable assemblies into account: especially when a cable is not very long (as in the case of current leads or laboratory cable prototypes) the contact resistance of the electric terminations can have profound influence on the cable's behavior.

The models presented in this contribution show that our numerical modeling expertise has now reached a mature level, and that our models can be used to design and optimize complex HTS devices.