3D mechanical-electric model for CICC degradation under operating load

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Due to the hierarchical structure of CICC and the complex twist trajectory of strand, it becomes a challenging work to calculate the mechanical response based on simple analytical models. Three dimensional spring rod, anyway, is taken as an optimal approximation for strand configuration, compared to a straight beam in most of previous models. With considerations of spatial spiral, mechanical support and geometry determination, the spring model simulates the single strand deformation assembled in CICC under two operating load cases, respectively. Then, contacts among strands allow introducing damping effects for resisting against further deflection within cable. Thus, the whole cable mechanics is totally built. Electrical model is another key issue in superconducting performance prediction. The interstrand current transfer is a well-known tough issue due to the complicated strand trajectory and unpredicted inter-strand contact resistance. An average integral formulation for transport electric field is developed, which is considered as both conservative and effective algorithm for the scarce knowledge of interstrand transport.

The spring model gives a clear distribution map of three-dimensional strand deformation within one characteristic length and the strain scheme in whole cable cross-section. The calculated V-I curve is compared to the experimental one and found a good agreement. This could figures out the transport properties at the whole cable level. Then, the effects of void fraction, n value and bending wavelength are simulated with the spring model. A certain extent of promotion for CICC performance is suggested with spring model to increase the subsequent twist pitch and reduce the void fraction in a reasonable range. And also increasing the twist degree properly is helpful for reducing the degradation.

Keywords: CICC, performance degradation, 3D mechanical-electric model, operating load