Current Distribution in Cable-in-Conduit Superconductors

by

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ABSTRACT

A numerical study of the current distribution in Cable-In-Conduit Conductors (CICC's) experiencing linearly ramping transport currents and transverse magnetic fields was conducted for both infinitely long, periodic cables and finite length cables terminated in low resistance joints. The goal of the study was to gain insight into the phenomenon known as Ramp Rate Limitation, an as yet unexplained correspondence between maximum attainable current and the ramp time taken to reach that current in CICC superconducting magnets. A discrete geometric model of a 27 strand multiply twisted CICC was developed to effectively represent the flux linkages, mutual inductances, and resistive contact points between the strands of an experimentally tested cable.

The results of the numerical study showed that for fully periodic cables, the current imbalances due to ramping magnetic fields and ramping transport currents are negligible in the range of experimentally explored operating conditions. For finite length, joint terminated cables, however, significant imbalances can exist. Unfortunately, quantitative results are limited by a lack of knowledge of the transverse resistance between strands in the joints. Nonetheless, general results are presented showing the dependency of the imbalance on cable length, ramp time, and joint resistance for both ramping transverse magnet fields and ramping transport currents.

At the conclusion of the study, it is suggested that calculated current imbalances in a finite length cable could cause certain strands to prematurely "quench"—become non-superconducting—thus leading to an instability for the entire cable. This numerically predicted "current imbalance instability" is compared to the experimentally observed Ramp Rate Limitation for the 27 strand CICC sample. Using the unknown quantity of the transverse joint resistance as the single fitting parameter, the results of the hypothesis reasonably match several major trends in the data. It is concluded that the results are encouraging but require further refinement and a direct measurement of the transverse joint resistance.

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