AP7-2-INV

Dynamic resistance in REBCO coated conductors

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Dynamic resistance occurs in a superconducting wire carrying a DC transport current whilst exposed to AC magnetic field. REBCO-based coated conductors are steadily becoming the mainstream wire choice for HTS power applications. The HTS field coils in rotating machines, are exposed to an alternating ripple field while carrying DC current and dynamic resistance generated in this process adds to heat load to the cooling system. Dynamic resistance also plays a key role in HTS flux pumps, where it sets a limit for the maximum achievable output current from the flux pump. Although there have been some experimental results in dynamic resistance in REBCO wires, an analytical expression which can fully describe dynamic resistance in REBCO conductors (a 'superconducting strip') has not previously been validated.

Here, we review our recent research into dynamic resistance in REBCO wires exposed to applied AC magnetic fields with arbitrary angular orientations, and at different operating temperatures. We show that these experimental results can be fully described using two different analytical expressions for threshold magnetic field for the coated conductors. At low transport currents (($I_t/I_{c0} \leq 0.2$, where I_t is DC current level and I_{c0} is self-field critical current of the wire), Mikitik and Brandt's expression shows good agreement with experiment. At higher currents ($I_t/I_{c0} > 0.2$), an alternative expression based on the effective penetration magnetic field obtained from Brandt and Indenbom's analytical magnetization losses. We also show that a non-uniform critical current distribution at the edges of coated conductors plays an important role, and that at different field angles the dynamic resistance is dominated by the perpendicular magnetic field component, with negligible contribution from the parallel component. Dynamic resistance measurements at different temperatures show that dynamic resistance follows the predicted dependence on critical current density (which has been measured at each operating temperature).

This work now provides a clear foundation for the understanding of dynamic resistance in coated conductor wires, and has validated equations which predict the magnitude of this often neglected source of AC loss.

Keywords: HTS REBCO coated conductors, Dynamic resistance