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M3Or4A-01: [Invited] 3D Numerical Modelling of AC Loss of Multifilamentary MgB2 Wires at 20 K

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All-superconducting rotating machines, utilizing superconductors for both field windings and armature windings, are a promising candidate for future all-electric aircraft, due to their high-power density and low weight. However, very high AC loss can be generated in the armature windings because they carry AC current under AC magnetic fields. The resulting total AC loss consists of magnetization loss due to the AC magnetic field and transport loss originating from the transport AC current. To reduce AC loss in the armature windings, round non-magnetic MgB2 wires with multifilamentary structure, small filament size and tight twist are required. To date, most of the 3D AC loss simulations on MgB2 wires have been performed at low magnetic field/frequency at 4.2 K, and they are not relevant to aviation applications. In addition, the MgB2 wires contain magnetic sheaths which is not preferable for AC loss reduction. Therefore, AC loss estimation for multifilamentary MgB2 wires with a non-magnetic sheath operating under realistic conditions is an urgent task for aviation applications.

In this work, we first systematically study the magnetization loss of a twisted, non-magnetic superconducting wire with two filaments using the finite element method, based on the H -formulation. The amplitude of the AC field ranges from 0.1 T to 2 T. The frequency, twist pitch, filament size, matrix resistivity and inter-filament gap are varied to study their impacts on each loss component. Then 3D AC loss simulations on two non-magnetic multifilamentary MgB2 wires at 20 K, manufactured by Hyper Tech Research, were carried out. The wire diameter, filament diameter, and number of filaments of the two wires are 0.48 mm/0.32 mm, 25 μm/10 μm, 54/114, respectively. The DC critical current Jc(B, T) and power-law index n(B, T) of the wires were measured and used in the 3D AC loss simulations as input parameters. The simulation transport AC current was varied from 10% to 90% of the critical current and the amplitude of the AC magnetic field ranged from 0.1 T to 2 T with frequency up to 200 Hz. The dependence of each loss component, as well as the total AC loss, on the matrix resistivity, frequency, and twist pitch of both MgB2 wires are presented and discussed. The magnetic field and critical current density distributions are analysed to better understand the AC loss characteristics.

Keywords: all-superconducting rotating machines, total loss, magnetization loss, MgB2 wires, 3D modelling

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