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Remarkable difference in thermal runaway behavior between a Ni-alloy reinforced Bi-2223 coil and a REBCO coil

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A Ni-alloy reinforced Bi-2223 conductor (Bi-2223) enables the construction of a compact high field magnet due its high mechanical strength. However, its thermal runaway behavior has not been investigated. The purpose of this paper is to investigate (a) the thermal runaway behavior and (b) the subsequent degradation of a Bi-2223 coil. For this purpose, a five-turn pancake with an artificially degraded section was made and tested at 77 K. The different behavior between the Bi-2223 coil and a REBCO coil will be discussed.
The degraded section in the middle turn continuously generates heat, resulting in a premature thermal runaway. In a case of the Bi-2223 coil, the thermal runaway initiation current for the paraffin impregnated coil (adiabatic) was 117 A, 105 % of Ic, while that for a dry coil (cooled) was 158 A, 142 %. The corresponding heat generation was 4.4 W and 28 W, respectively. In the case of REBCO coil, the thermal runaway current for a paraffin impregnated coil was 53 A, 54 % of Ic, while that for a dry coil was 90A, 92 %. The respective heat generation was 1.7 W and 5.3 W. Thus, from a viewpoint of thermal runaway, the Bi-2223 coil is several times more tolerant than the REBCO coil. Based on numerical simulations, such a high tolerance is due to the lower n-index and higher Tc of Bi-2223.
For the Bi-2223 coil, fatal degradation did not appear until the temperature exceeded 483 K, i.e. the melting temperature of the solder bonding a Bi-2223/Ag and a Ni-alloy. This temperature is higher than that of a REBCO coil, 340 K [1]. Thus, the Ni-alloy reinforced Bi-2223 coil is superior to the REBCO coil from a view point of thermal runaway tolerance and permissible temperature rise.
[1] Yanagisawa, et al., SUST075014, 2012.

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