MT25

KOREA UNIVERSITY

A Study on Post-Quench Behaviors of No-insulation HTS Magnet under Over-Current Conditions

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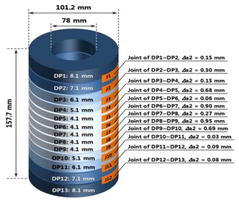
Abstract

Recent studies on no-insulation (NI) winding techniques for high temperature superconducting (HTS) coils have demonstrated that an NI coil has a self-protecting feature: a localized quench heat inside the coil can be automatically diverted in the radial direction owing to the absence of turn-to-turn contacts. The obvious benefits of NI may resolve difficulties in the protection of the HTS coil, which is highly vulnerable to the quench. However, prior to applying the NI technique to the full-scale magnet including several double pancake (DP) coils, it is essential to examine the availability of the self-protecting features between the “axially connected DP coils” as well as between the turn-to-turn contacts in each DP coil. In this study, post-quench behaviors of an HTS magnet including four GdBCO DP coils were investigated through over-current tests. The purpose of the over-current tests was to intentionally quench the HTS magnet, thereby subjecting it to severe operating conditions, and then examine the thermal, electrical, and magnetic integrities of the magnet, validating the intactness of its axial self-protecting feature.

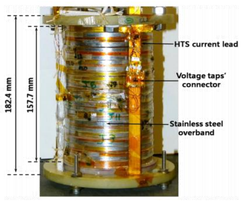
Background

★ Post quench behaviors of no-insulation HTS magnet

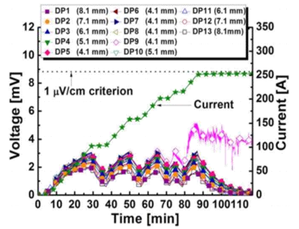
J. B. Song et al., Over-current quench test and self-protecting behavior of a 7 T/78 mm multi-width no-insulation REBCO magnet at 4.2 K, *Superconductor Science and Technology*, **28**, 114001 (2015)



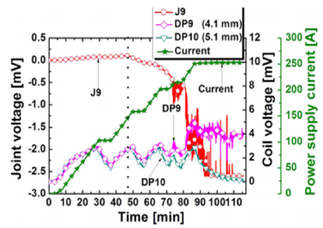
< To-scale drawing of the 7 T 78 mm winding diameter MWNI magnet; J1–J12: 12 DP-DP splices; Da2: difference in outer radii between two adjacent DP coils >



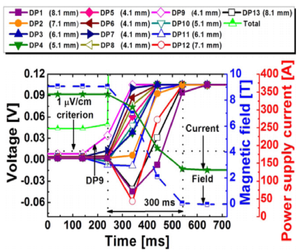
< 7 T 78 mm winding diameter MW-NI magnet ready to be installed in a cryostat for 4.2 K test >



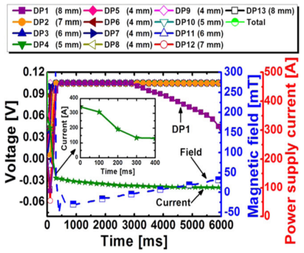
< Voltage traces of DP coils during charging from 0–253 A >



< Voltage traces of DP9, DP10, and the DP9-DP10 joint (J9) during charging from 0–253 A >



< Voltage traces of DP coils during quench event >



< Recovery of DP1 and consequent rise of magnet center fields >

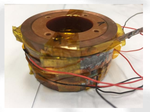
Experimental setup

★ Fabrication of a GdBCO magnet consisting of 3 double pancake (DP) no-insulation (NI) coils

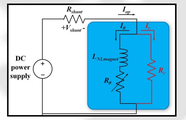
< Specifications of a GdBCO magnet consisting of 3 DP NI coils >

Parameters		Values			
Conductor (GdBCO, SuNAM Co., Ltd.)			~246		
Total thickness; Width	[mm]		~0.15; 4.1		
Cu stabilizer	[μm]		32–50		
I_c @ 77 K, self-field	[A]		~246		
GdBCO double pancake test magnet		Coil 1	Coil 2	Coil 3	Total
Inner diameter	[mm]		40		
Outer diameter upper; lower	[mm]	49; 48.5	49.4; 49.7	49.7; 50.1	n/a
Turn per pancake			35		
Total tape length used upper; lower	[m]	4.89; 4.86	4.92; 4.93	4.93; 4.95	29.48
I_c @ 77 K, self-field	[A]	75	101	101	71
Magnet inductance	[mH]		5.764		
Magnet constant	[mT/A]		2.936		
Joint resistance #1; #2; total	[μΩ]		12.2; 9.9; 22.1		

< A photo of a small GdBCO coil >

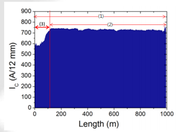


< A photo of a GdBCO magnet with 3 DP NI coils >



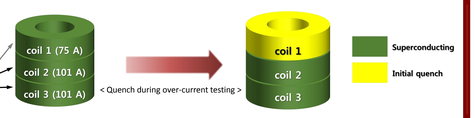
< Equivalent circuit diagram of a GdBCO magnet >

★ Quench tests by applying over-current into the magnet including 3 coils with different Ic values



	Width	12 mm
	Length	980 m
	Max. I_c	760 A
	Min. I_c	571 A
	AVG. I_c (1)	710 A
	AVG. I_c (2)	740 A
	AVG. I_c (3)	650 A

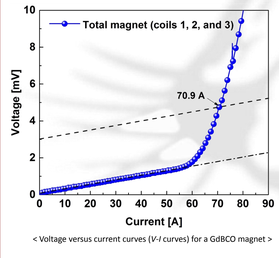
< Critical current values of GdBCO wires in the longitudinal direction >



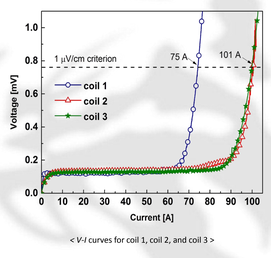
< Arrangement of coils with different I_c values >

Results & discussion

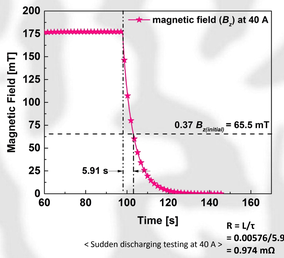
★ Critical current measurement and sudden-discharging tests of a GdBCO test magnet



< Voltage versus current curves (*V-I* curves) for a GdBCO magnet >



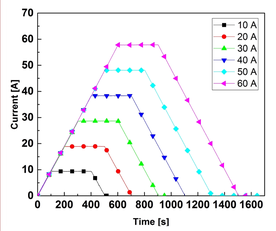
< *V-I* curves for coil 1, coil 2, and coil 3 >



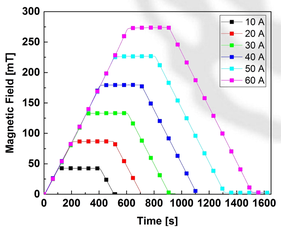
< Sudden discharging testing at 40 A >

R = L/τ
= 0.00576/5.91
= 0.974 mΩ

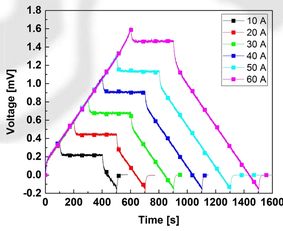
★ Charging and discharging tests of a GdBCO test magnet



< Power supply current vs. time curves obtained from charge-discharge tests >

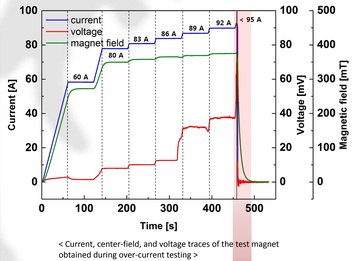


< Axial center magnetic fields vs. time curves obtained from charge-discharge tests >

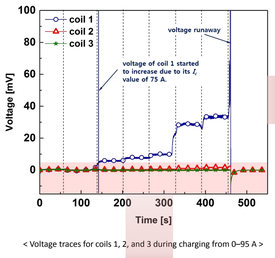


< Voltage vs. time curves obtained from charge-discharge tests >

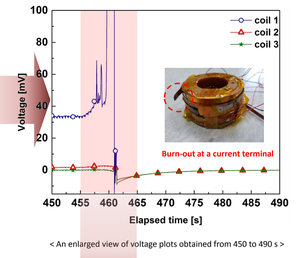
★ Over-current test results



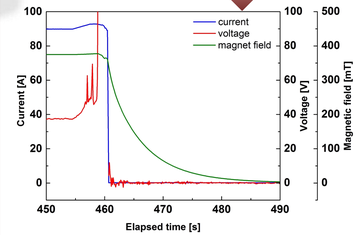
< Current, center-field, and voltage traces of the test magnet obtained during over-current testing >



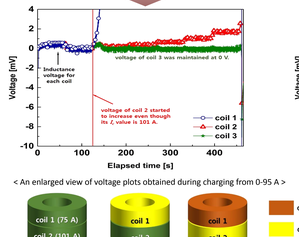
< Voltage traces for coils 1, 2, and 3 during charging from 0–95 A >



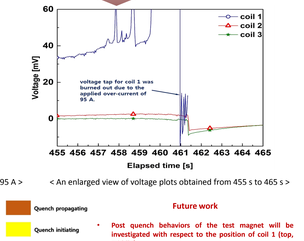
< An enlarged view of voltage plots obtained from 450 to 490 s >



< An enlarged view of over-current test plot obtained from 450 to 490 s >



< An enlarged view of voltage plots obtained during charging from 0-95 A >



< An enlarged view of voltage plots obtained from 455 s to 465 s >

Quench propagating
Quench initiating
Superconducting

Future work

- Post quench behaviors of the test magnet will be investigated with respect to the position of coil 1 (top, middle)

Presented at the Applied Superconductivity Conference, 2017 Aug. 27 – Sep. 1, Netherlands, Amsterdam; Session: Quench and Normal-Zone Behavior; Program I.D. number: Mon-Af-Po1-10 [532]