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Improvement on Temporal Stability of HTS No-insulation Coil by Enhancing Transverse Resistivity

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Introduction

In this study, a scheme to improve the temporal stability of the NI HTS coils by enhancing the transverse resistivity of stainless steel (SS) tape is proposed and verified by experiments. Initially, the SS tape was thermally and chemically treated in order to increase its transverse resistivity of SS tape for several times, and then three NI HTS coils were designed and fabricated by co-winding the non-treated SS tape or the treated SS tape with REBCO tape, respectively. We measured the magnetic field and analyzed its effect caused by the screening current in those coils under various operating conditions.

Preparation of NI Coils

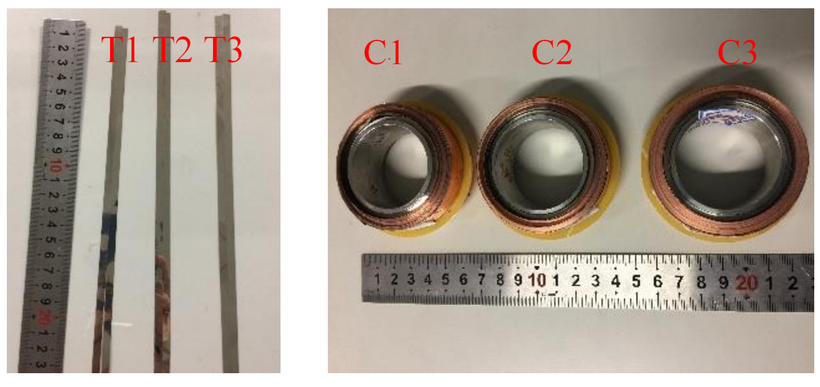

Fig. 1. Photograph of three NI HTS coils. (a) Non-treated SS tape T1, chemical treated SS tape T2, and thermal and chemical treated SS tape T3. (b) The NI HTS DP coils C1, C2 and C3.

Table. I. Specifications of three HTS double-pancake coils

ITEMS	Coil C1	Coil C2	Coil C3
Coil inner diameter(mm)	50	50	50
Coil outer diameter(mm)	60.82	60.85	60.87
Height(mm)	24.5	24.5	24.5
Turns	120	120	120
Insulation	NI	NI	NI
SS tape	T1	T2	T3
SS tape transverse resistivity relative value[1]	1	2.0	3.5
Coil inductance cal.(mH)	0.955	0.955	0.955

[1] SS tape transverse resistivity 8743 Ω·cm^2 is defined as reference value in the stress of 80 MPa and temperature of 77 K.

Experimental Set-up

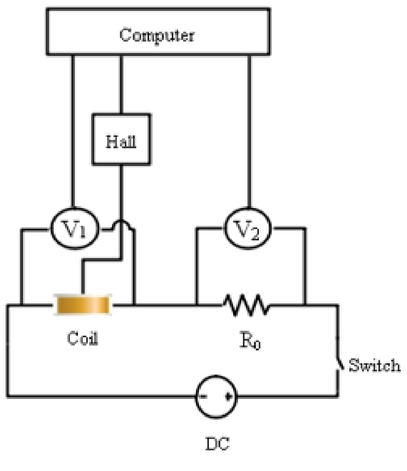

Fig. 2 Experimental schematic view

A superconducting magnet power supply MV-PLC8/120, current shunt R_0 1500 A/75 mV, two Keithley Instrument 2000 multimeter, high sensitivity Hall probe.

Measure and Test

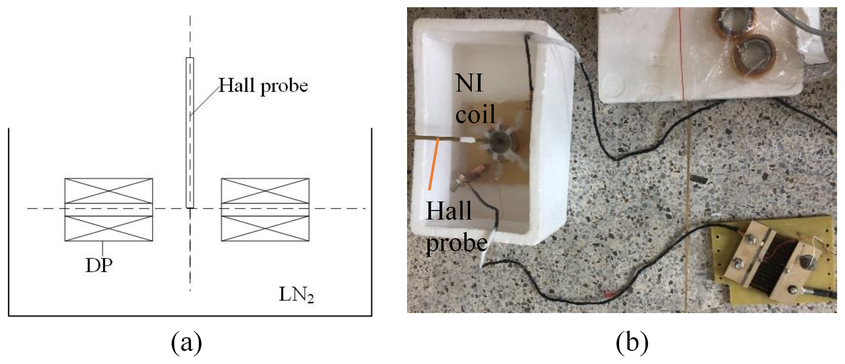

Fig. 3. The schematic diagram and view of coil test. (a) Schematic view, (b) Photo of test arrangement.

The Hall probe was used to measure the axial magnetic field at the center point of the coils. The experiments were undergone in the liquid nitrogen (77 K). In the tests, the NI coils were charged up to 20 A at ramping rates of 0.5 A/s and 1 A/s. Then, the currents were remained 360 minutes constantly to observe the temporal drift of magnetic field.

Results and Discussion

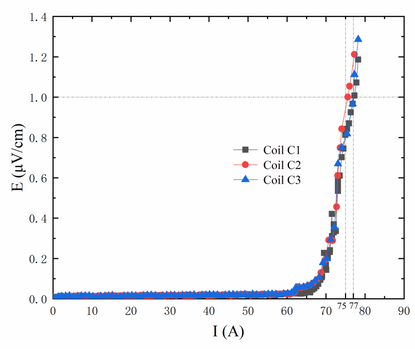

Fig. 4. *E-I* curves of NI HTS coils.

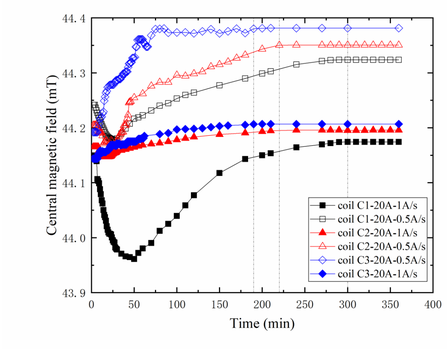

Fig. 5. The central magnetic field waveforms of the Coil C1, Coil C2 and Coil C3 charge test. Coil C1 (■,□) , Coil C2 (▲,△) and Coil C3(◆,◇).

Table. II. Comparison among coil C1, C2 and C3

Coil	Coil C1		Coil C2		Coil C3	
Coil constant exp.(mT/A)	2.209		2.211		2.212	
Coil constant cal. (mT/A)	2.221		2.221		2.221	
Excitation speed (A/s)	1	0.5	1	0.5	1	0.5
ΔB (mT)	0.0245	0.0822	0.0304	0.1457	0.0630	0.1893
Temporal drift (min)	280	300	205	220	175	190

We can see intuitively that magnetic field of coil C3 rises fastest, coil C2 takes second place and coil C1 rises slowest. Comparing coil C1, we can find that the time of the temporal drift is reduced by 27% and 37% after increasing the transverse resistivity by 1 and 1.5 times separately. We can easily find that the effect of enhancing transverse resistivity is very obvious. And we can also find that the coil C2 and coil C3 can achieve a higher magnetic field and reach steady state in a shorter duration than coil C1.

Conclusion

- The experimental results demonstrate the potential of enhancing transverse resistivity of SS tape in NI HTS coil as a new fabrication method of NI HTS coil.
- The method of enhancing transverse resistivity of SS tape can effectively improve the temporal stability of NI coil except for reinforcing its strength.
- The NI HTS coil fabricated by the method is promising for promoting HTS magnet applications.