Study on Screening Current-induced Stress in No-Insulation REBCO Insert

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Introduction

Post-mortem of No-Insulation Insert (LBC3)

- The coil was tested at 4.2 K in a background field of 31.2 T.
- Overall magnetic field was measured as 45.5 T before insert coil's quench.
- There's no sign of damages observed through the visual inspection.

Figure 1. Plastic deformation of the tape.

- After a single quench, the plastically deformed tapes were identified.

➡ Due to the over-strain during quenching or the screening current effect during charging?

Driving Question

- **Identification of what happened in previously tested NI coils.**
  - Current distribution in the tape
  - Forces to the sample

Experiment

LBC Type Test Coil

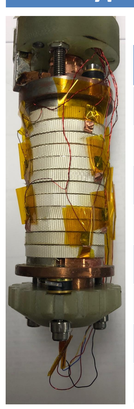


Table 1. Key parameters of the insert.

Parameters		Values
Tape width; thickness	[mm]	4.04; 0.049
I.R.; O.R.	[mm]	7; 13.19
Height	[mm]	51.23
Total number of turns		1392
Magnet constant	[mT/A]	31.51
Inductance	[μH]	10.37
Characteristic resistance	[mΩ]	1.8
Time constant	[s]	5.76

Result and Discussion

Test Coil Operation with Background Field

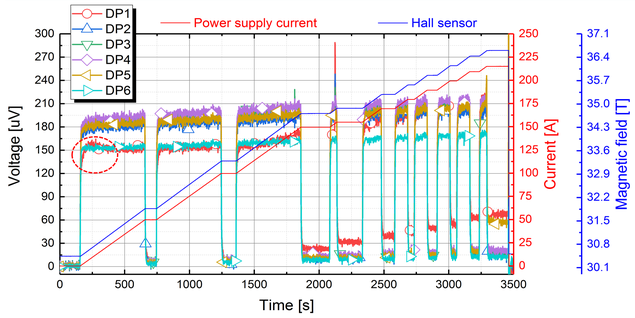


Figure 2. Charging profile of the insert.

- The test coil was charged to 215 A in a 30.5 T background field (ramp rate: 0.1 A/s).
- Voltage overshoot was observed at double pancake 1 (DP1) at the beginning of the charging (red circle).

Table 2. Estimated coil voltage.

Voltage [uV]					
DP1	DP2	DP3	DP4	DP5	DP6
144.82	181.13	191.77	191.93	181.43	146.16

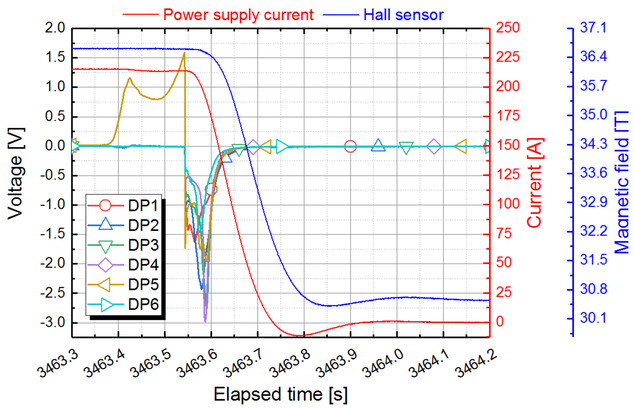


Figure 3. Enlarged view of quench moment.

- Quench was initiated at DP5. However, unlike the previous LBC3, the quench detection box had been operated (trigger voltage: 0.5 V) before the quench started to propagate.

➡ Test coil didn't experience full quenching.

Post-mortem of the Insert Coil

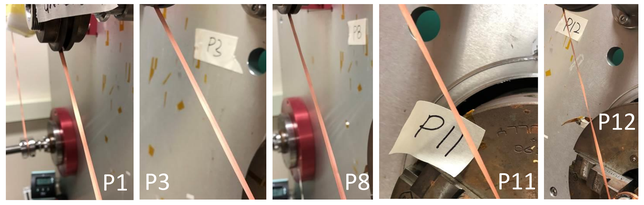


Figure 4. Plastic deformation confirmed.

- Two post-mortems (visual inspection and YateStar measurement) confirms the plastic deformation of the tape.

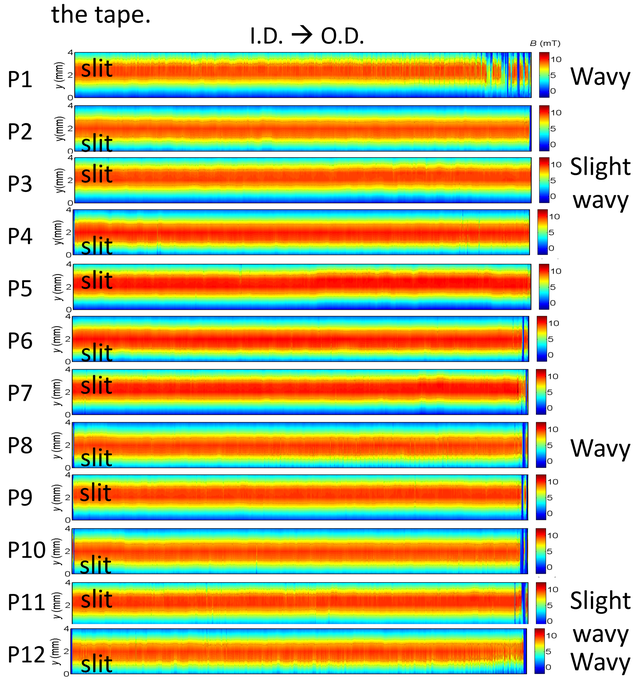


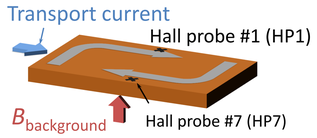
Figure 5. YateStar measurement results.

- DP5 (P10-11), quench initiated pancake, doesn't show the tape degradation.

➡ Quench possibly caused by the inner crossover.

Follow-up Experiment

Short Sample Test in Background Field



- 4 mm width tape (SuNAM)
- Array contains 7 hall sensors
- 15 T background magnet
- Field perpendicular to surface

Figure 6. Experimental setup.

Test Result

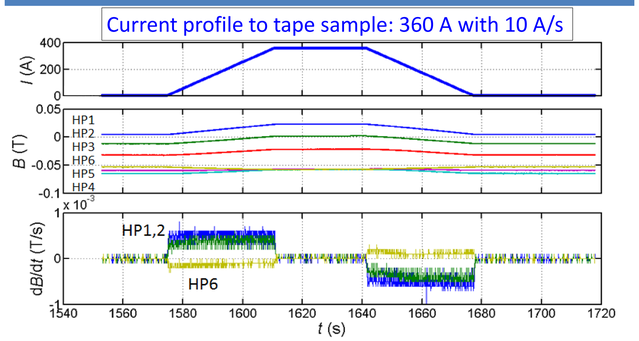


Figure 7. Obtained profiles at background field = 1 T.

- Field changed faster at HP1 which located on the non-slit edge of the sample. Electrical center seems to shift toward HP6.

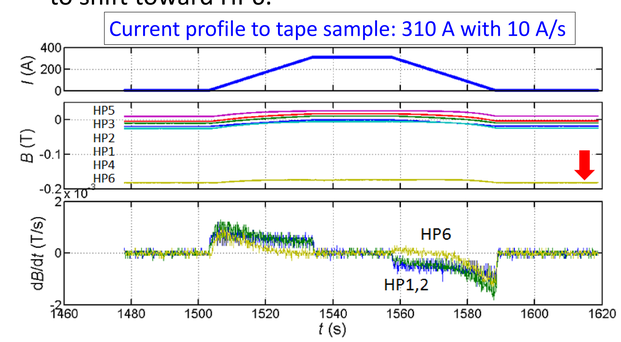


Figure 8. Obtained profiles at background field = 5 T.

- HP6 shows slower increasing rate than HP1. Field increases asymmetric unlike previous case. In both cases, negative dB/dt was confirmed at HP6.

Conclusion

- Plastic deformation was confirmed at the tape from near the coil ends. According to the calculation results based on the critical state model*, the maximum local hoop stress is not at the end pancakes.
- Identification of current distribution in the tape sample is in progress.

* J. Xia, *et al.*, "Stress and strain analysis of a REBCO high field coil based on the distribution of shielding current," Supercond. Sci. and Technol., Vol. 32, 095005 (2019)

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