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Effect of Current-sharing and Heat Capacity of Metal Core on Quench Protection of Spiral Coated Conductors

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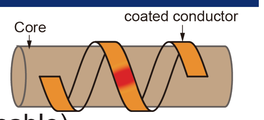
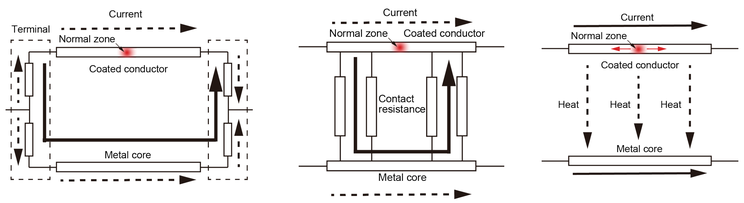
1. Background

Spiral coated conductor: the coated conductor wound spirally on a round metal core (e.g., CORC® cable, SCSC cable)

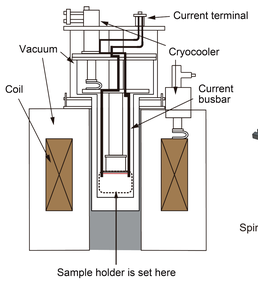


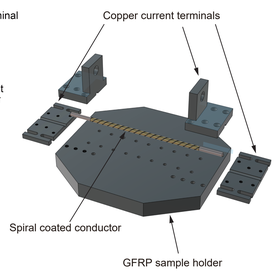
When quench occurs in spiral coated conductors, the current-sharing by the metal core might reduce joule heating to prevent the coated conductors from burning out. Also, the metal core might suppress temperature rise by its heat capacity.



(Current sharing from the terminal) (Current sharing through the contact resistance) (Heat transfer to the core)

2. Experimental setup and conditions



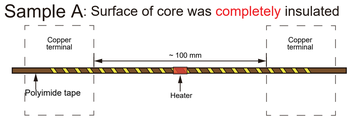


Coated conductor information	
Manufacturer	SuperPower
Width	2 mm
Entire thickness	71 μm
Thickness of plated-copper	20 μm (× 2)
Thickness of superconductor layar	~1 μm
Thickness of Hastelloy substrate	30 μm
Copper core (tube) information	
Outer diameter	3 mm
Thinkness	0.5 mm
Experimental conditions	
Critical current (at 100 μV/m)	~ 170 A
Operating current	160 A
Power of quench heater	20 W
Heater pulse of sample A	0.25 s
Heater pulse of sample B, C, D	2 s

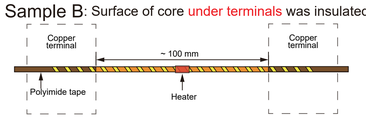
3. Experimental samples

Four samples with different insulation method:

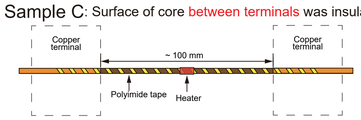
Sample A: Surface of core was completely insulated



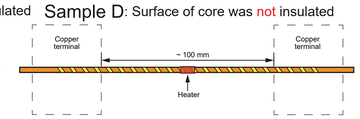
Sample B: Surface of core under terminals was insulated



Sample C: Surface of core between terminals was insulated

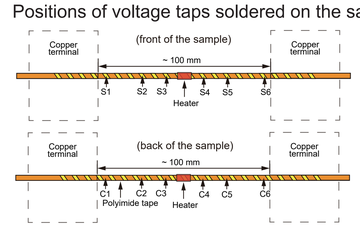


Sample D: Surface of core was not insulated

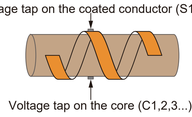


*The polyimide tape was used to insulate the surface of the core

Positions of voltage taps soldered on the sample (use sample D as an example):



Voltage tap on the coated conductor (S1,2,3...)



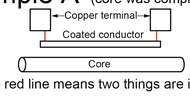
The voltage measured in the experiment:

(1) Voltage on the coated conductor: S1-2 S2-3 S3-4 S4-5 S5-6
(2) Voltage on the core: C1-2 C2-3 C3-4 C4-5 C5-6
(3) Voltage between the coated conductor and the core:
S1-C1 S2-C2 S3-C3 S4-C4 S5-C5 S6-C6

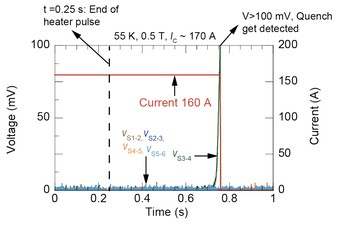
*On sample A , the voltage taps were only set on the coated conductor, because there were no current flows in the completely insulated core.

4. Experimental results

Sample A (core was completely insulated)



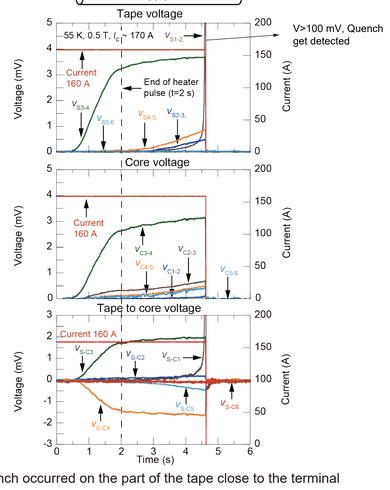
(The red line means two things are in contact)



(Quench occurs just 0.75 s after heater activated)

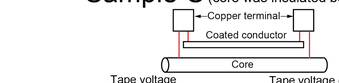
The hot-spot temperature of spiral coated conductors using metal core is much lower than those with heat-insulating core (e.g., GFRP core).

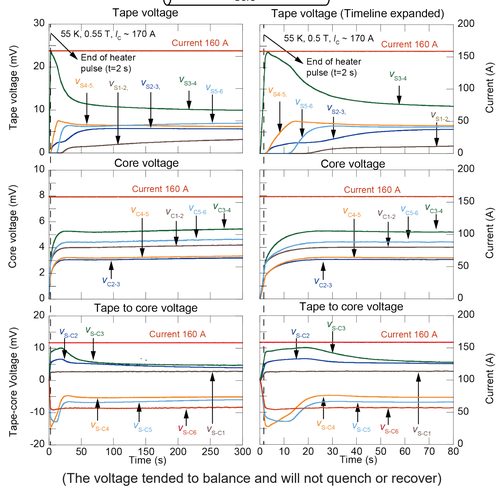
Sample B (core was insulated under terminal)



(Quench occurred on the part of the tape close to the terminal when the normal zone propagated there)

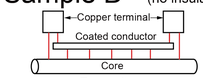
Sample C (core was insulated between terminals)

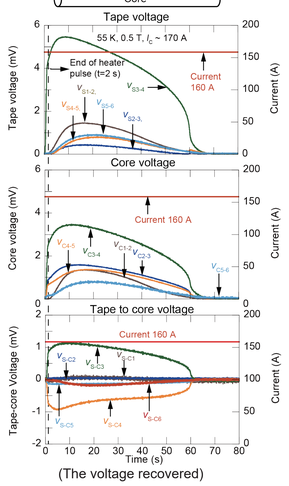




(The voltage tended to balance and will not quench or recover)

Sample D (no insulation)





(The voltage recovered)

5. Summary

Compared with sample A (completely insulated), result of sample D (not insulated) shows the contribution of the metal core on quench protection.

It is observed that current sharing through contact resistance (sample B) and those by the copper terminals (sample C) suppress the joule heating of the superconducting tape and is helpful for quench protection.

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