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Electrical and Strain Behaviors of Solid Nitrogen and Conduction Cooled YBCO Coil under Thermal Disturbance and Over Current Pulse

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Abstract

In the power system application of high temperature superconducting (HTS) devices, large amount of heat caused by thermal disturbance and over current during sudden electric interruptions will endanger the thermal stability of HTS devices. In this paper, the electrical and strain behaviors of solid nitrogen (SN_2) and conduction cooled YBCO coil under thermal disturbance and over current pulse has been investigated at 60 K. For the thermal disturbance experiment, the minimum quench energy (MQE), longitudinal and transverse normal zone propagation velocities (NZPV) in SN_2 and conduction cooled system are compared and discussed. The strain response characteristics of the coil during the quench process are also reported. In addition, the accumulated peak voltage and strain of the coil during the over current pulse test have been studied. These results show that the thermal stability of YBCO coil is significantly enhanced due to the large heat capacity of SN_2.

Experimental detail

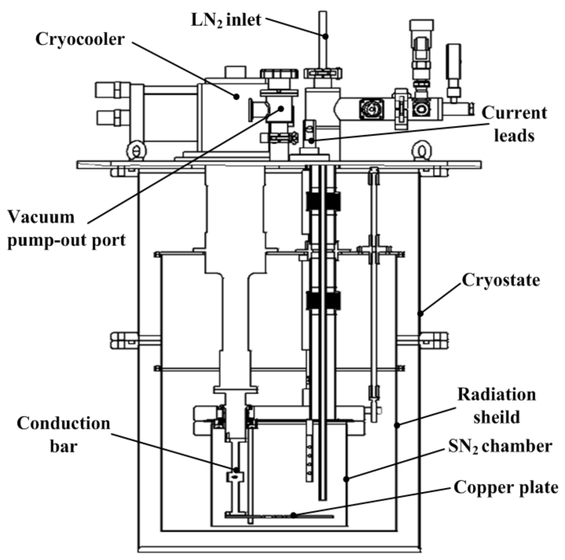


Fig. 1. Schematic diagram of a cross-section of the SN_2 cooled system

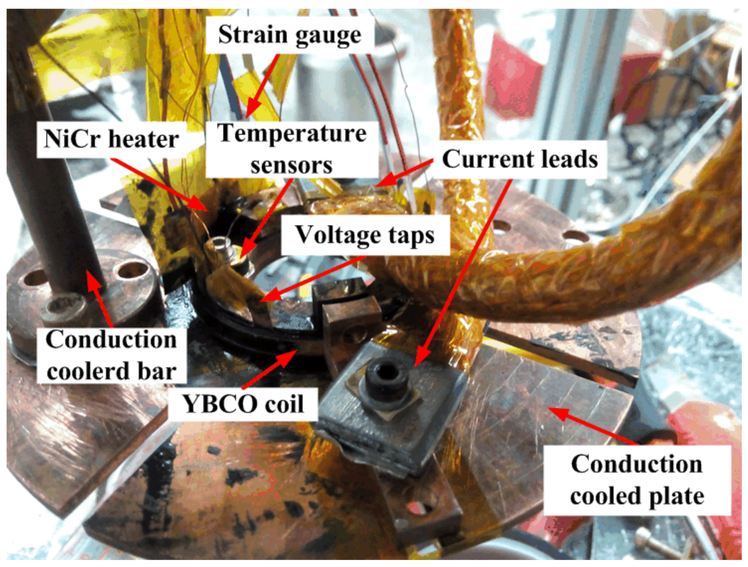


Fig. 2. Photograph of the sample holder in the SN_2 chamber.

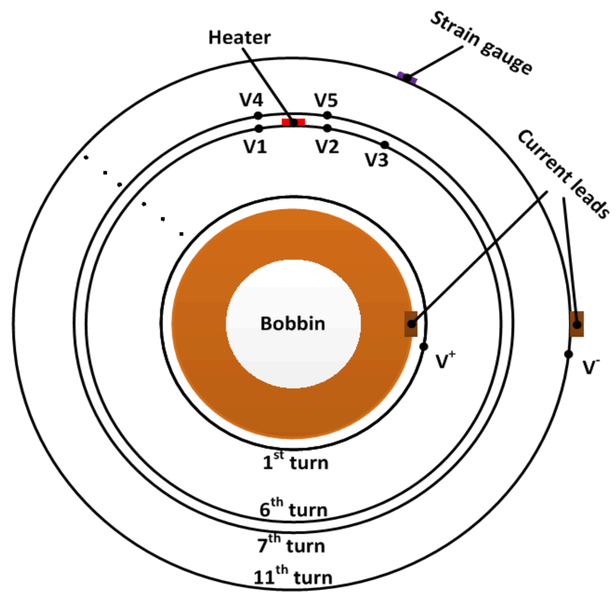
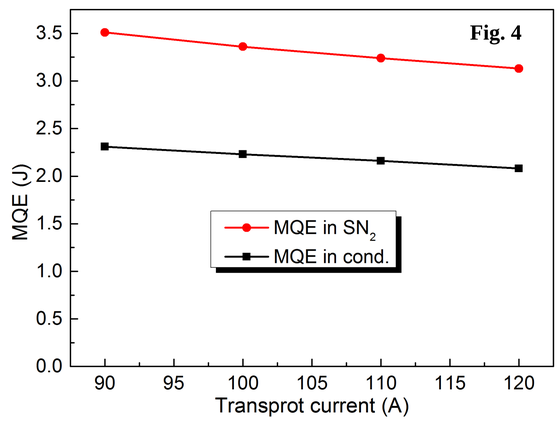
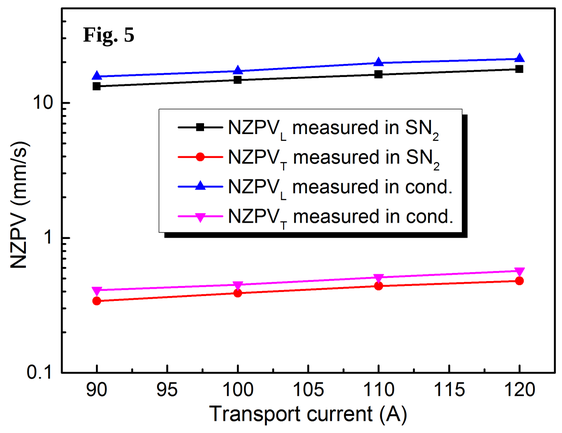


Fig. 3. Schematic drawing of the arrangement of measurement leads, strain gauge and the heater in the coil.

Results and discussion

A. Electrical and strain behaviors under Thermal Disturbance





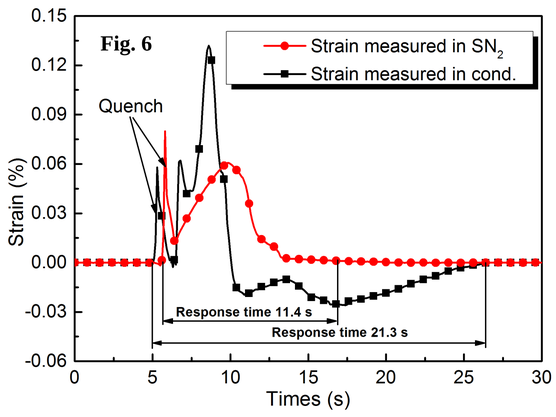
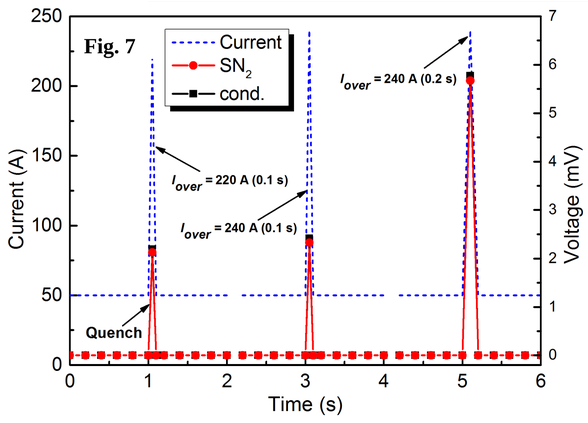
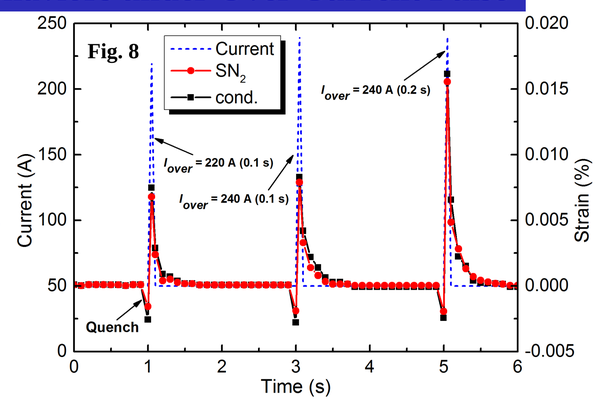


Fig. 4 and Fig. 5 show MQE and transverse and longitudinal NZPVs of YBCO coil with respect to It in both SN_2 and conduction cooled systems. Fig. 6 shows the strain behavior of the outermost turn of the coil in SN_2 and conduction cooled systems during quench at It =90 A.

B. Electrical and Strain Behaviors under Over Current Pulse





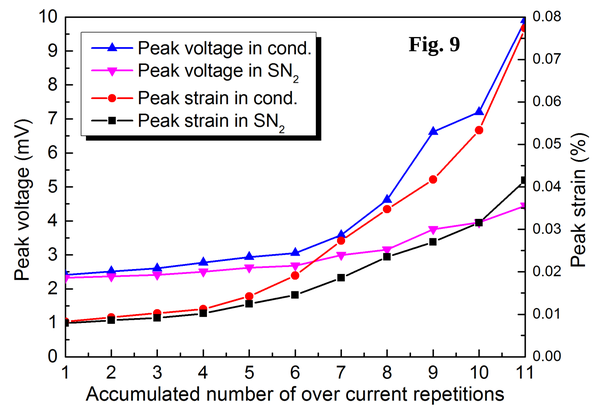


Fig. 7 and Fig. 8 show the coil voltage (V+ and V-) and strain at Iop=50 A and Iover=220, 240 A with 0.1, 0.2 s pulse width and 2 s relaxation time in SN_2 and conduction cooling system measured at 60 K. Fig. 9 shows the accumulated peak coil voltage and strain in SN_2 and conduction cooling system at I_{op}=50 A and I_{over}=240 A with 0.1 s pulse width and 1s relaxation time under 10 repetitive over current pulses.

Conclusion

For the thermal disturbance experiment, the MQE declines along with the rise of I_t, but the NZPVs increase with the increase of I_t. MQE in SN_2 system is larger than that in conduction cooled system due to the heat capacity of SN_2. Moreover, NZPVs in SN_2 cooled system is slower than those in conduction cooled system, and the $NZPV_L$ is faster than $NZPV_T$. The strain response time during the quench in SN_2 cooled system is shorter than that in the conduction cooled system. In the over current pulse test, the accumulated peak voltage and strain increase with the number of over current pulses. The peak voltage and strain increase slowly at the beginning. After the sixth over current pulses, the peak voltage and strain increase rapidly. The peak voltage and strain in SN_2 cooled system is lower than that in conduction cooled system. These results show that the thermal stability of the HTS coil is enhanced due to the large heat capacity of SN_2.