§19. Reinforcing Stabilization of Advanced Superconducting Wires and High Current Density

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Recently, the CuNb in-situ composite[1], has been studied as a high-strength high-conductivity materials. The stability of two kinds of $(Nb,Ti)_3Sn$ conductors; $CuNb/(Nb,Ti)_3Sn$ and $Cu/(Nb,Ti)_3Sn$ is studied in order to obtain basic information about the future compact design of high field superconducting magnets using a $(Nb,Ti)_3Sn$ conductor stabilized with the high-strength high-conductivity CuNb in-situ composite.

A possibility of future compact design of high field and/or large scale superconducting coils will be discussed on the basis of the experimental results on minimum quench energy (MQE) and their ramp rate dependence.

Figure 1 shows the specifications of the studied conductors. The coils were wound after the Nb_3Sn formation heat treatment(React and Wind method). Thermal disturbances are given by a carbon resistor. All experiments were done at 4.2K and 14.0 T in Liq. He. MQE was obtained as a minimum threshold value of thermal energy given by a heater where the coils goes to quench. A numerical analysis on the stability test was made using the two-dimensional thermal conduction equation.

Figure 2 shows the experimental data on the MQE for highly operating current of $0.80I_c$ to $0.95I_c$ (I_c: critical current) and very small ramp rate dependence. It is found that the MQE value of the $Cu/(Nb,Ti)_3Sn$ wire is about three times lager than that of $CuNb/(Nb,Ti)_3Sn$. This is probably due to the difference in Residual Resistivity Ratio (RRR) of stabilizers. That is, RRR_{Cu}~100 and RRR_{CuNb}~30. Degradation in MQE due to the current ramp rate was very small. There is very small ramp rate dependence of MQE, suggesting a possibility of nearly dc coil operation up to the very high current level. These results show there is not substantial degradation of the stability in the conductor stabilized and reinforced with CuNb in-situ composite at least near critical current, suggesting a possibility of the future compact design of a high field superconducting magnet using a $CuNb/(Nb,Ti)_3Sn$ conductor. A numerical analysis on the stability test is in progress.

	$CuNb/(Nb,Ti)_3Sn$	$Cu/(Nb,Ti)_3Sn$
stabilizer	Cu - 20wt.% Nb	pure Cu
diameter	0.8mm ϕ	0.8mm ϕ
Sn concentration	13wt.%	13wt.%
Ti concentration	1.2wt.%	1.2wt.%
filament dia.	3.4 μm	3.9 μm
filament no.	5587	5587
bronze ratio	4.09	4.09
Cu ratio(pureCu)	0.25	0.53
(Cu-Nb)	0.66	
barrier	Ta	Ta

Fig. 1 The specifications of the $Cu/(Nb,Ti)_3Sn$ wire and the $CuNb/(Nb,Ti)_3Sn$ wire.

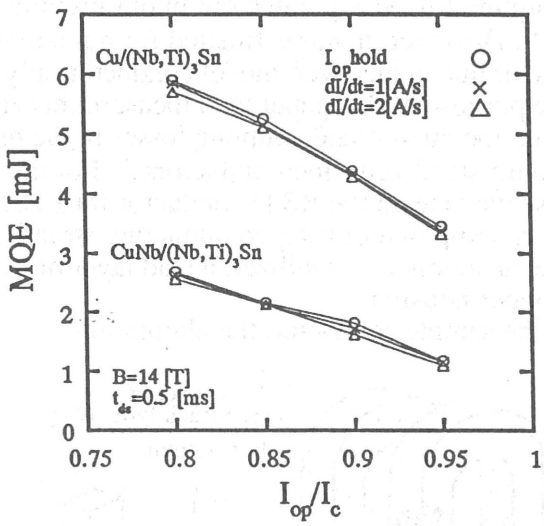

Fig. 2 Current and dI/dt dependence on both the $Cu/(Nb,Ti)_3Sn$ wire and the $CuNb/(Nb,Ti)_3Sn$ wire.

References
1) Noto, K., Matsukawa, M., Katagiri, K., Iwabuchi, A., Sato, T., Watanabe, K., Kawabe, H., Fukutsuka, T. and Monju, Y.: Fusion Engineering and Design 20 (1993) 455