§19. Development of UPS-SMES as a Protection from Momentary Voltage Drop

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We have been developing the UPS-SMES as a protection from momentary voltage drop and power failure. Five-year project to develop 1 MW, 1sec UPS-SMES is being started from 2002 fiscal year as one of the research promotion program of NEDO. The superconducting system is suitable as electric power storage for large energy extraction in a short time. The most important feature of superconducting coil system for the UPS-SMES is easy handling and maintenance-free operation. We have selected Low Temperature Superconducting (LTS) coils instead of High Temperature Superconducting (HTS) coils from the viewpoint of cost and performance. However, it is difficult for the conventional LTS coils to fulfill maintenance-free operation since the cooling methods are either pool boiling with liquid helium or forced flow of supercritical helium. Thus, a conduction-cooled LTS pulse coil has been designed as a key component of the UPS-SMES.

The design optimization of 1 MJ conduction cooled pulse coil has been done as a base on the measured AC loss data of the manufactured SC conductor. The specifications of the optimized 1MJ pulse coil are listed in Table 1 and its load line is shown in Fig. 1. The new twist winding method is adapted to the coil, which can reduce the AC loss and enables stable operation of the coil within the temperature margin. The comparison between the conventional flat winding coil and new twist winding coil is listed in Table 2 Temperature rises inside of the windings for both coils are compared in Fig. 2.

We have developed the special winding machine for the twist winding and have been constructing 100 kJ coil to do a principle actual proof. We are planning to construct a 1 MW, 1 sec UPS-SMES and to perform the long-term field test in NIFS as the final stage of this project.

Table 1. Specifications of a 1 MJ pulse coil

Cooling method	Conduction cooling with a cryocooler
Dimension of the windings	
Inner radius: a1	0.300 m
Outer radius: a2	0.402 m
Length: 2L	1.098 m
Number of turns per 1 layer	183
Number of layers	14
Length of conductor	5.65 km
Inductance	2.00 H
Maximum magnetic field in coil	2.48 T
Magnetic stored energy	1 MJ
Start operating current	1000 A
Stop current after 1 sec discharge	707 A
Discharge energy per one coil	500 kJ
Initial operating temperature	4.2 K

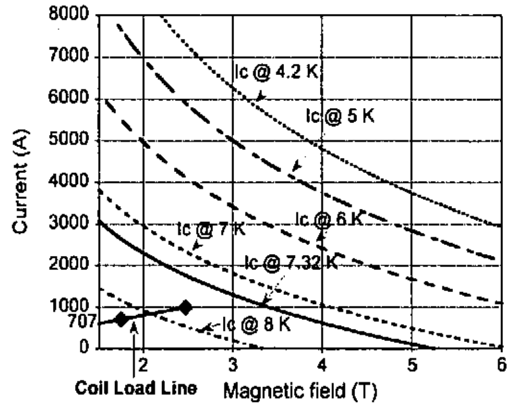

Fig. 1. Load line of the optimized 1 MJ pulse coil.

Table 2. Comparison between twist winding coil and flat winding coil

Winding method	Twist winding coil	Flat winding coil
Maximum temperature after 1 sec discharge	7.32 K	9.19 K
Position of max. temp.	1 layer, 92 turn	6 layer, 1 turn
Magnetic field at max. temp. point after 1 sec discharge (before discharge)	1.76 T (2.49 T)	1.12 T (1.59 T)
Coil current after 1 sec discharge (before discharge)	707 A (1000 A)	←
Current sharing temp:Ts after 1 sec discharge (707 A)	8.21 K @ 1.76 T	8.48 K @ 1.12 T
Critical current at max. temp. point	2643 A @ 7.32 K	quench (over Ts)
Maximum AC loss density	4.51 kJ/m^3	10.81 kJ/m^3
Total AC loss	204 J	349 J
Coupling loss	174 J	319 J
Hysteresis loss	30 J	←

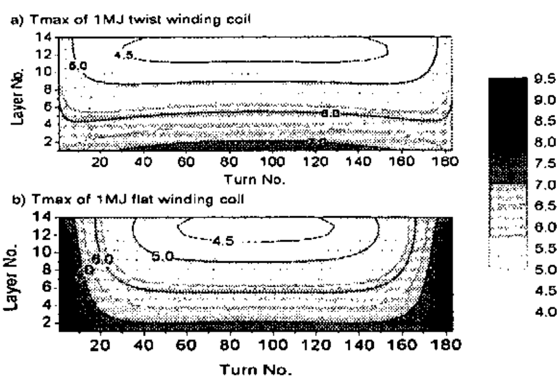

Fig. 2. Temperature rises of the twist winding coil and the flat winding

Reference

1) Mito, T., et al., "Development of UPS-SMES as a protection from momentary voltage drop," presented at 18th Int. Conf. on Mag. Tech. in Morioka, Dec. 2003, to be published on IEEE Trans. on Appl. Super.
2) Kawagoe, A., et al., "Development of conduction cooled LTS pulse coils for 100 kJ class UPS-SMES as a protection from momentary voltage drop," presented at 18th Int. Conf. on Mag. Tech. in Morioka, Dec. 2003, to be published on IEEE Trans. on Appl. Super.