Operational status of the superconducting SAMURAI magnet

H. Sato,*1 K. Kusaka,*1 M. Ohtake,*1 and T. Kubo*1

The first cooling down of the superconducting SAMURAI magnet[1)] was done by TOSHIBA in April 2011, and we had maintained the operation of the cryogenic systems of the magnet. However, the magnet was warmed up in September 2013 in order to save the operation time of the cryocoolers[2)]. Therefore, the magnet was cooled down again in February 2014 for the coming experiments. The cooling operation was performed by ourselves in order to save the cost.

Firstly, the pumping of the vacuum vessels of the cryostats was started. We waited for 8 days until the vacuum level reached 2×10^{-5} Torr. Secondly, the cooling-down procedure was started. The temperature of each point in the cryostat, excluding the coil, was monitored by thermometers. The temperature of the coil was monitored by measuring the resistance of the coil using the correlation shown in Fig. 1. Although the temperature below 9 K cannot be measured with this method, there is no problem for the cooling-down operation because the temperature of the coil vessel is also monitored.

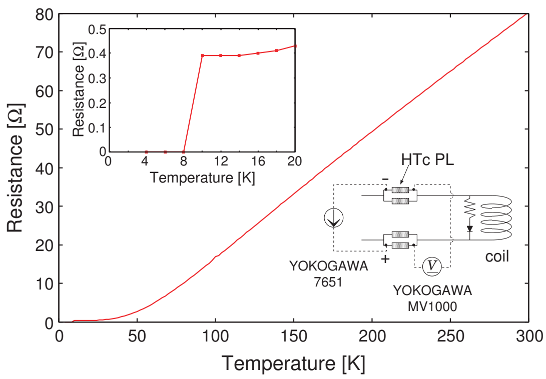

Fig. 1. Correlation between resistance and temperature of the superconducting coil. The upper and lower insets are an enlarged graph of below 20 K and a schematic diagram of the measurement of the resistance, respectively.

Figure 2 shows the trend of the temperature, pressure in the helium vessels, and liquid helium level. It took one month to complete the cooling-down operation, and 7,125 L of liquid nitrogen (LN_2) and 3,145 L of liquid helium (LHe) were used in total.

The graph of the lower coil exposes our inexperience of the cooling of the magnet. This led to imperfect removal of LN_2, resulting in the dissipation of LHe. However, we gathered technical know-how during the cooling-down procedure of the lower coil. (1) The cooling-down speed during LN_2 transfer should be around 10 K/h. (2) Special care must be taken when checking the residual LN_2. (3) The pressure of gaseous He should be 0.03–0.05 MPa when pushing and removing LN_2. (4) The coil vessels should be evacuated to be −99 kPaG before replacing the residual gaseous N_2 in the coil vessels with gaseous He. It takes about 30 min. (5) The position of the transfer tube in the service port is very important in order to transfer LHe without loss. (6) The pressure of gaseous He should be 0.03–0.05 MPa, and that of the LHe Dewar should be 0.028–0.034 MPa (4–5 psi) when transferring LHe. These were successfully applied to the cooling of the upper coil. In our next operation, the period of the cooling down will be shortened, and the amount of LN_2 and LHe will be reduced with the experience gained in this study.

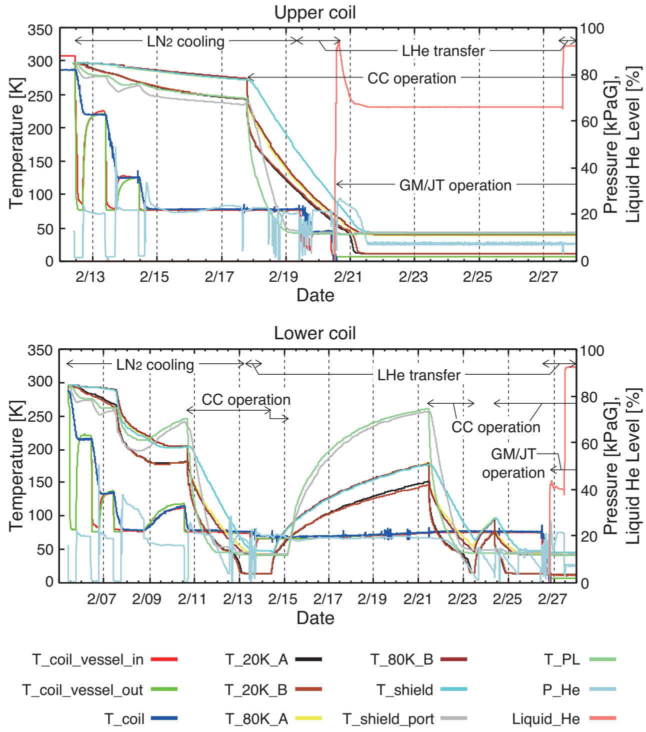

Fig. 2. Trend graph of the upper and lower coil during the cooling. T_ means the temperature of each part[1)]. P_He means the pressure in the helium vessel. Liquid_He means the LHe level (100%≈240 L). The notation "CC" means 20 K, 80 K, PL cryocoolers, and "GM/JT" the GM/JT cryocoolers[1)].

References
1) H. Sato et al.: IEEE Trans. Appl. Supercond. **23**, 4500308 (2013).
2) H. Sato et al.: RIKEN Accl. Prog. Rep. **47**, 173 (2014).

*1 RIKEN Nishina Center