Contribution ID: **132** Type: **Poster**

Thu-Af-Po.05-05: Inductive energization of one-turn secondary coil with single high-temperature superconducting wire by exciting primary coil with alternating current

Thursday 3 July 2025 14:00 (2 hours)

High-temperature superconducting (HTS) generators cooled by liquid hydrogen are being researched and developed, with a 6kA-class assembled conductor required to superconduct the field winding of a 600 MW-class generator. The development target was a conductor consisting of 9 HTS wires in a thiree-layer structure with a 5 mm diameter former. To verify the current capacity of the assembled conductor, it is necessary to perform a 6 kA-class energization test under liquid hydrogen immersion cooling. However, the current capacity of the liquid hydrogen cryostat installed at the Noshiro Rocket Test Center of the Japan Aerospace Exploration Agency (JAXA) is 500 A. There are significant challenges in upgrading it for a 6 kA-class energization test apparatus.

The induction method has traditionally been used for energization testing on high-current low-temperature superconducting (LTS) conductors. It involves shortening both ends of the conductor to form a low-inductance secondary coil. A high current is induced in the secondary coil by the sweep excitation of a magnetically coupled high-inductance primary coil. The same method is supposed to be used for energization tests of the HTS assembled conductor. However, the measurement accuracy of the induced current using Rogowski coils, extremely low-resistance joint technique of the assembled conductors, and zero-reset method of the induced current are challenges that need to be addressed.

Therefore, a new inductive excitation method was investigated by applying an alternating current (AC) to the primary coil, and the configuration of the 6 kA-class inductive excitation test was discussed. The primary REBCO coil consisted of four double pancake coils wound with 4 mm-wide REBCO wires divided into upper and lower sections by a central space (24 mm). The inner diameter, outer diameter, coil height, and average number of turns were 130 mm, 206 mm, 9.5 mm, and 444, respectively. A short-circuit coil with an assembled conductor was used as the secondary coil, and the secondary coil was placed in the center space of the primary coil. Applying an AC to the primary coil induced an AC in the magnetically coupled secondary coil. When the frequency was approximately 1 Hz, and the joint resistance was 100 nΩ or less, the effect of the joint resistance on the induction factor of the secondary current was almost negligible. Considering the stability of the primary coil carrying AC, a higher induction factor was desirable, and the number of turns was chosen to be one. A radius of approximately 75 mm was found to be appropriate, with the position of the conductor having a minimal effect on the induction factor.

To verify the high-current inductive excitation test configuration, one-turn 144 mm-outer diameter short-circuit secondary coils were fabricated using a single REBCO or BSCCO wire, respectively, and installed in the center of the primary coil. A Rogowski coil was attached to measure the induced current in the secondary coil. The inductive excitation tests were performed under liquid nitrogen cooling. The primary current frequencies were 0.5 Hz and 1 Hz. The phase difference between the primary current and the Rogowski coil voltage decreased sharply when the secondary peak current was above the critical current (Ic) of the HTS wire. These results indicate the possibility of determining the Ic of the secondary coil using the phase difference of the Rogowski coil as an indicator. In addition, a transient electric circuit simulation was performed using an n-valued model targeting the region where the peak current exceeds the wire's Ic. The measured and simulated Rogowski coil waveforms will be discussed in the presentation.

Author: Dr OHYA, Masayoshi (Kwansei Gakuin University)

Co-authors: Mr SHIMADA, Ken (Kwansei Gakuin University); IMAGAWA, Shinsaku (National Institute for Fusion Science); Mr OBUCHI, Takuma (Kwansei Gakuin University)

Presenter: Dr OHYA, Masayoshi (Kwansei Gakuin University)

Session Classification: Thu-Af-Po.05 - Conductor and Coil Measurement/Test Techniques and Facilities III