8P12

高温超伝導WISE導体の高磁場試験における電流導入部の振る舞いについて
Behavior of Current lead structure in High-Temperature Superconducting WISE Conductors under High-Field Tests

成嶋吉朗、柳長門、宮澤順一
NARUSHIMA Yoshiro[1,2], YANAGI Nagato[1,2], MIYAZAWA Junichi[1,2]

1)核融合研、2)総研大
1)NIFS, 2)SOKENDAI

For constructing magnets for the next-generation fusion devices, the HTS (high-temperature superconducting) conductor is a feasible candidate because of its higher critical current in a high magnetic field in comparison to LTS (low-temperature superconducting) conductors. Various types of HTS conductors have been fabricated and studied in NIFS (National Institute for Fusion Science). The WISE (Wound and Impregnated Stacked Elastic tapes) conductor [1] is made by winding laminated HTS tape wires into a specified coil shape, etc., and then impregnating, and fixing the wires with low-melting-point metal. Before impregnation, the stacked HTS tape wires are free to move, enabling strain-free winding [2] and flexible coil construction. The purpose of this study is to clarify the current-carrying properties of this WISE conductor in a magnetic field. As shown in Figure 1, a U-shaped WISE conductor with a length of 2 m was fabricated by connecting an HTS tape contained inside an aluminum pipe to an oxygen-free copper current feeder. A critical current I_c = 10.8 kA @ 40 K, 5 T was obtained [3, 4]. On the other hand, at T = 30 K, a maximum current value of 16.9 kA was recorded at B = 5 T. Before reaching the critical current value, the HTS tapes in the current feeder were burned out. Figure 2(a) shows the conductor part of the WISE-U conductor removed from the current feeder after the current test. The HTS tape on the left side (anode) remained, but that on the right side (cathode) was burned or cut off. Notches were found on the edge of the aluminum pipe, likely due to current flow (Fig. 2(b)). The voltage at the current feeder before the quench is shown in Fig. 3(a). On the anode (black), the voltage increases linearly with increasing current, while on the cathode (red), the voltage increases nonlinearly. Therefore, for I_{ps} < 12.3 kA, the voltage on the cathode is lower than that of anode, while for I_{ps} > 12.3 kA, vice versa. The average resistance on the anode is about 32 nΩ, while that on the cathode increases with current, reaching 51 nΩ at I_{ps} = 16.6 kA as shown in Fig.3 (c). The linearity in anode voltage indicates normal conductivity. Non-linearity of the cathode suggests current-dependent degradation. Figure 3 (b, d) shows that the sharp increase in voltage and resistance at I_{ps} = 16.6 kA indicates that the HTS tape burned out at this time; for I_{ps} > 16.6 kA, the anode voltage and resistance do not change, while the cathode ones increase sharply. Since the resistance increases when superconductivity is destroyed, it can be inferred that the HTS tape is being destroyed. The current feeder was connected to an oxygen-free copper current terminal and REBCO tape by low-melting-point metal impregnation. The current feeder was not sufficiently fixed to the aluminum pipe, and distortion during the manufacturing process was thought to be the cause of the burnout in the current introduction part.

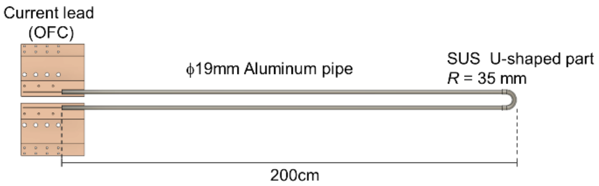

Fig.1 Overview of WISE-U conductor

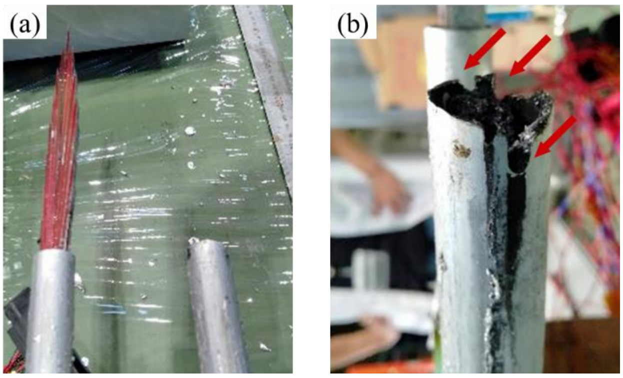

Fig.2 (a) End of the WISE-U conductor removed from the current feeder. HTS tapes on the anode side (left) remain, but those on the cathode side (right) are burned and cut. (b) Aluminum pipe on the cathode side. The notch can be seen indicated by arrows.

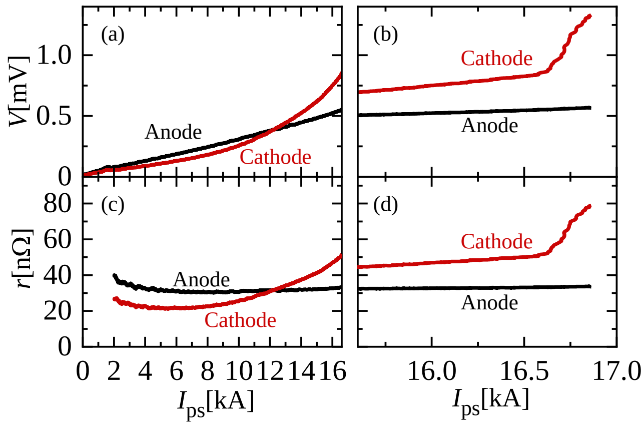

Fig.3 (a) (b) Voltage V and (c) (d) resistance r of current lead against the supply current. (a) (c) before quench. (b) (d) during quench.

This study is supported by NIFS UFZG-003 and UFZG-009

1. J. Miyazawa, et. al. Japanese published examined patent application No.6749541
2. N. Narushima, et al. PFR, Vol. 15 (2020) 1405076
3. N. Narushima, et al. Abstracts of CSSJ Conference, Vol. 103 (2022) p.115
4. N. Narushima, et al. PFR, Vol. 17 (2022) 2405006