Development of a Small-Scale Superconducting Magnet Using YBCO High-Temperature Superconducting Wire

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Railway Technical Research Institute (RTRI) is studying the possibility of applying an yttrium-based high-temperature superconducting wire, the performance of which has recently been remarkably improved, to a superconducting magnet used in maglev systems. The application of the yttrium-based wire, which can be used at a higher temperature than a conventional niobium-titanium wire, can improve the stability of the superconducting state of a superconducting coil and reduce the weight and power consumption of a cryocooler for cooling the superconducting coil. The results of the study have clarified that these advantages are greatest when the superconducting magnet is used at approximately 50 K (Kelvin: unit of absolute temperature, 50 K = -223°C).

Accordingly, RTRI fabricated a high-temperature superconducting coil about one quarter of the size of a real machine using the yttrium-based wire and completed a small-scale superconducting magnet by inserting the fabricated superconducting coil in a cryostat capable of long-term cold insulation (Fig. 1). Further, this superconducting magnet is not fitted with its own cryocooler, although a cryocooler can be connected when required. RTRI's objective was to try and develop an ultimate form of the superconducting magnet using the yttrium-based high-temperature superconducting wire.

This superconducting magnet can generate a magnetic field stronger than 1 T (Tesla: unit of a magnetic field) at a coil temperature of 50 K (Fig. 2). (For reference: the magnetic field to be generated by the superconducting magnet used in maglev systems is approximately 5 T.) Further, this superconducting magnet has been shown to have a cold insulation performance that is able to keep the coil temperature lower than 50 K for nine hours after the coil is first cooled (Fig. 3). To do this it utilizes the heat capacity of a metal arranged around the high-temperature superconducting coil, together with a mechanism to maintain the vacuum in the cryostat with activated carbon.

With this level of cold insulation performance, this superconducting magnet can generate the required magnetic field for a long time even after an excitation power source and the cryocooler have been separated from the superconducting magnet. Although there is a time limitation, RTRI has succeeded with this new type of superconducting magnet in overcoming the problem of cooling, which in the past has been essential for superconducting magnets. This means that RTRI has developed a new form of superconducting magnet which was not envisaged from the conventional superconducting magnet, that is, a superconducting magnet which is highly portable and easy to handle like a permanent magnet. From now on, RTRI is going to carry out research and development with the aim of producing a higher magnetic field and a larger version of the high-temperature superconducting magnet.

This work has been carried out with the support of a government subsidy from the Ministry of Land, Infrastructure, Transport and Tourism.

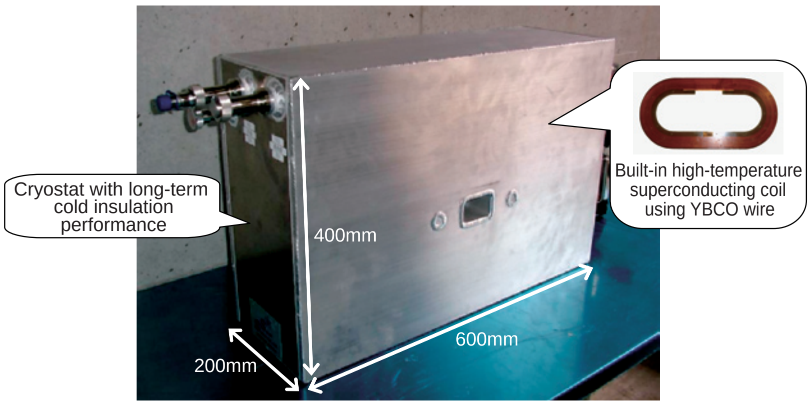

Fig.1 Small-scale superconducting magnet using YBCO high-temperature superconducting wire

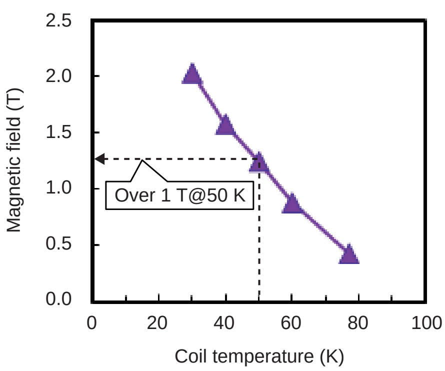

Fig.2 Magnetic field performance

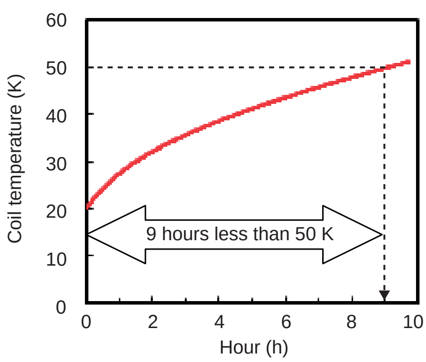

Fig.3 Cold insulation performance