§4. Development of High Temperature Superconducting Current Feeders in NIFS (1)
Join Experiments of 20 kA Bi-2223 Current Lead

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1. Introduction

The development of High Temperature Superconducting (HTS) current leads, which cover the low temperature part of current leads from 4.4 K to 60 K, is progressed in the frame of the LHD International Mutual Experiment (LIME) with the Forschungszentrum Karlsruhe (FZK) and the Max-Planck Institut für Plasma Physik (IPP) in Germany, and universities and laboratories in Japan. The nominal current of the helical coils increases to 17.3 kA and the maximum current of poloidal coils becomes 31.3 kA in phase II experiment of LHD. Six pairs of current leads are necessary for the helical coils, while three pairs of them are required for the poloidal field coils. If helium gas cooled conventional copper current leads are used, it becomes a large heat load, which consumes 650 L/h liquid helium. By using HTS current leads, this heat load could be reduced to about 1/4 of them.

A 20 kA HTS current lead, made of Ag/Au stabilized Bi-2223 tapes, has been developed by FZK. The HTS current lead is a hybrid type, which consists of a copper upper stage and an HTS lower stage as shown in Fig. 1. The upper stage is cooled by the forced flow helium gas, which enters from the metal-to-HTS connection. The HTS itself is not actively cooled but cooled by conduction from the cold end. The performance tests of 20kA HTS current leads were conducted in NIFS with FZK, as collaboration in LIME.

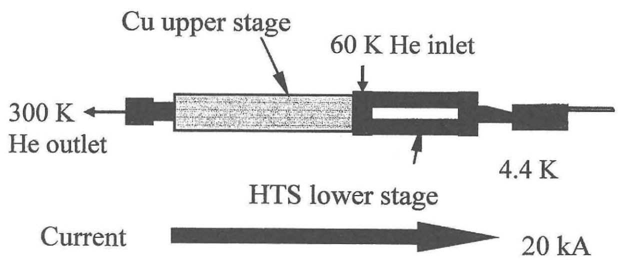

Fig. 1. Schematic drawing of the 20 kA HTS current lead

2. Experimental Setup

Fig. 2 shows a test cryostat for the HTS current lead, which was designed and used to test model poloidal field coils of LHD. The 20 kA HTS current lead was installed in the test cryostat with a 30 kA conventional copper current lead. A SC bus bar, a prototype Cable-in-Conduit conductor for the Wendelstein 7-X, was used to connect the current leads at the ends. Thermal radiation shields cooled by liquid nitrogen were installed in the cryostat to minimize radiation heat leak.

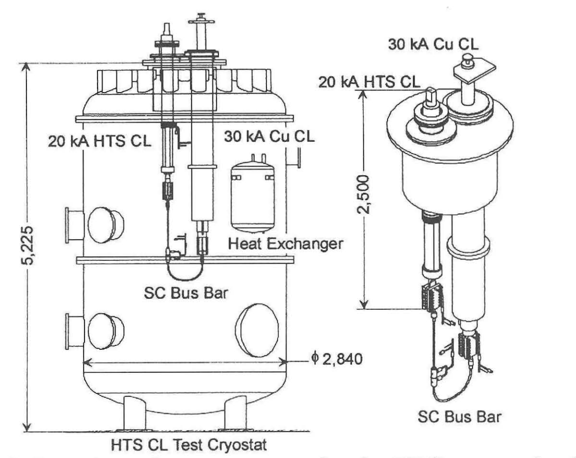

Fig. 2. Drawing of a test cryostat for the HTS current lead.

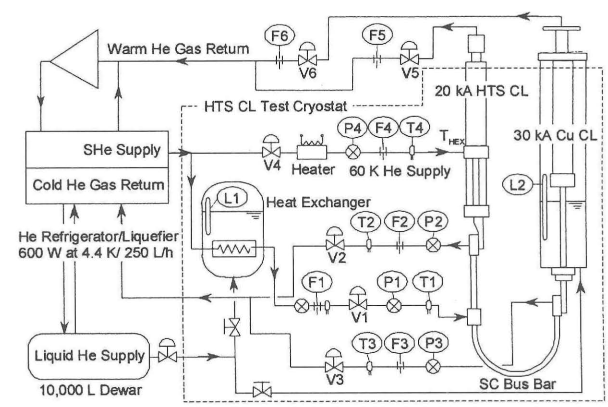

Fig. 3. Schematic of the cryogenic system.

Fig. 3 shows a schematic of the cryogenic system for the performance test. The intercept temperature of the HTS lead, T4, was controlled by the heater to establish various conditions.

3. Experimental Procedure and Results

The experiments were conducted form May 30 to June 9, 2000. Before starting the cool-down, the helium gas in the cryogenic system was purified for a week. The helium refrigerator had been operated throughout that period except for the weekend (June 3-4). The performance tests of the HTS current lead were successfully conducted. The critical current was measured approximately 30 kA by maintaining the connection of the copper-to-HTS part, T4, at 85 K. The 40 kA excitation current with 10 s hold time was achieved by a fast ramp up test with 1kA/s and T4 at 60 K, although the HTS current lead was design to the nominal current of 20 kA with the operating temperature at the HTS upper end of 70 K. These test results demonstrated the high potential of the HTS current lead using Ag/Au stabilized Bi-2223 tapes.

A joint experiment of a 20kA HTS current lead developed by FZK was conducted in NIFS with FZK, as collaboration in LIME. The performance tests were successfully conducted and demonstrated the high potential of the HTS current lead using Ag/Au stabilized Bi-2223 tapes.

Reference

1) Heller, R., Takahata, K., Friesinger, G., Mito, T. et al., IEEE Trans. Applied Superconductivity, Vol.11, No.1 (2001), pp.2603-2606.