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Design of a helium-liquid hydrogen based indirect cooling system for an HTS coil cooling

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Recently, energy production and cooling technology using hydrogen has been developed worldwide. In particular, the ortho-para conversion process, which was a problem in hydrogen liquefaction, was overcome through the development of catalysts. Hydrogen has been an attractive material as a refrigerant due to its low liquefaction point and high thermal conductivity. In superconducting applications, operating temperature is an important design condition for improved performance and stability. Compared to liquid nitrogen or liquid neon used for typical indirect cooling, liquid hydrogen can cool helium gas to a lower temperature, increasing the performance and stability of superconducting devices. Therefore, there is a need for the development of hydrogen-based cooling systems for superconducting equipment operating at cryogenic temperatures. This paper deals with the design of a helium-liquid hydrogen indirect cooling system for an HTS coil cooling. The helium-liquid hydrogen indirect cooling system consists of a hydrogen liquefaction system, a helium-liquid hydrogen heat exchanger and a 2G HTS coil. The hydrogen liquefaction system liquefies gaseous hydrogen precooled by liquid nitrogen using a cryo-cooler. The heat exchanger was located in the inner tank of a hydrogen cooling system filled with liquid hydrogen, and gaseous helium exchanges heat through the contact surface of a copper tube cooled with liquid hydrogen. The temperature distribution and heat load of the hydrogen liquefaction system and HTS coil were analyzed by a 3D finite element method program. The helium-liquid hydrogen heat exchanger was designed based on the outlet temperature of the hydrogen liquefaction system and the heat load of the HTS coil. As a result, the temperatures at the outlet and inlet of the hydrogen liquefaction system were 22 K and 31 K, respectively. The heat load of the HTS coil was 25 W, and the temperature during operation was maintained at 29 K.

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