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Development of a Peltier Current Lead for the 200-m-Class Superconducting Direct Current Transmission and Distribution System

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Reducing cryogenic heat leaks is critical for superconducting applications. Reduction of heat leak at the terminals is essential for uses with short-length applications, where cryogenic losses at the terminals dominate. We are developing a 200-m-class superconducting direct current (DC) transmission and distribution system (CASER-2), and have used a Peltier current lead (PCL) for heat insulation at the terminals. The PCL consists of thermoelectric elements and copper leads, which enhance the performance of superconducting systems. As DC flows through the current lead, thermoelectric elements on opposite terminations of a superconducting line can be used to decrease the heat ingress to the cryogenic environment (*n*-type on one end, *p*-type on the opposite end). During the current feeding and cooling test, a large temperature difference was observed across thermoelectric elements in the PCL. This demonstrates that we have successfully insulated the heat leak at the current lead. During the fourth cooling test, we established a new PCL design with *p*-type elements at terminal B, and then compared the performance of the terminals. Several improvements were implemented, including balancing the resistances of the PCL to enhance the stability of the superconducting systems.

Key words: Peltier current lead (PCL), superconducting applications, DC transmission and distribution system, BiTe alloy

INTRODUCTION

Thermoelectric systems have been proposed as key technologies to solve environmental problems. Meanwhile, superconducting applications are also highly attractive for energy saving to address environmental issues for a sustainable Earth. Among these applications, a long-distance superconducting transmission system is one of the most promising and can be utilized to save energy through energy sharing. Such large systems can be built by incorporating smaller network systems to form a highly integrated "superconducting grid." Projects focused on the development of superconducting transmission systems are currently underway in Japan, the USA, Korea, China, and other countries, and involve long-distance, high-voltage, and/or grid-integration systems;[1–6] For example, the Albany project successfully transmitted electric power to 70,000 houses in New York State.[2] Yokohama projects will be the first field test in Japan connecting a superconducting transmission line to the electric grid.[6] A direct current (DC) system is

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