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Gas-cooled Peltier current leads for compact HTS devices

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As is known, heat losses through current leads largely determine the economic efficiency of the superconducting systems. Much attention is paid to the design of optimal current leads, but the benefits of standard approach are physically limited by the Wiedemann-Franz law. An innovative way to further reduce heat inflow is to use current leads equipped with Peltier thermoelectric elements. These elements are connected in series in the power circuit. Therefore, the thermoelectric effect counteracts the heat flow caused by the temperature gradient in the current lead when the transport current passes through the Peltier element. Another advantage of this design is that when the circuit is de-energized the heat loss is reduced due to the low thermal conductivity of the Peltier elements. In addition to theoretical works devoted to the Peltier current leads (PCLs), a number of experiments were carried out confirming a decrease in heat loss by about 30%. Moreover, PCLs were installed on 500- and 1000-meter HTS power transmission lines in Ishikari (Hokkaido, Japan). Further improvement of the characteristics of the PCLs can be achieved by cooling the current-carrying parts with evaporating nitrogen. In this work, experiment on testing gas-cooled PCLs was carried out for the first time. A 20% additional reduction in heat inflow was achieved. At the same time, the dependence of the specific heat loss on the current became flatter, which means an expansion of the operating current range. In the experiment, the vented gas passed through copper pipes used as conductors. To increase the efficiency of the gas-cooled PCLs, it is necessary to improve the heat transfer between the gas flow and the conductor by means of surface ribbing.

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