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Research on combined use of magnetic refrigeration technology for refrigerant circulation type high temperature superconducting coil cooling system

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A refrigerant circulation cooling system for a HTS (High Temperature Superconducting) coil shows better cooling performance than a heat conduction cooling system when the distance between a cryo-cooler and the HTS coil becomes large because the temperature gradient between the coil and the cryo-cooler becomes small. By combining this excellent cooling system with magnetic refrigeration technology that uses the magnetic field generated by the HTS coil, we aim to realize auxiliary cooling technology that can easily maintain around 20 K. Magnetic refrigeration requires a change in the magnetic field acting on the magnetocaloric material. The alternating magnetic field can be obtained by passing AC (Alternating Current) through the HTS coil, but this is not a good method considering the heat generated by AC losses. Therefore, we investigated a method of causing the magnetic field change by inserting or removing a magnetic shield made of a superconductor that blocks the magnetic field by the Meissner effect between the HTS coil and the magnetocaloric material. Numerical analysis confirmed that the shielding effect increases as the thickness of the shield increases. Experiments also confirmed the shielding performance of superconducting bulks in liquid nitrogen. In order to increase the cooling assistance effect of magnetic refrigeration, the waste heat generated with applying a magnetic field to the magnetocaloric material should be removed by convective heat transfer. Therefore, optimization of the waste heat by changing the circulation method of the refrigerant was investigated by numerical analysis. As mentioned above, this presentation reports on the magnetic shielding by superconducting bulks and the effect of magnetic refrigeration assistance on the cooling performance of the cooling system.

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