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A long-life, high-capacity and high-efficiency cryogenic system developed for high-Tc superconducting magnet applications

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Cryogenic system plays a vital role in the development of magnet technology. Especially for superconducting magnet, it would be in more widespread use now if it were not for the problems associated with the cryocoolers or cryostats required to cool down those superconducting devices or facilities.
For a variety of high-Tc superconducting magnet applications such as energy storage, generators and superconducting maglev train, the technology itself is relatively mature. However, the problems associated with the used cryocoolers have hampered the advancement of their practical applications. An ideal cryocooler for the applications should have the following features: low maintenance, high reliability, stable operation, long life, high capacity and high thermodynamic efficiency.
In the authors'laboratory, a cryogenic system based on the Stirling-type pulse tube cryocooler (SPTC) has been developed and built. The system was designed to be integrated into a new generation of high-temperature superconducting maglev prototype train. The developed SPTC is inherited from a series of ones developed for aerospace applications and thus keeps the merits of high reliability and long life which is evaluated to reach 5 years.
The high-capacity SPTC unit in the cryogenic system uses the configuration of multiple cold fingers, which can provide 100W of cooling capacity at the working temperature of 45K for a single superconducting magnet module. Another advantage of the cryogenic system is that it can vary freely from 35 K to above. The SPTC has also achieved high efficiency with a relative COP of 20% of Carnot at 77 K.
The overall design approach, coupling and integration of the cryogenic system for the high-temperature superconducting maglev train and the arrangement of related low-temperature circulation pipelines will be described. Meanwhile, the performance characteristics of the developed cryogenic system during the laboratory testing will be presented and discussed.

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