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C2Po1C-05: Proposed Gas Refrigeration Cycles for Forced-Flow Cooling of High-Field Magnet Systems at 20 K

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Thermodynamic refrigeration cycles are designed and optimized for the emerging application to high-field HTS magnet systems at 20 K, such as fusion, NMR, or large accelerators. The refrigeration requirements are specified as the forced-flow cooling of HTS magnets at 20 K, a thermal shield at 100 K, and current leads from 50 K up to ambient temperature. The current leads are a serial combination of metallic conductors (as warm part) and REBCO tapes (as cold part), but only the metallic conductors are gas-cooled. In order to design a fully closed system without any supply of liquid nitrogen or boil-off loss, standard or modified Brayton refrigeration cycles are proposed to be thermally coupled with a circulation loop for forced-flow cooling. Since gaseous helium is used as refrigerant and coolant at the same time, an integrated design of refrigeration cycle and cooling loop is also proposed. The proposed cycles are optimized for the best thermodynamic performance with iterative analysis with process simulator (Aspen HYSYS) and real-gas properties. It is rigorously verified that the optimized cycles can achieve a great thermodynamic efficiency. Details of various cycles are presented and discussed towards the practical development.
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