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## **Finite-Time Thermodynamic optimization of a large-scale helium Brayton cryo-refrigerator with static gas bearing turboexpander**

Large-scale helium cryo-refrigerator is widely used in superconducting systems, nuclear fusion engineering, and scientific researches etc., however, its energy efficiency is quite low. We built a 2kW at 20.0K helium Brayton cryo-refrigerator. As to the characteristics of the plant/cycle, we put forward a model of helium Brayton cryo-refrigerator/cycle according to finite-time thermodynamics. Analytical expressions of cooling capacity and COP are obtained, and we found that the expressions are piecewise functions. Further, comparison between the model and the experimental results for cooling capacity of the helium cryo-refrigerator shows that error is less than 7.6%. Effects of the pressure ratio, efficiency of turbine and compressor, etc. on cooling capacity and COP of the helium cryo-refrigerator are investigated. In a word, this study provides a better understanding of energy conversion and utilization of the cycle and helps to optimize it.

**Primary author:** Dr ZHANG, Yu (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences)

**Co-authors:** Dr WANG, Bingming (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Prof. WU, Jihao (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Mr ZHANG, Peng (School of Energy and Power Engineering, HuaZhong University of Science and Technology); Dr LI, Qiang (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Prof. LI, Qing (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Mr LU, Wenhai (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Mr XU, Xiangdong (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Dr XIE, Xiujian (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Dr QIU, Yanan (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Mr SUN, Yu (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Prof. XIONG, lianyou (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Mr SUN, lijia (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences); Prof. LIU, liqiang (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences)

**Presenter:** Dr LI, Qiang (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences)

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