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C2Po2E-07: Simulation and optimization of reliquefication refrigerator for cryogenic liquid

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Boil-off gas (BOG) in cryogenic vessels must be vented to keep the pressure below the limit and preserve the safety of the tank. Since liquefaction consumes a lot of energy and BOG in the tank only loses latent heat, it is not economical to vent it directly. Undoubtedly, providing refrigeration power to reliquefy the evaporated gas or subcool the cryogenic fluid is a superior scheme. Therefore, an efficient cryogenic refrigerator is essential to provide sufficient refrigeration power, and the performance of the refrigeration system is determined by the composition of the refrigerant, the design of the refrigeration cycle, and the operating parameters. In this paper, we optimized the working fluid composition and process parameters of the turbine-Brayton cycle in the temperature range of LNG, liquid nitrogen, and liquid hydrogen. Moreover, we proposed and optimized two new processes for the same temperature ranges. The refrigeration cycles are established in Aspen HYSYS, and the optimization is performed in MATLAB using the genetic algorithm. Reasonable constraint parameters and variables are given for the optimizations. The optimal composition of the working fluid and process parameters were obtained by 9 independent optimizations. The performance of the three cycles in different temperature ranges was compared in detail. The results show that the new process has significant advantages over the turbine-Brayton cycle. The refrigeration system can be easily scaled and combined so that it can be arranged in scenarios with different refrigeration requirements. This paper will provide an important reference for zero-boil-off storage of large cryogenic tanks.

Authors: Dr CHAO, Baohua (1 Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing, China 2 University of Chinese Academy of Sciences, Beijing, China); Dr WANG, Jinzhen (Technical Institute of Physics and Chemistry, CAS); GONG, Linghui (1 Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing, China 2 University of Chinese Academy of Sciences, Beijing, China); LV, Cui (Technical Institute of Physics and Chemistry, CAS); WU, Jihao (1 Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing, China 2 University of Chinese Academy of Sciences, Beijing, China)

Presenter: Dr WANG, Jinzhen (Technical Institute of Physics and Chemistry, CAS)

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