Proceedings of CHT-17
ICHMT International Symposium on Advances in Computational Heat Transfer

May 28-June 1, 2017, Napoli, Italy

CHT-17-259

PERFORMANCE OPTIMIZATION OF PLATE-FIN HEAT EXCHANGERS USED IN A THREE STAGE PROPANE PRE-COOLING CYCLE OF THE CASCADE LNG PLANT

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ABSTRACT

The most important equipment in natural gas liquefaction plant is the heat exchanger. Natural gas liquefaction processes use tailored heat exchangers to involve all streams participating in heat exchange into a single piece of equipment. In addition, the pressure drop in heat exchangers decreases the suction pressure of compressor in LNG cycles, leading to an increase of compressor's shaft work. The improvement in heat exchangers yields higher thermal efficiency and lower capital cost, number of equipment, space requirements, etc. Plate Fin Heat Exchangers (PFHE) have been used in LNG production from the earliest days of commercial liquefaction to the present day and cover the complete size spectrum. Plate Fin Heat Exchangers are used in a wide variety of cryogenic process applications such as Nitrogen Expander, Cascade and Mix Refrigerant Cycles. The main goal of the present research is to present a performance optimization procedure, based on Non-Sorting Genetic Algorithm (NSGA-II), for plate-fin heat exchangers used in a three stages propane pre-cooling cycle of the cascade LNG plants. Four input parameters, such as fin type, fin height, fin thickness and fin frequency, have been used on numerical simulations. The simulation of energy and mass balances of LNG process is performed by ASPEN HYSYS® using Peng-Robinson equation of state. The design and heat transfer calculation of heat exchangers are carried out by Aspen EDR (Exchanger Design & Rating) integrated to the ASPEN HYSYS®. The Coefficient of Performance (COP) is considered as objective function of the optimization. Four inlet parameters have been chosen for the optimization procedure, such as fin type (offset strip, perforated, plain and wavy), fin height, fin thickness and fin frequency are. An automated optimization process was developed for coupling the softwares ESTECO ModeFrontier and ASPEN HYSYS®. The optimization procedure has used the Genetic Algorithm (NSGA-II) in order to maximize the COP based on the several design conditions. The results obtained for the optimal design showed great improvement of the coefficient of performance compared to the literature results.

Keywords: Liquefied natural gas, Cascade liquefaction process, plate and fin heat exchangers, optimal design, Genetic algorithm