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Krill-Herd Step-Up Approach Based Energy Efficiency Enhancement Opportunities in the Offshore Mixed Refrigerant Natural Gas Liquefaction Process

Authors : Kinza Qadeer, Muhammad Abdul Qyyum, Moonyong Lee

Abstract : Natural gas has become an attractive energy source in comparison with other fossil fuels because of its lower CO_2 and other air pollutant emissions. Therefore, compared to the demand for coal and oil, that for natural gas is increasing rapidly world-wide. The transportation of natural gas over long distances as a liquid (LNG) preferable for several reasons, including economic, technical, political, and safety factors. However, LNG production is an energy-intensive process due to the tremendous amount of power requirements for compression of refrigerants, which provide sufficient cold energy to liquefy natural gas. Therefore, one of the major issues in the LNG industry is to improve the energy efficiency of existing LNG processes through a cost-effective approach that is 'optimization'. In this context, a bio-inspired Krill-herd (KH) step-up approach was examined to enhance the energy efficiency of a single mixed refrigerant (SMR) natural gas liquefaction (LNG) process, which is considered as a most promising candidate for offshore LNG production (FPSO). The optimal design of a natural gas liquefaction processes involves multivariable non-linear thermodynamic interactions, which lead to exergy destruction and contribute to process irreversibility. As key decision variables, the optimal values of mixed refrigerant flow rates and process operating pressures were determined based on the herding behavior of krill individuals corresponding to the minimum energy consumption for LNG production. To perform the rigorous process analysis, the SMR process was simulated in Aspen Hysys® software and the resulting model was connected with the Krill-herd approach coded in MATLAB. The optimal operating conditions found by the proposed approach significantly reduced the overall energy consumption of the SMR process by ≤ 22.5% and also improved the coefficient of performance in comparison with the base case. The proposed approach was also compared with other well-proven optimization algorithms, such as genetic and particle swarm optimization algorithms, and was found to exhibit a superior performance over these existing approaches.

Keywords : energy efficiency, Krill-herd, LNG, optimization, single mixed refrigerant
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