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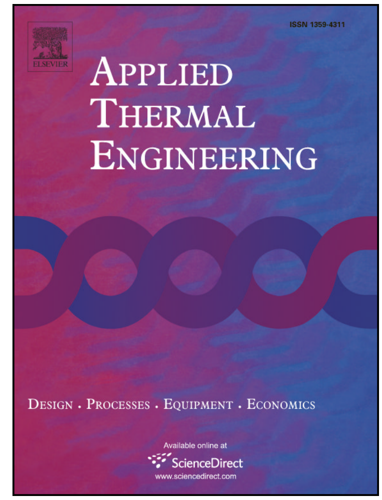

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Thermodynamic comparison of three small-scale gas liquefaction systems

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Abstract

Natural gas liquefaction systems are based on refrigeration cycles, which can be subdivided into the cascade, mixed refrigerant and expander-based processes. They differ by their configurations, components and working fluids, and have therefore various operating conditions and equipment inventory. The present work investigates three configurations suitable for small-scale applications because of their simplicity and compactness: the single-mixed refrigerant, single and dual reverse Brayton cycles. The impact of different feed compositions and refrigerant properties is analysed. A detailed assessment of the energy and exergy flows is conducted, and the most promising cycle layouts are identified by performing multi-objective optimisation procedures. The findings illustrate the resulting trade-offs between the system performance and size in different operating conditions. Mixed-refrigerant processes prove to be more efficient (1000-2000 kJ/kg_{LNG}) than expander-based ones (2500-5000 kJ/kg_{LNG}) over larger ranges of operating conditions, at the expense of a greater system complexity and higher thermal conductance (250-500 kW/K against 80-160 kW/K). The results show that the use of different thermodynamic models leads to relative deviations of up to 1 % for the power consumption and 20 % for the network conductance. Particular caution should thus be exercised when extrapolating the results of process models to the design of actual gas liquefaction systems.

Keywords: Gas liquefaction, process optimisation, process modelling, multi-objective optimisation, exergy analysis

1. Introduction

Liquefied natural gas (LNG) is a liquid mixture of hydrocarbons consisting mainly of methane, generally produced at high pressure (20 to 50 bar) and stored at about -160 °C and near atmospheric conditions. LNG is a cleaner fuel than conventional fossil fuels such as black oil because of the smaller emissions of nitrogen and sulphur oxides. For this reason, it is suggested as a substitute for heavy oil as a marine fuel. LNG

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