

Robust implementation of optimal operation of small LNG refrigeration cycles.

Project IKP-70/2015

TKP4550 - Process Systems Engineering, Specialization Project

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Project Background:

Natural gas is a fast growing energy resource in most regions of the world. Liquefaction plays an important role in the distribution of natural gas to locations in which pipeline transportation is not available. Boil-off gas (BOG) is the natural gas that boils-off during the voyage of a liquefied natural gas (LNG) carrier. Pressure in the tanks cannot exceed a certain limit and the common way to avoid overpressure is to burn BOG to onboard power steam turbines, or simply flare it. Small-scale LNG plants have been installed recently on LNG carriers to re-liquefy BOG, reducing product loss and minimizing flaring.

As the majority of small LNG plants are either onboard carriers or in remote locations, specialized staff is not available and there might be limitations for obtaining continuous or reliable information regarding the process. For example, chromatography for refrigerant or natural gas composition is not readily available. This situation makes difficult to track changes in the process and to rely on onboard personnel to perform the appropriate adjustments every time a disturbance occurs.

The optimum composition of the refrigerant is determined by the natural gas feed composition and pressure, plant pressure, and ambient temperature. Ideally, refrigerant composition would be adjusted accordingly, but it is not a practical or even applicable solution.

Additionally, refrigerant may leak from the pipeline. As refrigerant components do not leak at the same rate, the composition of the refrigerant varies and the optimal operating point might also change. Being onboard a carrier, it is a challenge to maintain near to optimal operation when having this type of disturbances, which are in principle very difficult to measure directly.

This situation is an excellent example to explore the convenience of using self-optimizing control variables. The concept behind this is to maintain near-optimal (with acceptable loss) operation in presence of disturbances and implementation errors using constant set points (Skogestad 2000, 2004).

The analyzed plant would preferably be the one described by (Nekså et al. 2010) but it could be another simple LNG plant.

Proposed activities:

- Literature search on: small LNG technologies, types of models, and typical control strategies for this type of processes.
- Modeling for control purposes. There are two possible options:
 - Develop a steady state HYSYS model of the refrigeration cycle.
 - Develop a simple (possibly dynamic) model of the refrigeration cycle using MATLAB.
- Optimization: analysis of optimal operating conditions when disturbances occur.
- Analysis of research challenges. May include a proposal for Master thesis work.

Specific activities and methods will be discussed and defined with the project student. The student will write a project description at the beginning of the semester, specifying the actual objectives and proposing a time schedule.

References:

- Nekså, P., E. Brendeng, M. Drescher, and B. Norberg. 2010. "Development and Analysis of a Natural Gas Reliquefaction Plant for Small Gas Carriers." *Journal of Natural Gas Science and Engineering* 2(2-3): 143–49.
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