Abstract

Cryogenic air separation is a process that can be integrated into other processes. Yet, many processes that include a cryogenic air separation unit (ASU), such as gasification, still utilize the standard design typically used to produce relatively pure nitrogen and oxygen products for retail purposes. The energy efficiency of processes with a cryogenic ASU could be improved by using a non-standard design, where nitrogen and oxygen products of lower purity are produced and used in downstream process units. However, it is complex to simultaneously optimize an ASU with other processes. The most complex units in a cryogenic ASU are the distillation units and the multistream heat exchanger. Therefore, a simple model of an ASU that can be integrated with other process units is developed in this work.

A novel simplified distillation model was developed that can accurately represent the distillation column units in the cryogenic ASU. The model utilizes insight from material and energy balances to predict the change in liquid and vapour flow throughout the column, instead of relying on the constant molar overflow assumption.

Other than that, a number of equation-oriented pinch analysis methods were reviewed and tested on a number of problems to characterize the performance. The best method, known as the Multi-M formulation, was selected for use in the case studies.

Finally, the distillation model, heat integration model and other auxiliary models were combined to perform simultaneous process optimization and heat integration on a selected cryogenic ASU flowsheet. The results obtained from the optimization were compared against an ASPEN simulation conducted using parameters from the model. A close match between the model and the ASPEN simulation results was obtained, showcasing the accuracy of the models used. The optimized results also showed close agreement with results observed in literature.