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C2Po1F-06: Model development and optimization of cryogenic mixed-refrigerant cycles with phase separators

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Cryogenic mixed-refrigerant cycles (CMRCs) are a promising technology for providing cryogenic temperatures in several areas of research and technology, offering high power density and high efficiency combined with scalability and inexpensive process design.
In order to achieve high process efficiency, the ideal mixture composition and operating conditions for a specific application need to be identified. For this purpose, a simulation and optimization tool is being developed at the Karlsruhe Institute of Technology. The tool uses the Differential Evolution algorithm for optimization, taking advantage of parallel computation.
This contribution focuses on a subgroup of CMRCs known as auto-cascade refrigeration cycles (ARCs), which use one or more phase separators to split the initial mixture into a liquid phase enriched with the high-boiling components and a vapor phase with a higher concentration of low-boiling components. The developed ARC model covers a wide range of process configurations with up to three phase separators and five heat exchangers, optional subcooling of the separated liquid as well as multistage compression. The modeling approach and the optimization algorithm are introduced, and the benefit of phase separators is demonstrated by comparing the efficiency of optimized cycles with and without phase separators.

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