Comprehensive Design Method of Mixed Refrigerant Cycle for Low Temperature Processes Case study: Cold section of olefin plant of Tabriz petrochemical complex

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Abstract

In industrial processes, there are many processes that operate below ambient temperature. Usually when these processes demand refrigeration over a very wide temperature range, cascade refrigeration systems are employed. Unfortunately, the cascade refrigeration systems are capital intensive because of major use of installed equipment and large energy requirement in operations. Therefore, the continuing development of new methods to reduce net power and capital costs of refrigeration systems is important in the design of low temperature processes. A recent advancement has been the introduction of mixtures as refrigerants in place of pure refrigerants. In mixed refrigerant cycles, the composition of the mixture can be selected such that the liquid refrigerant evaporates over a temperature range similar to that of the process cooling demand to provide the desired refrigerant characteristics. Small temperature driving force leads to near-reversible operation, thus better thermodynamic efficiency and lower power requirement. Also, a mixed refrigerant cycles feature simpler machinery configuration and fewer maintenance problems. Due to the lack of comprehensive design method for mixed refrigerant cycle, conventional approaches are largely trial-and-error and therefore operations can be far away from optimal conditions. The difficulty in design mainly stems from two aspects: one is the expensive and highly nonlinear nature of computation and the other is the sensitivity of the cycles to the operating changes, especially the change in the composition of refrigerant mixtures and, the suction and discharge pressures of compressor. In this paper, a novel method for comprehensive design of mixed refrigerant cycles is proposed by combined mathematical programming and thermodynamics approach. This method combines the power of thermodynamics and mathematical programming. While the mathematical programming can satisfactorily give the optimal choice of pressures operating conditions and refrigerant compositions, thermodynamics at the same time gives the user insights and confidence in solution. The procedure is demonstrated using a case study of design of two mixed refrigerant cycles for cold section of olefin plant of Tabriz petrochemical complex.

Keywords: Sub-ambient process, refrigeration system, natural mixed refrigerant, combined pinch and exergy analysis, comprehensive design method.