243l Effect of Design Constraints on the Energy Efficiency of Multi-Effect Evaporative Crystallization Process

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Crystallization is a popular technique to recover substance dissolved in a solvent. Crystallization of the substance occurs when the solution is kept supersaturated. There are two different ways to realize supersaturated condition. One is to lower the solution temperature, and often regarded as cooling crystallization. This technique is not suited for crystallization when the variation in the saturation concentration with temperature is not large enough. In such a case, evaporative crystallization can be used. In this type of operation, the solution is heated to remove the solvent from the solution. One of the disadvantages of the evaporative crystallization is its large energy requirement. The energy efficiency of the evaporative crystallization can be improved by reusing the hot vapor arising from a crystallizer. In a salt (sodium chloride) process, for example, typically 3 or 4 evaporative crystallizers are configured in a multi-effect manner. The energy efficiency of the multi-effect process can be improved further by recovering the enthalpy from the condensed liquid. The heat exchange network for this purpose can be designed when the temperature and flow rate of each process stream are determined. To maximize the energy efficiency of an evaporative crystallization process, it is necessary to optimize both the operating condition of each crystallizer and the heat exchange network for heat recovery. In our previous work, a system for deriving the optimal process design was developed. The system consists of three modules. The first is to calculate the energy and mass balance of the process flow based on the thermodynamics. The second module derives the optimal heat recovery network by using pinch technology. The genetic algorithm was employed to adjust the design variables to optimal heat efficiency and implemented in the third module. The objective of the present study is to explore the effects of design constraints on the final design of the process flowsheet. A 200kt/yr process consisting of three crystallizers and one evaporator was used in the case study. The focus was on the effect of feed brine concentration and flow rate and the constraints on production rate of each crystallizer. It was revealed that small deviation in production rate from its optimal does not affect the amount of energy required for producing unit mass of salt.