243n A Simultaneous Model for Men Retrofit

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There are two main techniques of the research regarding heat exchanger network (HEN) synthesis, such as Pinch Analysis and Mathematical Programming. Until recently, compared to the burgeoning investigations on the synthesis of heat exchange networks (HENs), there are not many research reports have been presented to address the integration of mass exchange networks (MENs), though the design of individual mass exchange unit is a well-established topic.

In the early development, a systematic two-staged procedure for the synthesis of cost-effective MEN's is firstly proposed by El-Halwagi and Manousiouthakis (1989). Therein the pinch points, the thermodynamic obstacles that limit the extent of mass transfer between the rich streams and MSAs, are identified and a preliminary network is generated to feature maximum mass exchange in the first stage of synthesis. The preliminary network is then improved in the second stage to develop a final cost effective configuration to satisfy the assigned exchange obligations. Thereafter, a linear transshipment model is also established for automatic synthesis of MENs with single-component targets (El-Halwagi and Manousiouthakis, 1990a). This work is further extended in a later report to include networks for regeneration of recyclable lean streams (El-Halwagi and Manousiouthakis, 1990b). Therein a mixed-integer nonlinear program is formulated to obtain the minimum cost of mass-separating and regenerating agents. Then a mixed-integer linear program is provided to solve the configuration with minimum number of mass exchange units. The synthesis problem of reactive MEN's is also discussed by El-Halwagi and Srinivas (1992), where chemical as well as physical MSAs can be used to separate a certain species from a set of rich streams.

Recently, Hallale and Fraser (2000a-d) present a method in a series of papers for targeting the capital cost as well as the operating cost of a mass exchange network, and these costs are further combined to give total annual cost target. The design of MEN's to meet the targets is also discussed in detail. These papers demonstrate that, contrary to previous belief, using the minimum number of units does not necessarily lead to a minimum cost design (Hallale and Fraser, 2000a). The primary limitation of these sequential approaches, as pointed by Papalexandri, Pistikopoulos and Floudas (1994), is due to the inappropriate consideration of all cost factors and trade-offs.

In contrast to previous works that simplify the problem by decomposition based on the concept of pinch points, a hyperstructure-based representation of MENs is proposed by Papalexandri et al. (1994). Therein the MEN synthesis problem is formulated as a mixed-integer nonlinear programming optimization problem with both network operating and investment costs being optimized simultaneously. The impact of simultaneously minimizing operating and investment costs to waste minimization problems are demonstrated via several examples. The formulation is somewhat intricate for many designers, however.

All of the above-mentioned work, however, has mainly been aimed at grass-roots designs. Fraser and Hallale (2000) applied the Pinch Technology approach for the retrofit of HENs to the retrofit of mass exchange networks (MENs) but the Mathematical Programming approach has not been proposed. This paper proposes a optimization approach to retrofit MENs based on the stage-wise superstructure representation of MENs, analogous to the one introduced by Yee and Grossmann (1990) for synthesis of HENs. One example from Fraser and Hallale (2000) will be illustrated to demonstrate the efficacy of the proposed MEN retrofit method.

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