Large-Scale MILP Transshipment Models for Heat Exchanger Network Synthesis

Yang Chen a,*, Ignacio E. Grossmann a,**, David C. Miller b

a Department of Chemical Engineering, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, United States
b U.S. Department of Energy, National Energy Technology Laboratory, 626 Cochrans Mill Road, Pittsburgh, PA 15236, United States
* Email: yangchen@andrew.cmu.edu. ** Email: grossmann@cmu.edu

Problem Statement

In this problem we are given a set of hot process streams \( i (i \in H) \), cold process streams \( j (j \in C) \), that are to be integrated in a network of heat exchangers with possible use of hot utilities \( m (m \in S) \), and cold utilities \( n (n \in W) \). To model this problem, the temperature range is divided into \( K \) temperature intervals. In each temperature interval \( k \), hot process stream \( i \) supplies heat content \( Q^H_{ik} \) and cold process stream \( j \) demands heat content \( Q^C_{jk} \). The unit cost of hot utility \( m \) and cold utility \( n \) are given by \( c_m \) and \( c_n \). In the first step, the objective is to minimize the utility cost by optimizing the amount of heat exchanged between hot stream \( i \) and cold stream \( j \) (\( Q_{ij} \)), hot utility \( m \) and cold stream \( j \) (\( Q_{mj} \)), and hot stream \( i \) and cold utility \( n \) (\( Q_{nk} \)) at each interval \( k \) and the heat load of hot utility \( m \) (\( S_m \)) and cold utility \( n \) (\( W_n \)). The first step also determines the location of pinch points.

In the second step, the temperature intervals \( k \) are partitioned into a number of subnetworks by the pinch points determined in the first step. The match between hot stream \( i \) and cold stream \( j \) in subnetwork \( q \) is represented by the binary variable \( y_{ij}^q \). Each match has a given upper bound \( Q_{ij}^{U,q} \). The heat load of hot utility \( m \) (\( S_m \)) and cold utility \( n \) (\( W_n \)) are fixed to the optimized values in the first step. The objective is to minimize the number of units, which is equivalent to minimizing the number of matches given by the sum of the binaries \( y_{ij}^q \) for all hot streams \( i \) and cold streams \( j \) in each subnetwork.

Reference