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Bilevel heat exchanger network synthesis with an interactive multi-objective optimization method

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HIGHLIGHTS

► Increased calculation efficiency for simultaneous heat exchanger network synthesis.
► Interactive multi-objective optimization with General Algebraic Modeling System.
► Bilevel decomposition applied.

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ABSTRACT

Heat exchanger network synthesis (HENS) has been an active research area for more than 40 years because well-designed heat exchanger networks enable heat recovery in process industries in an energy- and cost-efficient manner. Due to ever increasing global competition and need to decrease the harmful effects done on the environment, there still is a continuous need to improve the heat exchanger networks and their synthesizing methods. In this work we present a HENS method that combines an interactive multi-objective optimization method with a simultaneous bilevel HENS method, where the bilevel part of the method is based on grouping of process streams and building aggregate streams from the grouped streams. This is done in order to solve medium-sized industrial HENS problems efficiently with good final solutions. The combined method provides an opportunity to solve HENS problems efficiently also regarding computing effort and at the same time optimizing all the objectives of HENS simultaneously and in a genuine multi-objective manner without using weighting factors. This enables the designer or decision maker to be in charge of the design procedure and guide the search into areas that the decision maker is most interested in. Two examples are solved with the proposed method. The purpose of the first example is to help in illustrating the steps in the overall method. The second example is obtained from the literature.

1. Introduction

Efficient heat recovery is a necessity in modern process industry. Well-designed heat exchanger networks enable heat recovery in an energy- and cost-efficient manner. For this reason Heat Exchanger Network Synthesis (HENS) has been an active research area in the field of process systems engineering for more than 40 years and a lot of research effort has been devoted into developing models and methods for this network synthesis problem. In methodology development, two main research branches have been pinch technology (see for instance Refs. [1,2]) and mathematical programming. In pinch analysis, different targets (minimum utility consumption, minimum number of units and minimum heat transfer area) of HENS are solved sequentially. Mathematical programming has been used with this sequential strategy (see for instance Refs. [3–6]). Because the sequential nature of the methods can cut off the best solutions, simultaneous methods formulated as a mixed-integer nonlinear programming (MINLP) model, have been developed (see for instance Refs. [7,8]). An extensive review of HENS methods can be found in Refs. [9,10]. A comprehensive review of the major turning points and emerging trends in developing and improving of heat integration and HENS methods through the years 1975–2008 is given in Ref. [11].

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