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Abstract

3UREOHP GHFRPSRVLWLRQ LQ SURFHVV LQWHJUDWLRQ ZKLFK ZDV ¿UVW GHVF at making pinch technology capable of solving problems that included constraints. However, this method directly depends on human decisions, and as a result, it is not possible to automate it with a computer program. Therefore, the possibility of making errors is very high for complicated problems. In this study, a new methodology for grouping streams is presented that eliminates the above-mentioned problems. The method considers each hot stream and all of the cold streams, which have no constraints concerning group membership. Contrary to the previous method, in which each stream only belongs to one group, in our improved method, each cold stream may appear in more than RQH JURXS WKHUHIRUH D IDFWRU FDOOHG WKH ³%HOQJLQJ)UDFWLRQ´ LV GH¿Q D FROG VWUHDP EHORQJV WR D JLYHQ JURXS 7KH ¿QDO JURXSV DUH GHWHUPLQH In addition, a heat exchanger network is obtained by solving the problem. The network can be used as a basic design by heat exchanger network designers.

Keywords: Pinch technology; Heat recovery; Process integration; Problem decomposition; Heat exchanger network

Introduction

e heat exchanger network synthesis problem is one of the most studied problems in process synthesis and the development of cost e cient heat exchanger networks has proven to be a challenging task. In the synthesis process, decisions about level of heat recovery as well as network structure, size and type of heat exchangers are made. A network resulting in the overall most economical solution when considering both utility costs and investment costs for all units of the energy recovery network is targeted. During the last three decades, a considerable number of methods have been proposed for the design task. ese methods are thoroughly presented in the review articles by Gundersen and Naess [1], and Furman and Sahinidis [2].

In general terms, the objective of heat exchange network synthesis is to nd out the structure of a heat exchanger network, which facilitates the task of the cooling of a given set of hot streams and the heating of a given set of cold streams to the desired levels with a minimum of investment and operating costs. Basically, there are two types of approach for solving the heat exchange network synthesis problem: (1) sequential methods and (2) simultaneous methods. e sequential methods attempt to reduce the computational complexity of the problem by decomposing the main problem into sub problems, which are then solved sequentially. e simultaneous methods solve the problem without any decomposition. e sequential methods seldom lead to globally optimal solutions.

Optimization methods form the backbone of the heat exchange network synthesis models. For a speci ed number of hot and cold streams, there are a large number of possibilities of network structure. Heat exchange network synthesis attempts to nd the optimum among all the network con gurations from the standpoint of minimum utility consumption, minimum number of units and minimum cost, etc.

Although heat exchange network synthesis has been one of the most-studied problems in process synthesis, even small heat exchange network synthesis problems have not been solved to global optimality to date. In fact, even nding feasible solutions using simultaneous synthesis methods has been troublesome. e complexity of the heat exchange network synthesis problem provides, therefore, enough scope for the development of specialized optimization algorithms [2].

One of the best known heat exchange network design methods is the pinch analysis method [3,4]. In pinch analysis subproblems are solved successively with di erent targets in a heuristic order of decreasing signi cance. e subproblems are solved with the aim of obtaining: the minimum utility cost, the minimum number of exchanger units and the minimum capital cost of the network.

Pinch Analysis

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because it cannot be used simultaneously with the material balance, but it quickly proposes good ideas for heat and power integration during complex processes. Combined heat and power design adds degrees of freedom to the optimization method [6].

Pinch techniques are used in the chemical industry for improving heat integration regarding utility systems. Ahmad and Hui [7] extended the concept for direct and indirect integration.

Using the site-source and site-sink pro les, the targets for steam generation and utilization between processes were set by Dhole and Linnho [8]. Hui and Ahmad [9] developed a procedure for the cost optimum integrations of di erent processes using exergetic steam costing.

Over the last four decades, the problem of designing and synthesizing optimal heat exchanger networks has been the focus of an extensive number of studies [1,3,10-16]. In regard to this problem, a set of hot streams at a set of initial (stream) temperatures need to be cooled to a corresponding set of target temperatures, and a set of cold streams at a set of initial (stream) temperatures need to be heated to another corresponding set of target temperatures. e objective is to determine the structure of the heat exchange network and associated heat exchanger (HEX) heat load/duty, together with additional heaters and coolers (utilities), if required. is brings all streams to their target temperatures provided that the heat exchange network's HEXs input and output temperature di erences are greater than or equal to the heat exchange network minimum approach temperature 'T (min).

A heat exchanger network's design may depend on the heat-pinch targeting stage, as an approach whereby the hot and cold composite curves (CCs) are used to determine the heat energy targets (heat recovery, cold utility, and hot utility) at a speci ed minimum approach temperature 'T min [1,17]. e targeting stage will allow the designer

Forbidden matches for the problem are shown in Table 2.

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