CHEMICAL ENGINEERING RESEARCH AND DESIGN 90 (2012) 1883–1895

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Research and Design

journal homepage: www.elsevier.com/locate/cherd

Multi-period design of heat exchanger networks

Muhammad Imran Ahmad[a,*], *Nan Zhang*[b], *Megan Jobson*[b], *Lu Chen*[c]

[a] *Department of Chemical Engineering, University of Engineering and Technology, 25000, Peshawar, Pakistan*
[b] *Centre for Process Integration, School of Chemical Engineering and Analytical Science, The University of Manchester, PO Box 88, Sackville Street, Manchester, M60 1QD, UK*
[c] *Process Integration Limited, One Central Park, Northampton Road, Manchester, M40 5BP, UK*

ABSTRACT

Heat exchanger networks are an integral part of chemical processes as they recover available heat and reduce utility consumption, thereby improving the overall economics of an industrial plant. This paper focuses on heat exchanger network design for multi-period operation wherein the operating conditions of a process may vary with time. A typical example is the hydrotreating process in petroleum refineries where the operators increase reactor temperature to compensate for catalyst deactivation. Superstructure based multi-period models for heat exchanger network design have been proposed previously employing deterministic optimisation algorithms, e.g. (Aaltola, 2002; Verheyen and Zhang, 2006). Stochastic optimisation algorithms have also been applied for the design of flexible heat exchanger networks recently (Ma et al., 2007, 2008). The present work develops an optimisation approach using simulated annealing for design of heat exchanger networks for multi-period operation. A comparison of the new optimisation approach with previous deterministic optimisation based design approaches is presented to illustrate the utilisation of simulated annealing in design of optimal heat exchanger network configurations for multi-period operation.

Keywords: Heat exchanger network; Multi-period; Simulated annealing; Design

1. Introduction

Heat exchanger networks are a means of utilising the heat available in a process by exchanging between hot and cold process streams, thereby decreasing energy demand and therefore utility costs, as well as capital investment in auxiliary equipment. Heat exchanger networks thus improve the economics of plant operation. Heat exchanger network design has long been the focus of research studies and remains an area of continuous development due to the current trend of increasing energy costs.

The operating conditions of a plant may vary with time. Firstly, unplanned and/or uncontrolled operational fluctuations in operating conditions around desired values or set points are inevitable. Secondly, planned periodic changes in operating conditions for enhancing performance is inherent to the nature of some processes. For example, the reactor operating temperature in processes such as hydrotreating and hydrocracking in refineries can be changed with time to compensate for catalyst deactivation; distillation column operating pressures can be varied to take advantage of seasonal variations in ambient temperatures. Heat exchanger networks that can remain operable in such varying operating conditions and optimal over the time period of interest are termed flexible heat exchanger networks. Flexible heat exchanger networks are classified as resilient or multi-period respectively, depending on the nature of variation in the plant operating conditions (Verheyen and Zhang, 2006). The aim of this work is to review and analyse multi-period heat exchanger network design and propose a new robust and effective approach using simulated annealing for optimisation.

1.1. *Review of design methodologies*

This section presents an overview of approaches for design of heat exchanger networks for fixed process operating conditions. A detailed discussion of these design methodologies can be found elsewhere (Nishida et al., 1981; Smith, 2005; Verheyen and Zhang, 2006). Since the pioneering work on

* Corresponding author. Tel.: +92 91 9218180.
E-mail address: Imran.Ahmad@nwfpuet.edu.pk (M.I. Ahmad).
Received 31 December 2010; Received in revised form 5 August 2011; Accepted 30 March 2012
0263-8762/$ – see front matter
http://dx.doi.org/10.1016/j.cherd.2012.03.020