Application of a novel multi objective optimization technique for a shell and tube heat exchanger

Hojatollah Meshkizadeh¹ - Ehsanolah Assareh²,⁎ – Mohsen Izadi³

¹Department of mechanical Engineering, Bushehr Science and Research Branch, Islamic Azad University, Bushehr, Iran
²Department of mechanical Engineering, Dezful Branch, Islamic Azad University, Dezful, Iran
³Department of mechanical Engineering, Engineering Faculty, Lorestan University of Khorramabad, Iran

ABSTRACT

Many studies are performed by researchers about shell and tube heat exchanger (STHE) but the multi objective Gravitational Search Algorithm (GSA) technique has never been used in such studies. This paper presents application of thermal economic multi objective optimization of STHE using GSA. For optimal design of a STHE, it was first thermally modeled using e-number of transfer units method while Bell–Delaware procedure was applied to estimate its shell side heat transfer coefficient and pressure drop. Multi objective Gravitational Search Algorithm (GSA) method was applied to obtain the maximum effectiveness (heat recovery) and the minimum total cost as two objective functions. The results of optimal designs were a set of multiple optimum solutions, called ‘Pareto optimal solutions’. In order to show the accuracy of the algorithm, a comparison is made with the non-dominated sorting genetic algorithm (NSGA-II) and MOGSA which are developed for the same problem.

Keywords: MOGSA Algorithm, Two Objective Optimization, Heat Transfer, Cost, Shell and tube heat exchanger

1. INTRODUCTION

Shell and tube heat exchangers (STHEs) are probably the most common type of heat exchangers applicable for a wide range of operating temperatures and pressures. STHEs are widely used in refrigeration, power generation, heating and air conditioning, chemical processes, manufacturing and medical applications.

A typical STHE is shown in [1, 2]. This widespread use can be justified by its versatility, robustness and reliability. The design of STHE involves a large number of geometric and operating variables as a part of the search for an exchanger geometry that meets the heat duty requirement and a given set of design contrains. Usually a reference geometric configuration of the equipment is chosen at first and an allowable pressure drop value is fixed. Then, the values of the design variables are defined based on the design specifications and the assumption of several mechanical and thermodynamic parameters in order to have a satisfactory heat transfer coefficient leading to a suitable utilization of the heat exchange surface. The designer’s choices are then verified based on iterative procedures involving many trials until a reasonable design is obtained which meets design specifications with a satisfying compromise between pressure drops and thermal exchange performances [1, 2].

Design of heat exchangers is a complex procedure and it requires a good knowledge of thermodynamics, fluid dynamics, cost estimation and optimization. Objectives involved in the design optimization of heat exchangers are thermodynamic (i.e. maximum efficiency) and economic (i.e. minimum cost). The conventional design approach for heat exchangers involves rating a large number of different exchanger geometries to identify those that satisfy a given heat duty and a set of geometric and operational constraints. This approach is time-consuming, and does not guarantee an optimal solution [3].

2. LITERATURE REVIEW

Several studies are presented to propose optimization of STHE. Zhao and Li used an effective layer pattern optimization model for multi-stream plate – fin heat exchanger using genetic algorithm. In this paper, an effective layer pattern optimization model using genetic algorithm (GA) is developed in detail [4].

Qian et al. presented Applicability of entransy dissipation based thermal resistance for design optimization of two-phase heat exchangers. In this study, the evaluation of two-phase entransy is achieved by optimizing one tube – fin heat exchanger and one micro channel heat exchanger based on a validated heat exchanger modeling tool [5].

⁎ Corresponding author: Email: assareh@iaud.ac.ir