Applied Thermal Engineering 42 (2012) 119–128

Contents lists available at SciVerse ScienceDirect

Applied Thermal Engineering

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

# A chaotic quantum-behaved particle swarm approach applied to optimization of heat exchangers

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ARTICLE INFO

*Article history:*
Received 26 September 2011
Accepted 13 March 2012
Available online 21 March 2012

*Keywords:*
Heat exchanger design
Shell and tube heat exchanger (STHE)
Economic optimization
Particle swarm optimization
Quantum particle swarm optimization
Chaos theory

ABSTRACT

Particle swarm optimization (PSO) method is a population-based optimization technique of swarm intelligence field in which each solution called "particle" flies around in a multidimensional problem search space. During the flight, every particle adjusts its position according to its own experience, as well as the experience of neighboring particles, using the best position encountered by itself and its neighbors. In this paper, a new quantum particle swarm optimization (QPSO) approach combined with Zaslavskii chaotic map sequences (QPSOZ) to shell and tube heat exchanger optimization is presented based on the minimization from economic view point. The results obtained in this paper for two case studies using the proposed QPSOZ approach, are compared with those obtained by using genetic algorithm, PSO and classical QPSO showing the best performance of QPSOZ. In order to verify the capability of the proposed method, two case studies are also presented showing that significant cost reductions are feasible with respect to traditionally designed exchangers. Referring to the literature test cases, reduction of capital investment up to 20% and 6% for the first and second cases, respectively, were obtained. Therefore, the annual pumping cost decreased markedly 72% and 75%, with an overall decrease of total cost up to 30% and 27%, respectively, for the cases 1 and 2, respectively, showing the improvement potential of the proposed method, QPSOZ.



## 1. Introduction

Heat exchangers are devices used to transfer heat between two or more fluids that are at different temperatures and which in most of the cases they are separated by a solid wall. Heat exchangers are essential elements used in a wide range of engineering applications, such as, automobiles and aerospace industry, computers, power generation, heating, ventilation, and air conditioning, chemical processes, manufacturing, medical applications, and cooling equipment.

There are numerous ways to increase the heat transfer in heat exchangers which include, treated surfaces, rough surfaces [1], extended surfaces, coiled tubes, surface or fluid vibration, jet impingement [2], and creating longitudinal vortices in the flow. An efficient heat exchanger in such systems could result in the lesser consumption of the energy resource, which provides both economic and environmental benefits.

In accordance with Caputo et al. [3] in the literature there are two approaches about heat exchanger optimization, the first focused on optimal sizing usually based on a cost minimization goal, considering capital investment and energy related expenses, or on the maximization of some thermal performance. The second approach assumes that the heat exchanger has been already built and that a maintenance schedule has been optimized in order to minimize maintenance and energy related costs while satisfying the required heat duty. Considering the functional importance and widespread utilization of shell and tube heat exchangers in process plants, several researchers had applied different optimization techniques considering different objective functions, design and performance evaluation, to optimize heat exchanger.

Several methods can be found in the literature for optimization problems, based on different strategies. A brief investigation of scientific literature with reference to the employed numerical optimization method in heat exchangers shows that Lagrange

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doi:10.1016/j.applthermaleng.2012.03.022