Optimal Arrangement of Thermoelectric Modules for Recovering the Waste Heat of Damavand Power Plant using Mutable Smart Bee and Neuro-Fuzzy System

Pendar Samadian, AAA Linen Co., London, UK
Ahmad Mozaffari, Babol University of Technology, Babol, Iran
Ali Goudarzi, Babol University of Technology, Babol, Iran
Alireza Rezania, Aalborg University, Aalborg, Denmark
Lasse Rosendahl, Aalborg University, Aalborg, Denmark

ABSTRACT

In current research, the authors intend to find the optimal arrangement of planar thermoelectric modules to maximize the generated electricity and minimize the maintenance cost of a power system called Damavand power plant. Optimal arrangement is done by mounting a number of thermoelectric modules within the condenser in order to recover the waste heat of the thermal system. For this purpose, firstly, an adaptive neuro fuzzy inference system (ANFIS) is utilized to model the generated power of thermoelectric module and the corresponding maintenance cost. Thereafter, Gambit and Fluent softwares are applied to evaluate the temperature rate through the length of thermoelectric component. Given the derived information, the authors use a recent spotlighted metaheuristic called mutable smart bee algorithm (MSBA) to optimally arrange the thermoelectric modulus for recovering the waste heat of Damavand power plant. Based on the obtained numerical results, it is proven that the proposed framework is completely capable of finding a practical arrangement of thermoelectric cells within the entry of condenser component.

Keywords: Adaptive Neuro-Fuzzy Inference System (ANFIS), Damavand Power Plant, Engineering Optimization, Mutable Smart Bee Algorithm (MSBA), Waste Heat Recovery System

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1. INTRODUCTION

Intelligent natural inspired tools and soft computational strategies are pervasively used to handle versatile domain of engineering tasks such as dynamic identification of nonlinear engineering systems (Mozaffari et al., 2014b), power plant management (Esen et al., 2007), intelligent production (Fathi & Mozaffari, 2012), engineering and financial control, robotics (Mozaffari et al., 2014a), vehicle systems design (Mozaffari et al., 2013) and etc. In this regard, several studies have been devoted to the applications of these nature inspired methods for modeling and optimizing different real world engineering problems. Deb and Datta (2012) developed a hybrid evolutionary multi-objective optimization and analyzed machining operations. Carrese et al. (2012) proposed a comprehensive preference based optimization framework with application to high-lift aerodynamic. Hu (2005) proposed a fused evolutionary fuzzy data mining approach to find a simple rule base of linguistic fuzzy for approximation problems. Mozaffari et al. (2013a) developed a hybrid multiobjective intelligent evolutionary algorithm for optimization of laser solid freeform fabrication process. There exist several researches in literatures that imply an ongoing demand of intelligent approaches in optimization tasks. Here, the authors try to take a step towards handling a complex thermal system, as an interesting topic of applied optimization. Fathi and Mozaffari (2014) developed an evolvable recursive black-box and a hybrid metaheuristic algorithm, known as the great salmon run (Mozaffari et al., 2012a), to identify the nonlinear behavior of shape memory alloy actuators. Mozaffari and Fathi (2012) used an aggregated artificial neural network (AANN) to model the behavior of laser solid freeform fabrication system.

Nowadays, the essence of optimizing large-scale power plants which use very high rates of energy resources, such as natural gas, is really clear. One of the most common traditional tools used for optimization power plants is to combine exergetic and economic characteristics of working fluid (such as stream and natural gas). As defined by Bejan et al. (1996), integration of exergetic and microeconomics forms the basis of an interdisciplinary concept known as exergoeconomic. In general, the optimization of any thermodynamical system should be done by combining the second law of thermodynamic with economics using the concept of energy availability. To be more precise, by doing so, the aim is to mathematically combine the second law of thermodynamic with economic factors to calculate the unit cost of product to quantify the monetary loss due to irreversibility. Along with the mentioned objective, one other important element should be also taken into account to assure the obtained solution is appropriate from practical point of view. The second element is to achieve acceptable properties due to the first law of thermodynamic. This is done by optimizing the maximum power and maximum efficiency of the power system.

Over the past decades, different types of optimization and predictive tools have been proposed to enhance the power plant’s efficiency (Toffolo & Lazzaretto, 2002).

Cammarata et al. (1998) used the exergoeconomic concepts to develop an efficient objective function based on the sum of capital investment and the maintenance cost of the components of the power plant. As for the optimization, Lee and Mohamed (2002) developed hybrid crossover operator for a variant of continuous genetic algorithm (GA) to find the efficient operating parameters of a power plant. Esen et al. (2007) adopted a number of thermodynamical principles for analyzing the energetic and exergetic properties of a ground-coupled heat pump system.

The main motivation of the current study is to utilize thermoelectric cells as waste heat recovery systems to improve the energetic and economic characteristics of Damavand power plant, as the biggest power system of middle-east sited in Iran. Along with the classical economic and energetic analysis of power plant, the authors try to embed optimal number of thermoelectric cells within the condenser for improving the power output of the power plant. The results reveal that an optimal number of
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