Energy 116 (2016) 637–649

Contents lists available at ScienceDirect

Energy

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

Backtracking search algorithm for solving economic dispatch problems with valve-point effects and multiple fuel options

Mostafa Modiri-Delshad [a, *], S. Hr. Aghay Kaboli [a], Ehsan Taslimi-Renani [a], Nasrudin Abd Rahim [a, b]

[a] UM Power Energy Dedicated Advanced Center (UMPEDAC), Level 4, Wisma R&D University of Malaya, Jalan Pantai Baharu, 59990 Kuala Lumpur, Malaysia
[b] Renewable Energy Research Group, King Abdulaziz University, Jeddah 21589, Saudi Arabia

ARTICLE INFO

Article history:
Received 6 May 2015
Received in revised form
26 September 2016
Accepted 30 September 2016
Available online 11 October 2016

Keywords:
Valve-point loading effects
Multiple fuel option
Economic dispatch
Non-convex
Transmission loss
Backtracking search algorithm

ABSTRACT

This paper presents backtracking search algorithm (BSA) for solving economic dispatch (ED) problems with considering valve-point loading effects, prohibited operating zones, and multiple fuel options. The proposed method is an evolutionary technique of optimization with simple structure and single control parameter to solve numerical optimization problems. It is a powerful method for effectively exploring the search space of an optimization problem to find the optimal solution within a low computation time. Different test systems with up to 160 generating units have been used to show the performance of BSA to solve ED problems with high nonlinearities. The results are compared with several methods of optimization to verify the high performance of BSA for solving the ED problems. Statistical analysis of the results among 50 independent runs has been carried out to validate the BSA as a highly robust method.

1. Introduction

Economic dispatch (ED) is considered to be a fundamental economic operation issue in power systems. It aims to determine the schedule of generating units to supply a specific power demand subject to the network and generators' constraints.

Economic dispatch (ED) problem as an optimization problem is composed of an objective function and several constraints. Previous attempts to solve the ED problem have employed the classical methods of optimization known as conventional techniques. In these methods, technical and practical constraints of the generating units and the network have to be simplified/ignored owing to the limits of these methods. Such simplifications divide into two sections. One is associated to the accuracy of the cost model of the generating units especially for different types of fuels or to consider the valve-point loading effects [1]. Another relates to the network topology, either ignored or limited to considering only the total transmission network loss [2].

The objective of economic dispatch is usually to minimize the generation cost in the power system. Traditionally, the cost function of a generating unit is modeled by a quadratic cost function to make the ED a convex problem to be solved by the classical methods. In this case, an analytical solution is proposed in Ref. [3] for solving convex ED problem in a basic form without considering the transmission network loss. Another analytical approach is presented in Ref. [4] for solving the problem by incorporating the transmission loss. However, it has not produced accurate results because of an approximation technique used in the power balance equation. So, it is improved in Ref. [5] and is combined with an iterative method to produce the exact solution to the convex problem. Quadratic programming [6], interior point technique [7], fast lambda iteration [8], lagrange relaxation (LR) [9], and linear programming [10] are other examples of classical methods addressing the ED problems.

In the real world, an ED problem is non-convex with high complexity, so the application of the classical methods is restricted. Although Maclaurin series [11] approximation is employed to solve the non-convex ED problems, it leads to a non-optimal solution. In addition, Dynamic programing (DP) among the classical methods has been proposed to solve the ED problem with no restriction on

* Corresponding author.
E-mail addresses: modiri@siswa.um.edu.my (M. Modiri-Delshad), nasrudin@um.edu.my (N.A. Rahim).

http://dx.doi.org/10.1016/j.energy.2016.09.140
0360-5442/