Chapter 2

Combination of Stochastic Methods for Solving ELD Problem of Thermal Power Generation System

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ABSTRACT

This chapter reports a hybrid optimization technique, a combination of stochastic methods – particle swarm optimization (PSO) and ant colony optimization (ACO), which is applied to find economic dispatch schedule and minimum generation cost for convex and non-convex power generation system simulated in MATLAB. A 40-generator system is considered here with combinations of valve point loading, ramp rate limit, and prohibited operating zone. The output is also noted when transmission loss is taken into consideration. The results are found better than those of many other hybrid methods. Considering the quality of the solution obtained and nature of convergence, PSO-ACO may be accepted as a good alternative for solving ELD problems of varying complexity. Though PSO has been extensively used in ELD problems for its flexibility, robustness, and fast convergence, it often produces suboptimal solution due to its premature convergence. ACO, on the other hand, known for its good global exploration feature, imparts better balance between local and global search when combined with PSO.

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INTRODUCTION

Economic load dispatch (ELD) has become an indispensable function in the operation and control of modern power generation system. One objective of ELD is to find the optimum generation schedule for the generating units whereby the power demand can be met satisfying the transmission loss at minimum generation cost. Improvements in scheduling the unit outputs can lead to significant cost savings. The fuel cost being the major component of the total cost of power generation in thermal power plants, the fuel cost function is considered as the objective function of the ELD problem. Grossly representing, the fuel cost function of a generator is a simple quadratic function while the constraints are linear in nature. However, in large thermal power plants with higher capacity turbines, the fuel cost function is highly non-smooth and non-convex owing to the effect of valve-point loading (VPL) and non-linear constraints like ramp rate limit (RRL) and prohibited operating zone (POZ). For realistic modeling the fuel cost function is taken as a segmented piecewise nonlinear function; this renders complexity to the load optimization problem since the cost function contains discontinuous values at each boundary forming multiple local optima which prevents the classical optimization methods (Grigsby, 2007) from obtaining the global optima. Also the complication of the problem increases significantly with increase in the number of generating units because of their combinatorial nature. This paper presents a novel solution approach to complex ELD problems of 40-generating units with non smooth fuel cost function i.e. with VPL effect together with singular or multiple constraints (generator constraint, RRL and POZ) and with and without transmission loss.

Over the years different soft computing approaches have been employed to find optimal solution of ELD problem. Neural Network (NN) (Mohammadi & Varahram, 2006) and Abdelaziz et al., 2008), Firefly Algorithm (FA) (Yang et al., 2012), Genetic Algorithm (GA) (Won & Park, 2003; Chiang, 2005), Bacterial Foraging Optimization (BFO) (Hazra & Sinha, 2008), Particle Swarm Optimization (PSO) (Gaing, 2003; Park et al., 2005), Ant Colony Optimization (ACO) (Swarup, 2005; Pothiya et al., 2010), Biogeography-Based Optimization (BBO) (Bhattacharya & Chattopadhyay, 2010), Evolutionary Programming (EP) (Sinha et al., 2003; Jayabarathi et al., 2005), Differential Evolution (DE) (Nomana & Iba. 2008), Gravitational Search Algorithm (GSA) (Duman et al., 2010) and Pattern Search (PS) (Al-Sumait et al., 2007) are some of the well known approaches tried. Predominantly in the 21st century, a new trend has been the development and application of various hybrid soft computing approaches (in ELD problem) producing interesting and improved results. A detailed account of research on various original and hybrid techniques to solve ELD problems of different complexity and for small to large power generation systems has been provided by Santra et al. (2014).

The focus of the present study is hybrid soft computing approach in 40-generator ELD problem. Out of the many studies found in literature, two distinct trends are observed in addressing 40-generator ELD – one is without transmission loss and the other one, with transmission loss. Very few have addressed both which the present study does. Some of the well documented hybrid approaches that do not consider loss are: Chaotic Differential Evolution and Sequential Quadratic Programming (DEC-SQP) developed by Coelho & Mariani (2006) uses DE with chaos sequences as the global optimizer and the SQP to sequentially fine-tune the DE run. Bhattacharya & Chattopadhyay (2010) proposed combination DE and BBO that improves the global search capability of DE by employing BBO effectively to generate promising candidate solutions of ELD. The migration operator of BBO is combined with mutation, crossover and selection operators of DE to enhance the convergence speed and improve quality of solution. Al-sumait et al. (2010) proposed hybrid GA–PS–SQP by combining GA, PS and SQP techniques