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A novel stochastic search method for the solution of economic dispatch problems with non-convex fuel cost functions

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ABSTRACT

This paper develops a Novel Stochastic Search (NSS) method for the solution of economic dispatch problems with non-convex fuel cost functions. The NSS solution procedure consists of three steps, namely Direct Search (DS), Goal Neighborhood Approximation (GNA) and Marginal Cost Dispatch (MCD). The DS step identifies a set of feasible solutions in accordance with prescribed equality and inequality constraints. The GNA step processes those feasible solutions to identify an appropriate direction for searching the global optimal solution. Finally, in the MCD step, the marginal cost of each generating unit is regulated in order to establish the global optimal solution. The proposed NSS scheme is applied to solve three examples systems of increasing complexity. The results are compared to those obtained using the conventional Simulated Annealing (SA), Genetic Algorithm (GA), and Evolutionary Programming (EP) methods. The results demonstrate that the NSS method provides a fast, robust and highly effective scheme for the solution of economic dispatch.

1. Introduction

In solving the economic dispatch (ED) problem, the objective is to minimize the total fuel cost subject to various unit and system constraints. In the traditional ED problem, the generator cost functions are approximated by piece-wise linear functions. The operating conditions of the cost function are generally segmented as piecewise quadratic functions. In [1,2], the authors demonstrated the successful solution of these quadratic functions using the lambda iteration dispatch technique. However, for generating units with non-monotonically increasing or non-linear incremental cost curves, particularly cost curves with a valve-point effect, this approach either ignores or flattens out the non-linear or discontinuous portions of the cost curve, resulting in a poorer quality of the optimized results. Therefore, to obtain an improved dispatch, a more efficient tool is required to solve the ED problem.

Dynamic programming (DP) provides a technique for solving non-linear discontinuous ED problems [3,4]. However, DP suffers the "curse of dimensionality" and is prone to the problem of "local optimality". Hopfield neural network models have also been applied to the solution of the ED problem [5–7]. However, such methods involve a highly time-consuming training process. Recently, several powerful stochastic search schemes have been employed to solve the ED problem, including Simulated Annealing (SA) [8,9], Genetic Algorithms (GA) [10,11], Evolutionary Programming (EP) [12–14], Particle Swarm Optimization (PSO) [15–18], Tab Search (TS) [19,20], and Taguchi Method (TM) [21]. However, when applied to highly complex problems, these schemes are obliged to search a wide solution space and the large number of searching iterations. The performance will be affected and downgraded.

In [22–24], the authors solved the large-scale economic dispatch based on differential evolution. In the event of infeasible solutions being identified, the proposed schemes re-dispatched the generation by applying certain heuristic rules to search the neighborhood of the optimal solution. Lin et al. [25] developed a Partition Approach Algorithm (PAA), which integrated the multi-section divided and interval elimination method to solve economic dispatch with non-smooth fuel cost. Al-Sumait et al. [26] presented a Pattern Search (PS) to solve the economic dispatch problem with valve-point effect. PS proceeds by computing a sequence of points that and appears to rely on how close the given initial point is to the global solution. However, such an approach may not consume more execution time if the problem contains many non-linear constraints. Although artificial intelligence techniques have the ability to overcome restrictions, their performance nevertheless requires further improvement. Stochastic search schemes provide a powerful method for solving optimization problems such as the ED problem. In such schemes, a prescribed number of candidate solutions are generated to form an initial population of parents. By carrying

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