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Equal embedded algorithm for economic load dispatch problem with transmission losses

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ABSTRACT

This paper presents equal embedded algorithm (EEA) to solve the economic dispatch (ED) problem with quadratic and cubic fuel cost functions and transmission losses. The proposed algorithm involves selection of lambda values, then the expressions of output powers of generators are derived in terms of lambda by interpolation and finally optimal value of lambda is evaluated from the power balance equation by Muller method. The proposed method is implemented and tested by considering 3, 15 and 26 generators to solve the ED problem. Simulation results such as quality of solution, convergence characteristic and computation time of the proposed method are compared with some existing methods like genetic algorithm (GA), particle swarm optimization (PSO) and Lambda iterative method. It is observed from different case studies that the proposed EEA algorithm provides the qualitative solution with less computational time irrespective of the size of the system.

1. Introduction

Main objective of the economic dispatch (ED) problem is to determine the allocation of output powers of generators so as to meet the power demand at minimum operating cost under various system and operating constraints [1–3]. The fuel cost function of each generator is represented by a quadratic function [4]. The minimization of cost of power generation depends on the efficiency of generator, fuel cost and minimization of transmission loss [5]. It is necessary to consider the incremental transmission losses for the ED problem.

Earlier, conventional optimization techniques such as Lambda iteration method, Lambda projection method and gradient methods [6] have been employed to solve the ED problems. In these methods, computational time increases when the size of the system increases and therefore more time is needed to get the optimal solution. In real time power system operation, the incremental fuel cost may not always monotonically increase. To overcome the above difficulty, dynamic programming (DP) [8,9,25] was used for solving the ED problem with monotonically increased and decreased fuel cost functions as it will not impose any restrictions on the nature of the cost curve. However, the DP suffers from problem of increase of computational time with increased dimensionality. Thus, this method is not suitable for online application of the ED problem.

In order to get the qualitative solution for the ED problem, artificial neural network techniques such as back propagation (BP) algorithm based neural network [10] and Hopfield neural network (HNN) [11,12] have been successfully applied for thermal generators with piecewise quadratic function and prohibited zone constraints [13]. The BP algorithm takes more iterations due to improper selection of learning and momentum rates. Similarly, the Hopfield model suffers from excessive iterations due to an unsuitable sigmoid function [14]. Therefore, it takes more time to give optimal solution at required power demand. In the past decade, global optimization technique like genetic algorithm (GA) has been used to solve the ED problem with quadratic, piece wise quadratic fuel cost function and valve point loading [15]. It is a parallel search technique, which imitates natural genetic operation. Due to its high potential for global optimization, the GA has received great attention in solving the ED problems with a quadratic and piecewise quadratic cost function and valve point loading including transmission losses, ramp rates and prohibited zones [16]. But recent research identified some deficiencies in the GA performance as the cross over and mutation operations cannot ensure the better fitness of offspring because the chromosomes in the population have similar structures and their average fitness is high towards the end of the evolutionary process [17]. Recently, meta-heuristic techniques such as evolutionary programming (EP) [19], particle swarm optimization (PSO) [20], ant colony searching

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